Methods and Techniques to Improve Root Initiation of Cuttings©

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INTRODUCTION

Plants rooted from cuttings need to have ample roots developed along the stems to provide good growth and proper anchorage. With the increase in clonal production of shade trees and large conifers, good root initiation is essential for long-term survival. Numerous nursery-produced trees were severely damaged during the hurricane season of 2004, with the majority falling over from poor root development. Adequate root initiation and development must occur during the propagation phase to assure good stability and long life of nursery-produced trees.

Stability of trees has been of concern to foresters for many years, particularly in areas of high winds and heavy snowfall in western Canada and Scandinavia. Tree toppling became a major problem in the 1980s when seedling production shifted from field to container-grown trees. Poor root regeneration and stability led to the development of copper-treated containers and later to air-pruning propagation trays and pots. Most forest seedlings are grown from seed so root initiation has not been a problem, whereas root architecture in containers and root regeneration after transplanting are of concern (Johnson, 1996).

Initiation of roots is a primary factor for selection of plants in large-scale nursery production. In recent years superior selections of shade trees, particularly oaks (*Quercus*), are being grown from cuttings. Clonal propagation from cuttings eliminates the variability associated with seed-grown trees and provides very uniform landscape plantings. Growing trees from cuttings is not without problems with root initiation and development being of concern to many growers.

CHEMICAL TREATMENTS TO IMPROVE ROOT INITIATION

There are numerous types of root-promoting chemicals currently on the market. Indole-3-butyric acid (IBA) is the primary root hormone that is available in liquid and talc-based formulations. Liquid IBA products are available in either alcohol or water. Alcohol formulations are rapidly absorbed by cuttings when the quick-dip method is used, whereas the potassium salt of IBA dissolved in water is used on plants sensitive to alcohol. In commercial formulations like Dip 'N Grow, naphthalene acetic acid (NAA) is formulated with IBA to improve root formation. Talc formulations are used when very high concentrations of IBA and NAA are needed for difficult-to-root species without burning the cutting (Dirr and Heuser, 1987). Double Dip hormone treatment is used on difficult-to-root plants where the cutting is quick dipped in a liquid formulation and then treated with a talc formulation to provide a residual amount of hormone for better rooting (Jones, 2004).

An alternative to this is to dilute products like Dip 'N Grow, Woods Rooting Compound, or C-Mone in a gel prepared from dissolving carboxymethycellulose (CMC) in water to the consistency of thick motor oil. The CMC is a thickening agent used in food products like salad dressings and ice cream. By using a gel preparation, you can use a lower concentration of IBA/NAA because more gel is present on the cutting than when you use plain water. A lower concentration of IBA/NAA is less likely to burn cuttings, especially if you wound. Gel dilutions are very stable, keeping IBA concentrations constant throughout the day when in use and preventing degradation when stored. The author has been very successful rooting camellias with this method. Blythe and Sibley (2005) found this method resulted in more roots per cutting on *Hibiscus syriacus*.

Other additives to rooting hormones reported to increase root initiation are DMSO (dimethyl sulfoxide), PEG (polyethylene glycol), and DMF (dimethylformamide). However, care must to taken when using these additives because they increase toxicity (Dirr and Heuser, 1987). Vitamin K_3 (menadione) is also reported to be synergistic with IBA for rooting hardwood cuttings of *Prunus* species (Christov, 1995).

Chemical pretreatments to improve root initiation include soaking cuttings in plain water overnight under refrigeration to leach out endogenous root inhibitors. This can be a very successful technique for native azaleas. Another technique used to increase rooting for plants high in phenolic compounds and peroxidase enzymes is to dip or soak the lower end of cuttings in ascorbic acid dissolved in water at a concentration of 1.7%–2.5%. Soaking time ranges from a few minutes to several hours depending on the plant and the diameter of the cuttings. The author soaks a difficult-to-root camellia cultivar 'Frank Houser' in a solution of 2.5% ascorbic acid for 1–2 h and increases the percent rooting and number of roots by 50%. Camellias are high in phenolic compounds that counter the effect of auxin. This technique is also effective for improved rooting of *Stewartia* (Bresko and Struve, 2001) and native azaleas (Cook, 2004).

One of the most effective ways of increasing root initials and improving root structure is the use of copper-treated containers (Crawford, 1998). During the development of Spin Out by Griffin Corporation, Valdosta, Georgia, it was discovered that treated propagation trays would improve the number of roots developing from the stem and callus. It has been suggested that when adventitious roots are pruned early in development, a branching stimulus occurs along the stem thereby increasing root numbers. Unfortunately, pretreated propagation trays are no longer commercially available at this time.

It is well known that amending the rooting substrate with products that increase porosity and air space will improve root development. Products like perlite, vermiculite, course sand or gravel, and pumice improve the rooting properties of bark and peat. Incorporating low rates of controlled-release fertilizer in rooting media will improve root growth and overall health of the cutting when ready to transplant.

Research by Scagel et al. (2003) suggest that incorporating inoculum of the vesicular-arbuscular mycorrhizal fungus (VAMF) *Glomus intraradices* in the rooting substrate increased root number and growth of *Taxus* ×*media* 'Hicksii'. In order to determine the benefits of VAMF, small-scale trials are necessary to determine the VAMF species required for the particular plant species you are growing.

Another soil amendment with biological activity to improve root numbers and growth is meadowfoam seedmeal marketed as AlbaAide (Deuel and Linderman, 2004). Meadowfoam seed (*Limnanthes alba* Benth.) is produced in Oregon for its oil. After the oil is extracted, the seed meal remains as a waste product. Uses for the seed meal have been explored for the last several years and include liverwort control in nurseries, improved potato production, and improved plant growth. Recent work by the U.S.D.A. Forest Service in Oregon has shown remarkable growth effects on forest seedlings when seed meal is incorporated in the growing substrate at 1%–5% by weight. Research showed that water extracts of the seed meal were more active than IBA for root promotion. Additional research is needed to determine the full potential benefits for rooting cuttings.

PHYSICAL TREATMENTS TO IMPROVE ROOT INITIATION

Physical manipulation of cuttings can have a profound effect on the development of roots. Wounding the cutting is a standard nursery practice to stimulate cell division and for better absorption of rooting compounds. There are three types of wounding: (1) scraping one side of the cutting 2.5 cm (1 inch) from the base, (2) scraping the opposite sides of the cutting, and (3) a split wound. The first two are the most common types and are very beneficial for certain types of *Camellia, Magnolia, Ilex, Juniperus, Rhododendron*, and *Thuja*. Cuttings of conifers like Leyland cypress are wounded when the needles are stripped from the base of the cuttings (Dirr and Heuser, 1987; Remmick, 1993).

The use of air-pruning containers has gained popularity among tree growers in the last few years as a way to manipulate root growth and eliminate root circling. Manufacturers have developed rooting trays incorporating air-pruning technology to improve the root structure of cuttings and liners (Appleton, 2001). Root initials and root branching are increased when these containers are used. There are several brands of air-pruning propagation tray available including RootMaker, Accelerator, Proptek, and Jiffy. These products have undergone many design improvements since first introduced and are currently the best container devices for rooting and seeding trees. It is necessary to remove trays from the mist area before excess aerial roots and root bridging between cells occurs.

There are differences in opinion whether to root cuttings in full sun or in shade. Most growers use shade because it provides a cooler rooting environment, which is beneficial in the Southern U.S.A. In the last few years, new types of colored shade cloths have come on the market to enhance plant growth in certain ways depending on the color used (Shahak, 2001). The author has been using 50% red shade cloth for rooting and growing camellias. According to the manufacturer, red light enhances root initiation and growth. I can speak from personal experience that it does enhance plant growth. My camellias are about 20% larger than plants grown under black cloth and magnolias from seed are nearly two times larger than plants grown outside under tree shade. Deciduous native azaleas rooted in 2.5 months and have a good growth flush 4 months after sticking.

STOCK PLANTS

It is known that plants in good nutrition will root better than plants under poor nutrition. Excess nitrogen applied to stock plants stimulates growth, but cuttings from these plants have lower rooting potential. Good balanced nutrition is the general rule, although good boron fertility is correlated to cuttings that root better. Since native soils in the Southeastern U.S.A. are deficient in boron and it is easily leached, improved boron nutrition may result in cuttings with improved rooting potential (Hartman et al., 2002).

Age of stock plants can be a critical factor for maintaining good rooting potential of cuttings. Young, juvenile plants are best for obtaining cuttings, especially hard to root trees and conifers. Timber companies that grow superior clones of pines from cuttings maintain stock plants as short hedges 0.6 m (2 ft) tall to sustain juvenility for several years. Hedges are replaced every 7–10 years when rooting potential declines (Hartman et al., 2002).

Etiolation is a practice to produce elongated stems in darkness to improve rooting potential. Although this is a proven way to improve rooting, it is not practical for commercial nursery production.

Other factors that can have an effect on root initiation are time of year cuttings are taken, lateral vs. terminal branch cuttings, photoperiod requirements, the use of bottom heat, and the use of mist or fog in the rooting area.

Table 1 is a recipe for rooting oaks. On the left are recommendations by Dirr (1997) and on the right are steps that can be taken to improve root initiation of trees and conifers that have problems initiating roots.

Table 1. Techniques to improve rooting of oaks.

Dirr (1997) Recommendation	Summary Steps to Improve Root Initiation
Collect cuttings from juvenile plants	Good boron fertility
Collect firm-wooded terminal cuttings from 1st flush	Wound
Treat with 10,000 ppm quick dip	"Double dip" hormone treatment or use a gel formulation
Stick in 3 perlite : 1 peat (v/v) medium	Incorporate mycorrhizal fungi and/or controlled release fertilizer; use air-pruning propagation trays
Maintain under intermittent mist	Bottom heat if irrigation water is cold or during winter rooting
Shadehouse	30%–50% red shadecloth

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Optimizing the Water Relations of Cuttings During Propagation©

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SO, HOW DO CUTTINGS GAIN AND LOSE WATER?

It is important to remember that water is the universal solvent. It brings minerals from the roots for biosynthesis within the leaf. About 1%–2% of water utilized is needed for photosynthesis and plant growth, while the remaining 98% of water is lost to transpiration and the subsequent cooling of leaves. Evaporative cooling occurs during transpiration as water passes from a liquid to gaseous phase (vapor). Transpiration is the "engine" that pulls (lifts) water up from the roots. Unlike people, who can move and find a more comfortable location, a plant lacks mobility, so it needs to do its best to reduce the heat load, which it does through transpiration. There is tremendous pressure (tension) that occurs in the top of a 100 m (300 ft) redwood tree (*Sequoia*) in the movement of water from the roots into the tops of these tall trees. The pressure in the xylem (part of the plumbing system of the plant) can exceed 250 psi, which is some 18 times greater than atmospheric pressure. The lifting of water occurs through transpiration and the process of cohesion with the hydrogen bonding of water molecules. This gives a column of water tremendous tinsel strength, i.e., as strong as metal.

ENVIRONMENTAL FACTORS AFFECTING TRANSPIRATION

There are three environmental factors that effect transpiration: light, temperature, and humidity.

Light causes plants to transpire more rapidly, stimulates the opening of the stomata (Fig. 1) and warms the leaf. Temperature increases transpiration since water evaporates more quickly. A 20 °F (10 °C) increase in temperature will cause a 3-fold increase in transpiration. Humidity affects the diffusion of water as a vapor from the leaf through the stomata into the surrounding drier air. Water travels from a high potential (saturated internal leaf cavities) to a lower potential (unsaturated, drier) surrounding air outside the leaf (Fig. 1).

VAPOR PRESSURE DEFICIT (VPD)

Vapor pressure is determined by temperature and relative humidity (RH). The vapor pressure deficit (VPD) is the gradient measured as difference between the