WHY WE MUST STILL BUD AND GRAFT

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Whenever new technologies in plant propagation are developed it is natural to take a critical look at old, long established methods to see whether they should be abandoned. Two of the very oldest methods of vegetative plant propagation are grafting and its later offshoot, bud grafting or budding. Twig or branch grafting is very old indeed, being mentioned in the old testament of the Bible and having been quite clearly portrayed in several ancient Egyptian tomb paintings. Cutting propagation is even older and found wide use in the ancient world, particularly in the propagation of grapevines and olive trees. Early propagators obviously experimented with cutting propagation of many fruit and nut plants and found that some important genera such as apples, pears, and stone fruits could not be rooted at all from cuttings. At some point, some genius learned how to graft woody plants either in the Orient or the Near East or, perhaps, independently in both regions.

Plant propagation by cuttings for many plant genera and by grafting or budding for others remained unchanged for many generations until the discovery of three new technologies which are now the cornerstones of much modern propagation. These were, in order, the discovery and refinement of root-inducing compounds and hormones prior to World War II, mist propagation in the post-war years, and finally tissue culture or micropropagation, which was developed in the past 20 years and is still being expanded and refined. Each of these new techniques made it possible to propagate new genera or species of woody plants which formerly had to be reproduced by grafting or budding if clones or cultivars were desired. Some very important ornamental plants such as rhododendrons, deciduous azaleas, magnolias, Japanese maples, some Japanese cherries and wisterias, for example, which were formerly propagated either by grafting or budding upon appropriate rootstocks, or by the slow and labor intensive method of layering, if superior clones were desired, could now be propagated by rooting cuttings.

For all the remarkable successes which the proper combination of the right hormones and mist propagation achieved in cutting propagation there still remained important plants such as birch clones, *Kalmia*, and some rhododendrons which still could not be rooted by cuttings in an economic and reliable manner. Further

research proved that many of these could be reproduced in tissue culture at low cost and in enormous quantities. Many writers have confidently predicted that grafting and budding, like plowing with a yoke of oxen, are antiquated techniques which will soon be abandoned in favor of more advanced and sophisticated ones. The purpose of this paper is not to be critical of the important advances in vegetative propagation but to draw attention to the many cases in which grafting and budding are still the most practical methods of propagation for clones for certain woody plants.

GRAFTING VERSUS CUTTINGS

New methods of cutting propagation have rightly replaced grafting or budding in the case of many important plants. Cutting-grown red maples are not susceptible to understock incompatibility which was a serious problem with budded trees. Grafted hybrid rhododendrons used to be short-lived garden plants because the favorite understock, *Rhododendron ponticum* was extremely susceptible to root rot from several fungi in our hot American summers. Cutting grown magnolias not only grow faster but are also free from the suckering problem with occurs when they are grafted on *Magnolia kobus* understocks, which used to be the standard practice. Cutting propagation is the method of choice for all of these plants.

However, in many cases cutting-grown plants will not survive cold winter conditions in which the grafted plants of the same clone in an identical situation are completely unharmed. Why this difference should be is still completely unknown. There are some theories, but the causes are probably not the same for each species or clone which exhibits this problem. *Cornus florida* 'Rubra' is a good example of these curious situations. The cuttings root easily enough. By a combination of extended day lighting and controlled temperature it is practical to bring the cuttings through the critical first winter without losses, which used to be the worst hurdle. However, when the plants go to the field for growing on into larger sizes, a slow but steady loss begins. No spectacular die-off occurs but in a few years all are gone. Similarly, cutting-grown *Acer palmatum* clones, particularly 'Bloodgood' are not long-lived. I vividly recall at Princeton a plastic covered can house filled with 'Bloodgood' in one-gal. cans one cold winter many years ago. Three thousand of the plants were own-rooted and 3, 000 were grafted on *Acer palmatum* seedlings. Both grew well the previous summer and averaged 15 in. in height. The following spring I noticed that some of the plants began to droop after leafing out. In three week's time every own-root plant was dead but no grafts were lost.

I was interested in Michael Dirr's recent article on rooting *Hamamelis* × *intermedia* 'Arnold Promise'. Six years ago we rooted 1,500 cuttings of this clone, carried them over the winter successfully and grew them on in 1-gal. cans. They grew beautifully, the best we had ever produced. In the fall we planted 500 out to be grown on, and over-wintered the rest in an unheated plastic house. The following spring all the plants in the field were dead, as were the plants remaining in containers. Of the latter all that we sold never leafed out, nor did those we had shifted up into 2-gal. cans. George Leiss reported similar problems with own-rooted *Hamamelis* cuttings at Sheridan Nurseries in Ontario. It may be that the mild winters at Athens, Georgia are warm enough so that cutting propagation of this popular shrub is practical. We still graft or bud all of these three plants, not because we like the extra work, but because we cannot afford such losses.

Years ago much work was done in Holland in attempts to root cuttings of various *Betula pendula* clones such as 'Laciniata', the cutleaf weeping birch. Techniques were developed to root softwood cuttings fairly easily but overwintering losses caused the project to be abandoned. *Pyrus calleryana* 'Bradford' and other clones can be rooted from softwood cuttings but overwintering results can be so extremely variable that budding is still the major method of propagation.

It is now possible to propagate orchard fruits such as apples and pears from tissue culture. Nevertheless own-rooted apples have not replaced traditionally grown trees because of some advantages for budded orchard trees. One is winter hardiness. Apples budded on hardy understocks like 'Antanovka' will survive winters in cold climates whereas the same clones budded on common apple (usually 'Red Delicious') seedlings or on their own roots will die. For reasons of easier spraying, trimming and harvesting, more tree fruits are now grown on dwarfing or semi-dwarfing clonal rootstocks and such combinations must be budded. The same fruiting cultivars on their own roots make full sized trees, be they propagated from softwood cuttings or by tissue culture.

There are cases in which plants on their own roots make such poor root systems that they are difficult or impossible to transplant. The Howe Nurseries in Pennington, N.J. had a disastrous experience with this problem in the 1920's. Their propagator worked out a method of rooting Koster's blue spruce (*Picea pungens* 'Koster') by taking late summer cuttings from bottom branches and they were soon rooting many thousands each year. When planted out, they grew vigorously and a fortune seemed to be assured. However, when the plants reached saleable sizes it was found that they developed but a couple of long, thick roots and they could not be

dug or transplanted successfully. At Princeton Nurseries we had the same unfortunate results with *Sophora japonica* clones grown from hardwood cuttings. They rooted in commercially acceptable percentages but their root systems were too sparse to be transplanted from the field.

PLANTS WHICH WILL NOT ROOT

Despite all the valuable advances in cutting propagation, rooting compounds, mist systems and light manipulation, there are still many desirable ornamentals which cannot be rooted at all or will do so in too small percentages to be successful. Most of these are trees , but there are some shrubs as well. Oaks and beeches are notorious examples of plants which will not root. The many popular clones of *Fagus sylvatica* refuse to root and must still be grafted to produce liners. Hans Hess reported success in rooting *Quercus robur* 'Fastigiata' many years ago but other species will not root. Any grower who produces large quantities of our native American oaks, has encountered super trees or unusual variants well worth producing, but they cannot be rooted. If they are to be vegetatively propagated at all, they must be grafted, despite some rather high levels of incompatibility in the case of oaks.

Magnolia denudata [syn. *M. conspicua*] is a curious example of a tree that will not root although most of the clones of its hybrid offspring *M.* × *soulangeana*, root quite easily. *Magnolia denudata*, still in the first rank of the hardy white magnolias, must be grafted, preferably on *M. kobus*. *Prunus sargentii* is another very desirable tree which will not root, unlike most of the other Japanese cherries.

GRAFTING VERSUS TISSUE CULTURE

While many plants which cannot be propagated by means of stem cuttings can be propagated by tissue culture, there are some disadvantages to the latter method that are beginning to appear. One of these problems is mutation. Tissue culture propagation produces many young plants from such extremely juvenile cells that the mutation rate is very much higher than what occurs in nature or in cutting propagation. Both of the most important clones of *Acer rubrum*, which are being widely grown from tissue culture, are exhibiting percentages of trees which are not the original clone. As yet it is not clear whether these are true mutations or whether some mixed trees get into the cultures. However, the results are some trees which are certainly not true to name. In the case of evergreen hardy rhododendrons and some deciduous azaleas the production of mutant plants is unacceptably high. Many growers are finding extreme variations in growth habits, leaf size, and flower color.

In the case of the cutleaf weeping birch mentioned earlier, plants grown from tissue culture are quite different from budded plants, being juvenile in appearance with greatly shortened internodes. The original form has been reproduced by grafting or budding unchanged for over 200 years.

Grafting still must be used to reproduce the desirable clonal forms of beeches and oaks. Oaks in particular have yet to be reproduced in tissue culture labs despite the best efforts of skilled technicians.

ADVANTAGES IN GROWTH RATE

There is yet another additional advantage to budding or bud grafting that is well known to shade tree growers, and that is rapid growth in the field. This is especially true of red-foliaged trees like *A. platanoides* 'Crimson King' that are evidently deficient in chlorophyll. It is possible to root cuttings or pot graft these maples on seedlings and get good stands in the field. However, such trees may take several years to reach 6 ft in height. The same clone, budded in the field on vigorous understock may reach 9 ft in height in the first summer following budding. Many expensive years of field culture are thus avoided.

Similar results favor bud propagation over cutting propagation in other tree species. At Princeton we have been successful in rooting clones of *Tilia cordata* and *Zelkova serrata*. However, subsequent growth when they were outplanted in the field was very disappointing. Field-budded trees grew more in one year than the cuttings did in 3 or 4 years. Where incompatibility with properly selected understock is not a problem as in *Tilia, Gleditsia, Zelkova, Fraxinus*, and *Acer saccharum* and *A. platanoides*, field budding is certainly the method of choice.

Even the most ardent shade tree grower will agree that field budding is not a cheap method of propagation. Skilled budders are hard to find and the daily cost of each budding crew is substantial. Understock must be grown or bought and field-grown for the summer in which they are budded. Cutting off the tops of the budded seedlings , suckering and staking the buds to prevent blow-off in summer storms are also costly. However, when the growing structures, labor, and culture costs necessary to grow the tiny plantlets received from a tissue culture lab up to a size suitable for outplanting are considered, the costs of the two methods begin to converge. When the tremendous growth rate of a yearling bud is accounted for, the picture changes and bud grafting has the advantage, particularly given the importance of a straight trunk in a shade tree.

No propagator today is very happy about the rising costs of grafting and bud grafting. Skilled workers are scarce and harder to find. Production rates, particularly in bench grafting and pot grafting are considerably lower than they were a generation ago. Despite the many marvelous techniques which have been developed so that so many plants that had to be grafted in former years can now be easily propagated by simpler methods, grafting in all its forms is still a very necessary part of the propagator's world.

VOICE: Just wanted to comment on the Bradford pear. In 1979 I put out some cutting-rooted Bradford pear and we still have those plants. They look great.

BILL FLEMER: Bradford pear is one of those plants that develops poor root systems when grown from softwoods. We lined out 600 to 700 at our Allentown Specimen Nursery, and when we went to dig them, the root systems were so poor that they just fell over in the balls and we had to discard them. That is one group of plants which tends to produce better by budding.

PETER VERMEULEN: Just a comment on your comment on *Picea pungens*. We have some that are on their own roots that have been there 40 years. With the new root enhancing techniques we have today would you like to qualify your comments.

BILL FLEMER: There probably are cultivar differences. *Picea pungens* 'Koster' produces poor roots but I think that 'Thomsen' produces particularly good ones. Certainly if you dig them up and transplant them a number of times you can develop better roots.

BOB SCHUTZKI: With all the known benefits of clonal rootstocks on fruit trees why have there not been more work done on clonal selection of rootstocks for ornamentals?

BILL FLEMER: Part of the problem is that most are very difficult to root, take the maples such as Norway maple for example. We use seedling rootstocks for those that are difficult to root. Many people are going to clonal rootstocks (M-7 for example) for flowering crabapples because you do not have the suckering

problem. Usually the clonal rootstocks that you would want are so difficult to root that there is no point at all to it. When you can root the cultivars, as with red maple you might as well root them.

DAVE BAKKER: Has anyone rooted *Syringa reticulata* 'Ivory Silk'?

BILL FLEMER: We have rooted it from softwood shoot cuttings very easily and some from hardwoods (low percentage).

FRASER HANCOCK: We have also been rooting it but it has proven to be a slow rooter.