Bringing the Art and Science of Cutting Propagation Back to the Bench©

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INTRODUCTION

As a propagation instructor at the University of Rhode Island for 20 years I often have been asked to help develop protocols for propagating research plants. Typically the scientist wants to start right away, and is frustrated when I let them know that they should have started preparing a year or two earlier. Of course they are even more frustrated when they set up a half-baked propagation experiment and it fails. Plant propagation has been characterized as part science and part art – which it is, but it also is part experience, part preparation and part good record keeping.

Unlike some other areas of horticulture education, we have excellent propagation texts and printed resources for students and researchers to consult. *Hartmann and Kester's Plant Propagation: Principles and Practices*, (HKDG), now in the 8th edition, is an unparalleled resource – with excellent references and both basic and practical information. This is still the best value for a textbook. Another book that all propagator-growers should have is Bruce MacDonald's *Practical Woody Plant Propagation*, which offers practical advice for the nursery grower or commercial propagator. Sadly it is likely, since Bruce has passed away, that this text will not be updated, but it is still a must for the propagator's shelf. The Combined Proceedings of the International Plant Propagators' Society, while harder to dig into for the lay propagator, is a great place to see if "it's been done" in over 60 years of IPPS meetings.

For sure, not every bit of propagation knowledge has been captured in courses or textbooks. There is a lot of knowledge still to be gained from local nurseries, greenhouses and garden centers. The folks that get into this business are mostly plant geeks at heart, and many are darn good propagators that would love to share their experience – you just have to ask. Or bring your questions to the next IPPS meeting!

Of the hundreds of students to whom I have taught plant propagation, only a handful have become commercial propagators – the majority resort to what they learn from me when they want to propagate a new plant or as a part of their garden routine. So I try in all lectures and exercises to give them methods that will stay true through time. I strive to teach them how the plants works, so they can – in essence – "Think Like a Plant." But the art and sciences of plant propagation is incredibly varied and complex. It takes years, or even a whole career, to become a real expert. This knowledge must be accumulated through experience; it cannot be substituted by a textbook, or a computer-programmed machine.

PRIMING CUTTINGS TO ROOT

As stated so well in HKDG, the goal of the plant propagator should be to "prime" the cuttings to root. Then get them to survive – in the propagation bench or nursery – and get them to grow on after rooting, which is not so easy for some species. Successful priming means working with the parent plant before the cutting is taken. Survival means understanding how the plant respond to its environment, and how delicate a severed shoot can be. Another big challenge is to coax a rooted cutting to grow again, after it is exhausted from the rooting process.

The establishment and use of propagation stock plants (blocks) is critical to maximizing cutting health and rooting capacity, and should be used much more. Regretfully, stock blocks are viewed as a traditional practice and are used much less now. Hoogendoorn Nurseries, Inc. in Middletown, Rhode Island was generous to let me conduct research on their stock plant hedges – more than a score of them (Case Hoogendoorn was a fixture in

the front row for decades of IPPS meetings). I have always stressed to my students that taking cuttings from production means compromising – what is good for production is often not best for rooting and survival of cuttings. I hope that if we ever get back to simpler times the stock plant will make a revival.

General recommendations hold that shoots used for cuttings should be moderately vigorous, not too high in nitrogen, and under little or no water stress. Cuttings should be at the right stage of growth, and not ready to flower or entering an active growth flush. It is the physiological or ontogenetic age, not the chronological age, that matters. Juvenile wood roots better. So how does this mesh with taking cuttings from production? Not very well perhaps, given that the production manager want to push growth for sale and flowers sell best.

Much of my research has been spent working with stock plants for cutting propagation. I have used extended day length to push growth, and shaded or even fully excluded light to prime cuttings to form adventitious roots. Hedges are wonderful tools for stock plant culture. You have great control over plant nutrition, water and soil, and the repeated cutting helps to keep the wood more juvenile. Others, like John Preece (Henry and Preece, 1997) and Paul Read (Yang and Read, 1992), have done excellent work forcing new growth on stem pieces under mist or priming with growth regulator solutions. It is accepted practice now to rejuvenate physiologically aged material through tissue culture – the effect lasting for at least a few rounds of cuttings – perhaps more if combined with a stock plant hedge program.

Each species has an optimal season for cuttings to be collected. Some can be propagated almost anytime, others only in the weeks after bud break, or in the fall after buds are dormant and carbohydrate levels are highest. This is the value of the IPPS Proceedings, and the chapters at the end of HKDG. Dirr and Heuser's *Reference Manual of Woody Plant Propagation* is also a wonderful resource to determine at starting point for timing the propagation of many difficult-to-propagate trees and shrubs.

In teaching students to "Think Like a Plant", I describe the competing sinks for carbohydrate that exist in the severed cutting and how growing shoots, or flowers, can compete with growing roots for this limited resource. For example, taking cuttings just before bud break is usually a bad idea. Since timing is often a factor of dormancy, and may be measured using chilling units or growing degree days it is surprising that more effort has not been made to standardize propagation research results in this way. I guess that after the fact it usually is too late to determine the growing-degree days experienced by a stock plant and how that relates to ease of rooting in the cutting. It would be a great tool to help predict the best time to take cuttings.

From where on the plant should cuttings be taken? While species will differ in this respect, as a general guideline cuttings should not be too thick or too spindly. The best cuttings may be found around the sides of a stock plant, not growing straight and vigorous from the top, or languishing in the shade at the bottom or interior. While side cuttings may be best, in some conifers this can result in prostrate (plagiotropic) growth. This is information seldom found in print, and is very much a part of the experience gained from repeated propagation trials. Predicting propagation success based on plant growth characteristics is almost an art.

Finally, with the stock plant primed to yield productive cuttings it is time to take the cuttings and get on with the project. The cuttings should be taken in the morning when the plant has the best water status, air temperatures are the coolest, and the plant is under the least stress. After taking cuttings, plunge them briefly in cool water to take off the field heat, and hold them in a cooler at ~5-8°C for a time before sticking. These are examples of the critical steps that should be noted for future review. If the cuttings fail to root was it because they dried out after they were collected? Or got moldy in storage? Ronn St. Jean, a Rhode Island friend and long time IPPS member, is my inspiration. I have him come in to help my students graft and always ask him to share with the class how important his notebook, always in his breast pocket, has been to his success as a plant propagator.

THE ROOTING ENVIRONMENT

The rooting environment is critical to success, but it does not have to be highly technological. Technology tempts us to ignore the plant material – just dial up a set point and let it run! This is not a smart way to propagate. I have found the most experienced propagators will not rely just on computers and set points. From past experience they know the plant, can read the conditions, and adjust ventilation, light or irrigation in minutes. The catch is that this level of attention is a full time job – in the old days the propagator would check his cuttings a half-dozen times a day, seven days a week. It is hard to justify that intensity of labor in today's competitive industry – which may be the "Big Problem" facing plant propagation in the 21st Century.

The cutting's leaves are typically trimmed by a third to a half to avoid overlapping of cuttings and fit more in the bench. However, I was very intrigued to read in the 6th edition of Hartmann and Kester's Plant Propagation: Principles and Practices that trimming leaves is no longer recommended. This makes sense if you "think like a plant" – since trimming may increase plant stress more than it solves water loss problems, but trimmed cuttings were long considered the most efficient use of bench space. On the other hand, you can trim some species without any problem, so you need the experience gained from propagating many different plants. This is also why if you are still relying on an earlier edition of Hartmann and Kester, you should check out the 8th edition – it is full of the latest information.

Everyone uses auxin to stimulate rooting. One important set of experiments I have students set up is a dose response of auxin and rooting on a variety of herbaceous and woody plants. It is an important learning moment for them when they discover that you don't need auxin to root everything. This lesson helps ensure they minimize the use of potentially dangerous chemicals in the future. Research done at Cornell University when I studied there showed that high auxin levels can inhibit subsequent bud break and growth, and cause leaf drop in the propagation bench (Sun and Bassuk, 1993). Clearly there is value to determining the minimum level of auxin needed to root each particular species, which in turn will likely vary with season and condition of the wood.

Most students are timid the first time they stick cuttings. They stick too shallow and don't firm the medium enough – so within a week the cuttings are falling over or out of the trays. I learned from a perennial grower how helpful it is to stick two nodes deep – and it works for woody plants too, as long as the propagation flat is deep enough. So we have moved to deeper trays or tree tubes for propagation – which gives the needed depth and improves drainage and aeration in the rooting medium. I make sure the students learn how to stick their cuttings deep and tight.

In the excitement of setting up class experiments I sometimes forget a key point of propagation – making money! So I sometimes have students "direct-stick" easily rooted material in larger growing containers, to skip the step of transplanting the rooted cutting – again, think like a plant – wouldn't you resent having your roots disturbed?

Plants need light – but cuttings don't need that much because light has the potential to cause heating and drying of the leaves. Light levels should start out low, be raised gradually when rooting occurs, and then increased to greenhouse or nursery levels once the plants are established and growing. There are intriguing hints that the light quality under which a cutting is rooted can influence rooting. Red light seems to be best – some research suggests better rooting in greenhouses covered with red-transmitting shade cloth. It is also possible to get very precise control of light quality using light-emitting diodes – though I have not seen studies on this. The price of light-emitting diodes (LED) is coming down, and many horticulturists start seedlings under LED light. Plants growing under red LED are odd looking, but it may be something new to try.

There are so many options available for rooting media that many new propagators can't decide what to use. The bottom line is that it may not matter that much – and almost certainly the optimal mix will differ among plant species. I led research showing that pH of the rooting medium influenced rooting of several species (Holt et al., 1998), but others have not found much of a pH effect. Certainly, aeration and drainage matter the most in

terms of enhancing cutting survival. I stress to my students that only a few species can root in "aeroponics" and it is critical to have good contact between the medium and the cutting. Perlite seems to be very good for transmitting whatever water is in the media to the cutting – I have seen cuttings survive better in moderately dry perlite than in moist peat – which holds on to its water more tightly.

Though we may not have much control over what medium we use – we should always strive to know as much about it as possible: water holding capacity, stability, aeration, and pH. In the northeast sharp sand is often preferred – particularly at large propagation nurseries. In the northwest pumice is the preferred well-drained medium. The bottom line is the same everywhere – the medium has to hold the cutting, hold and supply water, and yet be well-drained. It should shade the bottom of the cutting from light and possibly be acidic in reaction. Obviously the propagator has to experiment with this and find out what works best in each operation using locally available and sustainable materials if possible.

A potentially costly, but valuable component of a propagation system is some sort of bottom heat. As I teach my students, rooting is a metabolic process, which has a temperature optimum that can differ among species. Some degree of bottom heat always helps. At the same time we do not want to wake up the shoots, which would compete with the roots for carbohydrates – so keeping the shoots cool is also smart. I have seen more seat-of-the-pants innovation used to provide bottom heat than just about any other cutting propagation method – from running heat pipes under the bench to propagating over beds of composting manure.

The key to cutting survival is to minimize water loss. Mist was a revolutionary innovation in the 1950s. Next was the use of plastic films to create closed mist systems. This morphed into contact polyethylene methods in the 1980s and 1990s. Fog – too technical and expensive at first, is now a common tool in greenhouse production and has its place for large scale propagation in particular. Boom misting and misted geotextile coverings may represent the state of the art now – and recent research by Anthony LeBude (2004) shows that moisture sensors and computers can be combined in dynamic control systems to fine tune the maintenance of cutting moisture. This may allow us to use higher light levels to provide more energy to rooting, without the heat stress. It is easy to over do misting as well – too wet and the cuttings are too cold and waterlogged. Using deeper flats or tree tubes can help combat overwatering, but you have to stay on top of it. On a smaller scale I direct my students to look to the old timer propagators for inspiration on how to manage cutting irrigation – checking several times a day, learning to read the plant, experience and patience. There is no substitute for paying careful, and frequent, attention when it comes to rooting cuttings.

Careful attention to sanitation is the only way to prevent the scourge of all propagation methods – contamination. Whether fungi, weeds, or insects, there is no place for dirt or pests in your cutting bench. If you let these get ahead of you it is essentially game-over. As I stress to my students, the best propagators keep a spotless greenhouse at all times. You can never be clean enough.

ATTENTION TO DETAIL

Keep records and label obsessively. This is not my forte – definitely a case of do as I say and not as I do. I am good at labeling but horrible at keeping records. It is all stored up in my head, which, as I get older, is the worst place for it. A significant part of my student's lab grade comes from keeping a journal of their propagation lab work. I don't dictate how they do it, but insist that they do it regularly and that they build the story of what they have done throughout the semester. If their experiment fails I direct them to look back through their journal for clues as to what went wrong. Everyone will have their method – but it is dedicating yourself to a process and sticking with it that will generate the rewards. There is no way the excellent books I mentioned here could have been written if past propagators had not kept records.

Keep trying: It took me almost 5 years of trying to get *Lindera benzoin* 'Rubra' to root – but eventually I worked it out and I can root it almost every time now. We all have stories

like that – and that is why we belong to the IPPS and attend its meetings. How many of you have learned something new about plants or propagation from the proceedings or at an IPPS meeting? That is why we all value IPPS.

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