Propagation of challenging plants: creating a system that works©

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INTRODUCTION

I define a challenging plant to propagate as one that others have had problems propagating or one that doesn't propagate well as indicated in literature sources. Whether scientific or popular literature, information can range from observations to well thought out research reports that contain valuable information.

There are certain things to look for when reviewing plant propagation literature. Start by looking at the history of specific plant type propagation or propagation of related plants. Determine up front if the information is anecdotal (someone's observation), repeated observations by someone who is familiar with the plant in question, or a scientific study. Each type has some value as a starting point but as one moves toward a more scientific study, the value increases.

This work was initiated by two request. In tissue culture (TC), *Cornus kousa* 'Rutpink', Scarlet Fire® kousa dogwood multiplies well and produces great shoots. Unfortunately, procedures have not resulted in roots initiating. *Vaccinium macrocarpon* 'Haines' produces good shoots and roots in TC but first generation cuttings taken commercially from the rooted TC plants rooted very poorly. Additional plants noted in this paper were assessed in the system propagation developed because they were of personal interest.

I set some goals in the development of a propagation system. I wanted a system that would be the basis for a cost effective option for real world commercial propagation. It also needed to be able to effectively change and/or extend the propagating season. In addition, I was evaluating the propagation system for worker safety and reduced environmental impact.

RESEARCH PROTOCOLS

When reviewing scientific literature, always check the experimental design to be sure there are adequate controls built into the experiment. Recognize that a properly executed experiment employs a systematic approach in the design. Without proper experimental controls, information is nearly useless. Experimental controls include things like:

- Is the same medium being used?
- Are cuttings all taken at the same time of the day?
- Are plants being rooted under the same heat, humidity, and lighting conditions?
- How many variables are being investigated at the same time? Too many require a multitude of plants being evaluated to be able to have statistically significant results, so the work gets complicated.
- Propagators understand that timing is very important. If the experiment is conducted outside normal propagation times for the specific plant and it fails, it doesn't necessarily mean the plant is difficult to propagate.
- Make sure there are enough cuttings to see a significant difference between treatments.

Following a search for information relating to the plant being propagated, it's time to think about designing a system to propagate the plant in question. The best propagation system can vary depending upon the plant being propagated and while most plants will do well using existing systems, difficult to propagate plants sometimes need some tweaks. Moving to a totally new propagation system has some risk because of a variety of unknowns so do necessary homework first. Check with others who have tried systems out before you

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do.

When setting up a new system to propagate plants, set goals and be ready to think "outside the box" but use a systematic approach. Consider the following:

- Limit your exposure by starting with a manageable number of cuttings but have enough to see a difference and also to allow for sequential propagation cycles.
- While plants are more successfully propagated at certain times of the year, optimal timing can be measured in days and can vary by the hour of the day one collects cuttings.
- Consider that rooting success will vary by size and maturity of the cuttings.
- Have an appropriate "control" group of plants.
- Compare results against the system presently in use.
- Remember that plant propagation can be nearly as much an art as a science.

For a research scientist the control group of plants is often referred to as "untreated." For commercial nurseries, a comparison against the "present best treatment" is usually more appropriate than an untreated control group. If a totally new plant is to be propagated or if a new system is being evaluated, a "proof of concept" experiment can be set up that uses a historical propagation success basis from an existing system. Most of my propagation work has been a combination of "proof of concept" tested against "present best treatment" designs.

BACK TO THE BASICS

There are several environmental variables that need to be addressed for any plant propagation. They include evaluating the rooting medium for texture, the ability to hold moisture while avoiding being excessively wet, and the cation exchange capacity (CEC) that will serve as a reservoir and a buffer for plant nutrients. Evaluate cells and trays available for plant propagation for the volume available for a rooting medium and also the depth of the cell or tray to avoid issues related to the zone of saturation (Figure 1). For a given medium using the same cell diameter, the zone of saturation remains about the same irrespective of the total depth of the medium.

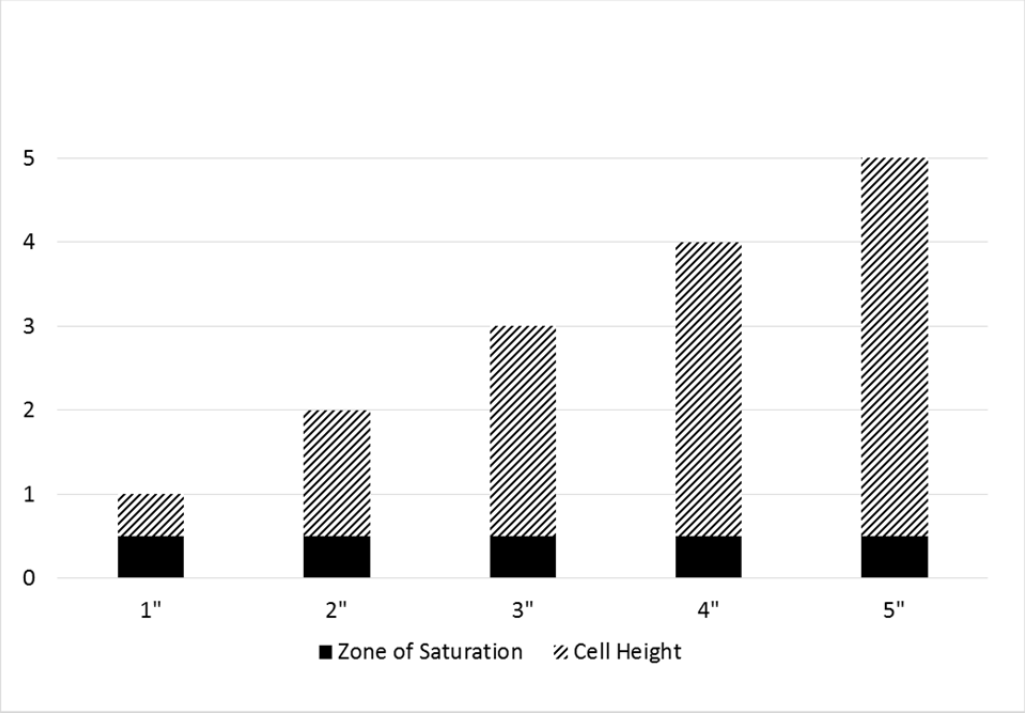

Figure 1. Saturated water zones for containers of various heights using the same medium and container diameter.

It's generally important to have bottom heat (generally around 72°F) and to keep the air temperature cool. The rooting medium needs to be maintained in a moist but not wet condition while the leaves need to be kept in a high humidity environment to reduce evapotranspiration (ET). ET is the movement of moisture out of the leaves when the stomata are open. ET also provides a cooling effect for the plant and also allows for movement of carbon dioxide and oxygen. In propagation, one needs to achieve a balance between humidity and temperature. That balance is usually a compromise because venting heat from a propagation house also vents humidity. On the upside, moist air also holds more heat so there is an increased buffer against high and low temperatures.

There are two general methods of maintaining humidity around cuttings. Condensing humidity is misting. Misting causes leaves to become wet and as the moisture evaporates it provides a cooling effect along with increasing humidity. Downsides of using misting include the increased potential for foliar diseases, the potential to leach nutrients from leaves and the potential to create an excessively wet rooting medium.

Non-condensing humidity is a true fog where leaves don't get wet although the humidity is at or near 100%. One can walk through a true fog and not get wet. Non-condensing humidity can reduce the potential for diseases while maintaining a non-stress condition that is optimal for rooting cuttings. The cost of a non-condensing humidity system is greater than traditional condensing humidity systems so choices need to be made

A compromise system that has been used for years is tenting cuttings. It offers many of the benefits of a fog system but moisture tends to condense on the plastic covering and drip onto cuttings and the media. It's not a perfect system but is quite effective on many cuttings.

Light is another component needed for propagation. Supplemental lighting is measured based on intensity, duration and quality. Excessive light intensity can dry leaves quickly and reduce photosynthetic activity thereby negatively affecting rooting. As soon as roots are initiated, however, light is needed for photosynthesis. Duration is how long lights are left on. Lighting for more than the longest day of the year is probably not cost effective.

The importance of light quality requires a determination of what wavelengths have a positive impact plant growth and development. Plant chlorophylls efficiently harvest blue and red light with peak efficiency at about 440 and 640 nm (nanometers). They don't capture light between 500-575 nm. Relating that to what we see, the region that is most visible to the human eye is least effective for plant growth (about 500 to 630 nm) so what we see is not what plants need. The reason plants are green is that green light is not used by plants so it's reflected and that's what we see. A good overall review of lighting including LED lighting is found in a white paper by Joseph Spampinato (Smart Grow™ Technologies).

Fertility after rooting is also important in propagation success. Since rooting uses plant carbohydrate reserves, it's important for them to be able to grow and produce additional carbohydrates soon. Low level fertilization as soon as cuttings start to root helps the plant to maximize the opportunity for photosynthetic activity and thus plant growth so it's an important part of propagation success. Plan to use a low salts fertilizer and be sure to leach some of the fertilization liquids through the medium to avoid soluble salts buildup that can injure new roots.

There are choices of hormones (auxins) used to enhance rooting. The naturally occurring auxin is IAA (indole-3-acetic acid) but it's not stabile outside of the plant. IBA (indole-3-butyric acid) is a synthetic rooting hormone that is more effective at generating roots. NAA (1-napthalene-acetic acid) is the other auxin generally in use and is used alone or in combination with IBA. Results of using NAA are somewhat variable with most plants responding better to IBA. Auxins have been applied in various ways and with various formulations. Carriers have sometimes resulted in toxicity issues. An excellent review of auxins was prepared by Blythe et al. (2007).

Timing, or when to take a cutting, and the type of cuttings are the final considerations for discussion. While it's generally better to take cuttings in the morning, results are also based on taking cuttings the optimal physiological stage of growth. That's why we have so many different methods of plant propagation. Recommended types of stem cuttings are generally softwood, semi-hardwood or hardwood depending on the plant to be propagated.

Check the literature for a basis from which to develop a protocol.

MATERIALS AND METHODS

Tissue culture shoots are succulent and have limited carbohydrate reserves from which to draw for rooting. For me, that meant they need to root quickly under conditions with little stress. Therefore, I had the need to develop a propagation system that was highly controlled (Figure 2).

Figure 2. Propagation tent setup.

I decided on LED (light emitting diode) lighting because it gave me the means to effectively change the season by extending day length. LEDs (light emitting diodes) produce light by electroluminescence so there is a limited amount of heat generated and they use less electricity than conventional lights. Light quality can also be fine-tuned by use a combination of different wavelength generating LEDs. Since I was propagating, I only needed lights that supported vegetative growth but most lights included a spectrum for flowering. Since I purchased LED lights, new sets have come out with just vegetative wavelengths. While LED lighting has a higher initial investment, operating costs are lower and they have longer life expectancy.

Other parts of the system included a grow tent with a Mylar™ BoPET interior that offered great reflectivity thereby enhancing light effectiveness, a heavy duty light timer, ductwork that included a ductstat and rheostat for heat control, a 15-amp heavy duty power station/surge suppresser, thermostatically controlled electrical propagation mats for bottom heat, tall domes to help maintain humidity, a small sprayer so I could mist leaves as necessary (especially during the first few days), a 1-gal. pad humidifier and a bench system. The total system cost was just under $1200. Most cuttings were stuck and rooted in a 50-cell tray with cells that measured 1.94 in. in diameter by 4.5 in. deep. A larger 38-cell tray with cells that measured 2.13 in. in diameter by 5 in. deep was used for larger cuttings and evaluated on smaller ones.

Rooting hormones were applied using the foliar spray technique as has been described by Joel Kroin (2016) of Hortus USA. Use of this technique offers an efficient method of application and minimizes worker contact with auxins. Procedures are described in a booklet authored by Joel (2) and can also be found in papers included in a number of issues of the Combined Proceedings of the International Plant Propagators' Society.

In the "back to the basics" section I wrote about various environmental conditions that

impact plant propagation. When one removes a competing variable, rooting success increases. For this experiment I had the early issue of excessive heat that effectively reduced the relative humidity in the tent. The solution: move the system to the basement of my home where the temperature generally stayed around 75°F, give or take a few degrees. It made the difference between success and failure.

All of the plant taxa listed below were propagated using the LED propagation system outlined above.

RESULTS AND DISCUSSION

Cornus kousa 'Rutpink', Scarlet Fire® kousa dogwood

A series of experiments were initiated that evaluated hormone rates, frequency of application of foliar applied auxins and cell size. Optimal treatments included use of a 50 cell, deep tray and only 1 foliar application to drip of K-IBA at 350-400 ppm. Fertilization was initiated as soon as the first roots appeared using a complete liquid fertilizer at 75 ppm. Shading for the first 7 days didn't make a difference. Rooting success was typically between 95 and 100%. Use of NAA in combination with IBA resulted in much lower success rates.

The complete procedure for *C. kousa* 'Rutpink', Scarlet Fire® kousa dogwood propagation started by keeping the shoots in the covered agar medium for 2 days. Shoots were received the day of removal from tissue culture so they seemed to harden off a bit. LED vegetative growth lights were run for 14-h days.

- On day 1: Stick the shoots and gently water them in so they are in good contact with the medium., being careful not to dislodge the shoots.
- Day 2: Apply the K-IBA at 350 to 400 ppm as a foliar spray that fully wets the leaves. Mist the inside of the domes and supplement humidity with the pad humidifier. Check the shoots later in the day and mist the inside of the dome as well as the leaves again if they are dry.
- Day 3 onward: Check the humidity and mist 2 to 3 times a day as necessary (its normal early in the propagation period).
- Day 7: Start checking for root initiation. As soon as the first roots appear, start fertilization at 75 ppm-N. Continue misting until top growth is established.
- Day 12: Top growth should be initiating
- Day 20: Start reducing humidity by removing the domes. Continue growing plants until the desire size is reached.

New growth is fairly active at about 22 or 23 days and plants may be as much as 4 to 6 inches tall in 60 days (Figure 3). It was noted that there seems to be some variability in success based on the maturity of the tissue cultured shoots. Use of the 38 cell tray was far less successful.

Corylus avellana

Hazelnuts are a "tough nut to crack." I used a system similar to that for dogwoods. Cuttings were traditional stem cuttings, usually from immature suckers. Because of the size of the cuttings, rooting was in 38-cell trays. A combination of IBA and NAA seemed to work best and mid-September dates seemed to offer the most success. Cuttings were taken from August through November and in late January.

Excess callus was consistently an issue and often resulted in a rooted stick (roots generated but the cutting died). Overall success with hazelnuts was not good with the best treatments on specific varieties and timing achieving around 20 to 50% rooting (Figure 4). There was a high degree of cultivar variability in success rate. While they are a challenge to root, once rooted they grow exceptionally well when planted into containers with growth of about 3 to 4 ft the first season. Only two plants had suckers and only 1 or 2 on each plant.

Figure 3. *Cornus kousa* 'Rutpink', Scarlet Fire® kousa dogwood at 60 days.

Figure 4. Excess callus on *Corylus* (left) and callus on *Corylus* and the rooted cutting (right).

***Vaccinium macrocarpon* 'Haines'**

Rutgers researchers have developed a new, hardier cultivar of cranberry that is able to withstand disease and has a larger round berry with more even color than other cultivars. It has been named the 'Haines' cultivar and will be focused on the Craisins® market. Production of tissue cultured shoots with roots has been successful but commercial multiplication by softwood cuttings from tissue culture plants had poor results.

An experiment was set up that focused on evaluating hormone rates. As is the normal procedure for cranberry propagation, rooting without hormones was ultimately the best treatment. Rooting problems were associated with short cells and a perched water table. Cuttings were stuck into the saturated zone of the medium and that led to *Pythium* infection that stopped rooting.

Cuttings rooted well above 95% without IBA in the 4.5" deep 50 cell trays. While no hormone was ultimately the preferred treatment, cuttings rooted more aggressively with the use of IBA at 200 to 400 ppm as a spray application. Unfortunately, while the use of foliar applied IBA was apparently effective in rooting, led to unexpected consequences. Top growth was effectively inhibited and could not be recommended. The higher the rate of IBA applied, the longer it took for top growth to restart with the restart time measured in weeks to months depending on the rate used.

I was unable to experiment with possible enhancement of rooting with basal applied IBA as a treatment due to time constraints. Also, based on the success rate without hormones it would probably not be cost effective.

Ilex

Over 30 years ago while walking through the Rutgers Gardens with Dr. Elwin Orton, I came across a holly tree that had no leaf miner issues and a glossy green ovate leaf with spines. I asked Dr. Elwin Orton what cultivar it was and he indicated that years earlier the USDA had initiated a cultivar evaluation trial and then lost the plot plan. That year I took quite a few cuttings and rooted a few using traditional methods of an IBA talc basal dip (Figure 5).

Figure 5. *Ilex* sp.

The four that rooted grew well on our property and I continue to like the plant so I took cuttings in mid-March in an effort to root one to take with me into my retirement. I used a single foliar application of IBA at 350 ppm for the hormone treatment. Out of the 10 terminal cuttings I took in mid-March all rooted and grew out very nicely.

***Ilex crenata* 'Beehive'**

The 'Beehive' holly is a plant that Dr. Elwin Orton selected quite a few years ago, it grows well with little care and over the time I had it in my landscape it grew to about 4.5 ft tall by 7 ft in diameter. This was another one that I wanted to have in my retirement landscape. I took terminal cuttings in mid-March and I used a single foliar auxin treatment of IBA at 350 ppm. Of the 30 cuttings taken 29 rooted and grew out.

SUMMARY AND CONCLUSIONS

As we move toward the future I see more regulation and less labor resources. There is the need for more intensive agricultural operations that have less employee exposure to risks and more mechanization. That is not to say we will need fewer people. As businesses expand we just need to make employees we have more efficient.

The system I have described is a capital investment that has lower operational cost than systems presently in place. It can root many plants in a small space using LED lighting, non-condensing humidity and bottom heat. I believe it can be adapted into a converted, insulated shipping container and operated at a relatively low expense. Insulated shipping containers are exceptionally well insulated and heat can probably be supplied by the LED lighting. Existing propagation space can be integrated as a step-down system so that won't be a wasted investment. From my experience, the system has enhanced rooting and has the

potential to provide for more of the year-round employment we need to keep our valuable labor force intact.

Literature cited

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