Recent Advances in Cutting Propagation©

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INTRODUCTION

Staying abreast of research developments is a challenge in any area of science and, perhaps, even more so in the relatively obscure area of fundamental and applied research of adventitious root formation on cuttings. There are not a large number of scientists doing plant propagation research, certainly fewer than there were even a few decades ago. As well, there are several journals that publish propagation findings, so there is not just one place to turn for timely information. Traditionally, more applied work was found in the *Combined Proceedings of the International Plant Propagators' Society* (CPIPPS), and more fundamental research was published in the *Journal of the American Society for Horticultural Science* (JASHS) or *HortScience* (HS). In the last 15 to 20 years, however, several other publishing venues have gained in popularity, including the *Journal of Environmental Horticulture* (JEH), the *Proceedings of the Southern Nursery Association* (SNA), and *HortTechnology*. Add to that the ease of using the Internet to find published and anecdotal information on propagation, and it is more apparent why so much less is being published in JASHS, HS, and CPIPPS.

Many industry professionals turn first to articles published in the popular literature — *American Nurseryman, NMPro, Grower Talks*, etc. Articles in these publications typically are written by one of the magazine editors or a respected horticultural scientist or extension faculty. The information usually is very basic, along the lines of an introductory textbook, and review years of work or industry practice, so are less up-to-date than the scientific literature. On the other hand the work is described in language that can be taken straight to the propagation house and put into practice by the average plant propagator.

Growers who are more technologically oriented, or who have an advanced degree in horticulture or a related science, may feel they can tackle the refereed scientific literature. This information is written by the scientists who did the work and, hopefully, is published no more than a few years after the work was completed. As well, the work often was done through a grant funded by a horticulture granting agency like the Horticulture Research Institute (HRI) or the U.S.D.A. and so has already passed a degree of scientific muster. However, many propagators may not feel they are qualified to read this level of scientific literature. My advice to these folks is to identify someone on your staff, or hire someone, to do this reading for you — as you will see in the examples below, there may be research results that will apply directly to your production system, and save you lots of money!

Of course, this disconnect between what the industry reads and what horticulture scientists publish is why the International Plant Propagators' Society (I.P.P.S.) was founded, as a venue for the interaction of all persons interested in plant propagation. Many I.P.P.S. members cite as a major attraction of I.P.P.S. and the annual meetings the opportunity to network with others with a range of training, from practical propagation-bench, to public garden, to large-scale industry, to university laboratory. To this I would add that I.P.P.S. attendees on tours should pay attention — since the propagator doing a dog-and-pony show at the nursery, but not attending the talks, may have some valuable information to share.

As I browsed scientific literature from 2003 to 2006 in the preparation of this paper I was surprised and a little disappointed to find that, despite the importance of plant propagation to the nursery industry, there is relatively little research information making its way into the literature. As mentioned above there are fewer nursery-production-oriented research faculty in our Land-Grant universities than ever before, and there remain few significant grant opportunities for research on plant propagation issues. On top of that there is unprecedented competition for faculty positions and funding from all those areas of research that fall under the umbrella of "biotechnology," which hold great promise for all aspects of plant production, but which also are expensive to develop and maintain — leaving little behind for applied horticultural science. So, these days, most propagation research is undertaken by those faculty and individuals who are passionate about the subject — indeed, passionate enough to carry on with limited or no funding.

Given the paucity of propagation research being published, one might reach the conclusion that all the important work was done in the 20th century — the heyday of horticultural research — but this is far from the truth. Now more than ever there is a need to maximize propagation and production efficiencies, in light of ever-rising fuel, materials, and labor costs. There are so many new plant species that are not described in past literature, and the differential behavior of cultivars is evident in all aspects of plant production.

Surprisingly there have not been the advances in the biotechnology or chemistry of adventitious root formation that we anticipated just 20 years ago. While we have more genetic mutations associated with adventitious rooting at our disposal than ever before, we have yet to learn anything we didn't know decades ago — and unless a significant economic incentive develops we may remain in the dark, well into the future, about many aspects of root formation and growth. A partial solution to this dilemma may rest in using cutting-edge genetic tools to re-evaluate stock plant and cutting pretreatments to rooting that were reported in the past and not followed up. Again and again a particular method, e.g., the etiolation of stock plants, will be studied intensively during the careers of a few horticulture scientists, then fade into obscurity. This, of course, is why we are so fortunate to have resources like the textbook *Plant Propagation: Principles and Practices*, and the CPIPPS to serve as a record of propagation methods only partially developed. Biological Science is now in a position to expose the underlying genetic and physiochemical controls that facilitate some of these novel propagation techniques — if only someone will take up the mantle!

Given the many sources of information available to us, and the many forms this information may take, there is always a need to look around at that research that is being published in the literature today — to see what is new or being given new importance. I am pleased to have this opportunity to review new advances in cutting propagation for the Eastern Region, North America, and quite surprised by some of the things I found. To maintain some semblance of organization I have grouped the research I chose to share into three broad categories, presented from more fundamental to more applied: cutting physiology, plant growth regulators, and propagation/production efficiencies. One area of research I have omitted is that of new plant propagation research. While this is important to the industry, there is not much "new" in cutting propagation that takes place when a researcher evaluates the rooting potential of a previously undocumented plant species, though the work, or course, stands on its own merits as original research.

CUTTING PHYSIOLOGY

In the area of the physiology of cutting propagation papers came out in the last few years in two basic areas that seem applicable to I.P.P.S. readers. A series of excellent papers by Anthony LeBude of NCSU describe the relationship between mist irrigation and cutting water potential, with the goal of being able to use computer-controlled mist irrigation in the most effective way to maximize rooting and root growth. The studies were presented over 2 years at research meetings of the Southern Nurserymen's Association (2003 and 2004) and were published in *Tree Physiology* (2004) and *HortScience* (2005). The impetus for this work was the observation that cuttings of loblolly pine, *Pinus taeda*, rooted better when they experienced moderate water stress (on the order of -0.5 to -1.2 MPa) during the initial 4–5 weeks in the rooting bench. Cuttings that were too wet or too dry did not root well. Using a mist research system based on a computer controlled irrigation boom, LeBude first linked cutting water potential (Ψ_w, which requires a destructive measurement) and rooting percentage. He then worked to link Ψ_w with vapor pressure deficit (VPD), which is essentially the evaporative potential of the cutting and is easily measured with a thermocouple and relative humidity sensors. LeBude showed that Ψ_w and VPD were both good predictors of the rooting potential of loblolly pine cuttings, opening up the prospect of dynamic environmental control of cutting irrigation. It is easy to envision mist levels being controlled by computers sensing VPD and giving the propagator unprecedented control over cutting water status. It is not known if the stem cuttings of all plants benefit from mild water stress during rooting — that research still needs to be done.

One researcher who has worked steadily on cutting physiology is Dan Struve of Ohio State University. Professor Struve has been trying for many years to solve the problem of poor overwinter survival of cuttings of certain species rooted in the summer that fail to produce new growth before winter sets in. Work in the past has focused on forcing new growth on rooted cuttings — with mixed success. Sometimes it is almost impossible to get cuttings to break bud again in the fall. Struve and a visiting scientist, Phillip Wilson, sheared stock plants of *Viburnum dentatum* to induce new axillary shoot growth before taking the cuttings. The idea was that if new shoot growth is pushing before the cuttings are taken, the shoots are more likely to continue growth after rooting. They also looked at incorporating controlled-release fertilizer (CRF) in the rooting medium as a means of increasing the new shoot growth. Wilson and Stuve found that cutting with actively growing axillary shoots grew more in the same year, and overwintered better, than cuttings from unsheared stock plants. Using CRF also increased growth both before and after overwintering. These results, found in the Spring 2006 issue of the *Journal of Environmental Horticulture*, should be applicable to other species that are notoriously difficult to overwinter, such as *Stewartia* and red maple. Cutting survival was influenced by the amount of axillary shoot growth in the present study, and the best time and degree of shearing would need to be determined for each species.

PLANT GROWTH REGULATORS

A number of papers have come out in the literature recently on novel methods of applying auxin to cuttings. The majority of this work has come from Dr. Jeff Sibley's group at Auburn University in Alabama, in collaboration with Dr. Ken Tilt of Auburn and Dr. John Ruter, a researcher for the University of Georgia who is based in Tifton. I had a number of papers to draw on — all authored by Gene Blythe, a graduate student with Dr. Sibley — from the I.P.P.S. proceedings (Southern and Western regions), the proceeding of the Southern Nurserymen's Association, and *Scientia Horticulturae*, an international horticultural science journal based in Great Britain. Because the synthetic forms of auxin used in plant propagation are potentially carcinogenic and more restrictions in the use of auxin for commercial plant propagation are likely, there is a need for research into novel methods of applying auxins that reduce worker exposure and the amount of auxin used in the industry. Despite the obvious need for more research in this area there has been remarkably little work reported in the literature.

Sibley's group has taken the lead in investigating two methods of applying auxins: through the rooting medium or via the cutting foliage. The foliar auxin work is based on research done in the 1960s by Professor John McGuire of the University of Rhode Island (my predecessor) and reported in early I.P.P.S. Proceedings. McGuire showed that isotopes of indole-3-butyric acid (IBA) applied to the base of cuttings were rapidly redistributed throughout the stem and leaves of the cutting. Blythe and coworkers took this as support for their hypothesis that auxins applied to the foliage should move to the cutting base and stimulate adventitious root formation. The present research used a range of plants in controlled comparisons of foliar sprays with conventional quick dips. The auxin formulations varies, but were based for the most part on dilutions of Dip 'N Grow® (Dip 'N Grow, Inc., Clackamas, Oregon). Foliar-applied auxin did not work as well as might have been hoped. The rooting response of cuttings treated with foliar auxin generally was equal to or less than those treated with a quick dip. One drawback with the species chosen for these studies was that for the most part they rooted fine without any auxin, so benefits of even the quick dip treatment were not always obvious. On the other hand, in certain species, shoot growth was inhibited, suggesting that auxin levels were too high in the shoots and not high enough at the base of the cuttings. The authors concluded that the foliar-applied auxin was not moving to the base of the cuttings in sufficient amounts to affect adventitious root formation.

In a similar vein, Sam Drahn of Bailey's Nursery reported, in the 2003 Western Region CPIPPS, on using Hortus water soluble IBA salts with a backpack or boom sprayer to treat cuttings of 30 plant taxa on a commercial scale. The goal of his studies was clearly to reduce to costs associated with sticking the millions of cuttings that Bailey's processes each year. Drahn experimented with much higher rates of foliar auxin than used by Sibley's group, in the range of 750 to 2,500 ppm, and again compared these treatments to a conventional quick dip. Though the optimal rate varied with the species, the foliar sprays worked well, and only in a few cases was any auxin toxicity apparent. Drahn went on in his paper to analyze the costs of each treatment and concluded that foliar sprays are an economical alterative to treating individual cuttings before sticking. I followed up with Sam, who reported that his trials are continuing with great success. He has been very impressed with the savings in labor and overall production costs and looks forward to switching the majority of his cutting propagation over to foliar auxin treatments.

In contrast to their results with foliar sprays, Blythe and coworkers' studies using auxin-pretreated rooting plugs (Q Plug™, International Horticulture Technology, Inc., Hollister, California, USA) worked quite well, with very low auxin concentrations (< 45 ppm) working as well as a quick dip auxin treatment for a range of species. At higher concentrations (> 45 ppm) a number of species began to exhibit symptoms of auxin toxicity, such as stunted roots, rooting higher up on the cutting, and delayed shoot growth. I contacted the authors about the longer-term effects of the auxin-laden plugs on subsequent plant growth. They reported back that the rooted plugs continued to grow well (presumably when using lower auxin rates). This is a promising technology that clearly deserves further research and commercial development. Using pre-treated plugs could dramatically reduce worker exposure to auxin as cuttings are being prepared and could also reduce the waste and environmental concerns associated with discarding unused dips or powders that have been contaminated during use.

PROPAGATION/PRODUCTION EFFICIENCY

Finally, I ran across a rather unlikely paper by a German scientist in the pages of the 2003 CPIPPS of the Great Britain and Ireland region. This paper, by Professor Wolfgang Spethmann of the University of Hannover, described a number of experiments with a wide range of woody plants using long cuttings to reduce production time and produce standards for grafting. Spethmann's strategy was to use cuttings in the range of 24 to 100 inches long that are then rooted in high humidity. He employs a peat-sand rooting medium and a plastic greenhouse with high-pressure fog. Spethmann has done a lot of work with the dog rose, *Rosa* 'Pfänders Canina', for use in rose standards. But what really caught my eye was a table of rooting results for what are traditionally thought of as difficult-to-root trees: *A. platanoides*, *Carpinus betulus*, *Pyrus* sp., *Quercus robur*, *Tilia cordata*, and *Ulmus* 'Regal', as well as apple, cherry, and pear. Cutting lengths for these taxa varied from 39 to 93 cm (15 to 36 inches), and stock plant ages up to 30 years old, and yet rooting ranged from 57% (*Pyrus* cv.) to 80+% for *Tilia*, *Carpinus*, *Quercus*, and 97% for *A. platanoides*. As my mother used to say, "Who would've thunk it?!" These can only be termed phenomenal results — certainly worthy of our scrutiny and follow-up research.

Spethmann's method presents a striking contrast to the normal practice of taking cuttings in the range of 5–20 cm (2 to 8 inches) — and getting weaker rooting responses! I can image that this technology could draw upon a coppiced stock block — taking advantage of the rejuvenation that comes with repeatedly cutting back the stock plant — maintained to produce long cuttings. Though I am sure this technique will not work for everything, it struck a chord with me because of my recent efforts to propagate Canadian hemlock, *Tsuga canadensis*, from mature adelgid-resistant forest trees. Last winter (February) I grafted putative resistant hemlock wood onto seedling Canadian hemlocks and had a number of branches left over from which all the suitable small cutting wood had been removed. On a whim, we treated the branches — ranging from 6 to 12 inches (15 to 30 cm) in length, and including some 2-, 3-, and perhaps even 4-year-old wood, with Hormex 45 (4.5% IBA in talc) and stuck them under mist in perlite and peat (4 : 1, v/v) with 70 °F bottom heat in a poly greenhouse set to 65 °F. Contrary to our expectation, the grafted plants failed completely, while the long cuttings rooted better than 60%. These cuttings also formed good root systems and grew on well the following growing season, while a group of shorter cuttings, which had rooted only 10%–25%, suffered high mortality or grew poorly.

In a series of follow-up communications, Professor Spethmann emphasized the use of high-pressure fog, the benefit of cutting back the stock to promote long shoot growth, the use of current year shoot growth, and taking cuttings (of sycamore maple, *A. pseudoplatanus*) from low on the stock plant. He continues an active research program with long cuttings — stay tuned for more exciting results from this effort.

In conclusion, my review of cutting propagation literature from 2003 to early 2006 revealed that in certain areas the science and art of propagation by cuttage does move forward, albeit at a slower pace than in decades past. While there is some work in molecular biology of rooting taking place, the majority of applied nursery propagation literature is still found in relatively few journals and proceedings, and it is obvious that there are fewer nursery-oriented horticulture scientists and faculty than there used to be. It was also very apparent to me that though it may be time consuming and a difficulty for propagators to keep up on the literature, there are important developments being reported that should not be missed — the professional can not afford to get behind on the literature if he wants to remain competitive. I am pleased to represent the International Plant Propagator's Society in my efforts to keep you informed — Seek and Share!

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