Basics of Propagation by Cuttings—Timing: Age-Related Effects on Adventitious Root Formation

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INTRODUCTION

The observation that some plants have a greater potential to form roots on cuttings was known to the earliest horticulturists and recorded by Theophrastus (300 B.C.). Today, root formation in cuttings can be categorized based on their response to auxin. Cuttings are **easy to root** if application of auxin is not required for rooting. Cuttings can be classified as **difficult to root** if they require auxin to root at high percentages. Finally, cuttings that fail to root even after auxin application are considered **recalcitrant**. In many cases, a species' ability to form roots is modified as an individual plant ages. Species with cuttings that are easy to root are not affected considerably by plant age. However, age-related influences must be considered a major limiting factor for cuttings that are difficult or recalcitrant for rooting.

The basic influence of plant age on root formation can be illustrated in red pine (*Pinus resinosa*) (Gardener, 1929). Red pine is considered a recalcitrant species for rooting. However, Gardener demonstrated that one-year-old seedlings of red pine rooted at 62%. Two- and three-year-old seedlings rooted at less than 10% and in subsequent years, the ability to initiate roots on cuttings was lost. This suggests that rooting potential is linked to the chronological age of the plant.

Unfortunately, the concept of plant age is not as straight forward as this example provided by Gardener for red pine. We must be careful not to bias our view of plant age by our observations of animals as they grow older. Superficially, age is similar in plant and animal systems. Following germination (birth), the individual grows through a juvenile period, then matures to a reproductive stage. The difference is that chronological age (years) does not equal biological age (maturity status) for plant systems. Theoretically, there can be portions of the same plant that contain a juvenile, mature, and a transitional phase at the same time. The chronologically newest portion of a tree is located at the growing tips, while this portion of the tree is biologically oldest. The biologically youngest (juvenile) portion is located at the base of the tree. This is termed the "cone of juvenility" (Hartmann et al., 1990). Therefore a working definition for juvenility is the stage of plant development where the tissue lacks the ability to flower under environmental conditions that normally induce flowering (Hackett, 1985). Also, for many species the ability to form roots on cuttings is inversely related to plant maturity.

With this in mind, it may be more appropriate to illustrate the influence of plant age on the rooting potential of cuttings by the study by Porlingis and Therios (1976) working with olive (*Olea europaea*). They demonstrated that the rooting ability for cuttings decreased as the distance the cutting was taken from the base of the tree increased. Therefore, it was the position on the plant that determined maturity status, rather than simple chronological age. This study also suggests that a cutting taken from a particular position "remembers" its maturity state.

The other important concept about plant age that influences rooting potential is that the stage of plant maturity is reversible (often stably). Methods to induce and/or maintain a juvenile stage of plant development are included in Table 1. The objective of this communication is to illustrate horticultural practices related to plant age that have the greatest potential to influence rooting potential in cuttings. This is not meant to be an exhaustive review of the literature and readers are recommended to the reviews by Hackett (1985, 1988) and the general discussion in Hartmann et al. (1990) for additional references.

Table 1. Methods to induce juvenility.

- Hedging
- Stump sprouts
- Root cuttings
- Tissue culture
- Serial grafting/cutting
- Embryogenesis
- Chemical induction

HEDGING

If shoots that arise from around the base of a tree have the potential to be juvenile, then pruning a plant to induce shoot formation from within the "cone of juvenility" is a logical treatment to maintain a pool of easier-to-root cuttings. This has been demonstrated convincingly for a number of species. Libby et al. (1972) used this technique to hedge radiata pine (*Pinus radiata*). They concluded that hedging arrested the normal decline in rooting potential by rejuvenating cuttings. Subsequent rooted cuttings grew faster and more characteristic of seedlings. They estimated that 100 upright, straight cuttings could be obtained per square meter of hedge. In a similar study, Black (1972) hedged mature Douglas fir (*Pseudotsuga menziesii*) and compared rooting percentages for 24-year-old trees. Cuttings from non-hedged plants rooted at only 5%, while hedged plants produced cuttings that rooted at 45%. Hedging represents the simplest treatment to maintain a large number of cuttings in an apparent juvenile stage of development.

STUMP SPROUTS

Many deciduous tree species have the potential to form adventitious shoots from the stump left after the bole of the tree has been removed. The best evidence that stump sprouts could be a useful technique to produce cuttings with a higher rooting potential comes from work with a 12-year-old American elm (*Ulmus americana*) by Schreiber and Kawase (1975). They showed a 45% increase in rooting for cuttings taken from shoots arising from stumps cut at 0.3 mm above the ground.

ROOT CUTTINGS

It is generally assumed that roots do not proceed through a maturation period and remain in a juvenile state. Stoutmeyer (1937), in a classic paper, made the observation that shoots arising naturally as root suckers on crabapple had the morphological characteristics of seedings. He demonstrated that root cuttings could be taken from mature crabapple trees and that the shoots arising from these root cuttings had a high rooting potential when taken as softwood cuttings. Robinson and Schwabe (1977) recorded a similar response in a difficult-to-root apple (*Malus* 'Lord Lambourne') but also observed that the rooted cuttings flowered in only two years following propagation. The combination of root cuttings to induce a juvenile state and hedging to maintain juvenility offers an attractive opportunity to produce a stock block with a high number of easy-to-root cuttings.

TISSUE CULTURE

The final technique with the potential to commercially alter the rooting ability of a large number of cuttings is through shoots regenerated in tissue culture. It has been documented many times that microcuttings have a higher rooting ability compared to the parent plant. Sriskandarajah et al. (1982) showed that the rooting ability in microcuttings of apple increased with increased time and subculturing in tissue culture. Additional morphological changes (i.e., leaf shape) associated with juvenility have also been observed in tissue culture. Commercial growers have found that some plants derived from tissue culture maintain a high rooting capacity as young liners. This enables growers to successfully root a crop of softwood cuttings harvested from these liners. Struve and Lineberger (1988) demonstrated that softwood cuttings of birch (*Betula papyrifera*) derived from micropropagated liners rooted at a high percentage (75%) similar to seedlings. Apparently, in a situation similar to root cuttings, micropropagated plants can attain a mature state (flowering) faster than would be expected for seedlings (Hackett, 1985). This suggests that the high rooting potential of micropropagated plants would be lost quickly in a stock block unless a technique to retain juvenility (i.e., hedging) was employed.

BIOLOGICAL VS. SEASONAL AGE

An additional factor related to age is demonstrated by species that are easy-to-root during one part of the year and difficult or recalcitrant for rooting at other seasons of the year. This well-documented phenomenon drives the cutting production cycle in all commercial nurseries. Some species show a dramatically short seasonal window for rooting. Stoutmeyer (1942) demonstrated that *Chionanthus retusus* would only root during a 2-week period in the spring. Lamphear and Meahl (in Hartmann and Kester, 1983) showed convincingly that andorra juniper cuttings rooted at higher percentages from November to April compared to summer cuttage.

Seasonal differences observed for root formation in cuttings is not well understood and probably involve a complex association between environmental and physiological factors including nutrition, carbon to nitrogen ratio, and anatomical changes in the stem. Recently, Blakesley et al. (1991) working with *Cotinus* cuttings suggested that seasonal changes in plant hormones could be an important factor contributing to seasonal rooting in this species. They found that the IAA to ABA ratio was inversely related to rooting ability with higher auxin ratios favoring rooting.

CONCLUSIONS

Root formation in cuttings is a complex, integrated phenomenon responsive to environmental, nutritional, and physiological factors. For some species, age-related effects can be the major factor limiting successful root formation in cuttings. Many of the horticultural treatments employed by propagators have taken advantage of the plastic nature of plant age. However, our understanding of plant maturation at the biochemical and molecular level is only beginning. Advances in our understanding of maturation holds the potential to provide a chemical or genetic basis to further manipulate plants to produce cuttings that are easy-to-root.

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VOICE: A comment on the use of plastic right on top of the cuttings for rooting. We have had real good success, especially with the ground covers that root in 3 to 4 weeks. We lay 50% white poly right on top of the cuttings that are under 55% shade. This procedure allows us to use houses that do not have mist, and we do not have to move the plants around.

PETER ORUM: A word of warning. You need to know how much light you have or you can burn up the cuttings. You need a lot of clouds as they have in northern Europe or additional shade to be successful.

The morning session was reconvened at 10:30 a.m. with Dr. Deborah D. McCown serving as moderator.