Nursery Costing: The "Easy" Way©

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Costing in the nursery industry is a powerful tool to identify the potential profitability of your business. But is it possible to cost each and every one of your product lines down to the last cent? The recording of production activities by the staff on a specific crop during cultivation up to its sale can specify at least a large portion of this crop's cost. But how to grasp the more difficult-to-determine expenses of a product, such as the running of an administration office, plant protection, or water management/irrigation? Different approaches to this topic are presented as well as the methods used to record production activities using Microsoft Access at New Plant Nursery, situated in George, in the Southern Cape, South Africa. The conclusion remains: product line specific costing involves considerable administrative effort, but is a non-regrettable exercise for every grower to be aware of where profitability begins and ends.

INTRODUCTION

Why should we know what the costs are for growing the crops we produce? "To know whether the crops we have chosen to grow are profitable" is probably the first answer that comes to mind. However, this topic needs to be looked at in more depth. We growers need to constantly know which of our plants are our so-called "bread and butter" lines that account for much of our turnover. But even more important, we need to know which lines are highly profitable, since these crops should receive most of our attention. Naturally, no costing can be done without considering the competitor's prices — if we cannot offer a special service connected to our product, we have to be extremely good at marketing and branding to sell our product at a much higher price than our competition. However, the next question arises, namely whether our fellow growers in return have done any costing for their products? After all, the client should not be the only winner in this equation.

There is general consensus between the South African wholesale growers that not enough effort is being put into the costing of our products — and that this should be urgently addressed on an association level. This is especially important since most production work is still done manually, with little automation, and labour costs are higher than in other African countries. The most common approach is to examine the competitor's pricelists and then decide on a price "in line with" the competitor. In so doing, two risks are taken simultaneously: either the chosen price might be too low for our own nursery and not result in any profit — or we could possibly offer the product at a more competitive price due to favorable climatic conditions at our specific nursery (South Africa's climate varies considerably from region to region) or due to a better organized work force. Both these scenarios lead to a loss of profit, which no grower can afford, especially at this point in the world economy. At the same time, when setting prices, there is a responsibility towards securing the sustainability of the national ornamental horticultural industry.

METHOD

There is a list of several items that need to be considered when attempting to cost accurately. These items shall be described in "semi-professional" language to gain the understanding of a larger group of readers:

1) Input costs: costs of young plant/seed, growing medium, container, stake, etc.
2) Initial labour cost to plant and pack at the nursery site.
3) Costs to grow the young plant on to a finished product (includes fertilizing, pruning, spacing, etc.).
4) Costs to maintain the product while on the nursery site (includes direct costs on the products, namely labour to weed, water, control pests, etc., as well as indirect costs to run the nursery as a whole, namely expenses for water, electricity, administration, sales, dispatch, etc.).
5) The average loss on the batch.

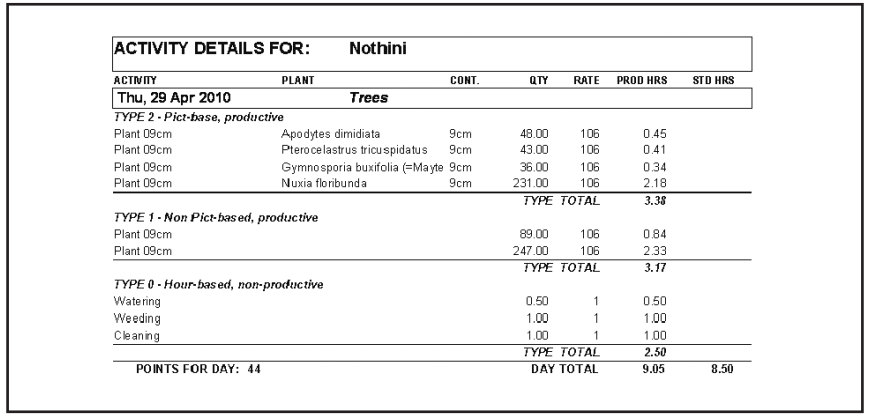
Additionally to these five factors, it is very important when the batch of plants gets sold, namely whether it gets sold immediately once it is ready, or one, two, three, or more months later, since every extra month in the nursery translates to extra maintenance costs listed under Point 4 above. Unfortunately, contract grown plants account for the minority in comparison to the crops grown "on spec" at most South African wholesale nurseries, i.e., most nurseries do never really know whether they will actually manage to sell their products or not.

THE MICROSOFT ACCESS DATABASE

For the further understanding of the method of costing applied to determine the costs described in Points 2 and 3, a short description of the Microsoft (MS) Access database developed by New Plant Nursery follows. One of the MS Access database modules has been designed to input daily production tasks of each member of production staff. Specific and non-specific activities get handwritten into a form and then entered into the database. Non-specific activities would include weeding, watering, cleaning — these are activities not directly linked to a selected plant/container combination. Information about specific activities describes in detail which activity (e.g., pruning) was done on which specific plant/container combination (e.g., *Acacia xanthophloea* in 10-L bags). All specific activities in the nursery have rates, i.e., the amount of work completed by a member of staff will then translate to a productivity figure for him/her. This information can then be drawn for any period of time to produce a report on the productivity of a staff member (e.g., for the period of a day, Fig. 1) as well as to produce a report for a specific plant/container combination listing all the specified activities done on that plant/container combination for any period of time (e.g., for the period of a day, Fig. 2). The latter report can then be used to calculate costs listed under Points 2 and 3 above, namely by totaling the time spent on these activities on a specific product and multiplying it by an average wage figure for the staff working with this crop within a team.

THE MANAGEMENT ACCOUNTS

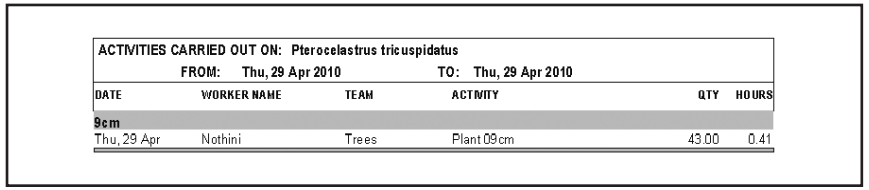
In addition, another module was designed in the MS Access database to record stock levels and the grading of stock present in the nursery. These stock takes get carried out monthly and the figures are subsequently entered into the database. This not



ACTIVITY DETAILS FOR: Nothini

ACTIVITY	PLANT	CONT.	QTY	RATE	PROD HRS	STD HRS
Thu, 29 Apr 2010	***Trees***					
TYPE 2 - Pict-base, productive						
Plant 09cm	Apodytes dimidiata	9cm	48.00	106	0.45	
Plant 09cm	Pterocelastrus tricuspidatus	9cm	43.00	106	0.41	
Plant 09cm	Gymnosporia buxifolia (=Mayte	9cm	36.00	106	0.34	
Plant 09cm	Nuxia floribunda	9cm	231.00	106	2.18	
				TYPE TOTAL	**3.38**	
TYPE 1 - Non Pict-based, productive						
Plant 09cm			89.00	106	0.84	
Plant 09cm			247.00	106	2.33	
				TYPE TOTAL	**3.17**	
TYPE 0 - Hour-based, non-productive						
Watering			0.50	1	0.50	
Weeding			1.00	1	1.00	
Cleaning			1.00	1	1.00	
				TYPE TOTAL	**2.50**	
POINTS FOR DAY: 44				**DAY TOTAL**	**9.05**	**8.50**

Figure 1. Microsoft Access database report according to staff member.



ACTIVITIES CARRIED OUT ON: Pterocelastrus tricuspidatus
FROM: Thu, 29 Apr 2010 TO: Thu, 29 Apr 2010

DATE	WORKER NAME	TEAM	ACTIVITY	QTY	HOURS
9cm					
Thu, 29 Apr	Nothini	Trees	Plant 09cm	43.00	0.41

Figure 2. Microsoft Access database report according to plant/container combination.

only generates an updated availability list, but it can also translate into a stock value figure. The stock value figure is very important not only for the process of preparing management accounts for the nursery every month, but also to know the quantity of plants in the nursery to establish a formula to determine the costs listed under Point 4 above. Since the nursery is divided into nine separate sections, these management accounts get summarized in a table listing the sections as well as the grand total. From these figures, the costs listed under Point 4 above can be calculated in the following way: Average figures over a period of 4 months are used for:

1) The individual section's total wage bill minus the costs already attributed to the product through the specified MS Access recordings.
2) Remainder of Nursery's wage bill (dispatch, growers, overtime, etc.) split between the sections according to set percentages.
3) Nursery's expenses (water, electricity, admin, sales reps, fuel, repairs, etc.) split between the sections according to set percentages.

These figures calculated for each Nursery section are then each divided by the average amount of plants in the section drawn from the monthly stock takes. This then produces an average maintenance figure for an average sized plant in the section.

RESULTS AND DISCUSSION

Two examples of products were chosen, namely a cultivar of the *Osteospermum* "FlowerPower" range in 15-cm pots (saleable within 4 months from planting) as well as *A. xanthophloeae* in 10-L bags (saleable within 24 months from young plant). As can be seen from Table 1, the figures are relatively different for products with a different grow-on time, like the two products chosen. Also, the need for specific fungicide drenches of the *Osteospermum* influences the profitability. But the most impressive differences arise when comparing the profitability of the two products when standing longer in the nursery than the respective 4/24 months until ready for sale: The figures decline rapidly for the *Osteospermum*, but stay above 50% for the *Acacia* for up to 4 months after the product has become ready for sale. Although to a degree this lies in the nature of the product and its shelf life (bedding plants versus tree), it makes it crystal clear how important that realization should be to any grower.

CONCLUSION

"Why should we know what the costs are for growing the crops we produce? To know whether the crops we have chosen to grow are profitable." These first two sentences of this article should now be reformulated: "What reduces the profitability of a crop below an acceptable level?" Noted here should be that the profit margin the grower strives towards is a subjective decision — it certainly is influenced by volume of plants sold as well as other factors prevalent on your (local) market — and last but not least your personality. Through the calculations in Table 1 it has become clear that although the grower can influence the costs of a certain chosen product to a degree by saving on the input costs (e.g., choosing a cheaper container) and the grow-on costs (e.g., higher productivity of staff), the most important impact can be achieved by accurate planning of batches to match market demand as much as possible or by finding a buyer for your product before it is even ready (e.g., through contract growing). The latter might be difficult in the South African context, since the contract growing for chain stores and other big retailers or landscape contractors is in its infancy. However, the wholesalers have an important role to play in joining forces to demonstrate to their customers that to grow plants "on spec" only is reducing their profit largely and is not sustainable in the long run. The situation is aggravated by the fact that since there are no formal nursery and plant quality standards in South Africa, plants that are much too old and overgrown may be sold and accepted by the customers. The grower knows that he/she can cut his product back two to three times and still has a chance to sell it, not realizing the waste of resources he has incurred during that time as well as the profit he has lost not using that space in his nursery more profitably. This situation is especially serious since most of the growers are reluctant to discard the plants they have grown with so much effort, not realizing that to maintain the plants past their sell by date in the nursery is arguably the biggest profit "killer." In addition, they could be using that space in the nursery for the next crop already, thereby at least making up a portion of the loss they have incurred.

Table 1. Costing calculations for two selected species.

		Acacia xanthophloea	*Osteospermum* "Flower Power"
Size		**10 L**	**15 cm**
Time in nursery	**from planting to finishing**	**2 years**	**4 months**
A. INITIAL COSTS AT PLANTING:			
A1. Container	from supplier	R 1.07	R0,83
A2. Plug	from supplier	R 2.50	R3,04
A3. Mix	R150/m3	R 0.95	R0,15
A4. Stakes	R48/100	R 1.10	R0
A5. Tags	R68.40/1000	R 0,34	R0
B. MAINTENANCE OF PLANTS:			
Number of fertilizer applications	every 6 to 8 weeks	12x	2x
B1. Terramax × number of applications	**R0.02 per 15 cm** (or proportional)	**R 0,36**	**R0,04**
Number of fungicide drenches		0x	3x
B2. Costs of fungicide × number of applications	**R0.07/15 cm**	**R 0,00**	**R0,21**
Hours spent directly on product (planting, pruning, opening)	from MS Access PAR module	0.258h	0.073h
Average hourly wage of team	before deductions	R 13,95	R15,02
B3. Wages direct on product		**R 3,60**	**R1,09**
Average wage per month per plant in section	average over 4 months	R 0,15	R0,24
B4. Average wage per plant × months less wages direct (B3.)		**R 0,00**	**R0,13**

Table 1. Continued.

Wages indirect to team average per month per plant in section	growers, drivers, dispatch	R 0,21	R0,40
B5. Average indirect wage of nursery × months		**R 5,04**	**R1,60**
Other expenses of nursery average per month per plant in section	admin, water, phone, rent, etc.	R 0,52	R0,83
B6. Average expenses of nursery × months		**R 12,48**	**R3,32**
Sub-total maintenance per plant		R 17,88	R5,30
TOTAL A & B		**R 21,82**	**10,41**
Average loss on batch	estimate	3%	1%
Costs of loss		**R 0,65**	**R1,04**
TOTAL COSTS (incl. loss)		**R 22,48**	**R11,45**
Average maint. cost of product for each month in the nursery	total work / months	R 1,54	R1,59
Plant price incl. delivery to Cape Town excl. VAT		**R 44,42**	**R18,04**
Profit margin in % if sold after 4 / 24 months		**98**	**58**
Effect on profit margin for 1 extra month in nursery	in %	85	38
Effect on profit margin for 2 extra month in nursery	in %	74	23
Effect on profit margin for 3 extra month in nursery	in %	64	11
Effect on profit margin for 4 extra month in nursery	in %	55	47
Effect on profit margin for 5 extra month in nursery	in %	47	-7
Effect on profit margin for 6 extra month in nursery	in %	40	-14
Effect on profit margin for 7 extra month in nursery	in %	33	-20
Effect on profit margin for 8 extra month in nursery	in %	28	-25

Mother-Stock Management and Control©

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INTRODUCTION

Thank you for the opportunity to share with you some of the things that we are doing and some of the thing that we aren't but probably should be doing in respect to the production of vegetative propagation material using a mother-stock system. I also hope to learn from everyone here how we can improve on what we are doing.

WHY MOTHER-STOCK?

At Arnelia we are dealing with a plant that is not that easy to root and that needs special attention to give us the desired results. Growing the vegetative material that is used for cutting production under more controlled circumstances can contribute to improved results. The level of extra effort that you put into your stock plants depends on what outcome is expected. Cutting production from mother-stock does not have to be limited to plants that are difficult to propagate but can also be a tool to get even better rooting percentages, to help schedule cutting production according to your timing requirements, both for an onward production point of view as well as a space point of view (staggered / spread production). Mother-stock, if managed correctly, can give you more uniform cutting material which can lead to a more uniform finished product. A focused mother-stock program can also give you a higher level of plant health in order to avoid or lessen potential losses due to disease outbreaks in the propagation phase. Propagation environments can be conducive to disease development, being warm and humid — if the level of disease or disease propagules that are being introduced into the propagation environment can be limited or reduced, one should have fewer problems going forward.

HOW WE GROW OUR MOTHER-STOCK PLANTS

We have chosen to grow most of our mother-stock plants in pots in tunnels on drip irrigation. The tunnels we use are Haygrove tunnels, where the plastic sheeting runs along the length of the tunnels to facilitate venting. For our purposes the tunnels are essentially a rain covering to avoid the foliage of the mother-stock plants from getting wet. In hot, dry weather, the sides of the plastic can be pushed up by varying degrees to allow for air movement and for hot air to escape. In rainy weather the plastic sheeting is pulled down to the ground and keeps the rain out. Haygrove tunnels are available on raised legs as well, and can accommodate gutters to collect rainwater. Apart from the primary purpose of the plastic covering against rain, we also get the spin-off of earlier spring growth due to the warmer environment inside the tunnels when they are closed during winter and spring.

We pot 1-year-old plants from 16-cm pots up to 20-cm pots for our mother-stock and if we need to keep the mother-stock plants for another year we pot up from 20-cm to 28-cm pots.

Irrigation and fertigation is by drip, every pot has one dripper for 20-cm pots, 2 for 28-cm pots. Drippers are 8 L/h non-leak, pressure compensated, each with a 4-way manifold with tubing going to four arrow drippers. We used angled arrow drippers

as opposed to straight arrow drippers to avoid unnecessary bending of the tubing and to be sure that all the water is delivered to the plant. Ideally we would like each variety to stand on its own irrigation valve, so that water and nutrient can be managed precisely per taxon. This ideal has to be balanced with the practicalities of having too many valves to manage. Having good control over the water and nutrient supply to each and every mother-stock plant ensures that plants never suffer water stress (in theory) and that we can control nutrient supply to give just the right quality of vegetative growth on the plants that is required for optimal rooting (in theory). Supply of nutrients can be used to manage hardening-off of vegetative growth according to a cutting harvesting schedule (in theory). When nitrogen is reduced to slow growth down before cutting harvest, opportunity is given for the shoot to accumulate carbohydrates. Shoots with a higher carbohydrate to nitrogen ratio will root better.

When we have issues with uniformity of plants on one irrigation block, we use pot saucers under the larger plants to collect drainage water for re-absorption thus giving the larger plants access to a higher volume of water per day without the smaller plants pots becoming water logged.

We also use saucers under pots raised by a small frame to collect drainage water under pots as an indication of whether or not we are irrigating too much or too little. Most of the irrigation runs at night, so first thing in the morning, if the saucer under the raised pots are dry, we know we need to irrigate more, if they are full of water, we know we are irrigating too much. Ideally we are looking for 10%–15% or the applied irrigation draining out the bottom of the pot. Remember that for this purpose the pot must be raised above the saucer, the pot must be level on the stand, all the drainage holes of the pot must be above the saucer and one must be able to take the saucer out from under the stand easily to measure the drainage.

We have our pots standing on stone chip and the entire nursery complex is stone chip as a precaution against soil-borne diseases. Ideally the mother-stock pots should be standing on benching for added protection against soil-borne diseases with the extra benefit of increased staff productivity.

HYGIENE, DISEASE, AND PEST CONTROL

We operate from the premise that the better the hygiene during the mother-stock and propagation process, the less risk of diseases — provided that your starting material was disease free. Our mother-stock plants are already grown in a separate production stream during the first year, before they actually become mother-stock. That means that the plants designated to become mother-stock are given extra care and are monitored carefully to keep them disease free during the first year of growth. Using the runts of your production or plants that you couldn't sell as mother-stock plants is counter-productive. Mother-stock is an expensive system and one should put good quality plants into the system to reap the benefits.

Our propagation units with its warm, moist environment can, potentially, be a high risk area for disease development, so if we are introducing disease with you propagation material there is bound to be trouble.

We sanitise all equipment used in the propagation process regularly. Buckets, crates, trolleys, and tables are sanitised daily and secatures between every mother-stock plant when harvesting cuttings and every couple of minutes while processing the cuttings. We have a single access point to our nursery area where everyone passes over a foam mat containing a high concentration of a quaternary ammonium

(QAUT) compound (spore kill or quattro kill). All quad bikes and trailers enter through the same point which ensures that wheel surfaces are sanitized with every entry. We only use a tractor in the nursery for spraying and when that enters the nursery area, the wheels are sprayed with the same high concentration QAUT.

Our insect control is based on monitoring for problems. One of the major insect pests that we have in our Proteaceae cut-flower production, pot-plant production, and mother-stock area is bollworm. We use bollworm pheromone traps to catch male bollworms. The counts for these traps give us a good management tool to know when flights are occurring so that we can target our sprays better.

PROCESS OF CUTTING HARVEST AND PREPARATION

We do our best to avoid any stress on the cutting material during the propagation process. We harvest cuttings only early in the morning, between 7 AM and 9 AM, when it is cool and the plants are fully turgid after the night's irrigation. Cutting material is harvested into buckets and buckets are emptied into shade cloth bags in frames. Another piece of shade cloth is used to cover the cloth bags in the frames on the back to the quad bike trailer to avoid direct sunlight on the cutting material. As the cutting material is harvested into the bags, it is wet with clean water to prevent desiccation. Once six shaded-cloth bags are filled with cutting material, the bags in their frames are taken to the shed and placed in a cold room at 4 °C. From the cold room the bags are taken for dipping, one at a time. After dipping and rinsing, the bags in their frames are returned to the cold room. Processing of the cutting material then takes place in the shed. One bag at a time is taken from the cold room for processing. On hot days it is important not to allow the cuttings to dry out while they are being processed. The prepared cuttings are taken from the shed to the greenhouse in small batches, to minimize the time spent in the shed. One or two people are constantly busy setting the cuttings prepared by the rest of the team (usually 8 others).

REJUVINATION OF MOTHER-STOCK

In difficult-to-root plants, rooting percentages are best when plants are young, so optimizing production off the mother-stock plants for 1 or 2 years is important as we then need new plants again. From some mother-stock plants we harvest cuttings twice in one season, from others once. Some taxa we keep for 2 years, others only for 1 year. After harvesting of cutting material some taxa can be grown out to produce a salable plant, others have to be discarded. Selling ex-mother-stock plants can sometimes be a compromise, either to the productivity of the mother-stock plant (because you have to harvest early to get sufficient re-growth) or to the sales plant (because it has been managed for cutting material). Also the number of mother-stock plants we need for production plan is not necessarily correlated to the market demand for the bigger sized plants.

OTHER OPPORTUNITIES OF MOTHERSTOCK SYSTEM

- Manipulation of photoperiod to keep plants vegetative and avoid dormancy; chrysanthemum is a good example of a short-day flowering plant that can be kept vegetative for better rooting.
- Etiolation, shading, nutritional balancing, and girdling are other techniques that can be applied to mother-stock to increase rooting of cuttings.

An Overview of the Seedling Growers Association of South Africa Certification Scheme©

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BACKGROUND TO SEEDLING GROWERS ASSOCIATION OF SOUTH AFRICA

The Seedling Growers Association of South Africa (SGASA) was started in 1981. This year marks the 30th year for the association. The association is ruled by a code of ethics which can be viewed on our web (<www.seedlinggrowers.co.za>). Most of the members' fees are used for research.

Membership is from most commercial forestry and vegetable seedling nurseries and includes active membership of the larger forestry and seed companies. The committee is run by elected members with a permanent Operations Director Viv Quin. This year our elected Chairperson is Shaun Biggs of Sutherland Seedlings. Each Chairman is allowed to stand for 2 years. Our research coordinator is Damien Naidoo of Sappi Research at Tweedie, KwaZulu-Nata. The Finances are monitored by Ken Leisegang. The financial standing of the association is excellent.

The association produces a magazine "The Leaflet" and runs a website (<www.seedlinggrowers.co.za>). Both of these are edited by Mike Kruger.

History. In the early years of seedling production in South Africa the grower members had little knowledge of the technicalities of growing seedlings.

The association was begun with the intention to pool resources and research topics that were seen as problematic.

A massive learning curve was achieved by initiating research through the old Natal University. Professors Irwin Smith and Mark Laing were instrumental in guiding many students through research projects.

By the late 1990s research slowed as many of the grower members were better informed in the art of growing seedlings.

The Seedling Growers Association of South Africa Comes of Age. Although research will always be a cornerstone of the association's function the retaining of membership needs to be maintained.

The association through its dynamic committee looked at many other aspects to ensure a majority grower membership.

The Leaflet newsletter, the website, and the annual conference are not enough. Many nurseries felt that standards needed to be set that all grower members could attempt to achieve thereby ensuring that customers would be assured of a quality product.

THE SEEDLING GROWERS ASSOCIATION OF SOUTH AFRICA CERTIFICATION SCHEME WAS BORN

Certification aims for SGASA:

- To ensure that we attract membership.
- To present to customers a selection of members that have obtained a certified standard of growing plants/seedlings.

- To allow for control of members.
- To ensure that members are legally compliant.
- To allow for the control of situations such as serious pathogens.
- To provide an affordable way to allow members the ability to obtain a relevant standard for the industry.

Where are we with the Certification scheme?

- The scheme was started about 10 years ago.
- It was developed from the Australian nursery standards and the South African Plant Improvement Act.
- Improvements are currently being implemented by Dr. Derek Askew (SGASA) of Macain foods.
- It covers all nurseries including those growing in bags.
- Special needs will continue to be incorporated with the aid of other interested parties such as the Fusarium Working Group. Sections 19 and 20 have been developed specifically for growing particular crops.
- Eurogap certification is being combined with the SGASA scheme.

A QUICK LOOK AT THE SCHEME

The Certification Scheme consists of 20 sections that cover legal, growing and best practice that may be encountered in a nursery.

Basic items such as supply and quality of water and growing media is covered. Legal requirements such as the storage and use of hazardous chemicals and the occupational and safety standards are also covered.

Then some specific areas of concern that some nurseries have to deal with are covered in specialized sections such as Section 19 Pine Fusarium control and Section 20 that deals with *Phytophtora* on peppers. In future new sections could be added to the scheme.

Section 20 has been added and this deals with growers who grow capsicums and wish to be certified.

THE SUMMARY PAGE

See Table 1.

WHO DOES THE INSPECTION FOR SEEDLING GROWERS ASSOCIATION OF SOUTH AFRICA?

Without a qualified independent inspector/auditor who understands the nursery industry a scheme such as this would be of no value.

We have been privileged to be able to engage and utilize the expert services of Kobus Serfontein. He can be contacted at this email address: <kobuss@agriscience.co.za>.

He travels to all nurseries around the country.

Advantages of Using Someone Like Kobus Serfontein.

- He is a qualified plant pathologist and is also qualified as an auditor.
- Kobus is prepared to travel country wide.
- Kobus understands growing media, irrigation, hygiene, and most aspects that are problematic to nursery managers.
- Kobus is able to produce a report from the findings associated with the SGASA check list.

Summary page and mininum compliance standards

RATED FACTOR	Actual % compliance			Minimum compliance	
				50%	75%
Section 1 : Water – Quality				√	
Quantity					√
Delivery				√	
Treatments					√
Storage				√	
Drainage				√	
Section 2 : Growing media - Quality for suppliers and users				√	
Mixing area				√	
Storage & handling				√	
Section 3 : Containers & trays – Storage				√	
Disinfection of used containers					√
Section 4 : Seed store					√
Section 5 : Sowing records					√
Section 6 : Sowing room				√	
Section 7 : Germination room				√	
Section 8 : Plant propagation					
Stock Plants – Ornamentals					√
Stock plants - Ornamentals (B)					√
Stock plants – Gras (B)					√
Stock Plants – Forestry (NF)					√
Propagation preparation area					√
Plant propagation area				√	
Acclimatization area				√	
Section 9 : Production facilities of nurseries growing crops under cover				√	
Section 10 : Nurseries growing crops in soil				√	
Section 11 : Agrochemicals storage and / or use					√
Section 12 : Imports from other nurseries				√	
Section 13 : Dispatch of seedlings					√
Section 14 : Product quality					√
Section 15 : General aspects & site appearance				√	
Section 16 : Health and safety compliance					√
Section 17 : Admin and financial controls				√	
Section 18 : Labour relations					√
Section 19: Fusarium circinatum					√
Section 20: *Phytophthora capsici*					√
Total Score					
Average Score					

Table 1. A summary of the 20 sections and the rating required by each section.

- He is able to advise nursery managers where they are having problems. This means that paying for certification will also make available to the nursery manager an expert to highlight problems that can then be solved.
- Through the continual inspections, of many nurseries nationally, benchmarking is available.

How Does the Seedling Growers Association of South Africa Certification Scheme Relate to IPPS Members?

- The SGASA certification scheme incorporates plants growing in bags. Similar challenges occur between both industries.
- The costs to get an auditor to all parts of the country are expensive. This can be shared by IPPS members and SGASA members as inspection times can be correlated.
- Specific requirements by IPPS members can be accommodated.
- The advantages of certification by the SGASA scheme will allow certified nurseries to be Eurogap certified.
- The two organizations will become closer especially in the technical growing aspects.

Nursery Certification©

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Why Certify?

1) As a means to gain market access.
2) As a tool to promoting a professional industry.
3) As a management tool.
4) To level the playing field in the industry.

Source of Pressure for Certification.

1) Legal / regulatory requirement: e.g., Global GAP for fruit exporters to the E.U.
2) Client demand: Retailers / buying public, e.g., Field to Fork for Marks and Spencer in the U.K.
3) Industry initiative: e.g., biodiversity in wine initiative for Western Cape wine producers with regards to fynbos conservation.
4) Public concern / pressure: e.g., Badger Friendly label for honey resulting from the media coverage on badger killings by bee keepers.

Role Players and Their Needs / Concerns.

1) Government: Legal and regulatory compliance
    a) Labour
    b) Safety
    c) Environment: Water and invasive plants
    d) Tax and registrations
    e) Biosecurity (movement of plants and plant material, e.g., citrus)
2) Client and Public: Retailer and buying / general public
    a) Reliable supplier
        i) Quality
        ii) Sustainable
    b) Good citizen
        i) Labour practices
        ii) Safety
        iii) Environmental
        iv) Legal
        v) Ethical
3) Certifying organisation:
    a) They must be independent.
4) Industry: The industry needs a strong industry organisation to balance the demands from the other role players.

Fruit Growers Situation.

1) They are in a situation where they need multiple certifications to maintain market access and this leads to costs in money and time. For e.g.:
   a) Global GAP
   b) Fair Trade
   c) Nature's Choice
   d) Field to Fork
2) Many fruit farmers are of the opinion that certification is a very profitable business for the certifying organisations and consultants.

Implications.

1) Negatives:
   a) Cost
   b) Time consuming
   c) Restrictive
2) Positives:
   a) Branded product
   b) Improved management and operations
   c) External audit
   d) Level playing field

Why Will We Certify With the South African Seedling Growers Association?

1) We believe it will become a requirement from our clients due to demands on them from their clients.
2) We want to support an industry initiative, thereby adding to a strong industry body that will look after our needs. An industry controlled certification that is acceptable to the clients is preferable to a scheme that is imposed on us where we will have little input into the content and cost of it.
3) I believe that it will improve our management and operations by bringing in sound process and procedures and by putting an external check in place to ensure that it is followed.
4) I support a professionally run industry and would like to see a level playing field where there are controls that ensure that every player plays according to the rules.
5) I believe that it is a brand that can add value to our product. It assures our clients that we operate our business in a way that can deliver quality and service in a sustainable and ethical way.

Implications for Us.

1) Cost:
   a) Initial cost of getting everything in place and management time needed
   b) Annual cost of audit.

Growing Media: What You Need to Know©

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INTRODUCTION

You don't need to know much about the growing medium you use in your nursery. All you need is a technically competent supplier. Leave it all to them, provide a bit of water, and your plants will do the rest.

I can see that you don't really believe me; I don't believe this myself, but I insist that it is important that your media supplier is technically competent. They must have an ability to produce media of consistent quality. And they must have the ability to sort out technical problems should they arise.

A technically competent supplier will be able to suggest a suitable medium for your particular plants in your particular environment. But you need to be able to assess their recommendations and you need to be able to discuss with them possible modifications, based on your past experience. In other words, choosing a growing medium for your plants must be based on a dialog with your supplier, the end result of which is a medium that will consistently perform well.

Here are some key properties that must be discussed.

PHYSICAL PROPERTIES

Getting the air-filled porosity (AFP) of your medium right for your plants in your environment and a particular time of the year is critically important. The medium must be open enough to allow good drainage, yet must hold as much plant-available water as possible. These two requirements are mutually exclusive, so every growing medium is a compromise that is based on what is most important to your situation over the growing period of your plants.

As a general rule, the AFP should be higher under low transpiration conditions than under high transpiration conditions. A good compromise is a starting point of 20% as measured by the Australian Standard method. You may choose a lower AFP for large containers and for summer in winter rain areas. You may choose a higher AFP for winter and for smaller containers.

The AFP of the medium is to be as it will be in your containers, after delivery and any damage done to the medium in your mixing/filling machinery. There is no point in a supplier delivering medium with an AFP of 20% if your machinery chews it to 15%. There is also no point in dealing with a supplier who cannot consistently deliver medium with the same or varied AFP. That means that your supplier must have grading machinery that can accurately grade the bark or other components into fractions that can be blended as needed to produce medium with the required AFP. So a key requirement you will have of your supplier is that they have excellent grading machinery that works under all weather conditions.

The other side of AFP is water-holding capacity. For summer this must be maximized, without compromising AFP. The best way of doing this is with coir fibre dust, at 15%–20% by volume. Of all the materials you can use, this is by far the best material for increasing water-holding capacity. It is better than fine bark, better than peat, and much better than water crystals.

CHEMICAL PROPERTIES

A key chemical property is medium pH. You need to agree on a starting pH for your mix. For most plants growing in soil-less media this will be 5.8 to 6.2. Only for so-called acid-loving plants should the medium have a pH in the low 5s. It should never be below 5. Your supplier will check pH before a load leaves their property. This check will typically be made within hours of the medium being produced. Inevitably the pH will change, usually rise, over the first week. Your supplier will have produced curves that show what will happen, so that the chosen lime addition rate will give the medium the required pH by the time you use it. In an ideal world this will always happen, but as this ideal may not always be reached, I strongly recommend that you always check the pH of each load soon after you receive it. If it is way out of specs you need to discuss this with your supplier before you use the medium.

Another aspect of medium pH is what will happen to it during the growing season. To know this you need to know the total alkalinity of your irrigation water. With water of low alkalinity (below 50 $mg \cdot L^{-1}$ calcium carbonate equivalent) you probably will need to build into the medium ability to buffer against pH decline. This is best done with coarse dolomite (0.5–2 mm grading) at 2 to 10 $kg \cdot m^{-3}$.

If your water has a total alkalinity of 60 to 100 $mg \cdot L^{-1}$ you probably do not need to build in buffering. If your water has a total alkalinity of 110 to about 140 $mg \cdot L^{-1}$, use of an acidifying fertiliser (high ammonium/urea) should keep pH steady. Waters of higher total alkalinity will usually need to be acidified with sulphuric acid to prevent pH rise in your medium.

Chemical properties such as calcium-magnesium balance and trace element concentrations are easily provided by technically competent suppliers.

If your irrigation water has less than 5 $mg \cdot L^{-1}$ sulphate-sulphur, you need to include a source of sulphur in the medium itself. An addition of 1–2 $kg \cdot m^{-3}$ of gypsum (preferably 1–2.5 mm grading) will do this.

You need to decide on a base level of phosphorus. For plants that are not prone to phosphorus toxicity, a base level equivalent to that provided by 0.4 $kg \cdot m^{-3}$ of single superphosphate is enough. For sensitive plants, the addition will be zero and the medium itself must not give more than about 2 $mg \cdot L^{-1}$ in a diethylenetriaminepentaacetic acid (DTPA) extract.

You also need to know the nitrogen requirements of your growing medium — i.e., the amount of soluble nitrogen that microbial activity will use each week, and which must be supplied on top of the amount needed by your plants. Technically competent suppliers know the nitrogen drawdown rate of their base media and know how to compensate for this drawdown through additions of nitrogen sources such as IBDU.

The other essential chemical property to decide upon is the type and amount of controlled-release fertiliser (CRF) to use. I don't intend to say much about this, other than to say that climate may influence the type (brand) chosen, and longevity will be determined by the length of the growing period, the likely temperatures during this growing period and the types of plants being grown. A key bit of information you need is the temperatures that might be experienced in your containers over a typical year. Several digital thermometers that record daily maximum and minimum temperatures in containers provide an essential base for choosing CRFs.

BIOLOGICAL PROPERTIES

Of course the medium supplied to you must not carry plant pathogens. You cannot easily check for their presence and your supplier probably rarely checks. If your medium is based on composted organic materials such as composted pine bark, and if the composting has been done competently, any plant pathogens in it should have been killed during composting, or at least reduced to very low levels. Evidence from practical experience throughout the industry supports a view that transmission of pathogens by suppliers is rare. It is then up to you to not contaminate the medium via sloppy hygiene.

The other important biological property you need to know about is the ability of the medium to suppress the activity of some plant pathogens. Suppression is possible only in media in which the organic components are still actively being decomposed by microbial action. A medium that is cold on delivery is usually one in which there is little microbial activity and hence little ability to suppress pathogens. On the other hand, a medium that is delivered with a temperature of 60 °C, or in fact any temperature above 40 °C, will in the short term have little suppressive activity because most of the microbes that do the suppressing will have been killed by the high temperature. If it comes to you hot, and this may be inevitable in the middle of summer, you can still use the medium if you must. Over a few weeks it will develop suppressive activity. Your hygiene must be good. But if you can store it in shallow piles for a couple of weeks, it should be suppressive by the time you use it.

The ideal situation is that the medium have a temperature at delivery in the 25 to 35 °C range. It will have gone through hot composting and will have been allowed to cure or mellow before delivery. Its nitrogen drawdown index will be in the 0.2 to 0.7 range.

FURTHER READING

Handreck, K.A., and **N.D. Black.** 2010. Growing media for ornamental plants and turf. 4th ed. Univ. New South West Press, Sydney.

Cutting Through the Fluff©

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INTRODUCTION

I like, no I really love, one liners…such as:

- "If it ain't broke…don't fix it" (Unknown Author)
- "That's no deal" (Nurseryman John Machen)
- "If you don't add value…then it's waste" (Henry Ford)
- "You haven't made a dime…till you sell number 12 of a dozen" (JC Penney)
- "We don't want to bake any birthday cakes" (Charlie Parkerson)

I use a multitude of one liners every day while conversing with my co-workers and family. On the surface one liners seem simple, they just roll off your tongue. However, when we give them more in-depth thought we find they are more like a key helping us unlock a much larger and more complex idea.

The purpose of this paper is to share with you my thoughts about plants having a birthday. What comes into your mind when you think about the word birthday? What does it mean to you? Something like: growing older, 1 year, a celebration, 12 months, gift giving, cake, ice cream, making wishes that you can't tell anyone about or they won't come true. These are basically happy and fun thoughts.

On the other hand if one of my plants has a birthday, while on our farm, then I am sad and angry.

Plant birthdays are not based on 365 days but on the logical, ideal production time that is established before the crop is started. Maximum profitability is achieved when the plant is sold or processed before its birthday.

Typical birthdays might be:

	Plant	Size (cm)	Source	Birthday
A	*Ilex*	7	Unrooted cutting	11 months
B	*Ilex*	27	7-cm liner (A)	18–24 months
C	pansy (*Viola* sp.)	13	72 plug	60 days
D	tomato (*Solanum lycopersicum*)	18	144 plug	60 days
E	*Quercus*	45	27-cm liner	12–18 months

Example A: In April of each year, an unrooted *Ilex* cutting is direct stuck into a 7 cm × 18 cell tray inside a poly house that is designed to produce a crop every 12 months. The *Ilex* is rooted, grown, and pruned to the desired size, overwintered, and harvested in March.

The *Ilex* cannot have a birthday because the next crop must take its place.

Now, you might think, "Gosh 11 months is a long time to produce a liner. My plants root in 3 weeks, and then they are out of the propagation department." Then 3 weeks is your plants' birthday.

Example B: The liner in Example A is planted in February-March each year. It is grown can tight for 12 months, spaced the following spring and sold in the fall (18 months) or subsequent spring (24 months) after planting. On our nursery, if a plant has a birthday it is destroyed. Holding on is false hope and the maintenance costs far outweighing what you can sell a junk plant for?

Example C: Pansies are planted the last week of August. harvest starts mid-October. Its birthday is in November, and must go because the spring pansy crop has to be planted.

I think you get the point, celebrate on the way to the bank not by baking birthday cakes.

Nursery Footprint — A Carbon Footprinting Tool for the Australian Nursery and Garden Industry©

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Carbon footprint is a term used to describe the total amount of greenhouse gas (GHG) emissions generated by a business or product. The term is often discussed in conjunction with climate change and variability and is also increasingly being used by consumers to identify more environmentally friendly products. During 2009, Nursery & Garden Industry Australia (NGIA) commissioned Growcom to develop a carbon footprinting tool for the Australian nursery and garden industry. Growcom developed a stand alone, easy to use calculator called *NurseryFootprint* that was officially launched at the NGIA National Conference in Darwin, 19–22 April 2010. This paper describes the calculator and its application in context with the Australian nursery industry.

INTRODUCTION

Carbon Footprinting Basics. A carbon footprint is a description of the total amount of greenhouse gases (GHG) emitted in the life cycle of a product or activity. Six key GHGs are considered in the calculation of a carbon footprint. These include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). These GHGs vary in their global warming potentials. For example, nitrous oxide (a by-product of fertiliser use) has about 300 times the warming potential of carbon dioxide. Owing to this variation among the different gases, the amounts of each gas must be weighted according to their warming potential before being combined into a single measurement. The unit used to measure a carbon footprint is tonnes of carbon dioxide equivalent (or t CO_2-e).

The calculation of a carbon footprint should include GHG emissions from the entire supply chain, including processes that might occur outside of the business boundary. For example, it should include both direct emissions that occur on-site (e.g., burning fuel in a tractor or boiler) and indirect emissions that occur elsewhere but are still associated with the product (e.g., electricity inputs, production of raw materials, or fuel for freight). In this way, a carbon footprint encapsulates all of the GHG emissions resulting from the production of a product, including the raw materials, manufacturing processes, transport, packaging, and distribution.

The Importance of Carbon Footprinting. A carbon footprint is a useful tool to quantify the contribution of a business or product to climate change and to identify areas where GHG emissions can be reduced. The nursery and garden industry has

the capacity to make a significant contribution to reducing GHG emissions and may also play an integral role in the mitigation of climate change. Some of the key challenges arising from predicted climate change and variability include securing adequate water supplies for irrigation of green-life and changes in pest and disease dynamics, such as heightened risk of exotic plant pest incursions.

Currently, the Australian nursery and garden industry has very low GHG emissions in comparison to other agricultural sectors. However, there is scope to further reduce these emissions and lessen the impact of production nurseries on predicted climate change. A carbon footprint is the first step in identifying opportunities for reducing GHG emissions. A reduction in the carbon footprint of a business is directly linked to other management practices that improve farm business efficiency. Many of the steps that can be used to reduce a farm's footprint, such as improved energy efficiency, reduced on-farm traffic, and less fertiliser, will also result in reduced input costs. Consequently, a small footprint can be used as an indicator of production efficiency.

It is also important to note that in the coming years, consumer preferences are likely to evolve and drive demand for more environmentally friendly products. A smaller carbon footprint may provide a distinct marketing advantage for more efficient businesses.

Greenhouse Gas Emissions in the Australian Nursery and Garden Industry. Carbon dioxide released by burning fuels in vehicles, farm machinery, pumps, and various heating applications (greenhouses, propagation benches, etc.) and nitrous oxide released from the use of nitrogenous fertilizers are the key GHGs in the nursery and garden industry. Small amounts of methane may also be released from waste and waterlogged soils. Other sources of potential GHG emissions arise from a variety of inputs and processes including freight, water, packaging, and waste.

Including supply chain emissions brings more gases and processes into consideration. For example, in the case of a plastic pot, GHG emissions may result from the extraction of the raw material (oil and natural gas), transport, processing into intermediate products (polymers), by-products, fugitive emissions from the processing plant, more transport, product manufacture, and even more transport (delivery). In addition to the direct emissions throughout the supply chain, each step has additional inputs (energy use, other raw materials, construction processes, etc.) that must be quantified. In reality, it is a supply tree or network rather than a supply chain.

METHODS

The NurseryFootprint calculator was developed in 2009 by Growcom using Microsoft Excel as a platform. This decision was made to ensure that it would run on almost any computer using a Microsoft Windows operating system (XP, Vista, or 7). The calculator is a basic tool that collects emissions data and does not provide a comprehensive life cycle assessment of emissions that complies with emerging standards (e.g., ISO 14040 or PAS 2050). It provides an approximation to a life cycle assessment by applying conversion factors obtained from published data.

The calculator was designed to be very easy to use and understand. For example:

- It assumed that users may not have a great deal of computing experience.

- It only required data that was easily available to nursery managers.
- It dealt with the huge number of products and processes in the nursery industry.
- It produced results that were relevant and easy to understand.

A copy of *NurseryFootprint* can be downloaded by visiting <www.ngia.com.au>. An easy to follow, yet comprehensive, User Manual was developed to accompany the calculator. It can also be downloaded from <www.ngia.com.au>.

RESULTS AND DISCUSSION

When you open up *NurseryFootprint* in Excel, a new custom toolbar will appear at the top of the Excel window. This toolbar features custom buttons to simplify some calculator functions such as printing data and clearing the cell contents. Once open, *NurseryFootprint* is organised into six main worksheets with distinct functions:

1) Introduction: Explains the purpose of the calculator and contains basic instructions, etc.
2) Data input: This is the form where the user enters all of the data required to calculate a footprint (Fig. 1). The form is arranged into logical sections to ease data entry. There are fields for:
   - General information such as the location and the start and end dates of the period of interest (i.e., financial year, calendar year, month, or quarter).
   - Energy inputs such as the amount of electricity consumed (in kWh).
   - Direct emissions resulting from fuel use and the application of fertilisers. Data on the amount of fuel and fertiliser used should be relatively easy to extract from business records.
   - The amount of waste produced.
   - Supply chain components such as freight, plastic products (e.g., pots), chemicals etc.. For these components, the user is required to enter data on the business's expenditure for a range of product, activity, or service categories.
   - Product information, including the total number of items sold in a number of different product classes (trays, tubes, small pots, etc.) and the relative contribution of each of these product classes to the total business income.

   [Note: You can clear or print your data at anytime using the "clear data" or "print results" buttons on the custom toolbar.]
3) Your carbon footprint: The results are all presented on this single sheet (Fig. 2). This sheet provides an estimate of the business's total carbon footprint, and also provides a breakdown of the emissions data into useful categories (energy, fuel, fertiliser, freight, plastics, services, etc.).
4) Conversion factors: This sheet contains all of the emissions conversion factors used in the calculations.
5) Cost-benefit analysis: This optional tool allows you to compare the emissions per unit consumed, per dollar spent, or per dollar generated for a range of products.
6) Information: This sheet contains brief notes and links to external information sources.

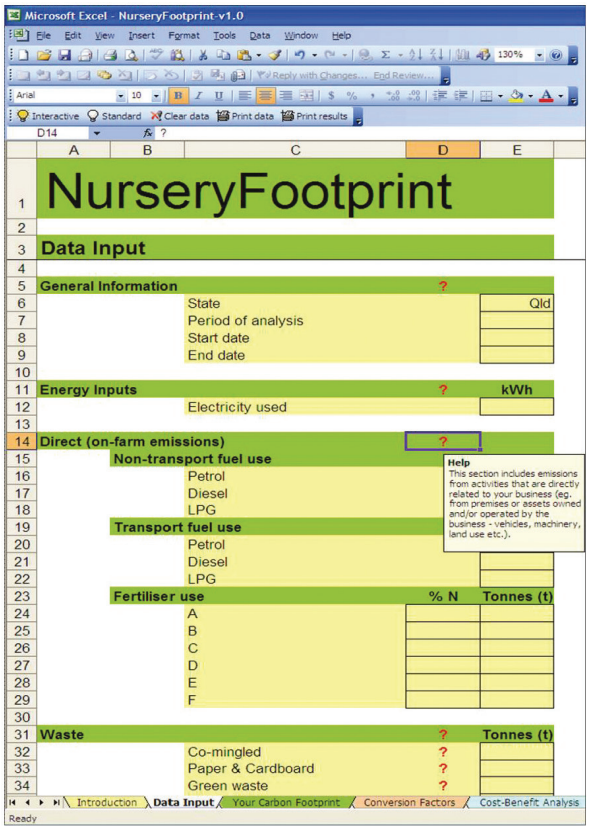

Figure 1. An example of the data Input worksheet showing a pop-up help box. The calculator will only allow you to enter or change values in the cells with the black borders.

Data Input. *NurseryFootprint* requires data on energy use (electricity and liquid fuels), fertiliser use, waste produced, and expenditure on a range of products or services. All of the data should be relatively easy to extract from business records and accounts, and there should be no need for the user to obtain additional information from upstream suppliers. Data can be entered in the Data Input worksheet (second tab from the left). For each category within the calculator, further details can be found by clicking the "?" or clicking each data entry box.

Viewing Your Results. Once all the business data is entered the user can simply click on the worksheet "Your Carbon Footprint" to view their results. This worksheet presents the total carbon footprint (in tonnes CO_2-e), and also provides a breakdown into general emission sources and product categories. This enables the business to clearly identify the emissions contributions of particular activities or products. There are tool tips to clarify what products or activities are included in each category.

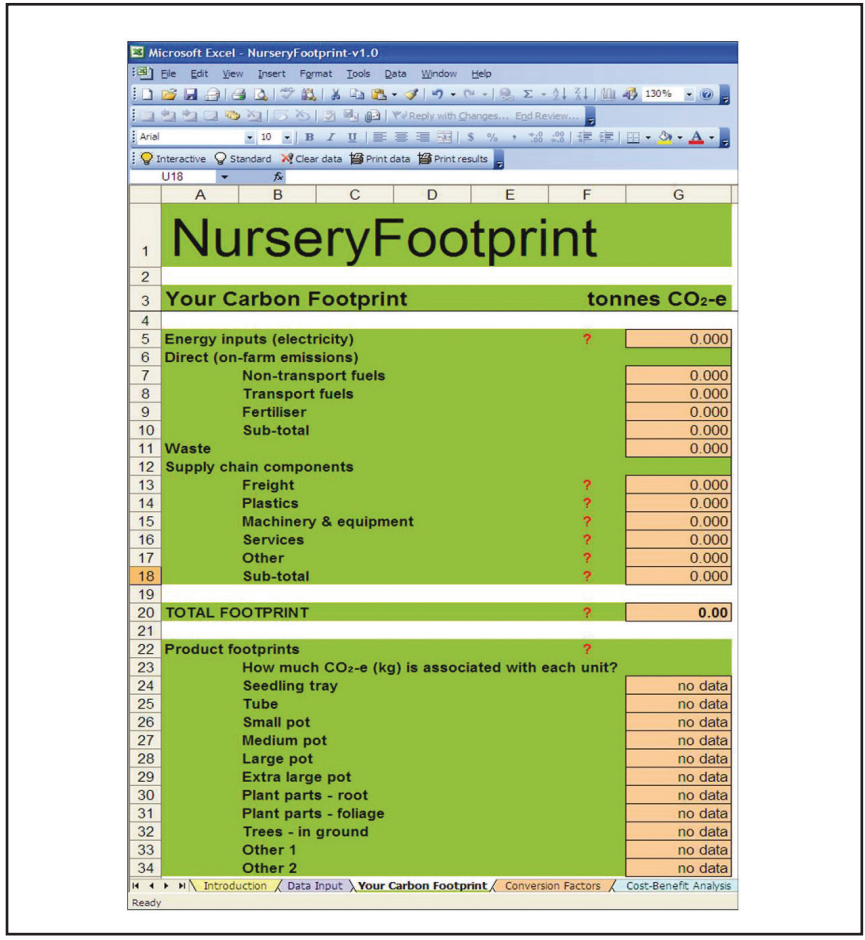

Figure 2. An example of the Your Carbon Footprint worksheet.

A graph at the bottom of this sheet provides a quick visual overview of the emissions profile by showing the proportion of the total emissions that are contributed by each category. Users can "hover" the mouse over a section of the chart to view a pop-up box that will display the name of the source of the emissions and the amount in tonnes. The calculator also produces estimates of the amount of emissions associated with each unit in a number of different product categories. These estimates are calculated using an Economic Input-Output approach. The results can be printed on this sheet using the "Print results" button on the custom toolbar.

Business Decisions Based on Carbon Footprinting. Calculating your businesses carbon footprint is smart business. *NurseryFootprint* will identify what areas of a business are generating the most greenhouse gases and help identify where efforts should be focussed to improve efficiencies and consequently reduce

emissions. Emission targets and goals could be set to assist in this process. For example, the results may indicate that electricity consumption is a major emissions source because the business relies heavily on electrical inputs (e.g., pumps, heaters, potting machines etc.). The business may then decide to switch to an alternate energy provider specialising in green energy or implement non-renewable technologies on-farm.

This tool also allows businesses to compare the emissions generated per dollar spent on selected inputs (electricity, fuel, and fertiliser) or emissions generated per dollar of income across a product range. These results will allow businesses to weigh up the various options for cutting emissions within their business whilst optimising their profit to emissions ratio. For example, the results might suggest that a business could consider alternative fuel sources for some operations or an adjustment to a product mix.

NurseryFootprint can also target the footprints of individual products or activities. To achieve this, data that relates to a specific product or activity of interest should only be entered. This can provide a business with an estimate of the carbon footprint for the targeted product and could also be used in carbon labelling. The emission information could be placed on plant labels to provide customers with pertinent information about the product allowing them to make smarter shopping decisions.

CONCLUSION

Calculating the carbon footprint associated with a business or product can create tremendous opportunity for that business to showcase its green credentials and demonstrate its commitment to the environment. Not only will this commitment deliver a tangible benefit to the environment and the wider community, but it will also drive efficiencies within a business. Carbon footprinting will also provide a business with a marketing opportunity that can appease consumer's appetite for information on how sustainable that business or product is.

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ADDITIONAL READING

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Department of Climate Change, 2009. National Carbon Offset Standard.

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What's Wrong With My Plant?

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As an agricultural agent (crop advisor) I am called on to provide a quick and accurate diagnosis of many types of plant problems. This is a review of basic diagnostic protocols that I use to help me determine what the problem is and why it may have occurred. I believe that a diagnosis is only as good as what one learns from it. Knowing "why" the problem occurred is important since it helps avoid or manage future problems.

Scouting nurseries and landscapes on a regular basis is the best way to catch problems early. Infestations, infections, and physiological problems can be controlled more effectively and with less environmental impact when caught early. Look for off-color foliage, areas of reduced growth, wilting, leaf damage, and weeping. If there is a problem with the foliage, be sure to check both sides of the leaves. If the problem is in the roots, be able to determine what a good and a bad root looks like on the plant in question.

Identifying the problem is then a matter of reducing optional diagnoses. Three things to remember as notes of caution:

1) A plant under stress is more likely to have problems.
2) Everything is not always as it seems.
3) There are exceptions to every rule.

It is necessary to identify the primary cause of the problem. More often than not, secondary problems will occur and can cause confusion in the diagnosis.

One of the most important resources in diagnosing plant problems is to know growth requirements for plants growing in their natural habitat and how they compare to nursery production conditions. Identify optimal temperature for the tops and the roots of plants, determine if shading is beneficial, and identify the plant's major pest problems. With that and other information, one can develop plant profiles to help with future diagnoses. Build a reference library to help diagnose plant problems (see "References Resources").

Insect adults have six legs, while their immature forms come in many configurations. They fall into two general groups. Those that have chewing mouthparts include caterpillars, beetles, and grubs. Insects that drink with piercing-sucking mouthparts include aphids, scales, and leafhoppers. Diagnostically, if plants are stippled with very small holes the pests are piercing-sucking insects while chewing insects leave irregular holes in leaves, sometimes only leaving the major veins? Look on the undersides of the leaves and on succulent stems to find aphids. Scales are most often on stems. Borers are chewing insects that leave holes in the trunk or stems of trees and a sap exudate is a diagnostic feature of borers.

Some pests fall into the "insect" category but are not true insects. Mites are major plant pests that have eight legs and are actually in the spider family (arachnids). Mite problems are identified by off color foliage. Be sure to look for them on the undersides of the leaves. Tap a branch with leaves onto a white paper and look for the moving dots that are actually mites. Wipe across the page to see telltale red

streaking. Slugs and snails are mollusks and chew leaves and may be noticed by their slime trails. Nematodes are also not insects and while there are many beneficial nematodes, there are also some that cause plant problems. They are very small and wormlike. Many times, decreased growth is the first sign of root nematode problems. Foliar nematodes show a characteristic mosaic pattern on the leaves. Microscopes are needed to identify most nematodes.

Over the last 6 years from our southern New Jersey scouting program, mites, aphids, and scales were, by far, the most numerous problems.

Diseases such as *Phytophthora* and *Pythium* infect a wide spectrum of plants but many diseases are related to limited genera or species of plants. The most prevalent disease infections on nursery crops are the result of the water molds *Phytophthora* and *Pythium*. A cinnamon browning of the wood characteristically identifies *Phytophthora. Pythium* can be a primary or a secondary disease and is characterized on roots by easy removal of the outer portion of roots while the cortex remains intact.

On nursery plant material, fungal infections are most common. When leaf spot problems occur, they are generally related to environmental conditions conducive to infection (periods of leaf wetness). One of the physical characteristics of leaf diseases is the pattern of infection typified by regular or irregular rings where the center has browned out or dropped out. Cankers, characterized by sunken stem lesions, seem to be related to environmental and mechanical stresses. It is important to determine the primary infector since environmental factors are usually conducive to secondary infection and treatment may not be the same.

Bacterial disease infections, while not seen as frequently as fungal infections, can quickly devastate plants. Typically bacterial diseases have a water-soaked appearance that looks a bit like the plants are melting. Later on, bacterially infected areas may appear blackened. Rusts are another class of plant problems that are easier to diagnose since they look "rusty." There are two significant types of mildew diseases. Remember that only the powdery mildew is a true fungus while downy mildew is a water mold so chemical controls will not be the same.

Critters also have the ability to cause significant damage. In our area the major problems come from deer, voles, and rabbits. It is sometimes difficult to attribute decreased growth to a pest problem when there are not distinct symptoms. The test used to identify the cause of the reduced growth for a grower who complained that crops did not perform as well as in the "old days" entailed protecting some plants with fencing and comparing the protected growth against unprotected growth. Deer damage was the problem.

Voles are more likely to attack the roots of plants, and damage isn't typically noticed until the tops die back. I viewed a case in New Hampshire where voles chewed the bark of young apple trees causing a spiral damage pattern that corresponded to the area that was exposed as the spiral tree protectors expanded. In that case, there was snow cover that allowed the voles to damage the trees without notice by the grower.

Rabbits are also chewers. They tend to go after plants and trickle irrigation systems. Rabbits and other small animals are also prime targets for dogs. When chasing animals through the nursery, dogs have the potential to cause what might be considered "secondary" damage to the plant population.

Physiological damage, much of the time, results in damage that is not presented in a fashion that sets it apart from other problems. Damage to plants may mimic diseases and/or result in secondary infections. A number of environmental conditions can lead to plant damage. Cold temperatures can result in frost, freezing, or chilling damage; high temperatures may result in desiccation and wilting; excessive light can result in leaf scorch; dry air can lead to desiccation and wilting, and especially on new growth when coupled with hot/bright/low humidity conditions can lead to almost instant leaf scorch.

More damage occurs in a shorter time period when environmental conditions combine. Radiational cooling on clear nights combined with low humidity conditions can result in foliar damage to sensitive plants, even at above freezing temperatures. As a result of warm temperatures and high humidity, plant leaves in overwintering structures can accumulate water (infiltration). When infiltrated leaves freeze, damage occurs. One needs to anticipate weather conditions and their effect on plants to reduce problems.

Experience, especially of others, is the best teacher. Keep a journal of plant problems, diagnoses and pictures of the problems. Keep notes about when and where it occurred, weather conditions leading up to and at the time of and the problem, temperatures, temperature extremes, light conditions, relative humidity, rainfall information, wind conditions, and any other environmental or situational conditions that made an impact. Make special note of any stresses the plant may have sustained leading up to the damage: water deficiencies or excesses, fertility issues, chemical applications, and mechanical damage. Remember that sequential stresses cause cumulative effects.

My abbreviated version of a checklist to help serve as a guide in the diagnostic process includes:

- When did the problem start?
- Did the affected plants get suddenly or progressively worse?
- What kinds of plants are being affected? Is there more than one species?
- Are most plants, a group of plants, or random plants damaged?
- Are the plants growing in conditions similar to native habitat: is the sunlight excessive or limited; is the soil too dry or too wet; or does the pH maximize the opportunity for plant growth?
- What parts of the plant show damage: leaves, branches, stems, crown, or roots?
- How is the damage characterized?
    - Is there evidence of insect activity or disease?
    - Is there browning of the roots? Does the whole root ball show damage or is it in a section of the ball? Is the browning only at the tips of the roots or into the heavier roots? Does the browning slide off when pulled leaving the cortex intact (*Pythium*)? Is the wood stained brown (*Phytophthora*)?
    - How does the plant appear? Is it chlorotic or dull in color? Are the leaves speckled or patterned? Are all the leaves affected or just certain ones?
- Were there environmental conditions that could have impacted the plant?

Problems that look like something else are the ones that may take additional detective work to diagnose. A mottled leaf may be a fungal disease, a virus infection, foliar nematodes, or even chemical toxicity. The process of elimination helps to lead to a solution. To identify foliar nematodes place cut up leaves in a shallow dish with water and check with a microscope in a few hours. If the diagnosis is indicating a disease problem, it may be necessary to collect and submit samples for analysis. Chemical toxicities are more complex. Is the problem as a result of an airborne, spray, or soil source? If the plant is not killed, they usually grow out of airborne and spray toxicities. The outcome from soil contaminants is highly rate-dependent.

The field tool kit that I use for most plant diagnoses includes the following items: a pocket knife including a sharp blade for checking vascular tissue and scissors for cutting and examining buds; bypass pruners for a clean cross cut of stems; a nursery spade to look for root problems; a pruning saw for when the wood gets too big to handle with pruners; a pad of white paper used for notes and identification of insects and mites; a hand lens (10X): sometimes it's better to get a closer look; a digital camera with a close-up option; a soluble salts meter and a pH meter or test strips; a thermometer used mostly for media temperature measurement; and polyethylene zip lock bags for samples and moist chamber use.

Diagnosing plant problems starts with asking questions about the event. Never assume anything; an inaccurate assumption is an easy trap to fall into. Consider asking a question that comes at the problem from a different angle so misinterpreted or misunderstood questions might be clarified.

Take a good look at the physical appearance of the plant and its environment. Attempt to determine when the problem started. In many cases, the start of the problem occurs well before it was first identified. Attempt to relate environmental events that might have had a part in the problem. Remember that the environment is not just the weather but also the physical location of the plant. Was puddled water splashed onto a crop that caused an outbreak of *Phytophthora*? Was there a dry period during a critical stage of growth that caused a rhododendron to wilt enough so when it regrew there was a "crook" in the shoot? Was there a period when the temperature spiked under clear skies and low relative humidity that may have caused a leaf scorch?

Look for ***key indicators*** to help narrow diagnostic options. Was browning of the leaves a clear brown that is usually typical of physiological damage or did it have patterns that might be associated with disease? Was the problem confined to a particular species or selection? Did the problem extend throughout the nursery, in various locations within the nursery, or was it sporadic? Did the leaves on the interior of the plant look better or worse than those on the exterior? How do the roots look in comparison to the tops of the plants? Was the damage or infection on the top of the leaf, the bottom of the leaf, or both sides? Did a neighbor harvest a crop next door that resulted in an insect pest migrating into your nursery stock?

Reduce options for a diagnosis. When the problem can be categorized into an insect, disease or physiological problem, the road to a diagnosis becomes a little easier. If a disease sample is delivered to a diagnostic laboratory, be sure to include both dying and good tissue. The culture needs to be taken from the area of active infection and that is at the interface between the two. Knowing what insects attack which plants is of immense value when there is evidence of insect injury. Use reference books to help identify insects and symptoms of the damage they cause.

When a problem arises that doesn't fit the profile of a disease or an insect, it may very well be a physiological problem but there are exceptions. Insects sometimes arrive, damage, and depart before injury symptoms show up (e.g., leafhoppers). When the tentative diagnosis leads to a physiological problem, confirmation is sometimes difficult. Physiological problems typically arise from the interaction of environmental and cultural components. A few physiological problems and resolution of the issues follow:

Example 1.

Plant: Several species, container grown.

Physical appearance: Plants were off color and growth had stopped.

Key indicators: Roots were burned. The nursery was focused on water conservation and used water sensors to schedule irrigation cycles. The problem occurred several weeks into a period of no natural rainfall.

Diagnosis: Elevated levels of soluble salts causing root damage. An initial pour through test did not show elevated salt levels. A sequential pour through test resulted in measurement of medium fractions. Results indicated the highest level of soluble salts in the middle fractions. The top and the bottom of the container had low salt levels caused by irrigation pushing salts only part way through the container. Irrigation also leached the bottom of the container.

Recommendation: Be sure to include regular leach cycles when rainfall is limited.

Example 2.

Plant: *Tsuga canadensis*: hemlock, field grown.

Physical appearance: Plants were generally off color with needles dying back from the tip.

Key indicators: Needle browning exhibited sequential dieback with banding across the needles. Roots were good. The damage was not progressive. Interior needles showed far less damage than those on the outside. Damage was more prevalent where the plants were exposed (without other plants nearby).

Diagnosis: Scorch from a combination of droughty conditions, high heat, low humidity, and wind. Hemlocks are more adapted to cooler temperatures, higher humidity, and partial shade.

Recommendation: Those plants that were not too seriously damaged will generate new needles as older needles drop. If possible, irrigate to keep foliage moist under these stress conditions.

Example 3.

Plant: *Vinca minor*: periwinkle, propagated.

Physical appearance: Rooted *Vinca* cuttings were transplanted into cells in the late fall. Plants were chlorotic and failed to make much progress over 2+ months.

Key indicators: Roots had not grown out into the medium. There was very little or no top growth. Most of the crop was affected. Few plants had actually died.

Diagnosis: pH (4.3) threshold effect.

Recommendation: Treat with pelletized dolomitic lime (very fine mesh size particles).

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New Pots and Procedures for Propagating Landscape Trees©

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INTRODUCTION

We can be proud of many landscape tree outcomes, but there are some alarming tree failures in our parks and streets that are costing us millions. Up to six parties are responsible for landscape tree outcomes: the designer, propagator, grower, planter, waterer, and maintenance crew. Too often the grower alone is held to account for any problems.

We are fortunate to have so many excellent participants, but there are weak links in the chain of responsibility. These weak links are exacerbated by price competition in the absence of adequate quality standards.

I noticed the first dead eucalypt in a nearby park early in 2010, about 7 years after it had been planted. I happened to walk past as the contractor was removing it, so asked to have it to take home. "No problem mate! There are plenty more like that." So I threw it over my shoulder and took it home to dissect. The cross section view of the root ball showed a girdling root that has strangled the tap root.

Three more trees have died recently in the same park. The trees were in their 8th year. Failure occurred in the wind on a wet day — the root ball then exposed was encircled several times by thick roots. Trunk caliper was 150 mm and height 3.0 m.

The Problem. Landscape tree seedlings are produced in tubes or cells developed for forestry. Delay in using the seedling can cause fatal root system flaws. Landscapers often need to cope with delays of weeks or months. Tubes and cells were designed for a shelf life of days.

The Solution? First, get the right tools and procedures. Then use skilled workers; trained tree planting tradesmen would make a big difference. "Advanced Tree Teamwork" is essential. Finally, measure outcomes and publish the results.

Tree Costs. City of Hume cost data show that the cost to buy, plant, mulch, and stake the typical tree is about $200 (AUD). The cost to water it to self sufficiency west of Melbourne is about $200. Total costs are about $400[1]…if there are no failures[2]. The Hume data suggest that the cost of a typical tree failure after 1 year is $288 [Tree Cost $110+plant and stake $51+ 1st year mulch, water (24 visits), and spray weeds $127]. The $288 is more than 35 times the cost of an elite propagated seedling. Why skimp on the seedling and risk wasting another $288 needed to plant a second time? Using anything less than a perfect seedling is false economy.

About 2 million advanced trees are planted annually in Australia. The annual cost of planting and bringing these trees to self sufficiency may be of the order of $800 million. So what proportion of advanced landscape trees we plant fail to survive and prosper? We should measure and know the Australian figure but we don't.

[1]Derived from data supplied by Daniel Rayment and Ronan Hamil of Hume City Council.

[2]David Willyams IPPS Freemantle 2010 "In restoration projects the cost-per-surviving-plant 2 years after planting is more relevant than the nursery plant price."

Figure 1. The third dimension in air root-pruning.

Consensus opinion among five tree growers with vast experience was that: more than 20% of advanced trees fail after planting and even more are seriously compromised.

The annual cost probably exceeds $100 million ($280 × 400,000) What other industry could tolerate 20% defective product? Cars? Appliances?

MANAGING CONTAINER-GROWN TREES THROUGH THEIR ROOT SYSTEM

After 8 years of trials, we have learned to manage trees by pruning their roots in all three dimensions 24/7 — starting a few days from germination.

Our research is unfunded and basic. It seems that basic horticultural practices are being overlooked. I believe that Industry R&D funds could be used to fine-tune a set of products and practices that will lead to consistent propagation, growth, and establishment of superior ornamental trees.

In our small trial nursery, we hand fill pots, direct sow seed with a depth-controlled dibble (nut and bolt with flange), cover the seed with the same mix, and water it in. We hand water until the radicle reaches the root-pruning base of the pot — then start "flood and drain" watering. We select the best seedling when it is about 50 mm tall. Procedures in large nurseries should include mechanised pot folding, machine filling, and machine seeding. It is already possible to stack palletized pots in blocks under existing overhead spray systems.

Three Dimensional Air Root–Pruning. We are using relatively new technology in these trials. Its generic name is three dimensional air root-pruning (3DARP). This may be defined as: "The use of containers with vertical walls and elevated flat bases with at least 20 mm air gap above recycling water flow, with both wall and bases fitted with at least 400 open ended root guidance cusps per square metre."

I have spent about 20 years seeking to control a tree's growth in a container through its root system. This picture is the culmination of that work (Fig. 1). For the first time, downward pointing roots can be made to grow on down and colonise the planting site below the root ball. We just have to have 24/7 automatic air root-pruning for direct seeding eucalypts in larger pots.

Caliper — Wise Buyers Purchase Trees and Tree Seedlings for Caliper and Not Height. We found that we can keep seedling height down and caliper up by:

- Limiting fertilizer incorporated in the media to less than 4 $kg \cdot m^{-3}$ of 9- to 12-month release.
- Letting in light as the seedling matures.
- Rotating inside seedlings to outside.
- Sheltering the pot against evaporative cooling and root scorching.
- Keeping the root ball warmer than the trunk and of course air root-pruning 24/7 with 3DARP. We attempt a caliper at least 1% of height but it is species specific.

Our trials have led to a better understanding of root behaviour in air root-pruning systems. This picture shows the effect of pot size on seedling caliper in the first 28 days from seed (Fig. 2). These *Corymbia citriodora* (syn. *Eucalyptus citriodora*) were direct sown with the same seed, sowing date, water, and nutrients but different pots. The diameters of radicles were:

- 0.5 mm for cell trays (RHS).
- 1.0 mm for forestry tubes.
- 1.0 mm for 1.5 litre pots.
- 1.2 mm for the 1.5 L and deeper 3DARP pots (LHS). So pot size does matter to seedlings.

Figure 2. The effect of pot size on seedling caliper in the first 28 days from seed.

Note that air root–pruning has started already on the 3DARP seedling.

Over 200 seedlings were "key-hole dissected" with a compressed air jet during the trials. In every case an un-branched radicle had air root-pruned at the base. These two typical root systems at Day 133 from seed show how the radicle is surrounded by an array of laterals uniformly arranged in 3D space (Fig. 3).

Part of understanding root behavior in 3DARP pots is to study root systems suspended in water. The specific gravity of the fresh seedling roots is fractionally higher than water (1.0). The washed out root ball hangs naturally in an aquarium tank. Notable findings being used in the design of new 3DARP pots are:

Figure 3. The two typical root systems — both at Day 133 from seed — show how the radical is surrounded by an array of laterals uniformly arranged in 3D space. LHS: sown in 1.5 litre 3 DARP, RHS: sown in 8 litre 3DARP.

- The radicle runs quickly to the base of the pot and air root–prunes each and every time — if the humidity in the basal air gap is low enough.
- Lateral root growth is stimulated and root-pruned at the wall — if the humidity in the air between pots is high enough.
- Three or more roots emerge from each root that is air root–pruned, then nine, then 27, and so on.
- The rate of root tip development becomes exponential
- In our Melbourne summer trials of fast growing eucalypts, colonization often occurred quite suddenly at about 110 days from seeding (8 litre) and 90 days (1.5 litre).
- The volume of wood in the trunk increases fourfold if the volume of mix in the 3DARP pot increases fourfold.
- Germination in this windy site increased from 80% to near 100% when we increased dibble depth from 5 mm to 10 mm. The length of the seed radicle when first pruned is probably determining the future shape of the tree, but much more research is needed to verify and detail this finding.

The seedling's natural shape fights with and suffers from the normal 7 degree inverted pyramid taper in smooth wall pots.

Consider two pots of the same diameter (Fig. 4).

- A 200-mm 3DARP pot normally has an effective depth of 240 mm and 7.5 L of useable volume (shown in black).
- A 200-mm smooth wall pot normally has a depth of 190 mm and 4.5 L of useable capacity (shown in red).
- Parallel wall pots give about 50% more root space — just where it is needed.
- The shelf life of a seedling germinated in a 200-mm diameter 3DARP is at least four times the shelf life of one in a 200-mm smooth-wall pot.

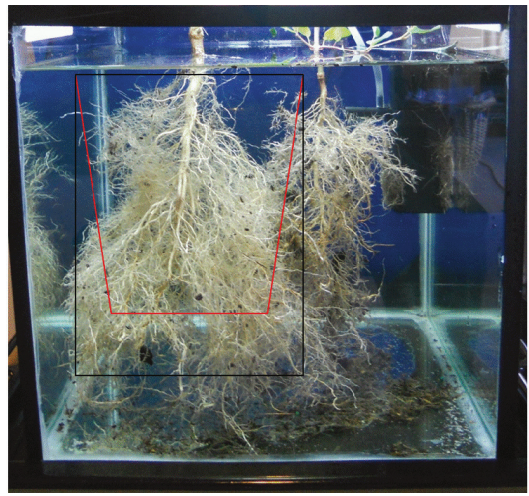

Figure 4. The seedling's natural shape fights with and suffers from the normal 7 degree inverted pyramid taper in smooth wall pots.

The trial equipment we used has led to the design of new procedures and racks. Notable findings from the trials include:

- We still need to cull 20% of the crop — despite multiple seeds per pot.
- Watering by weight works well. We weigh a sample at field capacity and monitor it daily. When the pot loses 30% of its original weight we flood, dwell for an hour, and drain. In 8-L pots, 1.2 L of air is expelled and replaced with water.
- Watering is every 3 days in windy hot weather but normally less frequent.
- Filtration and sanitation with a 24-watt UV bio-filter works well — running 50% of the time.
- Salinity is measured and adjusted by dilution if it exceeds 1.3 ms (rare).
- Culling 20% of a rack after 10 weeks allows re-spacing to let in more light to increase caliper and minimize height.
- Lifting 8-L pots repetitively is stressful. If the 8/10-L pot slides (or better, glides) across the rack floor it is very easy to grade, cull, and re-space stock.
- Correct working height and full access around the rack are essential for good occupation health and safety standards.
- Carrying pots individually from nursery to truck and truck to planting site is expensive and dangerous. It can be mechanized.
- New pots and racks have emerged as modules of a shipping container.

- Racks are fitted with a "mezzanine floor" that maintains an air gap of 50 mm beneath the pots for air root pruning and hygiene. This floor is a key component of the 3DARP system.

New Pots. Here is a 3D computer graphic of our new pot proposal (Fig. 5). Three new pots are shown on a new pallet. At the top of the picture, 400 of these 0.4-L pots will fit on the new pallet. The depth of the root ball is set at 160 mm for big trees. Bottom left, 100 of these 1.5-L pots will fit on the same new pallet. The depth of the root ball will be 180 mm. Bottom right, 25 of these new 10-L pots will fit on the same new pallet. The depth of the root ball will be about 250 mm. Detailed designs for our new 3DARP pots and patents are pending. We want to tackle this project now. The new 10-L pot offers a way to solve landscape tree root quality problems quickly**.** It will be a one-piece design selling for about $2.75. It will be designed for more than 10 reuses — stacked flat for easy return. There will be a folding machine to form the pot from the flat moulding.

New Procedures. We recommend sowing direct to the 3DARP pot size you will sell. For landscape applications we recommend sowing direct to 8-L 3DARP pots because it gives:

- Shelf life of many months.
- One step not two.
- 4 months to sale not 6 months.
- 25 pots per pallet not 16 taper pots.
- Root growth without circling.
- Grow outdoors in spring/summer.
- Selecting the best seedling without pricking out.

Root Ball Colonization and Shelf Life. We washed out seedling root balls at frequent intervals to understand root development in the first 5 weeks from seed. Root dimensions can now be scaled from photographs and used to track seedling growth rates. The results are shown in a graph. Plotting the radicle diameter (Y axis) against days from seed (X axis) shows the shape of the "root ball colonisation curve." Growth of fast-growing seedling caliper in 3DARP pots appears to plateau after 90 or 110 days. Our "best by" date is the day on which most of the media in the pot is colonized (shown circled). The shelf life of trees in 3DARP pots is much longer than smooth-walled pots but trials have proved that trees grow on significantly better when planted out close to their "best by" date.

Measuring Outcomes. We have found a radio-frequency identification (RFID) chip encased in a plastic moulding that can be buried in the root ball of tree. Millions of similar (half duplex) tags are used in the Australian cattle industry annually. We are exploring the possibility of having the planter collate and record the exclusive 13-digit chip number, along with details like the species and provenance, the growers name, the growers recommended "best by" and "use by" dates along with the GPS coordinates of the planting site. It is looking good.

SUMMARY

1) Propagating landscape tree seedlings in forestry tubes and cells is causing serious problems when landscape tree plantings are delayed.

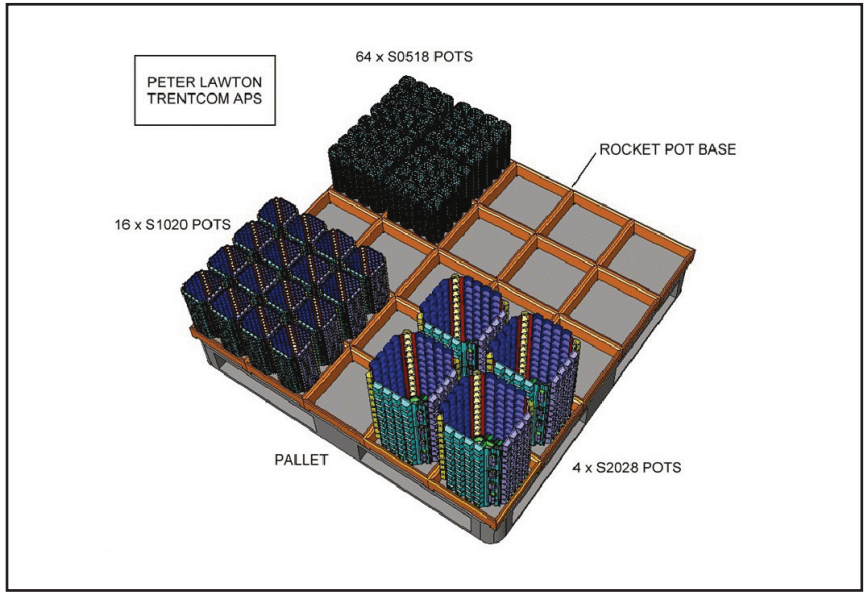

Figure 5. A 3D computer graphic of the new pot proposal. Three new pots are shown on a new pallet.

2) Twenty percent or more defects in any industry is unacceptable and the cost in our industry probably exceeds $100 million per year.
3) Sowing seeds directly into the 8-L 3DARP containers has given excellent caliper and shelf life — consistently over 8 years of trials.
4) The simpler process produces root systems with less labour, less water, faster stock turn, and reduced nursery space.
5) We need three new 3DARP pots [10 L, 1.5 L (V2), and 0.4 L] to allow propagators to sow direct to the pot that their customer wants to use or sell.
6) We need Australian industry and Australian government support to create these pots.
7) The pots might become part of a technology-based quality standard for trees.
8) A new tree growth measurement plan is available using simple electronic tags that are readable for years after planting.
9) Let's measure and recognise landscape tree excellence.
10) Hope springs eternal.

Acknowledgements. I appreciate the advice and help given to me by supportive customers who made the work possible and Dr Peter May, Treenet and David Lawry, Nicholas Rivett, Joe Cartman in Christchurch N.Z., and the late David Nichols who designed the original growing medium that made 3DARP succeed.

Note: The edited version as presented at the conference will be available at <www.trentcom.com.au>.

Propagation Media: Don't Forget What Is Not Easily Seen©

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INTRODUCTION

There are two parts to this talk. The first is about cutting media and the second is about media for seedling production. Within each, I concentrate on physical properties and a few aspects of nutrition. I take it for granted that your media are free from plant pathogens and that your hygiene practices are excellent.

CUTTING MEDIA

Physical Properties. Root production by cuttings requires that the cuttings remain turgid. Any wilting decreases rooting percentage. Turgidity is maintained in part with water from the medium itself and in part from humidity in the air.

It really does not matter what you use to make cutting media, so long as the physical properties are what your cuttings need in your environment. The main components used are composted bark, peat, perlite, sand, coir fibre dust, and vermiculite. By physical properties I mean air-filled porosity (AFP) and water-holding capacity (WHC). The AFP and WHC are mutually opposed to one another: increase one and the other automatically decreases. So it is necessary to strike a balance between them, based on the environment in which the medium is to be used.

For this discussion, the important part of that environment is how water is to be supplied. Specifically, the media requirements for propagation under fog are different from those for propagation under mist.

With mist, the cuttings themselves are intermittently sprayed with water. Some of this water runs into the cutting medium, which is likely to remain quite moist. If the AFP of the medium is too low, the cuttings may not get enough oxygen and so root formation is compromised. The medium must therefore have a high AFP, probably in the range 20% to 30%. However, it is also important that the basal part of the cutting remains in contact with liquid water, so the AFP should not be higher than is needed to ensure good oxygen entry.

With fog, while the air is kept humid, very little water actually enters the medium. The WHC of the medium should be higher — and AFP lower — for propagation under fog than under mist, so that cutting bases remain in contact with water. It will generally be necessary to irrigate occasionally to maintain WHC. An AFP in the 10% to 20% range can be appropriate. Including peat or coir fibre dust in the medium helps ensure good contact with the cuttings.

Chemical Properties. It has been repeatedly shown that the pH of cutting media should be fairly low in the range 5–5.5 generally. Low pH increases the "leakiness" of the cutting and so enhances auxin uptake and root formation.

While the cutting itself will not take up nutrients from the medium, as soon as roots form they should have nutrients available to them. It is therefore generally desirable to include a small-prilled, intermediate-term, controlled-release fertiliser (CRF) in the medium at about 1 $kg \cdot m^{-3}$.

If the cuttings came from stock plants that were over-fed with nitrogen, they may have a carbohydrate concentration that is too low for good rooting. A drench or two of sugar solution (50 $g \cdot L^{-1}$) should help.

It is also highly desirable that the medium contain humified organic materials. Humic and fulvic acids in the humates of such materials have hormonal activity that can promote root initiation and early growth. That means that the medium should contain some composted material that has been thoroughly cured at temperatures below 40 °C. If that type of material is not available, a drench or two of a humate extract may be useful.

The medium should have a low level of biological activity, as an aid to pathogen suppression. However, such activity must be minimal, such that the nitrogen drawdown index should be 0.7 to 0.8. Heavier drawdown will interfere with early root growth.

SEEDLING MIXES

Physical Properties. Seedlings are typically germinated in/on media contained in plugs, cells, or trays that are much shallower than pots. Shallowness means that the saturated zone at the bottom of the container can extend to the surface if the particle size of the medium is not carefully controlled. Increasing average particle size is the usual way of reducing the height of the saturated zone (by increasing AFP). Such an increase is opposed by the need to maintain good contact between water and small seeds at the medium surface.

Success in this balancing act calls for very close control over the spread of particle sizes in the medium. It is not good enough to specify, for example, composted bark of "minus 6 mm grading." Such a specification says nothing about the proportions of particles of different sizes below 6 mm. Thus a high proportion of 5–6 mm particles will give a medium with large enough holes that seeds fall down them and/or soon lose contact with water. Conversely, a high proportion of particles in the 0–3 mm range could produce a medium that remains saturated and oxygen-less most of the time. It is critically important that your supplier can guarantee consistency in particle size distribution from batch to batch, and can easily change this distribution to suit seasonal conditions.

Other important physical properties include an absence of slivers (as of wood) and long fibres (as from coir fibre dust) and a moisture content that allows good flowability into cells.

Chemical Properties. Seedlings being produced in plugs will receive their nutrients via fertigation. The contribution of the medium is via appropriate pH, usually around 5.8. Media for seedlings being produced in cells and trays can have a low rate of CRF, or a basal inclusion of a slow-release fertiliser.

Two precautions must be noted.

1) First, it is essential that the medium have a low ammonium concentration. Some seedlings are damaged when the ammonium-N concentration in a 1 : 1.5, v/v extract of the medium has as little as 10 $mg \cdot L^{-1}$. Such low levels are achieved through use of thoroughly cured composted organics, use of peat and perlite, minimal fertiliser addition, and/or the inclusion of zeolite in the mixture.

2) The second precaution relates to phosphorus. A normal result of the supply of ample phosphorus in the presence of adequate nitrogen is stretching that might or might not be limited through the use of growth retardants. The simplest way of controlling stretching in seedlings is to supply sufficient nitrogen, but have phosphorus supply such that the plants are slightly deficient in phosphorus. The P/N concentration ratio in the fertiliser used needs to be no higher than 0.07, as for example from a 13N-0.9P-11K fertiliser.

FURTHER READING

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Brachychiton Breeding: A Propagator's Journey©

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BACKGROUND

I started collecting *Brachychiton* in the early to mid 1990s. I had seen flowering *Brachychiton bidwillii* Hook. while at university and had grown several from seed while working at nurseries in Cairns, Queensland. A mate, Anton Van der Schans, is a plant collector and landscape architect who collected several species off Cape York on various trips including *B. garrawayae* (Bailey) Guymer, *B. velutinosus* Kostermans, and *B. grandiflorus* Guymer. These flowered and grafted readily. Grafted *B. velutinosus* were planted into landscapes and flowered and performed well. The spectacular and regular flowering of the tropical species inspired me to start a breeding program. I knew *B. bidwillii* was a precocious, prolific, regular flowerer with a compact habit which would make it ideal as a parent to reduce the size of the tropical tree species. Prior to this I had only bred *Grevillea* spp. In the mid 1990s I started to develop the pollination protocols to reliably produce hybrid brachychitons.

Since that time I have added the following:

Species:

- *Brachychiton acerifolius* (Cunn ex G. Don) Macarthur
- *B. albidus* Guymer
- *B. australis* (Schott & Endl.) A. Terrace
- *B. chillagoensis* Guymer
- *B. discolor* F. Muell.
- *B. populneus* subsp. *populneus* (Schott & Endl.) R. Br.
- *B. rupestris* (Mitchell ex Lindley) Schumann (broad leaf form)
- *B.* sp. (Blackwall Range)

Hybrids:

- *B.* ×*roseus* Guymer nothosubsp. *roseus*, hybrida nova,
- *B.* ×*excellens* Guymer, hybrida nova of which there are four selections
- *B.* ×*vinicolor* Guymer, hybrida nova
- *B.* ×*carneus* Guymer hybrida nova

Two Unnamed Hybrids:

- *B. chillagoensis* × *B australis* and *B. acerifolius* × *B. rupestris.*
  Both of these hybrids contain "bottle tree" parents so are extremely useful in decreasing the time to produce multiple parent hybrids containing these traits.

GENUS BRACHYCHITON

There are five separate sections within *Brachychiton* (Guymer, 1988) and these groups show differing characteristics such as growth habit, flower colour, shape, and the presence or absence of trichomes on leaves and other organs.

These sections are: Oxystele, Poecilodermis, Delabechea, Trichosiphon, and Brachychiton. (Guymer, 1988)

Within the genus there are 31 described species and numerous collections that are likely new species as well as collections waiting to be named. It is likely that the genus may actually contain 40 or more species.

There is some contention whether the genus belongs to Sterculiacea or Malvaceae I see many similarities with Malvaceae after dealing with the genus for as long as I have.

Opportunities. Generation time for *Brachychiton* breeding is 3–4 years and as such the program is always in lag as to what is available to commercialise and also what can be used to continue the breeding program.

The advantage is that most people see generation times for trees being too long to bother with, so there is ample opportunity to breed this and many other tree genera as not much work has been done to date.

General. This genus contains many familiar species that are important ornamental and agricultural trees. *Brachychiton populneus* (kurrajong) is used as an important fodder species during droughts, providing valuable feed for livestock and has been extensively planted for this purpose (Guymer, 1988).

Kurrajong is also used extensively for street tree plantings in more temperate climates and performs excellently in southern Australia. Specimens can be seen around Canberra in both planted and natural situations where during winter they stay green and lush while even *Eucalyptus* spp. and *Acacia* spp. appear to suffer from the cold.

The other more popular species are ornamental trees such as the illawarra flame tree, *B. acerifolius*; Queensland lace-bark, *B. Discolour;* and the Queensland bottle tree, *B. rupestris*. The latter has a spectacular bottle-shaped trunk that can grow to several metres in diameter (Guymer, 1988).

Breeding. Flowers are functionally unisexual by abortion [(Schott and Endlicher, 1832) in Guymer, 1988].

Flowers generally are open for 2 days falling on the 3rd day, though several species observed have flowers that only open for a day before abscising.

Masses of flowers of either sex occur in flushes but typically there are large numbers of male flowers and many fewer female flowers. *Brachychiton garawayae* (Bailey) Guymer is an exception in that the clone I have produces female flowers prolifically and it is possible to kill plants by setting too many flowers.

The number of hybrids to produce to express variability increases considerably once multiple parents are introduced where recombination of traits becomes unpredictable.

Parent Selection. *Brachychiton populneus* subsp. *populneus* and *B. australis*. A. Terrace were used in the 2009 season to produce about a 1,000 hybrids from a range of interspecific crosses *B. bidwillii* and *B. discolour* and the hybrid cross of *B velutinosa* × *B. bidwillii,* and *B.* ×*carneus* and *B.* ×*carneus* × *B. bidwillii*. The resultant seedlings look interesting with some unusual leaf expression in the juvenile phase that will likely be totally different in adult foliage but may indicate re-combinations. *Brachychiton populneus* subsp. *populneus* also has an extremely useful trait in that trimmed branches will abscise back to a branch collar leaving a clean and tidy wound. This is useful as it will allow trees that are trimmed to drop stubs and leave uniform and tidy branches and trunks after pruning activities.

The species that I have used to date for breeding are *B. bidwillii*, *B. garrawayae*, *B. grandiflorus*, *B. velutinosus*, *B. discolor, B. australis, B. acerifolius*, *B.* sp. Blackwall Range, and the natural hybrids *B* . ×*carneus* (*B. garrawayae* × *B. grandiflorus*), and *B.* ×*roseus* (*B. acerifolius* × *B. populneus* subsp. *populneus).*

This season I have also incorporated *B. acerifolius* a species I have stayed away from so far as it tends to lack regular flowering and is a large tree. However now I have a number of other hybrid streams in production I can invest in breeding species that likely have a longer juvenile period. However the juvenility may be influenced by putting such seedlings onto smaller rootstocks or dwarf interstocks that may influence flowering time and reliability by reducing vegetative vigour.

Once complex hybrids are flowered and assessed these will be further bred on to introduce "bottle tree" traits into a range of hybrids.

Assessment of Hybrids. Hybrids are assessed according to unique traits and suitability for certain purposes and climates. The inter-specific hybrids between *B. bidwillii* and *B. velutinosus* demonstrate this in that the hybrids may look identical but vary in the degree of frost hardiness. Where one does not suffer another may frost back and loose 2–300 mm of the previous season's growth. Knowing what traits to assess for and where to do it is critical in developing and releasing new unique selections.

Development of multiple parent hybrids (complex hybrids) that have five parents in the previous two generations show massive variation in the traits expressed by the progeny. Some show recombination of a variety of parents' traits to express new visual effects while others surprisingly show traits similar to one of the original species parents.

The next step is induce ploidal mutation to produce tetraploids and triploids of a range of the better selections.

Once assessed and trialled, suitable hybrids will be protected using Plant Breeders Rights to guarantee the security of the investment in this long-term breeding program.

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Vegetative Propagation of *Quercus robur*©[1]

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BACKGROUND

In Australia since the mid 1990s there has been a rapidly developing French black truffle growing industry. Truffles are the fruiting body of a mycorrhizal fungus that lives in a symbiotic relationship with the roots of oak trees (*Quercus*).

About the Propagator. Nathan Carter is the director of Trufficulture Pty Ltd. Trufficulture is a family business operating in Gembrook, Victoria. The primary business for the company is propagating oak seedlings and inoculating these with the French black truffle. Infection usually takes 12 to 18 months and after this the trees are ready for planting out.

Truffle Industry Issues. Many truffieres (truffle farms) are experiencing low and variable yields of truffles. According to a Rural Industries Research and Development Corporation (RIRDC) report titled "Taking Stock of the Australian Truffle Industry" (2008) only a small percentage of trees in truffières have yielded truffles to date. There is much conjecture and theories surrounding the reasons for this. One school of thought is that all *Quercus* trees are propagated by seed and therefore quite a lot of seed variability is seen in tree shapes and sizes. If *Quercus* could be vegetatively propagated this removes the factor of genetic variability. The industry may benefit from *Quercus* being vegetatively cloned from truffle-producing trees. However, *Quercus* are particularly difficult to propagate by conventional cuttings. Also micropropagation techniques have not been successfully developed. See the following link to "Taking Stock of the Australian Truffle Industry" <https://rirdc.infoservices.com.au/items/08-124>.

Aim of This Study and Trial Work. To develop and evaluate a method for vegetatively propagating *Q. robur*.

RESEARCH

In *Quercus* the production of naturally occurring plant hormones (auxins) may be suppressed. This may result in the plants inability to produce roots on cuttings.

Previous methods of propagating *Quercus* have been described using a method known as "etiolation." The following link was used as background information for this research <www.hort.cornell.edu/uhi/research/articles/IntPlantProp(57).pdf>.

This process involves growing plants under reduced light. The shoots grow with little/no production of chlorophyll and are therefore blanched and elongated. Light is then gradually increased and chlorophyll develops and the cutting becomes green. In theory rooted cuttings are produced.

TRIAL

The trial was conducted at Blue Frog Truffle Farm in Sutton, New South Wales, in September 2010 through to January 2011. The proprietor of Blue Frog, Wayne Haslam, is the immediate Past President of the Australian Truffle Growers Association. Wayne provided a 7-year-old *Q. robur* (English oak) for the trial work. The

[1]Editor's Note: This paper was selected by the Australian Region as the Rod Tallis Memorial Youth Award.

tree has produced truffles but was damaged and consequently was growing at an obtuse angle and was in need of major tree surgery.

The trial needed to be conducted in the field where the tree was growing. Therefore without the support of greenhouse facilities (no controlled environment conditions), a field process and equipment needed to be devised.

METHOD

1) The *Q. robur* was coppiced (cut down to ground level) in June 2010. Several new buds developed at the base of the stump.
2) In August 2010 the stump was covered with a 250-L drum. The drum was prepared by cutting off the lid on one end and cutting a 25 × 25-cm square flap in the other end. The flap was closed off allowing only a 3-mm diameter gap for light to enter (Figs. 1 and 2).
3) A shade cover was fitted over the drum to provide protection from sun. Also the drum was secured with three stakes and wire mesh to prevent blowing over in the wind. The developing shoots became blanched and elongated in the presence of 99% darkness (Figs. 3 and 4).
4) Preparation of the cuttings:
   - When the shoots reached an average height of 200 mm the drum was removed to allow the fitting of a pot and propagating medium. (Fig. 5)
   - Next the base of the shoots was painted with IBA root promoting hormone (3,000 ppm gel).
   - A 200-mm plastic pot with the base cut off was placed over the shoots.
   - Propagation medium consisting of perlite, sharp sand, and peat moss (2 : 5 : 3, by vol.) was moistened and placed in the pot around the base of the shoots. The medium was watered in.
   - Then the 250-L drum was reinstated with shade cover and secured with wire mesh and stakes. (Figs. 6 and 7)

Figure 1. The 250-L drum with the base cut out.

Figure 2. The flap cut from the top of the drum to adjust the amount of light entered.


Figures 3 and 4. Etiolated shoots (blanched) after 4 weeks of darkness under the drum. The photos were taken at night so as to not allow sunlight to reverse the process.

Figure 5. The pot (base removed) with propagation media around the shoots.

- The hole on top of the drum was adjusted to 3-mm diameter. Each day the opening was increased slightly to allow more light to enter over the next two weeks, until fully opened.
- Once a week the drum was removed to allow the propagating media to be rewatered.

5) In January 2011 the pot and media were removed to allow the cuttings to be inspected for root development. There was good evidence of root tip development and some cuttings were removed from the mother plant with secateurs and placed in water to remain hydrated (Figs. 8, 9, 10, 11, 12, 13, and 14). These cutting were potted into 75-mm tree tubes and moved to a greenhouse for root development and further growing on.


Figures 6 and 7. With the drum removed the shoots have returned to healthy photosynthesis and are protected by wire mesh against animals. Also a shade cover was used for sun protection on the soft shoots.

RESULTS AND CONCLUSION

The trial resulted in the successful propagation of *Quercus* cuttings (Figs. 15 and 16). These will later be inoculated with the French black truffle. It is possible that from one mother tree about 20 cuttings could be produced per annum.

Whilst the numbers are small and would be commercially unviable, this will allow genetically identical material to be developed for further trial work.

An improvement on this method to be included in future trials is the use of banding the base of the shoots. As the diameter of the stem increases the cambium layer (phloem) is restricted and hormone is accumulated and prevented from entering the mother plant. This will result in an independent cutting with a stronger root system.

Also in future these cuttings can be pot grown and propagated more conveniently in a greenhouse using the etiolation method.

LITERATURE CITED

Haslam, W. Australian Truffle Growers Association. <http://www.trufflegrowers.com.au/>.


Figures 8 and 9. The pot raised and the developing roots exposed.


Figures 10 and 11. Nathan reapplying the IBA gel hormone by painting the base of the shoots.


Figures 12 and 13. The developing roots on the shoots.

Figure 14. Two rooted cuttings removed from the parent plant.

Figure 15. One of the cuttings with healthy roots after growing on for 8 weeks.

Figure 16. Nathan Carter in the greenhouse at Trufficulture, with one of his prized clones.

Water Management in Propagation©

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For many plant nurseries, water restrictions are impacting both our landscape customers and also production. Limited access to high quality water has been exacerbated by population growth and climate change, in some cases leading to bankruptcy for growers and retailers who cannot compete for access with other water users. Regulations increasingly require growers to retain and re-use nutrients, pesticides, and stormwater rather than allowing contaminants to run off into the environment.

All of these pressures mean that growers should consider how to conserve water by only applying irrigation as needed by the crop. This article provides some rules of thumb to know if you may be over-applying water in propagation. Efficient watering during propagation involves both management and technology such as climate-controlled mist timing, but we will concentrate here just on monitoring steps that cost very little.

MEASURE AND CONTROL LEACHING

Minimizing leaching (the washing of irrigation water through the growing substrate) combined with adequate fertilization has several benefits. Root growth is inhibited when water is overapplied. A water-logged growing medium encourages pathogens such as *Pythium*, leads to reduced nutrient uptake because roots need air to grow and actively take up nutrients, and pre-plant soil-incorporated nutrients are rapidly leached out. There are environmental benefits from minimizing leaching because excess water either needs to be treated before recycling, or leaves the greenhouse as runoff. Fertilization is needed to ensure healthy plant growth, but over-application can result in greater top growth, requiring more growth regulator chemicals to produce compact plants. By applying only the water and nutrients that plants need, irrigation and fertilizer costs are reduced.

Growers vary widely in how efficiently they use water during propagation. One simple method is to place a water-tight tray underneath the propagation trays, and collect the leachate that runs through the tray. Using this method, the University of Florida (UF) quantified leaching of irrigation water and nutrients during a 4-week propagation cycle with *Petunia* and *Calibrachoa* cuttings in eight commercial propagation greenhouses in the U.S.A. Leachate was collected by placing a collection tray under propagation trays under mist, boom, or hand watering. The liters leached per 25 × 50 cm tray ranged from 0.6 L to 6.0 L, which represented up to 461 m^3 of water per hectare over the 4 week cycle. That is the equivalent of a large swimming pool!

A guideline for water-soluble or granular fertilizer is that once a complete soil volume of water (or about 2 L depending on the tray) is leached through, any pre-plant fertilizer charge has been leached out. Controlled-release (coated) fertilizers are more resistant to leaching, but hard to evenly distribute between small cells in a tray. That means that U.S.A. propagators typically either: (A) do not use a pre-

plant charge because it will be leached away, (B) ensure they leach less than one soil volume during misting, and/or (C) apply an irrigation with water soluble fertilizer (usually around 200 ppm of nitrogen from a complete fertilizer) as soon as plants are off mist and roots can take up nutrients.

You Will Need:

- A tray that fits beneath your propagation tray (we usually use a Rubbermaid™ cutlery tray). This is the "leachate collector."
- 1-cm-wide water-resistant tape or stickers.

Steps:

1) Select five propagation trays in the greenhouse. Choose trays at different spots in the greenhouse to check both volume and variability between trays.
2) If the tray has vent holes on the top of the propagation tray between cells, cover these holes with the tape or stickers so that water won't drip through the top of the tray. It is easier to tape those holes before planting (Fig. 1).
3) Place a leachate collector beneath each propagation tray. The bottom of the cells in the propagation tray should be at least 1-inch above the leachate collector so that the cells will not be sitting in water by the end of the week (Fig. 2).
4) Leave trays in the greenhouse for 1 week and irrigate normally under mist, boom, or hand watering.
5) After 1 week measure the amount of solution in each leachate collector (Fig. 3).

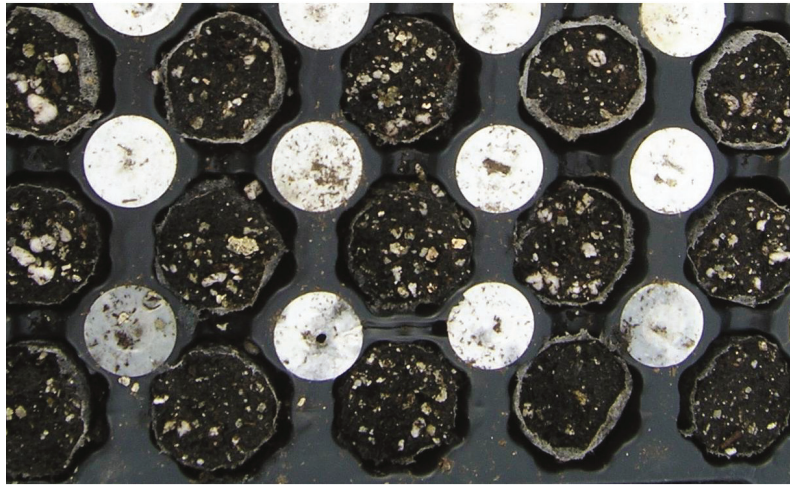

Figure 1. Propagation tray with taped ventilation holes.

6) Check electrical conductivity (EC) of the leachate. Low EC (near the EC of your water source) indicates that most nutrients are leached from the growing medium. Also use a plug squeeze test to check EC in the growing medium.
7) Run this protocol over several weeks, to track water and nutrient trends as the crop ages.

Calculate Leaching Volume per Propagation Tray.

- If the leachate collector is smaller than the propagation tray (Fig. 4), multiply the collected volume by the area of the propagation tray and divide by the area of the leachate collector) to calculate the volume per propagation tray.
- For example, let's say the propagation tray is 25 × 50 cm = 1,250 cm^2, the leachate collector is 20 × 40 cm (800 cm^2), and you collect 1.2 L over 1 week in the leachate collector. The leachate volume per propagation tray would be 1.2 × (1,250/800) = 1.9 L per tray.

If You Have High Leaching Rates (2 L or More per Propagation Tray over 4 Weeks):

- Check both irrigation frequency and duration.
- Check boom or mist nozzles are providing even coverage. Are you watering everything heavily to avoid wilting in a few dry spots? The more uneven your mist system, the more you will have to leach. Set up collection trays or cups over the benches, and run the mist for up to 5 min (Fig. 5). Check volumes in the collection trays. Identify the driest spots and consider changing the number, height, or type of emitters.
- Train staff to water evenly and moderately.
- Evaluate fog or other ways to increase humidity; or shade to reduce light so that water application can be reduced.
- Ensure adequate nutrients are being applied, based on plant appearance (pale leaves often indicate deficiency) and tissue nutrient levels.

Figure 2. Propagation tray sitting above the leachate collector.

Figure 3. Solution in leachate collector after 1 week.

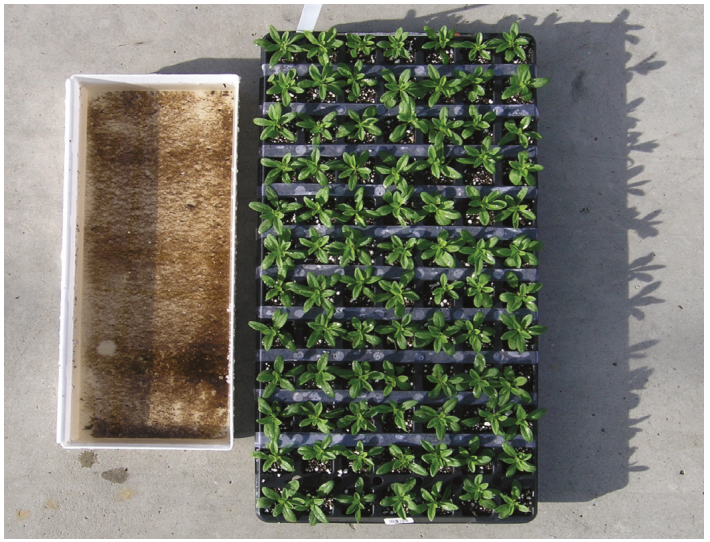

Figure 4. A leachate collector smaller than the propagation tray.

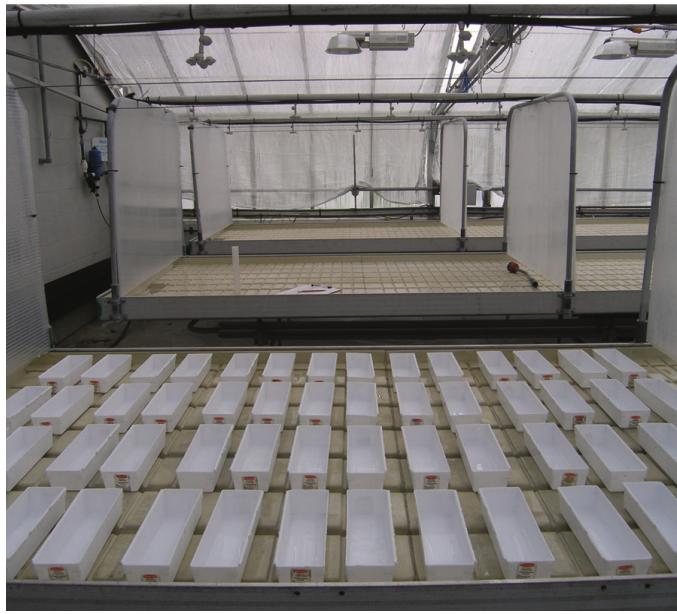

Figure 5. Collection trays set up to check for even mist nozzle coverage.

NIGHT MISTING

The goal during misting at night is to keep plants hydrated, without having excess free water that encourages disease. Hopefully your mist timer allows separate settings for day and night mist schedules, or you have an artificial leaf or similar to adjust mist timing. If you have just a simple clock with one setting, you either have to adjust the timer at morning or night, or you will overwater at night. A simple approach to know whether night misting is about right is to check first thing in the morning.

- Are plants hydrated? (If not, increase mist frequency.)
- Does the plastic on the tray or media surface have pools of water? (If so, there is too much water.)
- If you lift up the tray (Fig. 6) can you see clearly defined drips of water under each hole in the tray (about right), or is there a large puddle (too much water).

WHEN AND HOW MUCH TO WATER

There is no more important growing decision than when to water, and how much water to apply. Some people are "wet growers" and others are "dry." It can be helpful to use a common language when discussing moisture level in propagation, to have the consistent watering practices needed for uniform germination or rooting. This is especially true in larger operations with multiple growers.

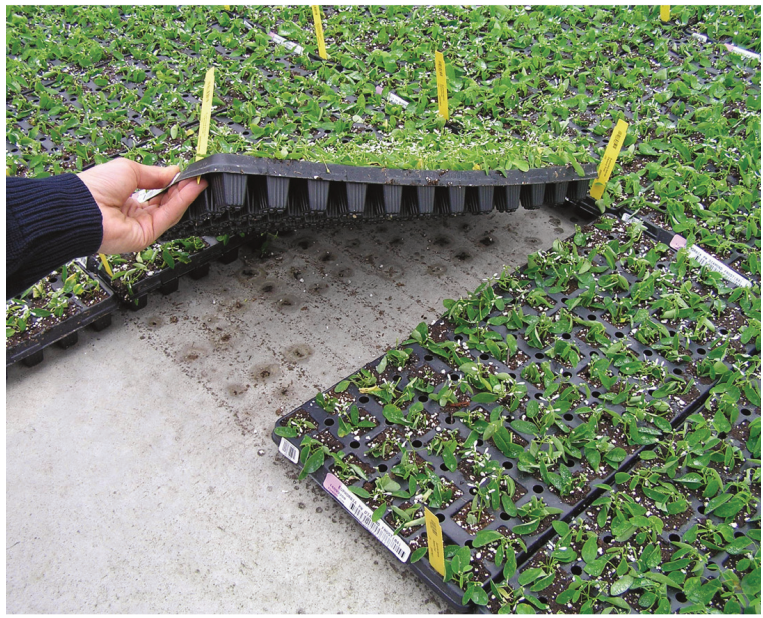

Figure 6. A check for correct hydration after night misting.

Ball Horticulture (Healy, 2008) has developed a moisture index for growing substrate (Table 1). A copy of the article is available for free at: <http://www.ofa.org/pdf/bulletins/08_marchapril.pdf>, with guidelines for different crops. Large-scale propagators train their staff to ensure they can identify the five stages of moisture. For seed germination, crops can be grouped as to the ideal moisture level (for example W4 for pansy and W2 for verbena). Specific seedling plug crops are watered at each stage when they dry down to a specific moisture level (for example, W2) and enough water is applied to reach an optimum level (such as W4). In general, if your crop is consistently at W5 this indicates overwatering. This concept can also be applied to finished plant production.

CONCLUSION

Consider whether your operation could improve watering practices with any of the simple concepts presented here. An old grower saying is that the person holding the hose controls your wallet. Don't just tell untrained new employees to "go out and water." Train them to water to plant needs, and you will see increased rooting success and less waste. Making efforts towards minimizing leaching in our own operations also shows we are doing our part in being a truly "green industry," before regulators enforce a change in grower practice.

Table 1. Growing media moisture levels used by Ball Horticulture (Healy, 2008) for improving irrigation decisions during propagation. (With thanks to Dr. Will Healy and Ball Tagawa, Colorado.)

Level	Class	Sight	Feel	Culture
W5	Saturated	Shiny black; standing water. Soaked	Very heavy; media feels soaked and dripping	No oxygen for roots; few seeds germinate; soak
W4	Wet	Dark brown; no standing water	Heavy; can squeeze out moisture when pressed	Maximum acceptable water level
W3	Medium	Brown	Average weight; media will feel moist; maybe squeeze out droplets	Optimum and transitional level
W2	Dry	Light brown	Light weight; no free moisture	Typically do not dry below level; wet / dry cycle develops roots
W1	Baked	Tan; media may pull away from cell sides	Very light weight; no moisture, almost dusty	Plants desiccate and die rapidly; only cactus survive at this level

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Everything You Wanted to Know About Fog: But Were Afraid to Ask©

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WHAT IS MIST?

Mist nozzles generally produce large droplets in excess of 200 µm from low pressure (20–100 psi / 2–7 bar) nozzles and provide irrigation and water to plants.

WHAT IS FOG?

Fog is defined as a water droplet around 10 micron (µm) in diameter (1/10th diameter of a human hair). High pressure water at 1,000 psi / 70 Bar is used to create the fog. Nozzle output is around 5 gph (U.S.A.) / 5 lph, this quantity of water is not intended to irrigate the crops below.

How to Create a 10-µm Droplet: take clean city water; filter it to 5 µm; boost the water pressure to 1,000 psi / 70 Bar; distribute through pressure tubes and pipes; filter water again at the nozzle; fractionate the water with an impeller and force the water through a 0.008-in. / 0.2-mm orifice. Billions of water droplets are created to flash evaporate in the air. Repeat this operation as often as necessary to achieve the result (cooling or humidification).

Some points to remember:

- Water only evaporates from the surface.
- 10-µm droplet has a large surface to volume ratio exposing maximum surface to surrounding air.
- Water changes from a liquid to a gas.
- Extracts latent heat from the air as it changes.
- Water vapour is added to the air changing the humidity ratio (kg H_2O per m^3 of air).
- Minerals are left behind in the air that can collect on the plant leaves. At this point reverse osmosis should be considered as a pretreatment.

What do plants want?

- Ideal humidity
- Ideal temperature
- Ideal sunlight
- Ideal soil
- Ideal water content
- Ideal fertilizer
- Ideal growing conditions

FOG SYSTEMS HELP TO CONTROL THE ENVIRONMENT AROUND THE PLANT

The objectives of a fog system are to:

- Create a "lace glove" around the emerging leaves.
- Reduce the transpiration from the leaves so that the growth energy is "redirected" to the root system.
- Create a high humidity environment that equalizes pressure in the rooting media, keeping the plant moist.

FOG SYSTEMS CAN DO THE FOLLOWING

Greenhouse Cooling. Depending on the temperate zone, greenhouses can be cooled up to 15 °C (or more) by using the adiabatic cooling process. This however requires a good air exchange and fan systems and IS less expensive to maintain.

Humidification Balance. Humidity levels in the greenhouse can be maintained up to 95% RH with no "rain" or dripping to damage plant leaves or flowers.

The system maintains a constant environmental level in the plant zone. There is minimal cooling as there are limited air exchanges in the greenhouse.

High humidity levels equalize the osmotic pressure between the leaf and the surrounding air. Plant transpiration is dramatically reduced and plant energy returns to the root zone. Balancing the humidity levels controls the growth of the plant and optimizes propagation conditions.

Humidity Control Is More Difficult to Achieve Than Temperature Control. The better and faster is the sensor, the better and faster is the control. Standard humidity sensors are good to a maximum 60%–75%. Rapid cycling can allow humidity levels to be maintained ±2%.

Making Use of Past, Current, and Future Climate Information Available From National Institute of Water and Atmospheric Research — An Overview®

Andrew Tait
National Climate Centre, NIWA, Private Bag 14901, Wellington 6241, New Zealand
Email: a.tait@niwa.co.nz

As it is with growing anything (including propagating plants), there are decisions being made by the grower at all times of the year which impact (hopefully positively) the health of the plants, their susceptibility to harmful elements, and their productivity. Many of these decisions are related to the weather and climate, and in some instances (for example frost protection measures) a decision can be of critical importance. Other decisions are more strategic, involving planning for next season or 1, 2, or even 20 years into the future.

Decision-making (or "good decision making" at least) is all about weighing up pros and cons based on the information you have at hand. If your information is poor, then the impact of your decision has a higher likelihood of being less than optimum (or even completely opposite to what you intended — e.g., the plant dies). If your information is good and useful, then your rational decision is likely to result in the effect you intended.

Climate data and information (when I use the term "climate information" I mean products derived from climatic data, e.g., expert analyses and interpretations, maps or line plots, etc.) are often used for decisions being made by growers — for example, estimating the likelihood of disease-causing weather in spring (e.g., blackspot or mildew). There are multiple levels and sources of climate data and information available from the National Climate Centre (NCC) at National Institute of Water and Atmospheric Research Ltd (NIWA) (much of which is either free or can be provided at a minimal cost). For example:

- Up-to-date meteorological data (including historical records) are available for free from NIWA for every climate station in New Zealand (go to <http://cliflo.niwa.co.nz>).
- Estimates of daily values of several climate variables for locations where there are no measurements (choose "Special Data Sets — Virtual Climate Station Data" from <http://cliflo.niwa.co.nz>).
- Line plots of the rainfall accumulation, soil moisture status, heat unit accumulation, and other variables for the growing season to date (and how this season compares to last year and the long-term average) for several locations around the country (available from <http://climate-explorer.niwa.co.nz> via subscription).
- Maps of the month-to-date and last-15-days rainfall, temperature, heat accumulation and soil moisture status, updated every day (available from <http://climate-explorer.niwa.co.nz> for free).
- Summaries of the climate of the previous month / season / year (go to <http://www.niwa.co.nz/our-science/climate/publications/all/cs>).

- Forecasts for the next 15 days of rainfall, air and earth temperature (see example below, as Fig. 1), wind, and solar radiation (available from <http://climate-explorer.niwa.co.nz> via subscription).
- Rainfall, temperature, soil moisture, and river flow outlooks for the coming 3 months for all of New Zealand (free at <http://www.niwa.co.nz/our-science/climate/publications/all/seasonal-climate-outlook>).
- Climate change projections for New Zealand for 50 and 100 years into the future (see <http://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/scenarios>).
- General information on New Zealand climate (go to <http://www.niwa.co.nz/our-science/climate/information-and-resources/clivar>).

At NIWA we believe knowledge is there to be shared, which is why we make as much information as we can publicly available. The National Climate Centre assists New Zealanders through the provision of climate information to understand our natural environment, to help prepare for exposure to climate risks, and to maximise use of the climate as a resource.

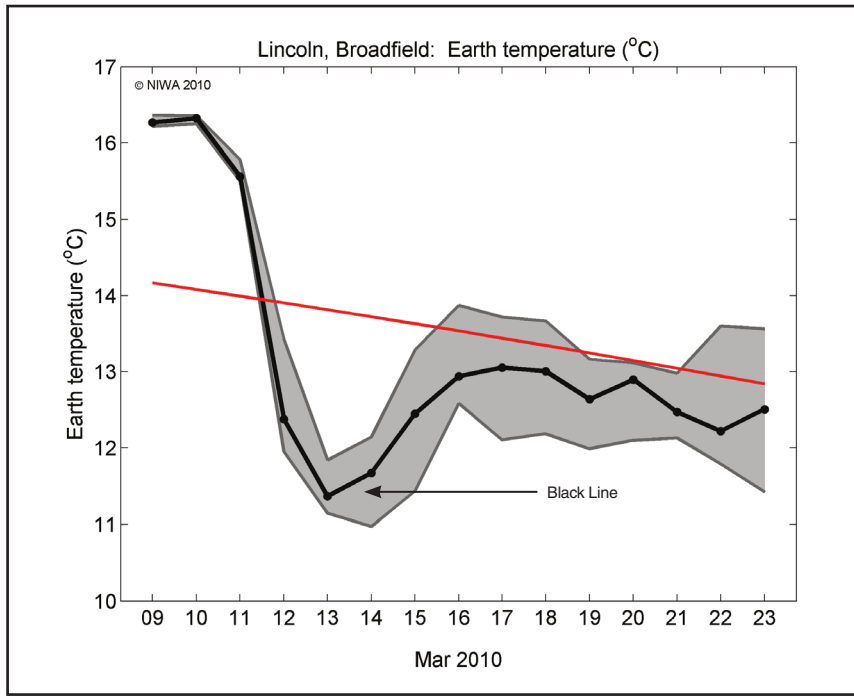

Figure 1. Forecast of 10-cm earth temperature at 9 AM on the date shown for Lincoln, Broadfield. The solid black line is the median forecast and the grey shading shows the interquartile range (25th to 75th percentile; i.e., an indication of the forecast uncertainty) from a set of 21 different forecasts for each day. The red line indicates the long-term average 10-cm earth temperature at 9 AM for the site and time of year.

Propagation of *Ilex aquifolium*©

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INTRODUCTION

The genus *Ilex* has more than 800 species, including both deciduous and evergreen (Galle, 1997); Huxley (2002) notes in the New Royal Horticultural Society Dictionary of Gardening that there are more than 400 species. My discussion is confined to the English holly and its allies, *I. aquifolium* and *I.* × *altaclerensis.* English holly (*I. aquifolium*) has many uses. The most obvious is as a colourful ornamental where the female forms have attractive, brilliant berries through winter. These are used by florists in their winter decorations and may last for many weeks. The English have a heritage for using these at Christmas time. The fruit in the garden is relished by wildlife, while most gardeners would like them left for their own enjoyment. Holly, when established, will tolerate even dry shade, thus making it an ideal choice for hedging and specimen planting.

PROPAGATION METHODS

Seed. Seed propagation is not normally practiced these days mainly because of the variability of plants produced. Many years pass before it is known which plants are male or female. In the cooler parts of New Zealand, where natural stratification of seed takes place, holly is gaining a bad name for its weed potential. In the warmer parts, holly is still an appreciated ornamental. In some areas where a security hedge is desired, male plants are requested and one cultivar called 'Mr. Hedge' fills this specification.

Cuttings. Clonal production is the normal method of propagation of the many selected and named cultivars of the English holly. Cuttings should be selected from current season's growth from the shaded side of the stock plant. The stock plant should be young, juvenile, healthy, and typical of the cultivar desired. We have found late summer to early autumn as the best time as the soft new growth is firming. We leave the top three leaves intact (but may reduce the size of the lower leaf) and then cut to 8 cm (3 in.) long. The bottom of the stem is side wounded for 1.5–2 cm ($^3/_4$ in.). This stimulates callous growth and then rooting. I also believe more rooting hormone is absorbed by these cuts. We use the powder type, the modern equivalent of Seradix 3 (0.8% IBA in talc). The medium used consists of coarse peat and crushed sand (2–6.5 mm) (2 : 2, v/v). If it were cheap enough we would use pumice instead of sand. The media is carefully placed in trays so as not to compress it. On top of this a thin mulch of sand is placed, 5–10 mm deep. The purpose of this is to have an inert surface to discourage sciarid flies and fungal problems. The cuttings are inserted one-half to two-thirds their length, which is usually to the axil of the lower leaf, and spaced as close as possible without leaves overlapping.

The trays are placed in a glass propagation house lined with plastic for heat and humidity retention. The benches have hot water heating to maintain a bottom heat temperature of 17–18 °C and mist nozzles to provide a continuous film

of water on their leaves when first inserted. As the weeks go by and callusing on the base of the cuttings is evident, we reduce the misting as soon as we can as this reduces fungal problems.

FINAL OBSERVATIONS

Now I come to the main reason for delivering this paper. I find it quite difficult to insert all our cuttings that we would like in the late summer and find there are still some left to do in early winter. During this time some plants, notably *Ilex,* object to being placed in a propagator late in the season and I believe it is mainly the temperature differential from the outside coolness to the inside warmth that causes stress and the severe leaf drop. I have also observed this phenomenon on other evergreens, such as *Pittosporum*, *Camellia*, *Pseudowintera,* and *Rhododendron*. To overcome this we have reduced the temperature of the propagation houses and used cool tunnels in our larger unheated greenhouses. This has alleviated the problem on the late propagation dates and has not reduced rooting percentage but has increased rooting time until the natural warm-up of spring.

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Mollis Azaleas, a Window of Opportunity©

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INTRODUCTION

The azalea mollis group of deciduous *Rhododendron* hybrids have generally been derived from several species, and were introduced into cultivation as follows:

- *Rhododendron molle* subsp. *japonicum* from Japan in 1861
- *Rhododendron luteum* from Eastern Europe and Asia Minor in 1793
- *Rhododendron molle* from China in 1824
- *Rhododendron occidentale* from North America in 1851
- *Rhododendron flammeum* (syn. *R. speciosum*) from North America in 1789

From Belgium and Holland the Ghent and Rustica forms were hybridised with single and hose-in-hose forms. English nurserymen produced the Exbury and Knap Hill hybrids. All these forms have been hybridised and re-crossed in Western Europe and England with many beautiful hybrids being produced.

At about the same time as the Exbury hybrids appeared, Edgar Stead of Ilam (in Christchurch, New Zealand) developed the Ilam strain by crossing the almost sterile Ghent 'Coccineum Speciosum' and 'Unique' with large flowered English mollis types. His strain was a larger flowered Ghent type with wide flaring florets in larger rounded trusses, some with nicely frilled petal margins.

Dr. Yeates of Palmerston North carried on this work and his Melford strain is the one with which I am most familiar. He selected and named two dozen or so of his best hybrids which all have big trusses of intense colours, with the individual blooms large, flared, and frilled. The hybrids which Duncan and Davies grew included those shown in Table 1.

Denis Hughes of Blue Mountain Nurseries has continued hybridising this general group of deciduous azaleas, expanding the scope with some excellent new forms, doubles and pastel selections.

The propagation of the azalea mollis group in the first half of the 1900s was from labour intensive layering, or grafting onto *R. luteum* seedlings which were prone to suckering beneath the graft and thus unsatisfactory. Many were grown from seed but only a few selfed forms came true to type. However with the advent of intermittent mist propagation methods, production from cuttings became a possibility. Root-inducing hormone treatment of vegetative soft to semi-ripe cuttings enabled selected named clones to be produced viably on a commercial scale. In more recent years tissue culture methods have enabled these deciduous *Rhododendron* hybrids to be produced commercially in large volumes. However my paper is aimed at the average small family nursery where modest propagation facilities and production of a wide range of products in quantities more in keeping with our smallish ornamental nursery market here in New Zealand.

At Duncan and Davies, softwood to semi-ripe cutting production of Dr. Yeates' Melford strain under an intermittent misting system began in the early 1970s and was a successful commercial production method. Numerous production trials were

Table 1. Melford strain hybrids bred by Dr. Yeates and grown by Duncan and Davies.

Hybrid	Description
'Carmen'	Pale salmon yellow with golden flare. Early flowering.
'Chartreuse'	Pale yellow with soft orange flare, buds lime green. Late.
'Jasper'	Pure vermillion red. Frilled, mid season.
'Ilam Louie Williams'	Delicate soft pink suffused cream. Large heads, frilled florets. Compact growth habit. Mid season.
'Martie'	Dusky red, frilled. Late.
'Melford Flame'	Fiery orange, frilled. Large compact head. Mid season.
'Melford Gold'	Golden orange overlaid with bronze. Mid season.
'Ilam Melford Lemon'	Glowing saffron yellow, apricot flare. Large florets. Mid season.
'Melford Red'	Rich orange red. Early to mid-season.
'Melford Salmon'	Bright salmon, orange flare, large frilled florets. Compact habit. Mid season.
'Melford Yellow'	Clear lemon yellow, orange flare, frilled. Mid to late season.
'Ilam Ming'	Brilliant tangerine orange. Large florets. Early to mid season.
'Persian Rose'	Neyron rose, prominent orange flare, very frilled margins. Large compact heads. Mid season.
'Red Ball'	Intense mandarin red, frilled compact heads. Late.
'Red Frills'	Deep scarlet red, frilled. Compact heads. Early.
'Red Gem'	Clear, luminous red, large florets. Compact head. Early to mid season.
'Red Giant'	Intense blood red, frilled. Compact heads. Mid to late season.
'Yellow Beauty'	Vivid buttercup yellow, deeper flare. Florets and heads very large. Mid to late season
'Yellow Giant'	Vivid buttercup yellow, deeper flare, large florets. Mid season.

undertaken testing various timing of cutting taken with different rates of root inducing hormones — IBA and NAA tested on semi-ripe vigorous vegetative young shoots. Results achieved indicated that by carefully monitoring shoot growth and timing of cutting collection, good commercial rooting percentages could consistently be achieved with various selected clones.

The window of opportunity offered by these deciduous azalea mollis hybrids is largely one of recognition of the vital right physiological state of the vigorously growing shoots and the correct timing of the cutting collection. This is the key. Collected too soft and the cuttings will rot at the base. Collected too firm and they do not give a viable rooting percentage. George Smith, our mentor and master propa-

gator at Duncan and Davies, taught us to recognise the crucial time, just when the outer whorl of leaves on the new shoots reach mature size and showed a firming blush. The time each year can vary depending on seasonal variances, usually from early to mid-November to about the end of the month in New Plymouth.

Mother stock has to be in a healthy, vigorous, vegetative state; well maintained and fertilised, hedged, and winter pruned to give strong, vital cuttings. But better still, the crop-grown young plants with youthful vitality give the highest percentage cutting strikes. The cuttings collected early in the cooler part of the day are held until processed in a dark, cool room at around 10 °C, but cuttings should be made and stuck as soon as possible.

Cutting making at Duncan and Davies was done with stainless steel surgical scissors, one blade file sharpened to a knife edge. This enabled cutting makers with no skills or experience with sharp knives to confidently make cuttings at a fast rate. The approximate 10–12 cm long cuttings with soft tips left in, base wounded on one side with a slicing motion, just exposing approximately 15 mm of cambium, making a larger contact area for the hormone powder's stimulation. Treatments used were talcum-powder-based IBA 0.8% or a 50/50 mixture of NAA 0.4% and IBA 0.8%. Cuttings are set in multipot plixi 54s in a medium of 50% good Cumberland peat and 50% cutting grade perlite which gave air-filled porosity of around 30%. Propagators will have their own media recipes which give them best results in their own varying facilities. Stuck cutting trays were placed in a poly tunnel intermittent misting house with bottom heat at 21 °C, lightly shaded, relatively bright natural light, misting controlled by a solar radiation calorie energy counter, solenoid sequencer system, with misting gradually reduced after the first 3 weeks. The azalea mollis-type cuttings take 8–10 weeks to root sufficiently for potting up.

The 8–10 weeks of rooting time from around mid-November makes potting up time around the end of January and into early February. Deciduous azalea mollis types are active, long-day-length plants, and as day lengths shorten they produce terminating overwintering buds, and quite quickly growth processes shut down. This can be detrimental to the establishment of the cuttings, hence the need for supplementary lighting. It is important to maintain daylight hours in a positive long-day-length regime. This enables potted up cuttings to continue to grow and develop a strong root system to utilise the nutrition in the potting medium to build an overwintering food store. Without supplementary lighting and extended day lengths the cuttings fail to establish strongly before becoming deciduous, and overwintering losses occur.

The window of opportunity for the deciduous azalea mollis types is a narrow one, but one that the "in tune" propagator can exploit for good financial reward. The many beautiful, easily grown, hardy hybrids produced by New Zealand breeders such as Edgar Stead, Dr. Yeates, and Denis Hughes, are all very desirable colourful ornamentals that have been poorly utilised by the garden industry in this country. In my view this is an opportunity waiting to be exploited.

Magnolia grandiflora Cutting Production©

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I am going to talk to you this afternoon on our experiences with cutting production of *Magnolia grandiflora* cultivars from stock plant management, cutting making, and care and potting on through to the saleable liner.

We produce mainly *M. grandiflora* 'D.D. Blanchard' and 'Little Gem', with smaller quantities of 'Ferruginea', 'Mainstreet', 'Russet', 'Saint Mary', and 'Samuel Sommer'. The success rate ranges from 55% for 'Russet' to 86% for 'Little Gem'.

Firstly I'll discuss stock plant care and maintenance. Before planting we do soil tests and add required fertilisers while ground preparation is being done. Black polythene mulch beds are formed and the young stockplants are planted out from 1-L pots for ease of handling. They are planted 1 m apart and 2 m between rows. This is fairly high density but it works well with our pruning methods.

Once they are established we work on a 3-year cycle for pruning to maintain their juvenility. Pruning is undertaken in late winter, when every third plant is cut back to a height of 60–80 cm. This leaves very little foliage on the plant, but after 4–6 weeks, depending on its age, young shoots appear on the stems. These shoots will grow up to 100 cm in a season. Minimal cutting material is produced on these plants that year, as most growths tend to be too thick and fleshy for good cutting material (Fig. 1).

In the second year, these growths are given a light prune to 120 cm and that year they produce good quality cuttings.

Figure 1. An example of hard pruning in the stockbed.

The third year the plants are pruned back to 120 cm high and 80 cm wide and this is the year when the maximum cuttings are produced.

This means that a third of the stockplants don't produce many cuttings, but the advantage is that they will overall produce good quality ones for many years. Our oldest *M. grandiflora* stockplants are around 10 years old and have many years left in them yet.

This also assists in keeping pest and diseases down as sprays penetrate better with smaller plants and cuttings are also easier and quicker to collect.

Evergreen *Magnolia* cultivars are relatively disease- and pest-free, with the main insect pests being brown scale and mealy bugs. To keep these under control we aim to oil spray the stockplants twice a year, once in early winter then a second in spring. The stock plants are also sprayed monthly with a general fungicide and insecticide spray during the growing season. In the propagation house spraying is done fortnightly and in the liner area monthly. The liners are also oil sprayed when the stockplants are sprayed.

Weed control is mainly achieved with Samurai™ (360 $g \cdot L^{-1}$ glyphosate), with Buster® (200 $g \cdot L^{-1}$ glufosinate-ammonium, Bayer CropScience) used when clover is present. If required, the pre-emergent herbicides Gesatop® 500FW (500 $g \cdot L^{-1}$ simazine, Syngenta Group Company), or Sharpshooter (500 $g \cdot L^{-1}$ oryzalin) are applied in spring and autumn. Hand weeding is done around the base of the plants every 2 months initially, reducing as the stockplants become established.

We take our cuttings once the current season's growth has matured and the growth tip terminated. This is usually in May for us in Taranaki, but does vary a little depending on the season and for different regions around New Zealand.

We make a 3-leaved tip cutting, reducing the leaf length to approximately 8 cm long to minimise transpiration and for ease of setting the cutting. The cuttings are 8–12 cm long with a calliper of 6–8 mm (Fig. 2). Thinner cuttings, although they will root tend to produce a weaker plant and cuttings larger than 10 mm tend not to produce roots as readily and are more difficult to set.

Where possible it is important to ensure that the tip of the cutting has a leaf bud and not a flower bud as this can produce a plant that needs staking to form a straight leader by training up a side shoot. However this can be sometimes difficult with *M.* 'Little Gem' as one of its attributes is that it flowers at a young age, so sometimes there is no option but to use cuttings with flower buds to attain numbers required.

Nodal cuttings are made and given a single wound 25 mm long and dipped in 5,000 ppm IBA. They are then set in a 54-plug tray in a mix consisting of graded bark, peat, and 2–4 mm pumice (5 : 3 : 2, by volume), pH adjusted, and 1.2 kg slow-release fertiliser added per 1,000 L.

They are then placed in the propagation house with under floor heating maintained at 18–20 °C, intermittent mist controlled by a light meter, and venting set around 22 °C.

They take around 16 weeks to root depending on cultivar. It is important to keep an eye on house conditions as too much humidity can cause *Botrytis* in the growing tips. These tips will then rot and the resulting plant will require staking to train up a new leader.

Hygiene is also important here, removing any leaf drop, fungus infections, and the like. We pick over our houses weekly to keep this to a minimum. The rooted cut-

Figure 2. A cutting showing the preferred leaf area, length, and calliper.

tings are potted into a mix consisting of bark and 2–4 mm pumice (4 : 1, v/v) with slow-release fertiliser at 4 kg•m^{-3} and pH adjusted. They are put in the crop cover to re-establish in their 12.5-cm pot and remain there for 10–12 weeks when they are shifted to the outside area. Here they are grown on for a further 10–12 weeks then they are ready for sale as a 15- to 25-cm liner, depending on the variety.

Why use a 12.5-cm pot for growing on instead of a 7-cm tube, you may ask. We have found that the larger pot gives the roots and top space to develop producing a stockier plant with a better calliper than the smaller tube. I feel this more than offsets the extra freight costs involved with the larger pot.

In conclusion the main points for successful cutting production of *M. grandiflora* cultivars are:

- Keep stock plants juvenile.
- Take ripe cuttings, those too soft tend to rot.
- Maintain good hygiene.

Techniques to Modify Plant Form for Ornamental Crops©

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INTRODUCTION

Growers and exporters tell us that to compete in domestic and export markets, we must deliver high-value product into niche markets. To achieve this, within my experience, I interpret this to mean each of us needs to focus on five key components, i.e., delivering plant products that are:

1) Novel and innovative: To me this highlights the ongoing need for breeding of new crops and selections.
2) Of a suitable quality: This refers to the product meeting the market specifications for height, colour, size, form, post-harvest performance, etc.
3) "Clean": For example, free of known viruses and free of pests and disease.
4) On time for particular market windows such as Christmas, Mother's Day, etc.
5) Targeting a solid market: This requires good market knowledge and contacts.

This is a long list of topics to deal with. In this presentation I have chosen to focus upon just one of these, "quality," focussing in particular on plant form. What do we mean by plant form? In this presentation I use the examples of both height and branching, or what we might refer to as visual "fullness" of plants.

As evident during the California Spring Trials in March/April 2011, plant form is a "hot" topic amongst breeders of ornamental plants. Examples included Syngenta Goldsmith Seeds' *Petunia* Ramblin™ Nu Blue petunia which, compared with *Petunia* Easy Wave™ Blue spreading petunia, is visibly more compact and floriferous. Similarly, Syngenta's *Antirrhinum majus* 'Arrow' (snapdragon cultivar) had clearly more well-developed and floriferous branches than a competitor's cultivar on display. PanAmerican Seed's *Impatiens* Impreza Series was being promoted as superior to its competitors by having more branches with a compact habit.

Throughout the preceding examples seen during the California Spring Trials, a repeating feature was the quality of the plant product being associated with "more branches." As growers, this therefore brings us to the obvious question as to what practical techniques can we use to achieve "more branches" in the plant products we grow?

Before exploring some techniques available, it's worth considering a little background information about branching in plants. We accept that plant growth regulators, which naturally occur in plants, effectively control the amount of branching that occurs (Shimizu-Sato et al., 2009). Auxins, one of the key groups of plant growth regulators involved, are produced within the apical buds and developing leaves of plants. Once produced, these auxins are transported downwards within the plant. At the same time, however, cytokinins are often produced by the plant in its roots, and are transported upwards. If we try and keep it simple, the net result

of this production and transport of both auxins and cytokinins is that whether or not a bud grows out to become a branch is the net result of the antagonistic effect of auxins and cytokinins (Shimizu-Sato et al., 2009). More specifically, if the amount of cytokinin increases and/or auxin decreases, the net result should be that more branching occurs.

SOME AVAILABLE TECHNIQUES

Pinching and Pruning. In terms of practical techniques growers can use to increase branching, the preceding background about plant growth regulators allows us to now understand what happens when we pinch or prune at the top of a stem. When we do this, we are effectively removing the site of production of auxins (McSteen and Leyser, 2005). With less auxins to be transported downwards towards axillary buds, the balance between auxins and cytokinins now tips in favour of the cytokinins, resulting in these buds growing into branches.

Plant Growth Regulators. Following the logic that the balance between auxins and cytokinins can offer possible techniques to trial, it is little wonder then that applying cytokinins to your plants is another technique that has commercial application (Jeffcoat, 1977). In our recent investigations with hybrid gentian (*Gentiana*) selections, we found that the cytokinin thiodiazuron (TDZ), applied as a 100 ppm drench to the growing medium, resulted in increased buds, i.e., branches, on the crown (Uttara Samarakoon, pers. commun., Massey University, New Zealand). In an herbaceous perennial-like gentian, having more branches formed increases the potential for more flowering stems.

While on the subject of plant growth regulators, it is appropriate to remember that they are also involved in height control in ornamental plants. Application of chemicals such as Paclobutrazol® [N-dimethylaminosuccinamic acid, α-tert-Butyl-β-(4-chlorobenzyl)-1H-1,2,4-triazole-1-ethanol; ICI Chemicals] influences the content of plant growth regulators, and when applied as a drench to growing medium of *Zantedeschia*, total plant height can be reduced to give plants suitable for sale as potted flowering plants (Reiser and Langhans, 1993). In investigations carried out at New Zealand's Nursery Research Centre, depending on the height reduction of *Zantedeschia* plants desired, rather than drenching the growing medium, tubers could be soaked in Paclobutrazol® prior to planting, at concentrations ranging between 80 and 160 ppm, for a duration of either 24 or 48 h (MacKay et al., 1986).

Breeding. As evident from my earlier comments about the new and improved cultivars of petunia, snapdragon, and impatiens seen during the California Spring Trials, breeding is also a practical technique to improve product quality via modifying plant form. While our experience with ornamental crops has been that you need to be prepared to wait for 10–15 years before new cultivars are a commercial reality, the genetic diversity among different species available to us makes it worthy of consideration. With modern breeding techniques such as embryo rescue available, undertaking extremely wide crosses can now be given serious consideration. A case in point here has been the successful crosses between *Sandersonia* × *Gloriosa* (Burge et al., 2008) and *Sandersonia* × *Littonia* (Morgan et al., 2001) which have resulted

in a range of novel genetic combinations with a diverse array of plant forms. These forms vary between those with short stems and clusters of flowers at the top, i.e., suited for marketing as potted plants, to those which are taller with flowers along their length, suited for cut flowers.

A breeding programme targeting new gentian cultivars for the cut flower market has led to a wide diversity in plant forms. As demand for potted plants has also increased, our initial strategy has been to use the same gentian cultivars for both cut flower and potted plants. To date, however, this strategy has not achieved commercially viable results as the natural plant form does not lend itself for both purposes. As an alternative, greater success has recently been achieved using some of the genetic diversity elsewhere within the Plant & Food Research breeding programme, with plants that naturally have shorter stems and greater branching.

Propagule Source. As part of our strategy to reconsider the diversity of different gentians from our breeding programme, we have also questioned the source of propagule we might best use in producing potted plants. For example, one unnamed selection, referred to here as "CV94," forms a clump with individual shoots reaching approximately 40 cm in height when grown as a stock plant in the open ground. Vegetative cuttings from emerging shoots in spring flower at the same time and reach approximately 30 cm in height, but show only limited evidence of branching. Hence, if used as a potted plant, three or more cuttings per pot would be required to create the visual fullness the market requires. In contrast, if instead of vegetative cuttings the propagule is derived from tissue culture, an individual plant in a 15-cm-diameter pot fills the entire pot to a height of 10 cm above the rim, creating the desired visual fullness and proportions. The resulting plant form was retained for more than 6 months, which should be desirable for marketing of most potted plants. Similar results have been achieved with one other unnamed selection of gentian, which leads us to suggest the use of different propagule sources is worthy of consideration when selecting different plant forms. At this point in time, we believe the change in form achieved reflects our ability to manipulate some of the plant growth regulators during the tissue culture process.

FUTURE PERSPECTIVES

Recently a new family of plant growth regulators called "strigolactones" have been identified as being involved with branching (Gomez-Roldan et al., 2008). Hence our knowledge of how plant growth regulators control branching in plants has now become that much more complex. At present little is known about how strigolactones are produced or how they work, but when present and active in plants, strigolactones actually inhibit branching. In terms of growers of ornamental crops using the application of strigolactones to control branching, the current price of US$5,300 per gram restricts its use to research institutions. However, a potential alternative strategy from our own research has illustrated that cultivars with lower strigolactone content are also more inclined towards natural branching. This therefore raises the possibility that in the future, perhaps we could be using strigolactone content as a screening tool within selective breeding programmes.

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Controlling Damping-off in Seeds and Seedlings Using *Trichoderma* Seed Coating©

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INTRODUCTION

Trichoderma spp. are beneficial fungi that have long been associated with disease control in many crops. Many *Trichoderma* can establish on plant roots and form a symbiotic relationship with the plant. They produce various compounds such as antibiotics and toxic metabolites, or have evolved various techniques such as coiling and parasitism to control plant disease. In addition, the root-fungal association induces a systemic resistance within the plant that can guard against pathogen attack, enhance root development and growth, increase crop productivity, and enhance nutrient uptake (Harman et al., 2004). *Trichoderma* are now widely used in horticulture, particularly the strains that are rhizosphere competent and can colonise plant roots. With increasing concern about the use of fungicides, resistance issues, and environmental and worker safety associated with their use, the desire to use biocontrol agents could well increase. New strains of *Trichoderma* are being categorised each year and several research groups in New Zealand and worldwide are working on biological control using *Trichoderma*. The research involves incorporating *Trichoderma* into various aspects of the production chain from propagation right through to postharvest (Fig. 1).

For example, recent work by the Bio-Protection Research Centre at Lincoln University has been carried out in an effort to control *Botrytis* in strawberries, *Fusarium* in cucumbers, and *Sclerotinia* in onion (McLean et al., 2005; Stewart et al., 2007; Card et al., 2009). In addition, as detailed here, research at Plant & Food Research and Massey University has recently focused on control of damping-off in seeds and seedlings (Debenham, 2010). Several research groups overseas are assessing various strains of *Trichoderma* for commercialisation, combining strains using protoplast fusion, and continuing work on different application methods for using *Trichoderma* at various stages of plant growth (Elad et al., 1999; Harman et al., 2004; Mastouri et al., 2010).

Strains of *Trichoderma* that confer some resistance against the damping-off pathogens of *Pythium* sp. and *Rhizoctonia* sp., have been identified and trialled on seeds and seedlings. Damping-off infection can occur rapidly, often within the first 24 h of planting (Lifshitz et al., 1986; Mckellar and Nelson, 2003). Therefore, it is desirable to have the biocontrol agent located on or near the seed, such as incorporated into a seed coating, to ensure rapid control of any germinating pathogens. However, specific details regarding seed coatings incorporating *Trich-*

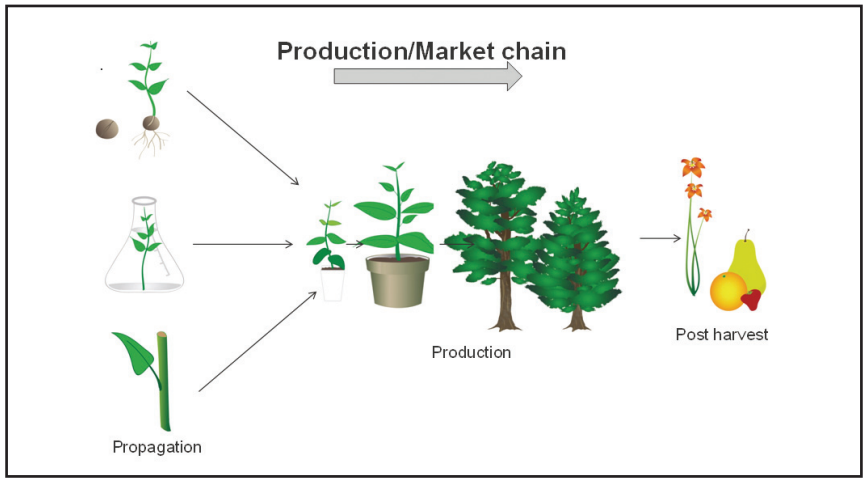

Figure 1. Production/market chain indicating areas of current research using *Trichoderma.*

oderma are commercially sensitive and not available publicly. Our literature and patent searches identified common components used in seed coating, such as adhesives like Methocel®, gum arabic, and xanthan gum, and fillers such as peat, lime, talc, vermiculite, gypsum, and sphagnum moss (Elad et al., 1982; Harman and Taylor, 1988; Spiegel and Chet, 1998; Howell, 2007). There is a wide range of application rates for *Trichoderma,* but the consensus is between 10^6 and 10^8 colony forming units (cfu) per seed (Ahmad and Baker, 1985; Lifshitz et al., 1986; Bennett and Whipps, 2008).

In addition, coating with biocontrol agents poses challenges that agrichemical coating does not have. For instance:

1) Sufficient biocontrol agent must survive the coating process and remain viable to colonise the roots and rhizosphere of the plants.
2) The biocontrol agent must survive storage on the seed.
3) The biocontrol agent may need to be applied in conjunction with insecticides or other fungicides.
4) The biocontrol agent cannot be detrimental to seed storage, germination, or vigour.
5) The coating must adhere well to the seed and not fall off excessively during storage, transit, and handling.
6) *Trichoderma* spores should be applied to the seed at a minimum rate of 10^6 (cfu) per seed.
7) The initial formulation of the biocontrol agent, varying environmental conditions, pathogen loading, and varying carbon soures on each seed, can all influence the proliferation of *Trichoderma* in the soil surrounding the seed.

Hence this study develops a method of coating several taxa of damping-off-prone seed with *Trichoderma*, then assesses the effectiveness of the coating to control damping-off pathogens.

MATERIALS AND METHODS

Seven seed lines were used for the trials: *Viola* × *wittrockiana* (pansy), *Lobularia maritima* (alyssum), *Impatiens walleriana*, *Antirrhinum majus, Latuca sativa* (lettuce*), Rudbeckia hirta, Zinnia elegans*; all from Egmont Seeds Ltd, New Plymouth, New Zealand. Before commencing the experiment, the presence of nonpathogenic fungi was confirmed using the method of Debenham (2010).

Seed Coating. A coating using Methocel oil, water, gypsum, and *Trichoderma harzianum* Rifai (Agrimm Technologies, Christchurch, New Zealand) spore biomass containing 2×10^{10} cfu/g was used. It was made as follows:

1) Mix 2.5 g of Methocel with 2 ml oil in a beaker for 1 min until soft, then add 20 ml water and leave to stand for 5 min until a a gel-like consistency is formed.
2) Remove approximately 2 ml of gel and add to one gram of seed. Stir with spatula to obtain a thin, even coating on each seed.
3) Add *Trichoderma* spore powder to give a final coating of 5×10^6 cfu/seed and stir until a thin coating is visible on the seed and no spore powder is left in the beaker.
4) Add gypsum, approximately 1 g at a time, and stir until the remainder of the gel is absorbed and the seed are well separated.
5) Tip seed onto a plate and leave to dry at room temperature for 2–4 h.
6) To confirm that the *Trichoderma* spores survived the seed coating process, a *Trichoderma* selective medium was used on the washed coating material from five zinnia seed using the method of Debenham (2010).

Determining Maximum Germination Potential. To determine the maximum germination potential of the seed lots, four replicates of 50 coated and uncoated seed of each line were used. Seed were sown on double-layer blue blotters (Steel Blue germination blotters, Anchor Paper Company, St. Paul, Minnesota) and sealed in plastic containers (170 × 120 × 40 mm) before being pre-treated with chilling or KNO_3 in accordance with International Seed Testing Association Rules (ISTA, 2011) to alleviate any dormancy requirements. Depending on the species, dormancy breaking involved 5–7 days of moist pre-chilling at 5 °C. After dormancy breaking requirements were met, seed were transferred to a cabinet with a fluctuating temperature of 20–30 °C with 8-h photoperiod during the 30 °C cycle for the required number of days as defined by ISTA (2011). Seed were assessed every 4–7 days for normal seedling development and for any evidence that *Trichoderma* could be causing detrimental effects to the seed or seedlings, such as coiling of the radicle or the shoot, or areas of necrosis. This controlled germination trial in the laboratory provided the optimum conditions; therefore the number of seedlings emerging was considered the maximum germination potential for each seed lot.

Effectiveness of Seed Coating on Damping-Off Incidence. Four replicates of 50 seed of each seed species, of both coated and uncoated treatments, were pretreated to alleviate any dormancy as previously described, before being sown in seed-raising trays each containing approximately 1 kg of bark and pumice mix (80 : 20, v/v). This bark : pumice potting mix had been previously screened and was known to contain *Pythium* and *Rhizoctonia.* The trays were placed in a greenhouse

and kept moist by hand-watering and overhead sprinklers. Seed were assessed after 14 days for germination and signs of damping-off disease. Sample seedlings with symptoms of damping-off disease were rinsed in water and placed on agar plates, then incubated at 24±1 °C for 3–7 days before assessment of fungal growth using a dissecting microscope.

Data Analysis. The results from each seed line were analysed separately. First, the germination of coated and uncoated seed in laboratory conditions was compared using a binomial generalised linear model with a logit link. From this analysis, separately for the coated and uncoated seed, the mean germination was estimated, along with a measure of variation or uncertainty in this mean. Second, again separately for the coated and uncoated seed from each line, the mean amount of germination lost to disease was calculated simply as the mean laboratory germination minus the mean potting-mix germination. In contrast, the variability in the percent disease was calculated as the variability from the laboratory plus the variability from the potting mix. These two variances were added and then the square root was taken of this sum to get the standard deviation. Finally, once the mean percent disease and variability had been calculated, these values were used in a standard two-sample Student t-test to compare the mean disease rates between the coated and uncoated seed for each seed line.

RESULTS AND DISCUSSION

There was variable control of damping-off, with zinnia and lettuce showing increased disease incidence with *Trichoderma* seed coating (P<0.001; 0.006), alyssum and pansy showing no significant difference (P = 0 45; 0.92), and *Impatiens*, *Antirrhinum*, and *Rudbeckia* showing reduced disease incidence (P = <0.001, 0.001, and 0.007, respectively) (Fig. 2).

In the controlled laboratory environment, seeds of alyssum, pansy, and zinnia showed increased germination percentage when coated with *Trichoderma* (alyssum 80% uncoated vs. 97% coated, P = 0.001), pansy (76% uncoated vs. 86% coated P = 0.010); and zinnia (71% uncoated vs. 81% coated, P = 0.013). Lettuce showed reduced germination (99% uncoated vs. 93%, P = 0.034) (Fig. 3). *Impatiens*, *Rudbeckia*, and *Antirrhinum* showed no difference in germination percentage (P = 1.0, 1.0, 0.89, respectively). There was no evidence of toxicity to any germinating seedlings, and all shoots and radicles were considered normal in appearance.

The seed coating adhered well to the seed and 94% of the spores survived the coating process and remained viable (Fig. 4). Previous trials indicated that spores remained at this degree of viability after 6 months of storage at 5 °C (Debenham, 2010). Fungi isolated from the seed coating were confirmed as *Trichoderma* (Fig. 5).

Successful results using *Trichoderma* to control a certain pathogen in a particular soil, under particular environmental conditions, cannot be extrapolated to imply that it will work just as effectively in a different environment. Unlike fungicides, which often show the same degree of control on a wide spectrum of pathogens, over variable environmental conditions, *Trichoderma* cannot offer that same control. From a commercial grower's point of view, inconsistent control over seasons is difficult to manage and may introduce unnecessary risks to their system. Growers may prefer a product that gives consistent 80% control, to one that sometimes gives 90% control and at other times gives only 50% control (Stewart et al., 2007).

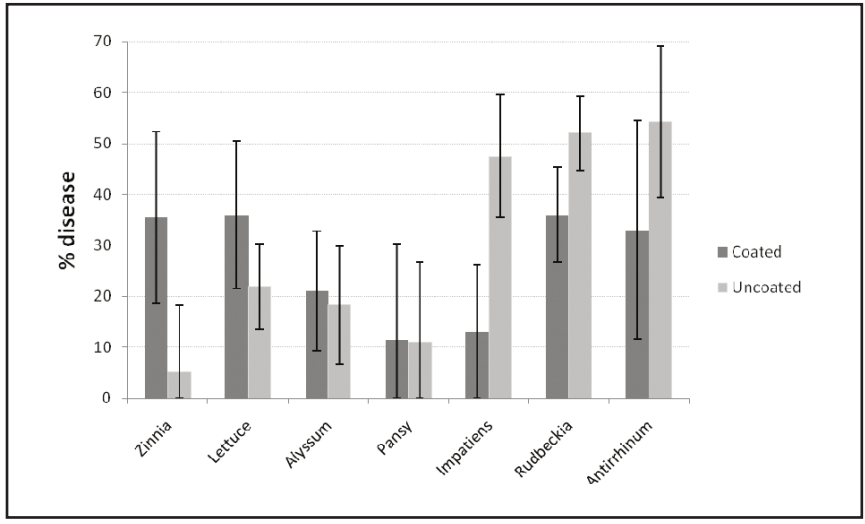

Figure 2. Effect of *Trichoderma* seed coating on disease incidence in a range of seedlings. Error bars indicate 95% confidence intervals.

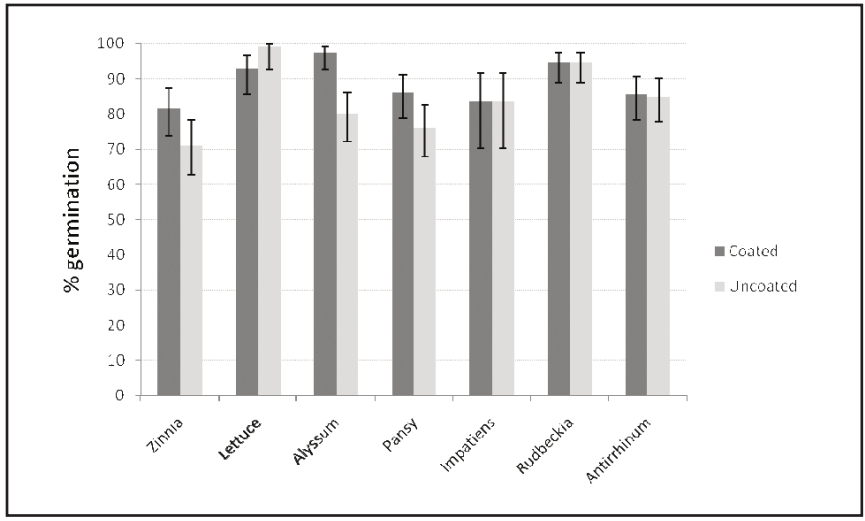

Figure 3. Germination of different seed lines whether coated or noncoated with *Trichoderma* (error bars indicate 95% confidence intervals).

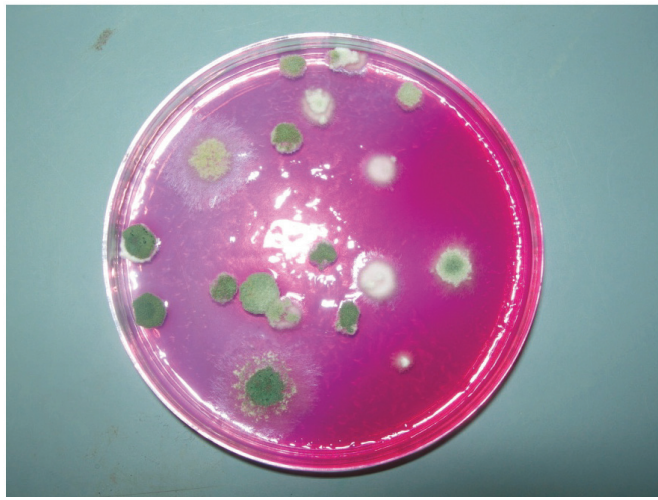

Figure 4. Colonies of *Trichoderma* growing on selective medium.

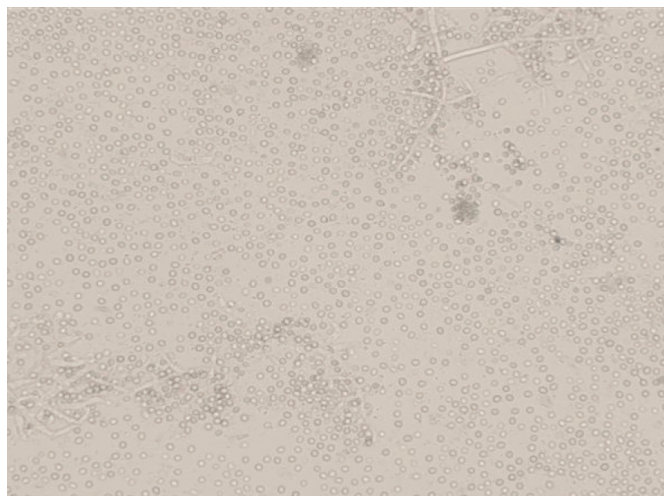

Figure 5. *Trichoderma* conidia isolated from selective medium (400 × magnification).

These findings are consistent with other studies that show variable control of disease using *Trichoderma*-based products (Bell et al., 2000; Harman, 2000; Keinath et al., 2000; Stewart et al., 2007) and highlights the limitations of biological control, and that even under closely monitored environmental conditions, *Trichoderma* has performed inconsistently. Under usual growers' conditions, which will have variable temperatures, moisture, light, pathogen loadings, different pathogenic species, and different soils or potting mixes, from those in this trial, it seems likely that *Trichoderma* performance would be inconsistent as well. Inconsistent control is one reason why the use of biocontrol agents, including *Trichoderma,* has not been embraced by industry. An holistic, integrated approach to the use of biocontrol agents may be required, perhaps involving combinations of different strains of biocontrol agents, or biocontrol agents with fungicides, to produce a more encompassing means of disease control.

Other beneficial aspects of *Trichoderma* that have not been quantified in this study are enhanced plant growth and production. Many growers have expressed anecdotal evidence of seeing enhanced growth when they have used *Trichoderma* products in their production systems. Hence, the use of *Trichoderma*, despite not being demonstrated to control damping-off pathogens in seed lines consistently, could still have considerable value in enhanced plant growth and disease resistance.

CONCLUSION

Seeds were successfully coated with *Trichoderma* spores, using Methocel®, gypsum and oil in a simple coating method. The coating adhered well to the seed, and *Trichoderma* conidial viability remained high. While the results were inconsistent, the potential of *Trichoderma* to control damping-off, plus possible benefits to subsequent plant growth and production, suggest that further research should be undertaken.

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Interspecific Hybridisation and Polyploidy for Creating Novel Genetic Combinations©

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INTRODUCTION

Interspecific hybridisation provides a valuable tool that creates exciting new opportunities for breeding of new plants. In crosses between closely related species there usually will be little or no difficulty in producing hybrids. In this paper we focus on interspecific hybridisation in parental combinations where outcomes may not be as expected for conventional crosses. Interspecific hybridisation differs from conventional crosses in that we are developing novel plant genotypes by overcoming the barriers that separate species. We also discuss the use of chromosome doubling to produce polyploids as a method to restore fertility in sterile hybrids, and a number of techniques used to verify the outcomes of hybridization and chromosome doubling will be described. Not all attempts to hybridise between species will be successful, but if barriers to success can be identified, in many instances there are solutions that will enable the production of a fertile hybrid or the transfer of a desired trait into a backcross hybrid. This paper provides a brief introduction to this topic; a more comprehensive review was recently published by Morgan et al. (2011).

Interspecific hybridisation and polyploidy are recognised as important forces in the evolution of flowering plants. There are many examples of hybridisation being used to improve crop performance. Hajjar and Hodgkin (2007) reviewed the breeding of 19 crop species and identified 13 with cultivars based on interspecific hybrids (60 wild species contributed over 100 useful traits in these crops). Distant hybridisation has even contributed new species to cultivation; triticale is a hybrid of wheat and rye. It is estimated that 15 million tonnes of triticale were harvested in 2009 <http://en.wikipedia.org/wiki/Triticale>. The role of hybridisation with wild relatives in the development of cultivars is probably under-estimated, as such breeding efforts are often poorly documented and parent species poorly described.

The value of hybridisation with wild relatives to crop improvement is clearly considerable, though difficult to accurately quantify. Pimentel et al. (1997) estimated a contribution of $115 billion per year to crop yields worldwide. There has thus been considerable research to better understand hybridisation and hybrids. Exciting new advances in identifying sought-after traits in related species and techniques for generating and characterising hybrids will facilitate future use of hybridisation as a breeding technique.

Interspecific hybridisation can be a natural process where species' distributions overlap, sometimes leading to new hybrid species. *Senecio* species (ragwort or

groundsel) provide a well documented example. Following its introduction to the United Kingdom *S. squalidus* hybridised with *S. vulgaris* resulting in two new species, *S. cambrensis* and *S. eboracensis* (Abbott et al., 2009). Hybridisation, both natural and directed by breeders, can have variable results. Outcomes from closely related species are often fertile hybrids combining traits from both parent species. Infertility, albinism, or "hybrid weakness" are frequent with wider crosses that additionally can be much more difficult to produce. The first successful attempt to create a synthetic hybrid species was ×*Raphanobrassica* by Karpechenko in the 1920s when he crossed radish with cabbage. Unfortunately for Karpechenko, his allopolyploid had the roots of a cabbage and the leaves of a radish.

For natural hybrids to give rise to new species with novel traits, the hybrid must be able to contribute to a next generation either through self pollination, crossing with similar hybrids, or back crossing to either parent. Plant breeders are often not seeking the hybrid, but rather are seeking to transfer (introgress) a trait(s) from one species to another. This requires that the hybrids are at least partly fertile. In sterile hybrids fertility can be restored through chromosome doubling of diploid plants to produce polyploid plants, often tetraploid (with four sets of chromosomes). Chromosome doubling can occur through natural processes or through treating plant tissues with chemicals such as colchicine that prevent chromosome separation at cell division. The "Triangle of U" is a theory on the evolution of a number of *Brassica* species (U, 1935). Essentially, three ancestral species combined resulting in three of the contemporary species, *B. carinata*, *B. juncea*, and *B. napus* (Fig. 1). From 46% to 68% of annual crop species are estimated to be polyploid; this figure is higher for perennial crop species, at 60%–76% (Hilu, 1993). The effects of polyploidy

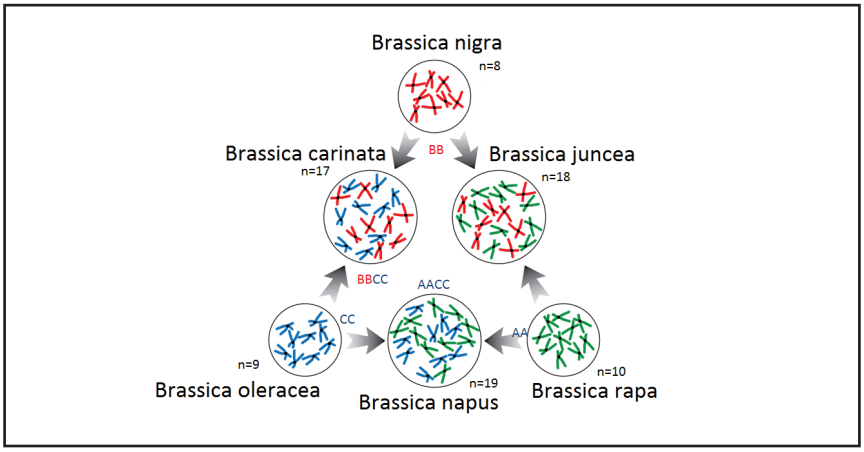

Figure 1. Evolution of cultivated brassicas through introgression of genomes by hybridisation coupled with polyploidy. Three "new" species were derived from three ancestral species though the processes of hybridisation and polyploidy. AA, BB, and CC refer to the genomes of the ancestral species *B. rapa*, *B. nigra*, and *B. oleracea* respectively. The combination AABB of *B. juncea* thus refers to the allotetraploid derived from hybridisation between *B. rapa* and *B. nigra*. More details are at <http://en.wikipedia.org/wiki/Triangle_of_U>.

on plant form, e.g., larger flowers, are such that tetraploids are frequently used as ornamental crop cultivars (it is estimated that 50%–70% of ornamental crops are polyploids [van Harten, 1998]). Chromosome doubling is therefore frequently used as a technique to create new options for ornamental cultivars.

SPECIES

"Species" is a concept which appears very familiar to most of us. It is the basic taxonomic rank in biological classification. Species are usually named using their binomial classification, e.g., *Gentiana triflora,* where *Gentiana* is the genus and *triflora* is the species. The definition of species most of us are probably familiar with is something like "species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups" (Mayr, 1942). For the purposes of this discussion we will use this definition and, therefore, developing novel genotypes by overcoming the barriers that define species is the focus of this paper. Additionally, while debate on the nature of species may seem academic it does have practical implications; for instance the New Zealand Plant Biosecurity Index is species based. A similar situation likely occurs for other countries where restrictions on plant imports are made on a species basis, even though there are many genera in which the "species" will hybridise freely and it may thus be difficult to accurately describe species. For example a recent study of cultivated sunflower showed that *Helianthus annuus* is hybridising freely with its wild relative *H. argophyllus* (Heesacker et al., 2009). This situation is further complicated by the "quality" of the definition of the species, with some species being poorly defined.

Species are isolated by barriers to gene flow that occur at different stages of the hybridisation process. These may be referred to as pre-or post-zygotic barriers depending on whether they occur before zygote (fertilised egg before first cell division) formation or following zygote formation. Pre-zygotic barriers act to prevent fusion of sperm and egg cells (zygote formation). These barriers may include one or more of spatial separation of the species, differences in flowering time, pollen transfer mechanisms, and interactions between pollen and both pistil and ovule. All these factors operate to prevent formation of the embryo. There are a range of techniques that have been used to overcome these barriers.

In the event that an embryo is produced, a range of post-zygotic barriers can operate to prevent formation of the hybrid plant, or if a hybrid plant is produced, prevent the new plant contributing to a next generation. The failure of hybrid seed development is usually attributed to failure of endosperm development; this is typically overcome using embryo rescue (embryo or ovule culture). Post-zygotic barriers may include infertility, "hybrid weakness," and albinism, all of which limit the ability of the hybrid to contribute to a next generation.

PROTOCOLS FOR HYBRIDISATION

A wide range of techniques has been successfully applied to overcome different barriers to the production of interspecific hybrids in diverse taxa. There are many publications on hybridisation in *Lilium* (e.g., van Tuyl et al., 1991; van Tuyl and De Jeu, 1997; van Tuyl, 1997; van Tuyl et al., 1997; van Tuyl and Lim, 2003). A similar situation exists for many crops in which hybridisation forms an integral part of breeding programmes. Difficulties in successful distant hybridisation can be divided into pre- and post-zygotic barriers.

Pre-zygotic Barriers. Pre-zygotic barriers that prevent the fusion of gametes and thus formation of the embryo can be manipulated in a range of ways. For example, collection and storage of pollen can provide a cost-effective way to overcome differences in flowering time. For many species storing pollen is reasonably simple using silica gel to dry anthers collected just prior to dehiscence, and freezing. Sukhvibul and Considine (1993) provide details of a protocol for *Anigozanthos*.

There is a complex interaction between pollen and pistil operating to protect the ovule from "inappropriate" pollen, such as that from other species. Many techniques have been used to overcome pollen-pistil barriers, but it is important to recognise that the interaction between pollen and pistil is more than just recognising the "right" pollen and providing a channel for the pollen tube to grow to the ovule. Techniques such as mixed or mentor pollination, use of high temperature or chemical treatments to block enzyme interactions, or cut style-pollination (removing the stigma and all or part of the style then pollinating the cut end) have all been successfully applied. Pollination of isolated ovules, placental pollination, or style grafts have also been used (discussed by van Tuyl and de Jeu, 1997). Vervaeke et al. (2002) experimenting with *Aechmea* found cut style and placental pollination gave lower rates of ovule penetration by pollen tubes than did stigmatic pollination. Improved ovule penetration following cut style pollination was observed when a longer portion of the style was left attached to the ovary. From their experiments Vervaeke et al. (2002) concluded that pollen tube growth through the style was needed to guide pollen tubes to the ovules. The role of the pistil in pollination is thus much greater than simply rejecting the "wrong" pollen, as there is also a role in supporting the growth of the "right" pollen.

Post-zygotic Barriers. Developing seed with hybrid embryos may fail to mature, and fruits may abscise at an early developmental stage. This is usually attributed to failure of endosperm development. Pollination in flowering plants leads to double fertilisation; one sperm cell fuses with the egg cell to produce a diploid embryo and the other sperm cell fuses with the two haploid polar nuclei to produce the triploid endosperm. The endosperm nourishes the embryo in later stages of seed development and/or during seed germination. The endosperm may be entirely absorbed by the embryo before the seed is fully developed, e.g., legumes, or part of the endosperm may remain to be absorbed at germination, e.g., cereals. The embryo begins to utilise endosperm reserves at about 28 days after pollination in *Sandersonia aurantiaca* (seed takes about 60 days to mature) (Zou et al., 2001). In vitro culture (tissue culture) of embryos (embryo rescue) can be used to grow immature embryos to plants. Plants grown aseptically under in vitro culture (tissue culture) conditions are provided all of the nutritional and energy requirements needed for growth and development in their growing media.

Producing hybrid plants by transferring abortive embryos to in vitro culture, commonly termed embryo rescue, has been successfully achieved across a diverse range of genera, for example *Brassica* (Diederichsen and Sacristan, 1988), *Sandersonia* (Burge et al., 2008), *Gentiana* (Morgan, 2004), or *Solanum* (Jansky, 2006). With the advancements of in vitro techniques, embryo culture following interspecific hybridisation has become an important application of this technology. Embryos, isolated or within ovules, are introduced to in vitro culture within days or weeks of pollination. As a rule of thumb, it is best to leave the embryos to develop on the plant for as long as possible. In general, the earlier the rescue is attempted the more

difficult it is to regenerate plants from the isolated embryos, and the more complex the needs of the immature embryo. Embryos may develop "normally" and grow into normal, healthy plants. In other hybrids, e.g., some crosses between various *Limonium* species, embryos will begin to grow then die (Morgan et al., 1998). This barrier can be overcome by using plant growth regulators to induce formation of a hybrid callus, from which plants can later be regenerated. The key to success is to maintain growth of the hybrid plant tissue, and inducing callus formation provides a mechanism for doing this. Embryo culture was used to rescue abortive embryos from inter-generic crosses between *Sandersonia aurantiaca* and both *Littonia modesta* and *Gloriosa superba* (Burge et al., 2008). Thus embryo rescue may be the only way for recovery of plants from some wide crosses.

There can be a considerable investment involved in producing hybrid plants, especially if in vitro interventions are required. It is thus important to be able to screen potentially valuable hybrids from any non-hybrids that may be recovered. A range of techniques with varying levels of sophistication are available for identifying hybrids.

VERIFICATION OF HYBRIDS

Techniques used to confirm hybrids can include morphological, cytological, biochemical, or molecular markers. Sometimes a combination of techniques may be used, the choice of which is based on available technologies, fitness-for-purpose, and sensitivity.

The chromosome complement of a species can be described by its karyotype, which includes details of the number, type, shape, and banding patterns of chromosomes. In many cases it is sufficient to only base the analysis on numbers of chromosomes and, therefore, plant breeders often use chromosome counts to identify hybrid or polyploid plants. Species can also be identified by their nuclear DNA content and flow cytometry is a technique for measuring the amount of nuclear DNA in plant cells. For example, diploid *Limonium sinuatum* has 16 chromosomes, *L. perezii* 14 chromosomes and their hybrid 2n = 15 (Morgan et al., 1998). Nuclear DNA contents for *L. perezii*, *L. sinuatum*, and the hybrid were 8.69, 6.42, and 7.59 pg, respectively (Morgan et al.,1998). In another cross between two *Limonium* species the situation was more complicated as both of the parents, *L. peregrinum* and *L. purpuratum,* and their hybrids, all had 24 chromosomes (Morgan et al., 1995). The existence of hybrids could be confirmed on the basis of leaf morphology as they approached maturity, but early confirmation of hybrids was made possible by flow cytometry. *Limonium peregrinum* has a mean 2C nuclear DNA content of 13.98 pg, the hybrid 16.81 pg, and *L. purpuratum* 19.37 pg (Morgan et al., 1995). This is a clear example of closely related species having different nuclear DNA content despite their similar chromosome number. In both these *Limonium* crosses symmetrical hybrids with intermediate chromosome number (*L. perezii* × *L. sinuatum*) and nuclear DNA content were produced. The morphology of the hybrids was also intermediate to that of the parents, e.g., the *L. perezii* and *L. sinuatum* hybrid had the club-shaped leaves of *L. perezii* with the "wavy" leaf margins of *L. sinuatum*. The intergeneric hybrid *Sandersonia aurantiaca* × *Littonia modesta* (Morgan et al., 2001a) was also symmetrical with respect to chromosome numbers and nuclear DNA content, but differences in leaf shape were less obvious than in *Limonium* hybrids; the partial fusion of tepals in flowers of the hybrid contrasted with complete fusion of tepals in *Sandersonia* and complete separation in *Littonia* (Morgan et al., 2001a).

In contrast to *Limonium* or *Sandersonia*, *Gentiana* is a much more genetically diverse and cosmopolitan genus, with natural introgression occurring within close communities. Therefore, some interspecific gentian hybrids cannot be identified using either chromosome number or flow cytometry due to very similar nuclear DNA contents. Recently developed molecular markers may be used to distinguish hybrids from closely related gentian species (Pathirana et al., 2011) or, if needed, morphological markers become more useful as the plants mature. With crosses between more distant species, e.g., *Gentiana triflora* × *G. lutea*, both chromosome numbers and nuclear DNA contents can be used to distinguish hybrid plants from their parents (Morgan, 2004).

OVERCOMING CHALLENGES ASSOCIATED WITH HYBRIDS

Hybrids are generated to form new genetic combinations but will include genetic material conferring both desired and undesired traits. Typically the hybrids will be backcrossed to one parent species to eliminate undesirable traits. In many cases it is a straightforward matter to begin a programme of backcrossing to incorporate the hybrid plants into breeding programs. However, this process of backcrossing may be complicated with infertility or various manifestations of incompatibility limiting breeding opportunities.

In many wide crosses the hybrid plants are infertile. This infertility can arise from poor pairing (homology) between the two sets of parental chromosomes or an uneven number of chromosomes, both of which result in the hybrid failing to produce viable pollen and egg cells (gametes), though other factors may also contribute to infertility. The *Limonium* hybrids described previously provide examples, where *Limonium sinuatum* has 2n = 16 chromosomes, *L. perezii* 2n = 14, and their infertile hybrid 2n = 15 (Morgan et al., 1998). In *L. peregrinum* × *L. purpuratum* the hybrids have 24 chromosomes (Morgan et al., 1995). Meiosis appears normal and pollen appears to be viable, but it won't germinate. Therefore backcross hybrids were produced using the hybrid as a seed parent. The reason for failure of hybrid pollen germination in this example is not known.

Infertility in interspecific hybrids is typically overcome by chromosome doubling to generate (allo-)polyploid plants. Chromosome doubling can be achieved in a number of manners, but in essence plant tissues with dividing cells are treated with a compound such as colchicine or oryzalin that interferes with spindle formation at cell division. The spindle separates the two sets of chromosomes in cells that are about to divide. If the chromosomes are not separated the resultant cell will have twice the number of chromosomes (is polyploid), and regeneration of a new plant from one of the cells with double the chromosome numbers will result in an allopolyploid (polyploid plant based on two species), thus restoring fertility to the hybrid. In vitro chromosome doubling has been applied to a range of genera. In our lab we typically transfer the plant material to proliferation medium and, when proliferating well, it is transferred to the same medium supplemented with oryzalin. The plant material remains on this medium for up to 4 weeks, and is then transferred to fresh medium lacking the oryzalin to recover and regenerate new tissues. The oryzalin treatment is stressful on the plant material, and there is likely to be considerable death and necrosis of the treated tissues. Nevertheless, when oryzalin is removed, new shoots can be regenerated. After two or three subculture cycles the plant material can be screened for polyploidy in the newly regenerated tissues using flow cytometry. After deflasking it may be possible to quickly screen plants in the

greenhouse for polyploidy on the basis of leaf thickness, leaf colour or stomata size. In our lab this protocol has been used with slight modifications for chromosome doubling in a range of genera, e.g., *Gentiana* (Morgan et al., 2003; Pathirana et al., 2011), *Limonium* (Morgan et al., 2001b), and *Zantedeschia* (unpublished data). In the example of *L. perezii* × *L. sinuatum,* chromosome doubling resulted in a fertile tetraploid plant with 30 chromosomes (Morgan et al., 2001b). The tetraploid hybrid was backcrossed to *L. perezii* to give a triploid hybrid, with plants produced using embryo rescue. The triploid plants were partly fertile, with further hybrids produced using embryo rescue (Morgan et al., 2001b).

Incorporating the newly created tetraploid hybrids into breeding programmes can be difficult if the hybrids are isolated from their (diploid) parents because of their increased ploidy (it can be difficult to hybridise diploid plants with tetraploids, even within the same species). Backcross hybrids (triploid) can be produced using embryo rescue to bypass the ploidy barrier as described previously. Another solution to this problem is chromosome doubling of the parent to produce a tetraploid (autopolyploid), which is then crossed with the allopolyploid hybrid, with further breeding occuring at this elevated ploidy level. This approach has been successfully applied to producing hybrids in genera where species occur at a range of ploidy levels, e.g., *Solanum*. *Solanum* species occur at ploidy levels from diploid to hexaploid, and most potato cultivars are tetraploid. Chromosome doubling of diploid species improved compatibility with cultivated potatoes (Jansky, 2006).

Hybrids may exhibit a range of traits that make them inherently weak or unable to contribute to further generations. Albinism has been documented in a number of cases, e.g., *Zantedeschia* hybrids, in which plastid development was inhibited by plastome-genome incompatibility (Yao et al., 1994). In interspecific *Limonium* hybrids, Morgan et al. (1998) described pale foliage which may be the result of a similar incompatibility reaction, though this was not specifically investigated. Backcrossing the hybrids to either parent resulted in dark green foliage, with plants of normal appearance (Morgan et al., 1998). Hence backcrossing appears to present a possible solution to overcome this problem.

In other interspecific crosses, the hybrids may have inherent weaknesses resulting in early senescence and plant death. For instance, the hybrids between *Gentiana triflora* and *G. lutea* (Morgan, 2004), as well as *G. triflora*, and *G. asclepiadea* (unpublished data), although green and apparently normal, have proven very difficult to grow after transfer to the greenhouse. Hybrid plants that grow poorly and display symptoms suggestive of pathogen attack or other stress may be subject to "hybrid necrosis." Hybrid necrosis is a phenomenon that has received little attention in the scientific literature and is poorly understood. A greater understanding of the underlying mechanism(s) will undoubtedly enable access to an increased range of interspecific hybrids in the future.

CONCLUSIONS

Modern techniques and tools for interspecific hybridisation create exciting new opportunities for developing novel plant genotypes by overcoming the barriers that define species. Hybridisation between widely separated species increases the likelihood of outcomes such as infertility or hybrid weakness, but in many cases there are solutions to these challenges. In spite of these challenges, the value of distant hybridisation to plant breeding ensures it will remain a valued tool in plant breeding programs.

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Horticulture in the Land of the Rising Sun©

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INTRODUCTION

On 10 Oct. 2010, I departed Auckland Airport for Japan as part of the IPPS Reciprocal exchange. In preparation for this exchange I had spent time speaking with IPPS members in New Zealand who had been to Japan for the IPPS in the past, and I also brushed up on my Japanese language and cultural skills. As part of my exchange I was required to give a presentation at their conference, so I spent some time taking photos of Christchurch and of the nursery operations at Oderings Nurseries.

HORTICULTURE IN JAPAN

Arrival into Japan. Upon arriving in Kansai International Airport, Osaka, I was met by Dr. Nobasa Nito, the IPPS Japanese International Director. It was great to find that Dr. Nito spoke excellent English. Dr. Nito and I caught a super express train for the main station in Osaka, which is about an hour long trip from the airport. Dr. Nito regaled me with stories of his recent trip to the American IPPS International conference, including New Zealand members he had met.

Dr. Nito also spoke about the current state of horticulture in Japan. It was most interesting to learn that in the 1960s 25% of the Japanese population was employed in horticulture or agriculture. In 50 years this has dropped to about 1%. Horticulture and agriculture are now mainly thought of as a weekend job for people who don't make enough during the week and need to earn a little extra to make ends meet. I also found subsequently that growers in Japan seem to all get on well with each other, and have a great deal of mutual respect. After our arrival into the main station (Shin-Osaka Station) Dr. Nito helped me to catch the bullet train (Shinkansen) to travel by myself to Okayama.

Okayama — Ohuchi Family. Upon arrival at Okayama Station (about an hour's train trip at speeds up to 285 kph) I was met by Shiginari Ohuchi (Shigie, who attended the 2010 New Zealand IPPS Conference in Blenheim). Shigie and his father Iwe (Johnny) look after the family farm or nursery, which is approximately 20 km from Okayama.

The Ohuchi family nursery is spread over an area of about 10 acres. The family owns several glasshouses scattered through the area, while other glasshouses in the same area are owned by two other growers. To make it easier for visitors to the area, each of the glasshouses has a colour poster with the glasshouse owner's face on it. The family, much like other Japanese growers, has diversified into food crops. I found out that the government offers incentives for farmers to grow food crops, with the country's aim to become more self-sufficient in the future.

The family specialises in *Cymbidium* orchids, and sell 8,000–10,000 orchids each year. *Oncidium* orchids are also grown, however in lesser quantities. The main times for gifting in Japan are midyear (Golden Week) and the Christmas–

New Year period. New Year is a traditional time for people to travel domestically and return to their home towns. The Christmas gifting season is a great time for orchid sales.

The *Cymbidium* orchids are grown during the summer months (May–Oct.) in a mountainous area about 120 km (2 h by truck) north-west from the family nursery. The orchids are grown under shade cloth and are suspended between metal poles for drainage. The orchids are brought back to the family farm for the winter (Oct.–Feb.) as the mountainous area is often buried under snow. The orchids are picked over at the mountain and placed into black plastic trays, five orchids per tray. Each truck that transports the orchids holds approximately 6,000 orchids, with 2 trucks in use for each trip. After all of the orchids have been moved from the mountain site the shade houses are dismantled, so no snow damage can occur. On arrival at the nursery the trays are pushed down a series of aluminium rollers so they can be run off directly into the glasshouse when unloading them from the trucks. There are five women working for the family in the nursery, who each do a lot of impressive heavy lifting of the trays of orchids. The orchids are all sold in flower, and kept separate by type in the nursery.

The Ohuchi family also grow dragon fruit (*Hylocereus* sp.) (Fig. 1) and grapes (*Vitis*). The dragon fruit is pink on the outside with intermittent bits of green foliage that look like scales. The fruit come in three colours of flesh; pink (sweet, round fruit), yellow (sweet, round fruit), and white (not as sweet, oval fruit). Dragon fruit are sold direct from the farm as well as delivered to specialised fruit and vegetable shops, and are priced according to their individual size and weight. The flowers are pollinated by hand, and from that stage it takes about 2 months before the fruit reaches a saleable size. Harvesting is done 3 times a week.

The Okayama area is famous for grapes, particularly sweet Muscat-type grapes. The family grows both red-skinned and white-skinned grapes. Japanese table grapes are large and have thicker skins than table grapes available in New Zealand. Quality standards are exceptionally high in Japan.

My visit to Japan coincided with the traditional time for the rice harvesting. Rice is harvested by a small machine which looked like a snowmobile. I found the Japanese to be incredibly resourceful, with the husks from the rice harvest slowly burnt (Fig. 2), then mixed with an all-round fertiliser (13-13-13) and use it to fertilize on the orchids and grapes.

Figure 1. Dragon fruit (*Hylocereus* sp.).

The Ohuchi family have a colour catalogue with examples of wrapped and beautifully presented *Cymbidium* and *Phalaenopsis* orchids and cyclamens (*Cyclamen*). When a client orders cyclamens or *Phalaenopsis* orchids these are brought in from other growers and repackaged to be sent out. These are gifted for many reasons in Japan, frequently on the opening of a new business for luck.

On one of the many outings I was generously taken on by the family we stopped at a mega-centre. They had a large range of conifers, shrubs, bedding plants, bulbs, and gardening accessories. Cyclamen and pansies seemed to dominate the current bedding trend. On another trip we stopped at a garden centre. People seemed happy to pay the extra to shop at the garden centre as a trade-off for the better selection and more specialised plant advice. I also found the Japanese garden centres sell fresh and dried fruit. The garden centre at Soja City had some of the Ohuchi family's dragon fruit on sale. They were available individually or in a presentation box of two, especially for gifting.

Suzuka — Uchida Family. I was taken to Suzuka by car, a trip of approximately 5 h. The Uchida family consisted of Mr. Uchida, his wife and four children (one girl and three boys), being a large family by Japanese standards. Their nursery is called Tumugi, which means "Together we are stronger, like the fibres of a rope bound together."

Mr. Uchida, like most people working in horticulture in Japan, works 7 days a week. The second day in Suzuka I went with Mr. Uchida to do a landscape gardening job, which he does in the weekends after spending the weekdays at his nursery.

Our first task back at the family nursery was to prune figs (*Ficus carica*). The nursery included a field with about 400 2-year-old figs planted out in rows of 15. We were pruning them for espalier training. Fruit and all laterals were removed to train the trees into a "Y" shape and the clippings were placed around the base of the tree. The wires for training were to be added the next winter.

Mr. Uchida also grows mondo grass (*Opiopogon japonicus*). We had to fill trays which were approximately 25 cm by 25 cm with 60 mondo grass divisions per

Figure 2. Rice husks being slowly burnt before the addition of an all-round fertiliser.

Figure 3. Jinenjo, or mountain yam (*Dioscorea* sp.).

tray. These were loaded onto the back of a flat deck truck to be delivered to a transfer depot.

The strawberries grown by Mr. Uchida were planted in mounded soil in tunnel houses. The fruit is sold by the punnet direct from the farm, as well as to outlets. The plants are also sold to other growers, after they have been raised from runners.

Another day I was lucky enough to be taken to a grower's meeting, where I was introduced to Jinenjo, a mountain yam (Fig. 3). Mr. Uchida was trialing seed and germinating this whilst I was there. At the meeting we ground these mountain yams up in a mortar and pestle and made a paste to be eaten raw. It was interesting to see a new vegetable which I haven't experienced before, and to see the size of it, which can get up to 1 m long.

IPPS Conference – Nagoya. I travelled to the conference with Mr. Uchida, who is the President of the Japanese IPPS Executive committee. The first day of conference was entirely dedicated to talks, with the first two special talks on genetic modification and creation of a blue rose and the second talk on management of human resources. These talks went for approximately 1 h each. The remainder of the day was filled with 15-min short topics. My presentation was the last for the day, and I showed a PowerPoint on my job in New Zealand and the New Zealand IPPS. I was lucky enough to be translated by Kaneto Aoyama who was to be my next host.

The second day of conference was dedicated to field trips. Both trip options started at the Toyoake Flower Auction which is a Dutch auction that runs on Monday, Wednesday, and Friday. There were upwards of 30 trucks unloading as we arrived, and numerous flowers moving around the auction floor on a train-type system. The groups then split and the other group visited a fig breeding facility. I was lucky enough to be put into the group to visit Hayakawa Engei, Japan's largest cyclamen breeder. The nursery was huge, with all the cyclamen grown under glass. At any time 3.6 million cyclamen are on site. The head grower has trained many nursery-

men about cyclamen and the nursery is considered the ultimate place to learn about cyclamen breeding and cultivation.

After the cyclamen nursery we visited Aoyama's pot factory, Kaneya Co. The company initially began making car parts after World War II before moving into plant pot production. Kaneya has a 30% market share in Japan as well as clients worldwide. Recently Kaneya has diversified into chemicals, plant support systems, and flower buckets for growers to display plants at auction. We saw the steam sterilising system to clean the flower buckets after use so they can be reused, which was surprising since I had encountered limited reuse of products in Japan before this point.

International Flower Expo – Chiba. Whilst being generously hosted by Aoyama and his company Kaneya in Chiba (20 min from Tokyo), we visited a Bonsai Museum. There where bonsai shrines and retail shops in the surrounding area. The museum was breathtaking, with many specimens hundreds of years old. The rules of bonsai style and form are incredibly confusing I found. I also discovered that the art form is dying, with the younger generation not interested in learning the complex art and methods of bonsai.

The next day I attended International Flower Expo (IFEX), which is one of the largest horticulture expos in Asia. Aoyama's company had two stands, one for pots and one for a tomato growing system that can be rented. The growing system lifts the tomatoes off the ground and grows them up a frame. Among the numerous other stands were international and Japanese seed companies, media suppliers, and plant breeders displaying their products.

Acknowledgements. I was privileged to be chosen to represent both the New Zealand branch of the IPPS in Japan, and also to be an ambassador for New Zealand. I found all my Japanese hosts to be more than generous, kind, accepting, and welcoming. The experiences and friendships I have made stand out for me; I also feel that I learnt and will gain from the horticultural experiences I had whilst in Japan. My enthusiasm and passion for horticulture has grown once again, and I look forward to fully utilising my experiences in the future.

I thank my host families (Ohuchi, Uchida, and Kaneto Aoyama) along with the Japanese branch of the IPPS and the New Zealand branch of the IPPS for this opportunity. I also thank Murray Mannall, Shirley Ogilvy, and Peter Waugh for their help and support. I encourage any young member to actively take part in pursing the chance to undertake the exchange that I have, and look forward to working with young members of our society to foster new learning and understanding. Since my Japanese experience I have moved to north Queensland, Australia, to take up the position of Production Manager at Anza Nursery in Mareeba.

Costs and Benefits of Renewable Energy for U.K. Nurseries©

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Heating fuel is one of the biggest single outgoings for nursery businesses so the importance of minimising the cost cannot be over-estimated. The price of heating fuel has trebled over the past decade and this trend shows no sign of slowing. Even without the other pressures from various quarters on the nursery industry, taking control of energy costs is likely to be crucial to the economic sustainability of many businesses.

In the U.K., government policy to encourage investment in renewable energy sources, such as wind or solar, has resulted in the introduction of the Renewable Heat Incentive (RHI), which offers payments for businesses for using renewable energy for heating. This, under certain circumstances, offers the exciting possibility of a business's heating requirements switching from being a cost to a new source of revenue.

But before any business considers investment in renewable energy it is important to begin with the over-riding principle of all energy management — reducing consumption. The cheapest unit of energy is the one not consumed at all and RHI policy encourages investment in energy conservation before payments will be made for renewables schemes.

Even a quick basic energy audit of all but the most energy-conscious nurseries will reveal instances of energy waste which, though individually small, when added together account for a very significant amount. A few years ago the cost of this wasted energy may not have been worth worrying about but now it is likely to be seriously undermining profitability.

The sustainable energy solution for any business will be a combination of adjusted management priorities and processes; training and incentivising of all staff to minimise waste; practical measures to reduce demand, such as insulation and draught-proofing; and, last of all, capital investment in more efficient and effective heating systems, particularly renewable heating equipment for which the RHI subsidy may be paid if certain eligibility criteria are met.

RENEWABLE HEAT INCENTIVE

The Renewable Heat Incentive (RHI) is a U.K. government environmental programme designed to increase the uptake of renewable heat technologies by providing incentive payments to eligible generators of renewable heat for commercial, industrial, and other purposes. This will contribute towards the target set under the 2009 European Union Renewable Energy Directive that 15% of total U.K. energy consumption should be generated from renewable sources by 2020.

The scheme is administered by Ofgem, the official energy market regulatory authority, and further details can be obtained from its website at www.ofgem.gov.uk.

Among the relevant eligibility criteria are:

- The heating plant must have been completed and first commissioned on or after 15 July 2009.

- The metered heat for which the RHI is being claimed must be being used for an eligible purpose, e.g., heating a building, as defined under the scheme.
- No other grant from public funds can have been paid in respect of any of the costs of purchasing or installing the technology.
- The plant must be new at the time of installation.
- The heating system to which the installation provides heat must use a liquid or steam as the heat delivery medium (i.e., not direct air heating).

The RHI regulations define a building as "any permanent or long-lasting building or structure of whatever kind and whether fixed or moveable which, except for doors and windows, is wholly enclosed on all sides with a roof or ceiling and walls." Ofgem will ask for information about the building(s) in which the heat is used as part of the accreditation process. It will look at situations on a case-by-case basis to assess whether the definition in the regulations is met.

Ofgem will normally consider that polytunnels and similar structures are erected on a temporary basis and therefore are not eligible because they do not meet the criterion of "permanent or long-lasting building or structure." However, moveable buildings or structures that are constructed with a view to having "long-lasting" use, such as "portable" office buildings, greenhouses, and shipping containers could be regarded as "permanent or long-lasting" provided they remain in the same location.

Permanent greenhouses, whether glazed or plastic, should also be eligible but this would need to be confirmed with Ofgem for each individual situation.

So what could the RHI mean to a nursery business? In a nutshell, the incentive payments translate into a sub-10 year return on an investment in a new boiler system, then free heating until Year 20.

A number of nurseries in Scotland have already switched to renewable heat with biomass as the fuel, including Pentland Plants near Dalkeith, Edinburgh, and Drumpellier Nursery, Coatbridge, Glasgow. Their installations received capital grant assistance so they are unlikely to be eligible for any RHI payments, even if the success of the RHI scheme drives up their fuel costs. However they have already made substantial financial savings as a result of their decisions.

BIOMASS HEATING CASE STUDY

To illustrate the costs and benefits of biomass heating under the RHI, let us look at a real life example of a nursery in Scotland with 3.2 ha under glass or plastic with various heating needs, including frost protection in some of the greenhouses and, in others, maintaining temperatures above 7 °C or 12 °C depending on the stock. To achieve this the company runs three oil-fired boilers totalling around 700kW in output, plus a variety of propane- and butane-gas air heaters dotted about the site. In the 12 months to May 2011 these systems burned approximately 50,000 L of oil and 20 tonnes of bottled gas at a cost of £28,000 and £22,000, respectively. This also generated greenhouse gas emissions equivalent to 360 tonnes of CO_2.

Let us now compare the figures following a theoretical (as yet) switch to a system heated by a wood chip fired boiler supplying heat via the same pipes and radiators as the existing system, but also providing the heat currently generated by the bottled gas blowers, via newly-installed fan coil heaters. The total amount of heat supplied, assuming an overall conversion efficiency of 85% of energy contained in the fuel being delivered as heat, would be around 670,000 kWh. To reproduce this

using local wood chip sources would involve a 500 kW boiler, matched with a large thermal store, burning 223 tonnes of chip at 30% moisture content.

There are two main procurement options for the nursery to consider:

1) **Boiler Owned and Fuel Supplied by an Energy Services Company.** If the boiler was installed and the heat supplied by a local energy services company at a realistic price of 4p per kWh including all servicing and de-ashing, the cost of that heating would be £27,000, a saving of 46% or £23,000. The nursery could also promote its environmental credentials having reduced its greenhouse gas emissions by at least 340 tonnes of CO_2 equivalent.

   The capital investment to achieve this might only be the cost of installing the new fan coil units which replace the bottled gas blowers and the new insulated pipework from the two existing boiler locations to the site of the energy services company's containerised wood boiler. The energy company might also provide the concrete plinth and water and power supplies for the boiler site. If this all cost £50,000 it would be paid off well within 3 years by the fuel cost savings. The principal requirement is that there should be a site available for the new boiler and convenient access for its delivery, and for the delivery of fuel by the supplier.

   The energy services company would make sufficient profit on the heat price to absorb fluctuations in its fuel and operation and maintenance costs over the period of the contract, but the main return for them would be the RHI payment of 5.1p per kWh registering on the heat meter which is a necessary component of the installation. This would be in the region of £34,000 giving them a 10% return on investment or greater.

2) **Boiler Owned and Fuel Sourced by the Nursery.** The alternative is for the nursery business to raise the capital itself to purchase and install the boiler system. Depending on many site-specific factors this might require £250,000 to £350,000 or possibly more, but then the £34,000 RHI payment, index-linked unlike loan repayments, and payable for 20 years, all comes into the business. The capital could be repaid in 10 to 12 years if using 100% of the RHI payment, after which the RHI payment becomes an addition to the business revenue and should cover entirely the other unavoidable electricity and road fuel energy costs, and more, totalling potentially more than £1m in real terms over the life of the scheme. On top of that, if the nursery has implemented energy efficiency measures to reduce heat demand, then a smaller, cheaper, boiler could be specified.

OTHER FACTORS TO CONSIDER

The RHI payment is protected by statute so should be as dependable as any income stream available to any business venture. However entrance to the scheme is subject to review and could be controlled or stopped, or the starting tariff varied, prior to any business gaining registration.

There are potential drawbacks of biomass systems. These may include smoke, noise, smell, particulate pollution, disruption by fuel deliveries, and fire risk. How-

ever, in most situations they can be managed, controlled, or designed-out so that they are insignificant in comparison with the financial and ecological benefits to be had.

There may be a trace of smoke as a boiler starts up from cold, which won't happen often during the heating season. Once up to temperature there will be nothing but an occasional small plume of condensation. The noise from augers and fans is easily retained within the boiler house if it is noticeable at all. Wood fuel does generate airborne particulates which, in high concentrations, can constitute a pollution issue. Larger boilers may be specified with ceramic tube filters to catch over 95% particles. Fuel deliveries may be required weekly in the severest winter conditions, possibly every few days depending on the size of the fuel store and delivery vehicle that can be accommodated.

Many nurseries will have a high and "spiky" heat demand, where a high proportion of total demand is concentrated into a few days or weeks of the year. This means that a large and therefore expensive boiler is required in relation to the average quantity of heat required. This means such nurseries will be installing boilers with a low capacity factor (Cf), probably generating less than 15% of the theoretical annual maximum. Even so the above example demonstrates that such installations can still be very cost-effective — which means that other situations where the demand is less sporadic, such as offices, will be more cost-effective still. The most attractive situation, commercially speaking, is where heat can be supplied to various customers demands within a small area.

The aspect of biomass heating which most strongly differentiates it from conventional heat sources of gas, oil and electricity, and which represents the biggest single obstacle to the widespread fast take-up of the technology, is the long-term reliance on local contractors to provide a reliable long-term supply of fuel of the requisite quality and quantity. We have learned to trust that oil and gas of dependable quality will always be available in quick response to a telephone call, but to assume the same of wood chip fuel is perceived to require a leap of faith. Therefore it is crucial that a solid contract for the supply of fuel, or ideally heat, can be settled before a boiler is purchased.

It is for this reason that the purchase of heat under a contract of several years in length, probably with the price linked to an inflation index, is the most attractive option. If there is not already an established energy services company with a fuel depot within 30 miles of your site, advertising locally for a tender for the supply of biomass heat to your site is likely to flush out an entrepreneur with the necessary equipment and experience ready to set up. The ideal solution may be the creation of a new energy services company as a subsidiary to your own business. You may have space to store sufficient processed fuel to supply to other local businesses. Advice on this aspect is easily available from sources such as the Forestry Commission and your nearest regional woodfuel forum.

The best way to build confidence is to visit existing installations and speak to others with hands-on experience and to join your nearest regional woodfuel forum — these are being supported by the government under a contract recently won by Rural Development Initiatives. An initial energy audit by an experienced independent energy consultant is a good starting point. This can be acquired from a consultancy firm with the necessary experience or even provided free of charge by the Energy Saving Trust and will identify the best combination of energy efficiency and capital measures and give you an action plan for an energy-led transformation.

SOURCES OF FURTHER INFORMATION

<www.ofgem.gov.uk> (information on the Renewable Heat Incentive)
<www.usewoodfuel.co.uk> (information on using wood for heating)
<www.ruraldevelopment.org.uk> (to find your nearest Woodfuel Forum)
<www.energysavingtrust.org.uk> (Energy Saving Trust, for audit and loan information)
<www.energyagency.org.uk> (Information on the Energy Agency)

Opportunities for Improving Energy Efficiency and Using Renewable Energy at British Wild Flower Plants©

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INTRODUCTION

In June 2011, as part of the planning and decision-making process for proposed new office accommodation, an energy audit was undertaken for the British Wild Flower Plants nursery business, which reviewed the quantity and costs associated with energy consumption at the site and assessed the initial feasibility for and costs associated with investment in small scale renewable energy technologies.

A range of no, low, and medium cost recommendations were made. These included analysis of energy meter readings against climate and occupation, adjusting time controls on irrigation and abstraction pumps, and use of night storage heaters to ensure that overnight (cheap) rate electricity was used whenever possible. Low cost recommendations included repair of the rain sensor feedback control on the irrigation system. The greatest energy savings would be realised by fitting insulation to the office area, or ensuring that the proposed new office meets, or exceeds current building standards for insulation.

Opportunities to invest in renewable energy included an air-to-air source heat pump and solar hot water heating to the proposed new office. Installation of photovoltaic panels at the nursery would generate up to 15% of the site's electrical consumption and, under the payment regime then applicable, realise over £1,500 in financial benefits, rising each year in line with the annual rate of inflation.

While the financial value of the projected savings was relatively small (approximately £1,220 per year) it would reduce the nursery's energy consumption by 64% and carbon dioxide emissions by 7.5 tonnes per year. The overall payback period for implementing the recommendations was about 2.3 years.

BUSINESS CASE

Business energy charges have increased substantially in real terms over the past 10 years. For example, according to the U.K. Office for National Statistics Quarterly Digest of Energy Prices, in the last year alone electricity costs have increased by 3.3% in real terms, gas by 16.4%, and oil by up to 25%. In addition energy prices have become increasingly volatile as a result of increased global competition for energy. In the U.K. electricity and gas generated from non-renewable sources also attracts taxation through the Climate Change Levy which increases the potential cost savings that could be realised by improved energy management within businesses. The U.K. Carbon Trust has estimated that 21% of the total UK businesses energy spend is wasted through inefficiency.

Consequently there is a clear economic case for businesses to reduce energy consumption and maximise the efficiency with which it is used on site. Reducing the consumption of energy generated from non-renewable sources (e.g., oil and natural gas) will reduce carbon dioxide emissions and contribute to an overall reduction in greenhouse gas emissions.

To reduce the U.K.'s overall dependence on imported energy and to increase the proportion of electricity and heat generated from renewable sources, the U.K. Government introduced the Feed in Tariffs (FiT) in 2010 and the Renewable Heat Incentive (RHI) in 2011. These two incentives provide a guaranteed level of return per unit of electricity (FiT payments) or heat (RHI payments) over an extended period of time (up to 25 years) the levels of which are significantly greater than that for earlier initiatives where they existed. Both have been index linked to the retail prices index and therefore provide long-term confidence in the level of reimbursement.

Therefore investment in small-scale renewable energy systems can help businesses to reduce the quantity and cost of imported energy, provide a regular source of income, and reduce exposure to price volatility to at least a proportion of on-site energy consumption.

ENERGY STUDY AT BRITISH WILD FLOWER PLANTS

British Wild Flower Plants is the U.K.'s leading propagator and supplier of U.K. native plants of known provenance to the wholesale trade. The site, which was formerly part of Norfolk County Horticultural College, includes offices, a lodge let as holiday accommodation, workshops and stores, an unheated greenhouse, unheated polytunnels, and open propagation areas. Water is abstracted from a borehole into a storage tank. This is subsequently pumped under pressure to provide irrigation throughout the nursery. Irrigation is time controlled to deliver a specific volume of water to each of 23 different zones.

The aims of the energy assessment were to:

- Identify existing energy management practices.
- Estimate the quantity and cost of energy consumption associated with key operating areas of the business.
- Identify potential opportunities to improve energy management and appraise these opportunities against economic and environmental criteria.
- To assess the potential for different small-scale renewable electricity and heat-generation technologies to provide a proportion of the site's energy needs.
- To appraise the potential for different small-scale renewable energy technologies against economic and environmental criteria.

METHODS

Established energy auditing techniques were adapted to the specific site. In brief the audit comprised:

- Analysis of existing energy billing information to determine the annual quantity and cost of energy consumption at the site, seasonal and daily trends in energy consumption, and cost.
- An assessment of energy consumption by key operating areas of the business including irrigation, space heating, lighting, and other horticultural equipment. This was estimated from the kW rating of equipment and data supplied by the business regarding operating hours.
- The quantity and cost of energy consumption associated with space heating the existing and proposed office was estimated using estab-

lished methods, site based measurements of the building fabric, and thermal conductivity coefficients of the specific building materials.
- The electricity meter readings were compared to publicly accessible data on space heating requirements (degree-day data) available from the Carbon Trust.
- Discussion of the existing operation of the site relating to energy management and how this may change in the future due to potential changes in operation and facilities.
- The potential for different renewable energy technologies to be applied to the site was assessed by:
  - A site visit to determine the layout, spatial constraints at and surrounding the site
  - Identification of the location and capacity of the electrical connection to the site
  - Identification of key factors on neighbouring property that could affect the feasibility of different renewable energy technologies at the site.

RESULTS

Electricity is the only energy source supplied to the nursery. Generating the National Grid electricity consumed at the site releases about 11.8 tonnes of carbon dioxide per year. Opportunities to reduce energy consumption by up to 64% were identified during the site visit. While the level of cost savings (approximately £1,220 per year) was relatively small this was a reflection of the already relatively low energy input of the nursery's operations.

Since May 2010 the electricity meter fitted to the site has been equipped with the capability to supply automatic readings on a monthly basis to the electricity supply company. This provided an opportunity to examine trends in electricity consumption. From this information it was determined that electricity consumption overnight during the winter (October to March) accounted for the greatest proportion of electricity consumed (Fig. 1). When the trends in the daily cost of electricity supplied to the site was compared against the requirement for space heating this showed a strong correlation which indicated that most of the electricity consumed by the business was associated with space heating (Fig. 2).

Electricity consumption by refrigerated appliances and for irrigation were the next major consumers of electricity (Fig. 3).

To improve energy management at the site the following recommendations were made:

- Assign responsibility for regularly taking and systematically recording and analysing electricity meter readings against a baseline and seasonal trends.
- Regularly check and adjust time controls on space heating, abstraction, and irrigation pumps to maximise the use of off-peak electricity supplied at a lower tariff.
- Replace or repair the automatic rain sensor used to switch off external irrigation when there has been sufficient rain.
- Purchase, install, and use 7-day programmable time switches to control space heating in the offices.

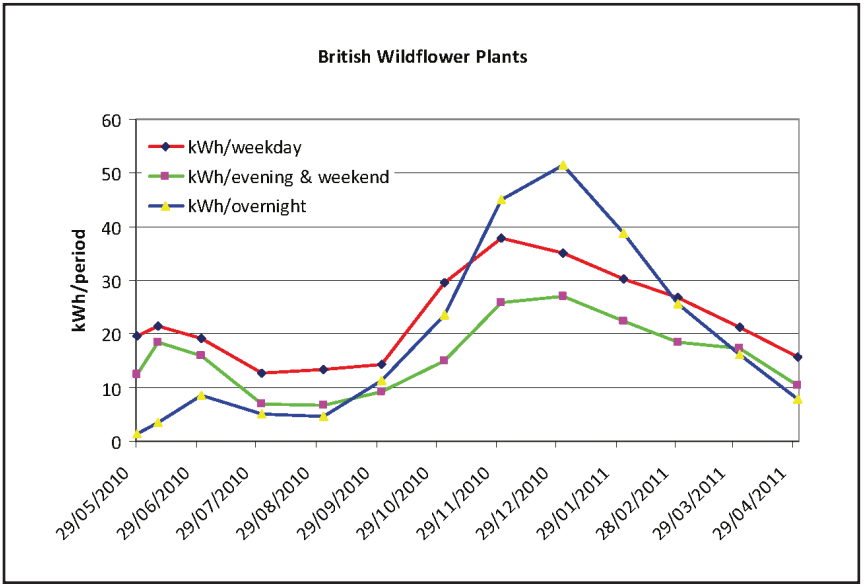

Figure 1. Trends in electricity consumption at British Wild Flower Plants from May 2010 to April 2011.

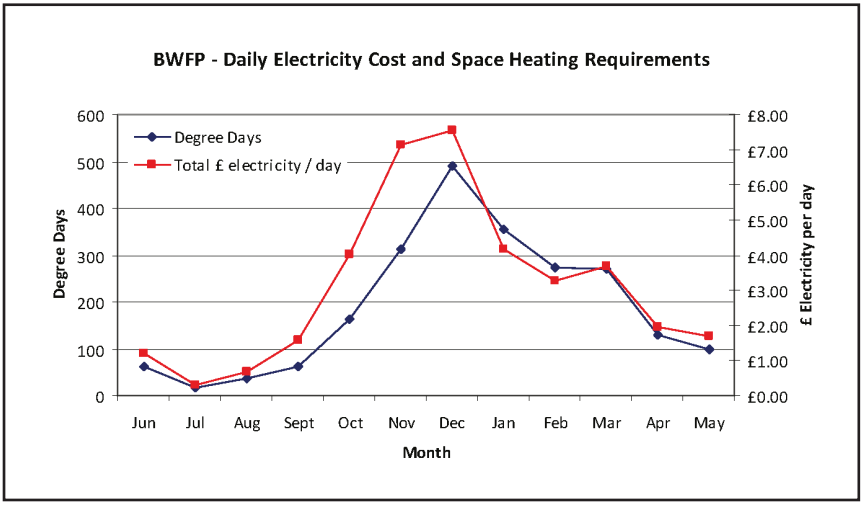

Figure 2. Comparison of daily electricity cost at British Wild Flower Plants (£ per day) against the requirement for space heating (degree days) from June 2010 to May 2011.

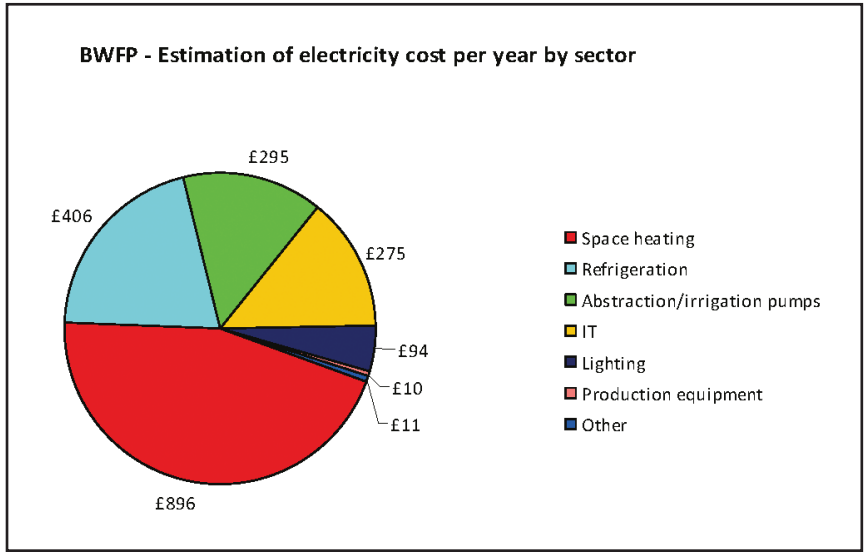

Figure 3. Estimated cost of electricity by sector at British Wild Flower Plants.

- Re-wire lighting controls to ensure that unoccupied areas of the site are not illuminated.
- Fit energy efficient lamps to existing light fittings.
- Replace and rationalise the existing refrigerated appliances with new A+ energy rated refrigerators.
- Purchase and install foil backed polyurethane insulation and fit to the inside of the existing office roof.

The great majority of these recommendations were no or low cost measures and the overall payback period was 2.3 years. It is estimated that implementation of these measures will reduce carbon dioxide emissions by 7.5 tonnes per year.

Given the nursery's energy demands and site specific constraints it was considered that the most applicable renewable energy technologies were solar hot water, solar photo-voltaic electricity generation, and air-to-air source heat pumps (the latter to provide space heating to the proposed new office).

It was estimated that a solar hot water system fitted to the proposed new office would reduce water heating costs by up to £100 per year and generate RHI payments of up to £90 per year. The estimated payback period was 10 years without financial assistance. In the UK, Enhanced Capital Allowances, resulting in a 100% tax allowance, are available for certain energy saving equipment in the first year following investment. More details can be found at <http://etl.decc.gov.uk/etl/default.htm>.

Solar photo-voltaic (PV) panels could provide a proportion of the site's electrical needs. However there was limited roof space available that was suitable for the location of the panels. It would be possible to install the panels on ground-mounted stands and connect their output to the site's existing electrical supply. It was estimated that a 3.69 kW peak PV system would reduce the cost of electricity from the

National Grid by £243 and generate £1,330 in FiT payments in the first year following investment. Such a system would cost approximately £14,800 to purchase and install and the estimated payback period would be 10 years.

An air-to-air source heat pump was considered to be viable to provide space heating to the proposed new office block on the understanding that the construction of this building would meet the insulation standards required by current building regulations. It was estimated that this would reduce heating costs by £63 per year and have a simple payback period of 3.2 years. At time of writing this type of technology is not eligible for payments from the RHI although specific models of air to air source heat pump can be eligible for 100% Enhanced Capital Allowances (ECA).

Biomass heating was not considered a viable option as the site has very limited and seasonal requirements for heat and there was insufficient fuel locally available.

Ground source or air-to-water source heat pumps were not considered to be viable due to the added investment cost associated with the installation of a wet radiator type or underfloor heating system and the relatively high cost for electricity, which would increase operating costs.

While the average annual wind speed in the area was greater than 5 m per sec, the speed at which wind turbines start to become financially meaningful, the presence of mature woodland surrounding, but not owned by, the nursery would cause significant local turbulence so the nursery was not considered to be a suitable location for a small-scale wind turbine. The site was not connected to the mains gas distribution network and had a relatively low and sporadic heat demand and therefore combined heat and power would not be appropriate at this site. The site was not on a river or watercourse suitable for small-scale hydro-electricity generation.

CONCLUSIONS

Since the completion of the study, British Wild Flower Plants has ensured that time controls fitted to space heating have been reset and that timings of abstraction and irrigation have been altered to maximise the consumption of electricity supplied at off-peak rates. In addition the company has ensured that the feedback control to turn off irrigation in the event of sufficient rainfall is fully operational. All of these measures were relatively easy to implement at no cost to the business and will yield immediate financial benefits.

Many of the results and recommendations relating to energy management made in this project can be readily transferred to other horticultural businesses. Where horticultural companies operate heated greenhouses there can be significant opportunities to improve the overall energy efficiency of space heating by a variety of means including making improvements to boilers and their insulation, improving and insulating heat distribution networks, improving efficiency of pumps and pump controls, improving thermostatic controls, and use of well fitted and maintained thermal screens. If artificial lighting is used there are opportunities to improve its efficiency through improved control, spacing and use of innovative low energy light emitting diode lamps.

The opportunities for site-based renewable energy technologies at British Wild Flower Plants were relatively limited by the spatial constraints, the relatively limited and sporadic requirement for space heating, and the lack of a suitable hydro resource. However it would be possible for the nursery to generate a proportion of its electrical needs through investment in a PV system which would generate income

from the feed in tariffs and reduce the cost of imported electricity. This site-specific financial assistance is available to UK businesses seeking to improve energy efficiency. This includes 100% ECA that are available for specific energy and water saving equipment, loans available from the Carbon Trust in partnership with Siemens finance and, if the business is in Scotland, interest-free loans available for energy saving and small-scale renewable energy technologies which are available through the Carbon Trust.

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Propagating Tropical Trees With Suitable Root Systems for Display Greenhouses©

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INTRODUCTION

Historically, Eden Project has had a number of larger species, mainly trees that have either fallen or have been removed from our rain forest biome because they were unstable. There is a whole list of factors that have contributed to this instability but poor root systems rank high on this list. The growing container shape could still clearly be seen in the root systems of a number of the fallen or removed plants; often they had not put out good extension growth into the soil and tangled roots and poor root architecture were common.

Achieving good active root systems, particularly on our tree species, therefore became an important aim of the Eden Project nursery. Many of the rain forest trees for the biome are grown from seed at the nursery, so we decided to examine and compare propagation systems traditionally used at our nursery with some newer innovations.

Many of the tropical tree seeds propagated at the nursery have come from wild sources so often have poor viability and/or long germination periods. To make best use of nursery resources, this seed was usually sown in seed trays and pricked out when large enough to handle into 9-cm liners or deep (rose) pots (depending on seed/plant size). Air-Pots™ were occasionally used for potting on.

MATERIALS AND METHODS

Investigating the root systems on several *Artocarpus heterophyllus* (jackfruit) plants that were about to be planted in the biome uncovered some serious problems with badly kinked roots and roots far longer than the depth of the deep pots in which they had been grown. As a result of these findings, an initial trial was set up using *Carica papaya* (pawpaw) to compare the effect on the root system of pricking out seedlings into four different pot types: Proptek™ pots, RootMakers™, Rootrainers™, and 9-cm liners.

Both the Proptek pots and RootMakers are air-pruning pots, having holes in their side walls to air prune roots as they reach them. There is evidence that this helps both build a fibrous root system and prevent the root spiralling often seen at the base of container pots (Whitcombe, 2003) The Rootrainer pots (designed for use in tree propagation) have ridged inner walls to guide any root growth to the base of the pot, again to help prevent root spiralling. The root systems of plants grown in each of the pot types were washed and examined several weeks after pricking out.

To find out whether the architecture of these early-formed roots really matters, plants from each container type were grown on in 8-L Air Pots, to test the theory that any initial differences in root system at this stage would persist when grown on (Single and Single, 2010). After 5 weeks in the Air Pots, the root systems were again washed and examined.

A further trial was set up using *Ochroma pyrimidale* (balsa) seedlings to determine the effects of root architecture on performance after transplanting into

the biome soil. Seedlings were pricked out into either 9-cm liners or RootMakers, with all plants grown on further in 8-L Air Pots and finally planted into boxes (1 m^2 by 0.6 m deep) filled with a loose gritty compost similar to our biome soil. After 12 weeks growth, the compost was carefully removed by hand to expose the architecture and extent of the root systems that had developed.

RESULTS

Roots formed in the RootMaker pot were considered to have the best structure, being dense, compact, and well distributed. The Proptek pots were considered to have produced the next-best root systems. The roots from the Rootrainer pot had

Figure 1. Rootwashed *Carica papaya* seedlings from initial pricking out. Top left (pricked out into 9-cm liner), top right (pricked out into Root Trainer), bottom left (pricked out into Proptek™ pot), bottom right (pricked out into RootMaker™ pot).

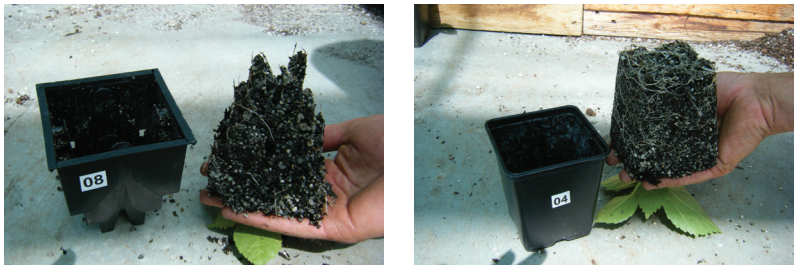

Figure 2. Root system of *Ochroma pyramidale* in 9-cm liner (right) and root system (left) from RootMaker™ pot.

maintained their "narrow shoulders" a shape that was thought unsuitable for our shallow soils and tropical tree species. Four out of six of the plants from the 9-cm liners had badly contorted roots (Figs. 1, 2, 3).

Effect of Root Architecture on *Ochroma pyrimidale* (balsa) Transplants. The RootMaker transplants were much smaller than the 9-cm transplants. They also had much less visible root on the outside of the root balls when compared with the 9-cm plants. This lack of visible root had also been noted in the *Carica papaya* trial. For the *O. pyrimidale* this top growth difference persisted until much later in the trial.

However, after final transplanting, the RootMaker plants grew away more quickly than those from the 9-cm liners and soon made up the initial difference in size.

Carefully removing the compost from the planting boxes revealed that two out of the three plants from the 9-cm liners had poor root architecture with much of the root system badly tangled and with evidence of root girdling. The plants quickly became unstable as the compost was removed. Two out of the three RootMaker plants had retained strong tap roots and had good root architecture. Roots extended to the sides and base of the planting boxes and ramified well through the compost. These root systems were extremely stable, even when completely undermined.

DISCUSSION

Producing plants with active root systems and good root architecture is critical to the stability and longevity of tropical tree species in display plantings such as those at the Eden Project. Our trials have confirmed that good root architecture must be "designed-in" from the moment seed is sown and that any root problems produced early on will persist.

Results from our trials using air pruning pots as pricking out pots for tropical tree species indicate that these are capable of producing very good root architecture, and that for such species 9-cm liners and deep (rose) pots should be avoided.

Owing to the holes in the side walls and shape of the pots, the Proptek and RootMaker pots do present a challenge as far as watering, handling, and potting is concerned but the superior root systems produced make any adaptation to nursery procedures worthwhile. The lack of visible root on the root balls of plants produced in these pots can be disconcerting and needs a leap of faith for those used to container pot root balls. The fact that the top growth and root ball appearance of tropi-

Figure 3. *Ochroma pyramidale* top growth and root system after 12 weeks from 9-cm liner (left top and left bottom) and from RootMaker™ pot (right top and right bottom).

cal plants such as those used in the Eden Project biome often gives no indication of any problems with root architecture means that finding a propagation system that almost guarantees good architecture every time is essential. In this case we have found that bigger is not better: before transplanting, plants grown in RootMakers are often smaller than those grown in conventional container pots but they will eventually make up the difference and, in the long term, the superior root systems are worth any initial lack of stature.

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Improving the Quality of Wildflower Seeds for Commercial Users©

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INTRODUCTION

Over the past 25 years or so there has been a great increase in the use of seeds of native wildflower species in the United Kingdom, as in other European countries and North America. Wildflowers have been increasingly sown in urban regeneration and civil engineering projects for their attractive appearance and low maintenance requirements. Wildflowers also attract wildlife so are used in habitat restoration, community biodiversity projects and individual gardens and estates. The use of wildflower species in agri-environment schemes is also popular.

The increased use of wildflowers has been followed by an increase in commercial production and trade of approximately 200 species of plants, most of which are new to commercial trading. In many cases seeds are not sold directly to the end users but may be sold to commercial growers to be raised as plants before being sold on.

"Traditional" agricultural and ornamental crop seeds are subject to quality regulations. Seed lots are sampled and subject to germination testing, purity analysis, and varietal testing. However, in the U.K., regulation does not extend to wildflower species. Some species are coincidentally covered by agricultural seed legislation, in the form of the Fodder Seeds Regulations. This legislation covers some species which are also traded as "wild" material such as *Lotus corniculatus*. However, the requirement for registered cultivars means that natural populations cannot possibly conform to varietal standards. Wildflower seeds are therefore generally traded without germination or purity results being available.

Scotia Seeds is a commercial supplier of wildflower seed. The company recognised the problems a lack of seed quality knowledge can cause for both producers and users and over the last 6 years has carried out research into the quality and dormancy of wildflower seeds. This research was funded by the Scottish Government in the form of 'SPUR' and 'SMART' project grants.

The research initially looked at establishing germination testing protocols and examining dormancy for commercially traded wildflower species. To date, Scotia Seeds has developed protocols for around 150 native species and in doing so has developed knowledge of the types of dormancy present in these species. Some species had germination conditions described in the ISTA (International Seed Testing Association) rules. However, these conditions are for cultivated material and wild populations can have different requirements. Each species has particular requirements for light and temperature as well as treatments to remove dormancy.

SEED QUALITY SURVEY

After establishing testing methods, a seed quality survey was undertaken to obtain an indication of seed quality available in the commercial market. The study tested nine wildflower species from eight seed producers and merchants. The samples were first examined for purity before being tested for germination. Germination was

Table 1. Comparison of (a) germination (%) (seeds that achieve at least physiological germination, with a 2-mm radicle) and (b) purity (%) of wildflower seeds from different sources.

(a) Germination

	Species								
Company source	***Primula veris***	***Leucanthemum vulgare***	***Ranunculus acris***	***Papaver rhoeas***	***Prunella vulgaris***	***Silene dioica***	***Ajuga reptans***	***Achillea millefolium***	***Galium verum***
1	49	64	3	20	93	22	-	45	95
2	61	61	58	3	92	74	-	81	76
3	48	86	52	28	-	88	-	-	67
4	0	20	20	-	88	30	44	-	13
5	90	87	60	23	85	92	-	83	78
6	34	69	65	-	3	57	-	88	75
7	51	7	-	9	98	-	37	92	56
8	81	78	77	50	52	74	9	100	-

(b) Purity

Company source									
2	100	98.7	99.4	98.8	96.3	99.4	-	97.2	99.5
3	98.7	91.5	97.3	88.3	-	97.9	-	-	95.4
4	99.1	99.2	82.6	-	95.6	100	85	-	99.2
5	100	86.3	97.0	82.3	93.7	97.7	-	91.9	99.4
6	92.4	95.2	99.7	-	93.5	98.8	-	98.3	98.7
7	92.4	95.4	-	100	97.7	-	100	100	95.5
8	100	100	99.3	100	100	100	100	99.3	-

assessed as total germination, which includes all seeds that have achieved at least physiological germination (production of a radical at least 2 mm long) (Table 1).

Large differences in germination were found between samples. For example, in the case of *Primula veris*, germination ranged from 0% to 90% and for *Leucanthemum vulgare* germination ranged from 7% to 87%. Of the 59 samples tested, 13 had a germination rate below 25%. One sample of *Achillea millefolium* reached 100% total germination whereas in *Papaver rhoeas* the maximum was only 50%. There were also consistent differences in the overall quality of seed from different companies.

Purity testing also showed differences in the proportion of inert matter found in some of the samples. In the case of *Leucanthemum vulgare*, purity ranged from 86% to 100% and for *Ranunculus acris* and *Papaver rhoeas* 82.6% to 99.7% and 82.3% to 100%, respectively.

These results reveal quality problems in a high proportion of the wildflower seed lots being sold in the U.K., with some lots being clearly unsuitable for propagation or planting because of very low (or no) germination. Most suppliers provided seed with poor germination in at least one species, suggesting that they could all improve quality control, and some offer seed which is inferior to other companies overall. The variability within species may be due to differences in field, processing, or storage factors and there is a clear need to identify the causes of problems. Variation in purity may also be due to field factors, such as weedy plots, but it is also strongly affected by processing. Results for both germination and purity suggest that some users may be purchasing seeds of poor quality so will have poor results from sowings.

DORMANCY

Dormancy in wildflower species can be problematic, particularly for commercial growers who may require seed to germinate within a certain period and for whom delays in germination can cause production problems. As part of the Scotttish Government funded projects, Scotia Seeds carried out research to establish priming methods. These techniques remove dormancy and mean that when seed is sown, germination occurs within a few days or weeks instead of many weeks, months, or even years. For example, unprimed *Echium vulgare* seeds had a germination of 10% after sowing into trays whereas the germination of primed seed was 74%.

In grower trials, untreated *P. veris* seeds had nil germination after 10 weeks whereas primed seeds had 52% germination after 10 weeks and were continuing to germinate. Similarly, untreated *Geranium pratense* had 11% germination after 10 weeks while primed seeds had a germination of 67% after the same period. The development of priming techniques not only has benefits for end users but has improved the efficiency of seed production at Scotia Seeds, with some crops being a whole year ahead.

CONCLUSION

The development of germination testing at Scotia Seeds has informed post harvest handling methods for many species allowing effective quality control for seeds lots. In particular, processing and storage has improved quality for previously problematic species such as *Rhinanthus minor*. Priming also has benefits for both producers and users of wildflower seeds, increasing germination and improving seedling establishment.

These findings suggest that successful establishment of wildflower plants is greatly dependant on initial seed quality and dormancy. More widespread germination and purity testing would benefit all users and prevent poor establishment due to seed quality. In order to ensure the success of wildflower sowings, users should insist that seed being purchased has been subject to quality testing.

Air-Layering Techniques for Conservation of Rhododendrons and Azaleas©

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Over the past 50 years or so many commentators have noted that air layering is not a viable method of propagation for rhododendrons and azaleas, or at best the results are generally poor. This paper describes a more practical approach developed from tests over the past 10 years, using basic tools and materials, which has achieved a success rate of around 90% in the author's garden and in field trials. In the past 3 years the methodology has been adapted to deal with conservation aspects relating to propagating plants that have been wind-blown and cannot be righted, plants damaged by falling trees, plants that are over-mature or dying back, and regenerating nursery stock plants. To date the results have been successful, including getting roots on air-layers where the plant itself is in poor condition or dying back.

INTRODUCTION

This paper describes methods for air layering to propagate old, difficult-to-root, or storm-damaged plants for conservation. Many commentators have suggested that air layering does not work, or at best the results are generally poor. However, the results that I have achieved over many years have been good, with a success rate better than 90%. Given that the methodology is one of the oldest techniques of vegetative propagation and was successfully used in China more than 4,000 years ago, this should not be a surprise.

PROPAGATION TECHNIQUE

Basic Requirements. Tools needed include a pair of clean secateurs, a clean sharp knife, and a pair of scissors. Materials required are a supply of damp sphagnum moss, a supply of fine or medium chopped bark, a clean, unused black polythene refuse sack (avoid clear/translucent material, as any light will inhibit rooting), and a supply of 15-cm plastic cable ties. It only takes a few minutes to complete each air layer once you are familiar with the methodology but patience is then required for root formation to complete.

Branch Selection. It is important to select as upright a branch as is practicable, 45 to 60 cm long, branched in two or three places and sturdy enough to support the layering materials. It is best to choose a branch that is out of full sun, not only to keep the layer a more even temperature, but to prevent the medium inside the wrapper completely drying out. Although the layering materials need to as lightweight as practicable, choosing too small a branch inevitably means it is under stress throughout the layering process and some form of support is required; it also leads to a very small root-ball that does not have much of a chance of establishment when the branch is severed and potted-on.

Preparation of the Polythene Wrapper and Growing Medium. Roll out the black polythene sack and, leaving the sack itself unopened, make three 25-cm-wide double-thickness strips by cutting directly across it.

Chop up a sufficient quantity of live sphagnum moss to loosely fill two-thirds of a 10-L bucket — a domestic kitchen liquidiser is ideal. Mix this with half the volume of medium or fine chopped bark. Add water to the mix until it is relatively wet. This volume of mix will provide sufficient medium for several air layers. Avoid using sphagnum moss by itself as this leads to the wound generating "water-roots" that will cause establishment problems later.

Wounding. I have experimented with four different types of wound and each has been successful. However, the most reliable method is to cut a 10-cm-long wound to expose the cambium. Completely remove the tongue that you have cut, as this will give the wounded area a better chance of rooting.

Creating the Air Layer. When putting the wrapper in place you are seeking to achieve a result that looks like an enlarged Christmas cracker rather than a ball, a cylinder which will be secured at each end with the plastic cable tie.

Take a large handful (about a litre) of the sphagnum moss and bark mix; this needs to be wet but not completely saturated, so squeeze out any surplus water. With one hand form the mix into a cylinder around the wounded area of the branch, then with the other hand wrap it securely in place with the black polythene to create a tube. Avoid wrapping too tightly as it is important that the mix remains wet, but it is equally important not to leave any large air pockets inside the wrapper once it has been sealed.

Fix the first plastic cable tie securely 4 cm from lower end of the wrapper as this will prevent part of the mix from falling out. Next, secure the top of the wrapper with a cable tie, and then open-up the loose ends of the wrapper so that the finished product looks like a Christmas cracker. Do not over-tighten either end of the wrapper, as it is important not to damage the bark — it does not need to be air-tight, just held securely in place. The upper end of the wrapper will act as a rain collector to irrigate the layer, the lower end acts as a drain to allow any surplus moisture, together with any salts generated during root production, to gradually leach away.

Securing the Branch. If the main branch tends to bend significantly under the weight of the air layer, or is likely to be blown around in windy weather, then secure it to another adjacent branch with a couple of long ties. Alternatively, if the air-layered branch is sufficiently low enough to the ground then, immediately below the branch, push a tall, thick bamboo cane well into the soil and secure the branch to it with ties.

ROOTING PROCESS

These air layers must be left undisturbed for at least two full growing seasons and resist the temptation to open up the layer to check on rooting progress as that will break-off the very fragile roots before they have had time to mature. A good indicator to look for in many instances, particularly with deciduous azaleas, is that once the air layer has rooted the plant begins to send out several new branches from its main roots. In the case of larger plants there is nothing to show that rooting has commenced other than the branch buds-up in the autumn and branches well in the spring.

Maintenance. Little maintenance is required, other than an occasional check to see that the cable ties are not too tight and to pour a small amount of water into the top of the wrapper if there is a long dry spell of weather. Remember that the air-layered branch will continue to grow over the 2-year period that the roots are being formed, so the branch may get significantly thicker. Sometimes, if the cable tie is under pressure, it will snap; or the leaves will start to wilt. Ideally the cable ties should be replaced each spring and autumn to reduce the possibility of the cable tie girdling the bark.

GROWING ON

Unwrapping. After two full growing seasons, cut the cable ties and carefully unwrap the polythene, taking care to support the new roots. Often the roots will grow partway into the layers of the polythene wrapper, so be aware of this. If there are only a few roots, or the roots are immature, then re-wrap the layer and leave it in-situ for a further year.

Severing and Growing-on. If the roots are mature then sever the rooted branch about 3 cm below the roots. Carefully tease and spread out the roots, plant in a wide 10-L plastic container. Position the bottom of the stem of the new plant against one side of the container, then hold the plant in place slightly diagonally so as the container is filled the upper part of the stem is centrally located when it exits the soil in the completely filled container. Get a piece of bamboo cane and insert this in the soil so it runs diagonally across the container and secure the main branch of the new plant to it with a cable tie or some twine.

The best potting mixture is pure medium chopped bark as this is relatively open and was a main component of the layering mix which helps minimise transplant shock. Place the container in the shaded area of a cool greenhouse for a year. The plant can then be planted out in a dappled-shade position, staking if necessary.

AIR LAYERING FOR CONSERVATION

Air layering is a useful technique that can be used for conservation purposes to propagate a wide range of difficult to root woody plants without resorting to specialised equipment or disturbing the parent plant unduly. Many old rhododendron hybrids are notoriously difficult to root from cuttings, as are some modern hybrids with complex parentages. Similarly Ghent azaleas are problematic to propagate. Air layering presents an easy alternative.

If a rare specimen has been damaged or toppled by wind, providing that at least some of the roots are still in the ground, or the root-ball can be back-filled with soil, then it is well worth considering air layering a few of the branches to provide a replacement. The technique is also particularly useful for propagating a replacement for an elderly specimen reaching the end of its life. In instances of this type it is suggested that three or four air layers are attempted, each on a different branch, so there is an increased chance of success.

Figure 1. Air layer placed on *Rhododendron macabeanum*.

Figure 2. Rooted air layer on *Rhododendron macabeanum*.

Figure 3. Potted-up *Rhododendron macabeanum* air layer.

Current Recommendations for Use of Rhizopon® Rooting Hormones©

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INTRODUCTION

Production of Rhizopon rooting hormones began in 1939 following research by the ACF Chemiefarma Company, originally the Amsterdam Quinine Factory, into propagation of quinine plants. The first Rhizopon rooting hormone products were introduced to nursery stock growers in the Boskoop area in 1940. Following a reorganization of ACF, Rhizopon was established as an independent company in 1987.

For the U.K. professional market Rhizopon offers several rooting hormone products based on the active ingredient, indole-3-butyric acid.

The formulated products are available as ready-for-use powders and water-soluble tablets in various packing sizes:

- ***Powders*:** Chryzopon® rose 0.1%, Chryzotop® green 0.25%, Chryzotek® beige 0.4%, Chryzosan® white 0.6%, Chryzoplus® grey 0.8%; Rhizopon® AA 0.5%, Rhizopon AA 1.0%, Rhizopon AA 2%
- ***Water-soluble Tablets*:** Rhizopon® AA 50 mg

This range of products ensures that there is a hormone product for almost any rooting situation. In addition they are extremely flexible in their method of application.

APPLICATION METHODS

Powder Quick Dip. This is the most common method of application and involves dipping the base of the cuttings to a depth of 1 to 2 cm into the powder and then shaking off surplus (Fig. 1).

Chrysanthemum cuttings are usually treated in bundles of 50 at a time. It is important to make sure that all cuttings are properly treated. Care should be taken that no leaves or other parts of the cuttings come into contact with the powder.

Water-soluble Tablets. Tablet formulations are unique to Rhizopon and offer a very convenient method of application by diluting in water. The tablets are placed in the required volume of water and are ideally mixed with a kitchen blender for 1 min. The active ingredient in the tablets will easily dissolve in water. A small part of the tablet will remain undissolved but this will have no adverse effects on the product's effectiveness. The insoluble sediment is simply part of the formulation which binds the active ingredients into a tablet.

The tablets are water soluble at concentrations of up to 30 tablets per litre water. If higher concentrations are required advice is available from the supplier.

The main application methods for the diluted products are:

Liquid Quick Dip. The most convenient method is a quick dip of the base of the cuttings for 5 sec in the solution. Take care that the solution does not come into contact with the leaves. Several cuttings can be treated at the same time (Fig. 2).

Figure 1. Bundle of cuttings treated in a powder quick dip. Make sure all the cuttings are well treated and that no leaves are in contact with the powder.

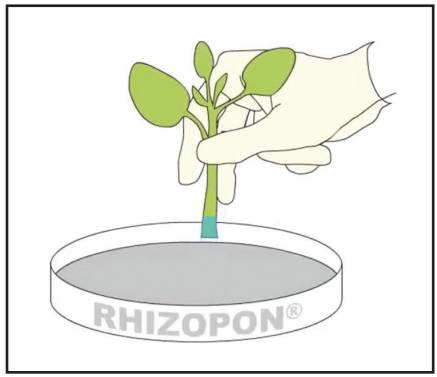

Figure 2. Liquid quick dip for 5 sec in the solution. Take care that the solution does not come into contact with the leaves.

Basal Long Soak. This is an old proven method that is currently making a comeback. The cuttings are placed in a perforated plastic box with the base of the cutting downwards. Then the box is placed in a plastic container of hormone solution, so that the bottom 10–20 mm of the cuttings are in the solution (Fig. 3). For conifers and shrubs the absorption time is 12 h. For leafless winter cuttings it is 24 h. This technique uses very low concentrations of hormone, but because of the long absorption time the cutting will absorb enough active ingredient to be effective. As with all the diluted methods do not re-use the solution after a treatment.

Another advantage of this method is that the active substance is incorporated with water that provides optimal turgor.

Total Immersion. This method is very suitable for soft cuttings and, again, low hormone concentrations are used. Place the cuttings in a plastic perforated box then completely immerse in the hormone solution for 5 sec (Fig. 4). After removal from the dip, let the excess liquid flow back into the container. Rhizopon advises that the solution should be used for no longer than 4 h in this method. The entire cutting will be in contact with the active ingredient and it can be absorbed through

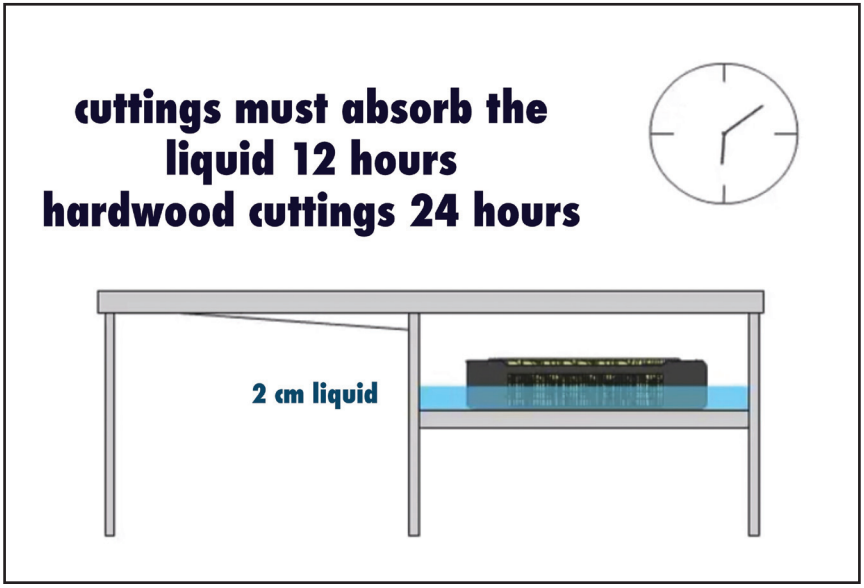

Figure 3. Basal soak. Dip the base of the cuttings 1 to 2 cm into the solution. For conifers and shrubs the absorption time is 12 h. For leafless winter cuttings it is 24 h.

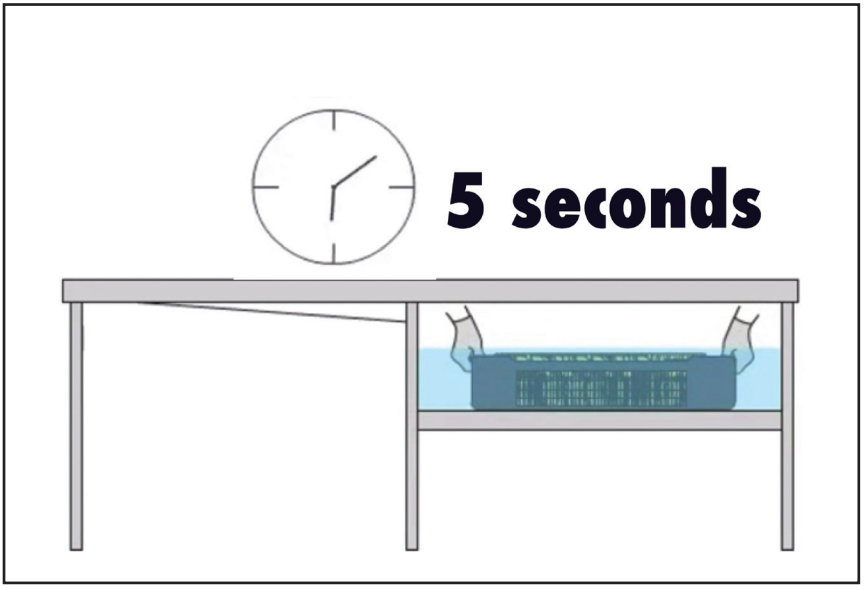

Figure 4. Total immersion. Place the cuttings in a plastic perforated box then completely immerse the cuttings in the solution for 5 sec.

stomata and pores. Because of the low concentrations, the total immersion method will not be harmful to the plant tissue.

Recent in-house research has shown that the total immersion method is suitable for rooting plants from tissue culture and micro-cuttings.

Spray and Drip Down. This is another very convenient method of using water-diluted hormone, often used by Dutch growers. After the cuttings are stuck, they are sprayed with hormone solution to runoff (Fig. 5). This method is suitable for soft shrubs, cut flower crops, pot plants, and perennials. Spray at a rate of 1 L of solution per 8 to 10 m^2 of stuck cuttings. Ensure even and consistent coverage by the spray.

This method can save labour, as one trained employee is able to treat a large number of cuttings at a time.

Inducing Additional Rooting. Where circumstances have resulted in poor rooting of cuttings it is possible to use hormone products to stimulate the cuttings to produce additional roots. Spray a solution of two Rhizopon AA tablets per litre of water, treating 8 to 10 m^2 of stuck cuttings per litre. This treatment can be repeated weekly or every 14 days. Ensure even and consistent coverage by the spray.

DISCUSSION

Vegetative propagation of ornamental crops is just like any industrial manufacturing process. It is important to properly identify and control all production resources and influences. In this case these can be considered under two headings, the crop and the cultural or environmental conditions.

Management of the Cuttings. Most growers understand that it is most important that the mother plants should be healthy and growing well. Cuttings taken from juvenile mother-plant growth will root faster and better. More mature mother plants can be pruned or even cut right back to just above the ground to stimulate the production of biological and physiologically active shoots from which to obtain cuttings.

In order to produce healthy well-rooted cuttings, feed the mother plants with organic fertilisers containing a moderate (4% to 5%) nitrogen content.

Rooting Conditions. The conditions to consider are climate, substrate, and production methods. In addition to careful management of temperature and humidity it is important to use a substrate that allows good gas exchange to ensure the base of the cutting has an adequate supply of oxygen and that CO_2 is not allowed to build up in the rooting zone.

The hormone product and treatment method should be carefully chosen with consideration given to:

- Shape, size, and sensitivity of the cutting.
- The number of cuttings to be treated.
- Speed and volume of roots produced.
- Expertise of the staff.
- Season.
- Ability to control the rooting environment.

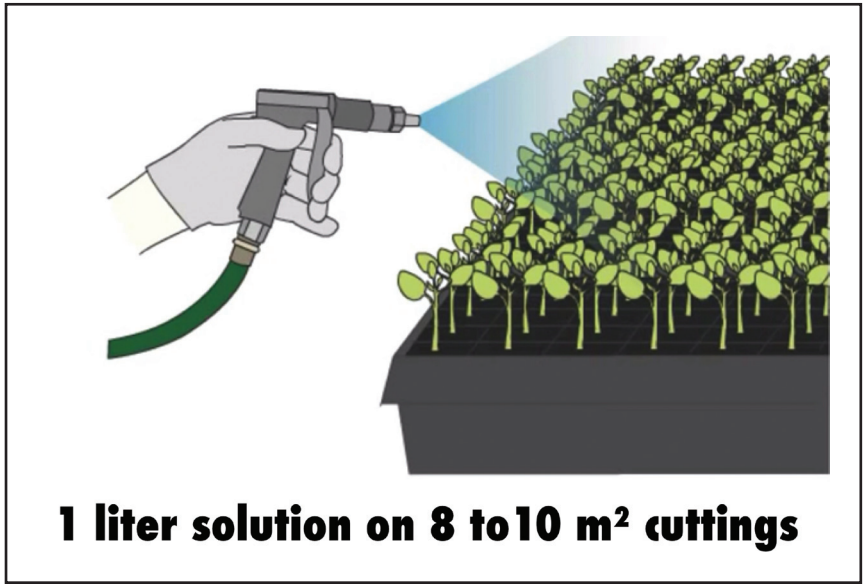

Figure 5. Spray application. After the cuttings are stuck, they can be sprayed with a Rhizopon® solution to runoff.

Further information on rooting hormones can be obtained from the following websites:

- <www.rhizopon.com>
- <www.fargro.co.uk>
- <www.rooting-hormones.com>

A New Propagation Guide for United Kingdom Nurseries©

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The Horticultural Development Company (HDC), the U.K. industry-levy-funded R&D provider, has been working on a project (HNS 183) which will result in a new comprehensive guide to propagation techniques which will be available free of charge to all HDC levy-paying nurseries.

The principal aim of the project is to critically review and collate key nursery stock research findings into a single publication which meets the needs of today's propagator. The guide, which is due for publication in 2012, draws on a considerable "back catalogue" of information and covers such key areas as stock-plant management, rooting media, post-rooting nutrition, rooting hormones, and propagation environments. Also covered are soft cuttings, hardwood cuttings, bench grafting, and propagation by chip budding.

A lot of useful information on propagation is tucked away in research papers and although widely dispersed still remains unused. Much of it is difficult — not to say time consuming — for busy growers to access but could usefully be applied to current day commercial practice to improve propagation performance. *IPPS Proceedings* and numerous research reports, notably those reflecting the pioneering work of, e.g., Dr. Brian Howard at East Malling and the late Margaret Scott of the former Efford Experimental Horticulture Station form significant points of reference. So too do the late Bruce Macdonald's iconic publication *Practical Woody Plant Propagation for Nursery Growers* and Lamb, Kelly, and Bowbricks seminal *Nursery Stock Manual*.

The project was conceived against this backdrop and has a broad coalition of industry support. All interested parties (which includes the Horticultural Trades Association and IPPS GB&I Region) agreed that the guide should bring together and harness current best practice and commercial knowledge with findings drawn from past and current research and development programmes. It should also be usable and accessible for training purposes. In many ways, it very much reflects the "Seek and Share" philosophy of IPPS.

This is a 2-year project, funded by the HDC and is being led by Andrew Hewson and David Talbot of ADAS. It is being guided by many industry leaders through a project steering group, some of whom will feature in the publication as case studies to show how research can be translated into successful nursery practice. The identification of current and future research priorities also forms an integral part of this project.

The first draft and case studies have been developed during 2011 and the final version is expected to be published in 2012.

A Propagator's Reflection: Thoughts on the Past and Future for the IPPS Western Region©

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I'd like to spend a few minutes with you talking about aging gracefully and responding to change. I'm hoping to inspire and challenge you (and myself as well). My goal is to make this relevant to us as professionals and Western Region members, so bear with me.

In one of my favorite books, *A Tale of Two Cities*, Charles Dickens begins with an observation of the contemporary history of the day:

> "It was the best of times, it was the worst of times,
> it was the age of wisdom, it was the age of foolishness,
> it was the epoch of belief, it was the epoch of incredulity,
> it was the season of Light, it was the season of Darkness,
> it was the spring of hope, it was the winter of despair,
> we had everything before us, we had nothing before us,
> we were all going direct to Heaven, we were all going direct
> the other way — in short, the period was so far like the present
> period, that some of its noisiest authorities insisted on its
> being received, for good or for evil, in the superlative degree
> of comparison only."

A similar metaphor is found in Chapter 3 of Ecclesiastes (Eccl 3: 1 8 NLT), where there is a well-known passage most of you will have heard:

> For everything there is a season,
> A time for every activity under heaven.
> A time to be born and a time to die.
> A time to plant and a time to harvest.
> A time to kill and a time to heal.
> A time to tear down and a time to build up.
> A time to cry and a time to laugh.
> A time to grieve and a time to dance.
> A time to scatter stones and a time to gather stones.
> A time to embrace and a time to turn away.
> A time to search and a time to quit searching.
> A time to keep and a time to throw away.
> A time to tear and a time to mend.
> A time to be quiet and a time to speak.
> A time to love and a time to hate.
> A time for war and a time for peace.

If you had to pick one word to describe the underlying theme in this passage, I don't think you could do much better than "change." It's interesting to note a few chapters later Solomon, the author, declares: "Do not say why were the old days better than these? For it is not wise to ask such questions." If Solomon wrote these 3,000 years ago, I think the following axioms can be drawn from his statements:

- Change is timeless and inevitable.
- Looking backwards can be educational, but can also be a snare.
- There are appropriate actions for the appropriate time.
- It should be possible to know where we are.

From my narrow point of view as a propagator and nurseryman, I have observed a great deal of change over the last 30+ years. I know that human nature tends to see the darker side of change; it would be easy to recite a litany of concerns I have as a member of the industry, if not as an American citizen; these are trying times for many of us. But that would hardly be too inspiring, would it?

I am not a flaming optimist by nature, neither do I think I'm tilted too strongly toward pessimism; preferring a more analytical viewpoint. When it comes to the glass half full versus half empty, I would tend to ask questions before committing:

- What's in the glass? Do I really want it anyway?
- Did I pay for a full glass? Why's it only half full?
- How big is the glass anyway?

And so on, you get the idea. I think I wore my mother out with questions when I was very young. One of my favorite things about propagation has always been the questions you can ask. There are always new things to learn, new discoveries and improvements to be made, along with an endless stream of new plants and cultivars to experience. If you're a little ADHD you can bounce from subject to subject for many years.

I have now been a propagator and a member of IPPS for over 30 years. In that span I have seen many changes affecting how we do business. My 55 years of life have included the advent of commercial jet aircraft, Sputnik and men on the moon; the demise of LP records, 8-track and cassette tapes, the invention of microwave ovens, photocopiers, fax machines, and personal computers, the Beatles and the Rolling Stones, etc. I know this dates me; some of you in the crowd maybe can't remember life before Starbucks and cellphones. I feel my oldest when I see a 1956 Chevy on the street and realize we may share the same birthday. Reaching this age has been a significant event for me and something of an obstacle to overcome. At some point I feel like I should grow up and act mature, after all I may not be a patriarch yet, but it can't be too far over the horizon from here. Knowing this, I have spent some time studying older people to learn from a few choice individuals who somehow managed to grow old with purpose, ability, and a good sense of humor. My favorites right now are John Wooden, the famous former basketball coach of the UCLA Bruins, and Art Linkletter, a past TV celebrity. What I admire most of these two individuals is the relevance and impact they had throughout their lives, long after their careers seemed to be over. Their examples still serve as relevant and inspirational.

Art Linkletter passed away in 2010 a few days shy of his 98th birthday. He was very active until shortly before his death, being an avid skier, swimmer, and surfer. He was a inspirational speaker, speaking 70+ times a year while in his 90s; talking to businesses, as well as those with Alzheimer's and in rest homes. His TV career included hosting several shows, including "House Party" and the "Linkletter Show." He was famous for his ability to interview kids, often with comical outcome. Out of these interviews came the book "Kids Say the Darndest Things."

John Wooden passed away last year a few months shy of his 100th birthday. He is justifiably famous for his coaching successes at UCLA, which included winning

NCAA championships 10 times in a 12-year period and 7 times in a row, as well as a record 88-game winning streak. Of far greater importance is his record as a mentor and teacher to his student athletes (which included Bill Walton and Kareem Abdul-Jabbar) as well many others in his retirement years through mentoring and books he authored; his impact post-coaching was arguably far more profound and wide-reaching.

One of John Wooden's quotes "Things work out best for the people who make the best of the way things work out" is significant for us today, perhaps more relevant is another: "Failure is not fatal, but failure to change might be."

John Wooden defined success as, "Success is peace of mind that is a direct result of self-satisfaction in knowing you gave your best effort to become the best of which you are capable." He left behind a model for achievement that he termed his "Pyramid of Success," which is built from traits to study and adopt; including industriousness, enthusiasm, loyalty, friendship, self-control, alertness, initiative, intentness, condition, skill, team spirit, poise, and confidence. At the peak is competitive greatness, illustrated by the principle that you give your best when your best is required, and that your best is required every day. I am challenged by the example he set and his words are a powerful motivation.

I see these two individuals as patriarchs whose lives and words provide guidance and inspiration worth studying. The International Plant Propagators' Society has had its share of patriarchs and mentors whose words are also worthy of remembrance.

The International Plant Propagators' Society was formed by a group of visionaries in 1951, whose primary goal was the betterment of an industry through freely sharing of knowledge among a brotherhood of professionals. The first several years of meetings were held in Cleveland, Ohio (from 1951 to 1958); we are very fortunate that not only were their presentations recorded but many of their discussions as well. The Proceedings from our first 10 years as a Society are available for free download on the Western Region website.

Edward Scanlon in his opening statement of the first IPPS proceedings said: "No man should ever entertain the thought that he is omnipotent. He may possess some little trick or secret of propagating successfully some difficult plant, but he should know also there may be others who have a better way, if not with his particular plant then with others in which he may also be having difficulties. He cannot help but be bettered by a frank interchange of knowledge; in the end, the introduction of plant aristocrats to common usage will redound to the enrichment of all, our cities, our homes, and our own personal well-being and satisfaction in having had any part, no matter how small, in the general advancement of the science of horticulture. We welcome to membership any person dedicated to a spirit of cooperation and general progressiveness."

He was followed by the first presentation of the Plant Propagators' Society given by James Wells, one of the greatest patriarchs of our Society. His opening speech should be required reading of all IPPS members. His address included these thoughts: "I have often thought that the plant propagator is more closely akin to the medical profession than to any other, for surprisingly similar qualities are required both for the good doctor and the good plantsman. A long and rigorous initial period of training followed by slow and sometimes painful acquisition of knowledge throughout a lifetime devoted to his work are equally true of both. The comparison is even closer when one considers how much success may depend upon painstaking study, the careful consid-

eration of all factors, before a diagnosis is given and treatment prescribed, for in both professions it is such attention to small intangible details."

The author John Steinbeck aptly echoed these sentiments in his book *The Grapes of Wrath:* "The men who graft the young trees, the little vines, are the cleverest of all, for theirs is a surgeon's hands and a surgeon's heart to slit the bark, to place the grafts, to bind the wounds and cover them from the air. These are great men."

James Wells went on to further elaborate on the premise of propagation being the cornerstone of horticulture: "I would like to dwell for a moment, if I may, on this question of craft. It is well for us to consider that the craftsmanship and skill of the plant propagator is the very beginning of a long chain of events running through every phase of our industry. It is upon this skill and upon nothing else quite so much, that all other parts of our great industry ultimately depend."

Of what use would the landscape architect or the landscape constructor be to the home owner if no plants of any kind were available? Where would the florist obtain his flowers, his bulbs and his seeds, and what could be the value of fertilizers, wheelbarrows, garden centers, and garden magazines without plants? Webster's dictionary defines horticulture as the art of growing fruits, vegetables, and ornamental plants, and all of these have to originate with the plant propagator. He is in very fact the basis of our industry.

The International Plant Propagators' Society was formed to be an elite Society, wherein membership was coveted and earned. Venerable members and patriarchs upheld these standards for many years. For well over 50 years propagation was not only the cornerstone, but the whole foundation of the IPPS. Now we have a new logo and a seismic shift that reflect a departure from this foundation, to embrace an expansive underpinning of "plant production," an apparent response to stagnating or declining worldwide membership; a change apparently intended to maintain the relevancy of IPPS in a climate of change.

Aging has taught me that although some change is sudden, most is gradual and best seen in hindsight. So it is with the marching on of our Society. We are constantly handing over the reins of leadership; with this also comes passing them on to younger and younger peers. Generation X, those of you born from 1965 to 1985, has become a pivotal group to direct the immediate future of IPPS; you in turn must determine how IPPS is to be relevant to Generation Y, born from 1985 to 2005. Generation Y is the most technologically savvy group the world has known, almost universally fluent in the cyber languages of our day, be it Facebook, Twitter, Skype, texting, etc. How is IPPS to maintain its relevancy to them? Perhaps an aging baby boomer is not the one who can answer this question entirely, but like James Wells, I will end my presentation with a little opinion.

The International Plant Propagators' Society, formed with strong principles, must not depart from them. It can still be an elite organization, especially to the extent its members hold to the ideals of "Seek and Share." The shift to embrace plant production as a primary focus ought to be regarded with great caution and our roots as a fraternity of plant propagators looked to as our first and primary focus.

Nevertheless, we face a great challenge to instill the same respect and expect the same honor and attention from a technologically erudite future generation. How can IPPS be winsome, 10, 20, or 30 years hence? I can't answer this, other than to postulate the solution is not to be found on Facebook, through Twitter, or propagation blogs, at least not yet. You cannot replace the strong impact of a cohesive

gathering of peers allied by a common interest, adhering to jointly held values. These annual meetings have been the backbone of IPPS worldwide for 60+ years and should remain so for decades to come.

Unfortunately, membership has declined. Perhaps this is partly understandable, in light of the sorry economic state of industry. The decline in membership is less traumatic if you take to heart the admonition of James Wells to be less concerned with numbers of members verses dedication.

Quoting him again from his address to the very first Western Region meeting in 1960: "Therefore, to sum up, I would urge you to organize on a very high level. Let membership in your chapter of our society be something to be prized above all other memberships that might be available to the person concerned. Let it be something that he has to strive to attain, and once attained, has to maintain at a high level in order to keep. Let there be stringent requirements of him not only to get in but to keep in. Let him be required to contribute regularly to the meetings or to the News Letter or to some aspect of your corporate activities, so that he remains an active contributing member. It is far better that you have a modest number of such people actively working together, than that you have a large number with but few contributors. The atmosphere generated and the pleasure each will receive from your meetings in the limited group will be far greater than in the wide unrestricted one."

It is possible we may need to plan for "smaller" meetings, at least in terms of attendance; this need not be discouraging, if we bear in mind that quality is not dependent on quantity.

Change has come to us as a society. Many of the founding members were owners or employees of much smaller nurseries compared to today's standards, people who supervised every facet of their business, from propagation to sales. Today we are more likely to be employees and IPPS expense and involvement must be justified to a superior. We need to be able to demonstrate the value of participation. We also may need to adjust our meeting structure to keep costs down. There are creative ways to accomplish this.

For those of you here and those who may read this in the future, please examine your involvement with IPPS. When have you attended a meeting and not gained substantially, above and beyond your contribution? IPPS needs your enthusiasm, your presence, your seeking and your sharing. When was the last time we thought of our membership as a privilege? Our founding members did and strongly sought to build this into the fabric of our Society.

I have valued my participation with IPPS more than any other group or activity as a professional nurseryman and propagator. My hope is that this organization is able to prosper for a long time to come and that many more will find the same delight and benefit. Long live Seek and Share!

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QUESTIONS AND ANSWERS

Douglas Justice: Mike, I think that was a brilliant presentation. I've often thought that, like society, we're have this idea that as we go forward we must get bigger and that could be the demise of the IPPS. I certainly think it's going to water down the IPPS. So, I would agree with you and I think this deserves some greater discussion. We probably need to look at what an IPPS with fewer members would be like. I think that's clearly where we're going.

Mike Anderson: That's something that I got from reading these first Proceedings. They had a certain amount of infighting that you can find by reading through it. One of things they labored over a little bit was the number of members. There were some that really didn't want to see it grow above a small group. Part of it was the comfort level of addressing a small group as opposed to speaking to a large group. Also the freedom to share in a smaller group as opposed to a larger group. I think they understood how the dynamic would change as it grew. Jim Wells was all over that. They met 8 years in Cleveland, OH, and some fought moving anywhere else; they really wanted to stay right there. They ultimately moved to Philadelphia where they began laying the foundation for a western region. If you remember there was a presentation a few years ago from Don Dillon, a founding member of the Western Region, and there was some infighting even then since some were opposed to that happening. They wanted it to stay as one group and wanted it to stay small. The most cheering thing to me is that growing smaller isn't necessarily a bad thing. If you pick up the quality and the interchange grows, you may have a smaller group, but you can still accomplish an awful lot.

David Hannings: As I remember it, when Doug and I served on the International Board when these sorts of things were discussed, it used to be that to become a member you had to be recommended by a current member and it used to be that you had to attend and/or present every so often at an annual meeting in order to keep your membership. We've let those things slide by or gotten rid of those rules all together. Maybe that's something we can rethink. We would end up with a smaller group where active participation is more common. Many come to the annual meetings, but many others don't do anything to add to the Region.

Mike Anderson: We used to also have a junior membership level for people with limited experience. Membership used to be restricted; it wasn't easy to become an IPPS member, but I think it made it all that more desirable at the time.

Fred Hopkins: When I became a member you had to have 2 or 3 nominations. Bruce Briggs signed for me so did Fred DeWalt. That wasn't enough; you had to be "inspected." I got a phone call that a gentleman was going to come out to my nursery and I was young and really excited about joining because I had met these storied members of the Society and I wanted to borrow that knowledge. He asked me lots of questions to see whether I knew what I was doing or not and when he left I didn't know whether I was going to be accepted or not. It was really something.

Kristin Yanker-Hansen: We have a similar problem with the California Horticulture Society. We're struggling with this very issue because we're concerned that we're not bringing new people into the field of horticulture. I'm more concerned is that we're not going where society is going. Young people I see today are getting their information from the Internet. They don't yet see the value of coming to an organization like this. Some see the benefit of face-to-face contact, but there's still a disconnect. There is less respect for experience now since so much information is available online. I don't know how we address that, but I think that has to be part of the discussion.

Mike Anderson: This is the generation we need to appeal to. They have technological skills most us can only dream of having, but will never get there. How can you replace a meeting like this? You can't replace it with a blog. You can't replace shaking someone's hand and hearing some new information or seeing it for yourself.

Mike Bone: It's really easy to look around and see the demise of these great big organizations whether they are companies or societies. Our Area Meetings make it so much easier to be active, to have a voice and to seek local knowledge.

Betty Young: I'm privileged to have a vibrant internship system. Part of our internship program is teaching classes throughout the internship year that provide the scientific background for those who need it and practical experience classes during the year while they're doing regular work. Consistently, the classes that are most appreciated are the ones that are hands-on where they are learning and practicing new techniques. Our recent college graduates are so sick of PowerPoint presentations that makes teaching them new things a challenge. Maybe one way of increasing interest in the Society and in annual meetings is to make more of our activities of the hands-on type.

California Native Plants: Easier to Promote than to Propagate©

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Through the years, California's native plants have enjoyed alternating periods of attention and neglect, depending mostly on the current water supply for landscape irrigation. During periods of drought, when reservoir levels are low and it behooves the water industry to promote conservation, there is often a promotional push for plants that require less supplemental water and natives easily step into the limelight. Eventually though, the rains return, along with the old habits of planting and maintaining thirsty exotic plants. It becomes quite easy to forget about all water crises — past, present, and future. This is the fickle nature of promoting a line of plants based principally on water supply emergencies.

There is no disputing that California's native plants are perfectly suited to the climate, weather conditions, soils, and environmental conditions for California gardens. Also, with more than 5,000 taxa, the sheer statistical odds of a few being beautiful are quite high. The fact is, with a nearly 50% endemism rate and a fantastic diversity in geography and climate, California native plants are among the most unique and beautiful in the world. So "promoting" them for garden use should be a no-brainer. Those in the know are continually pitching natives as the appropriate alternative to high-maintenance exotic plants. Native plant landscaping is truly "sustainable" in every sense of the word.

But in the big picture of California horticulture, native plant gardens still fall into a category of a somewhat "boutique" garden. Because of the great abundance of available plant material grown in California, exotic plants still rule the day as the common choice for outdoor decoration. Those gardens are usually not "sustainable" in any sense of the word.

A new line of plants called "California Friendly" is the most recent attempt to promote plants that supposedly use less water than their thirsty counterparts. The problem with this label is that many plants are included that actually need copious amounts of water, especially when they are used in hot inland locations. There is no real definition for a "California Friendly" plant except that the water industry is desirous to work with the horticultural industry to showcase plants that will grow with less irrigation.

Without clear lines defining what is and what is not a "California Friendly" plant, the promotion effort is in the hands of the promoter, thus the plant industry has put forward more than a few taxa that are not really sustainable in California's dry growing conditions and are therefore not (by definition) very "friendly." Meanwhile, native plants are easily defined (native is native) and, being wholly sustainable and suitable for California's conditions, are the "friendliest."

And herein lays the problem. When the easily defined natives get lumped into the wishy-washy line of exotic and so-called "California Friendly" plants, they get lost in the fray, because for the most part, the non-natives are easier to propagate and grow in the nurseries. They are simply more readily available in the trade.

The "California Friendly" plants are promoted in the name of water conservation and many of the "poster-child" selections happen to be California natives. Not only that, but some of the cameo shots (the cover photographs—let's call them yearbook pictures) happen to be of species which are amazingly beautiful and photogenic, and also difficult to grow in nurseries [e.g., *Fremontodendron* (fremontia), *Romneya* (Matilija poppy)].

In those cases, and with water conservation as the driving purpose, the natives are then much easier to promote than to propagate.

What are a couple taxa that have great yearbook pictures, but are a challenge to produce in the nurseries?

***Fremontodendron* spp. and cultivars.**

- Problem: Summertime root rot in containers.
- Cause: *Phytophthora* and *Pythium*.
- Solution: Proper warm-season water management, cool root-balls, fungicides, fully rooted plants by late spring, no summer pruning, shade, dry foliage.

***Romneya coulteri* and *Romneya* 'White Cloud'.**

- Problem: Difficult to propagate, scarce availability of stock.
- Cause: Species plants require seed treatment by fire. 'White Cloud' can only be propagated from root cuttings.
- Solution: specialized propagation in winter. Seed treatment and laborious root cutting harvest to make new plants.

SUMMARY

Propagators should be involved in the promotional efforts of "California Friendly" plants, especially the natives, so water and resource conservation programs do not backfire. The plants have to actually be in the marketplace and not just in brochures, posters, and other promotional materials. Better coordination is needed between the horticultural community and the water agencies who promote drought-tolerant plants for water conservation.

QUESTIONS AND ANSWERS

Mike Bone: For the root cuttings coming from the trenches, are you constantly moving your stock block as you remove root cuttings or do you backfill the trenches and replant your motherstock?

Mike Evans: We replant the crowns, but never totally decimate the entire stock bed. We give it 1 year so it can grown back. The crowns will be set aside and planted either in pots or back in the ground right back in the plot, but we can't take root cuttings from there for 2–3 years. This, then, is a rotation plan on the stock bed.

Germain Boivin: What soil mix do you use and do you use any fungicides for *Romneya* and *Fremontodendron*?

Mike Evans: The soil medium is about 80% inorganic materials (vermiculite, perlite, and sand) with 20% coir peat so it drains really well. We dust the root cuttings with sulfur or something like that. The timing for taking cuttings is probably the most important factor for *Romneya*.

Seed Propagation of Several High-Elevation California Natives©

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INTRODUCTION

Cornflower Farms propagates a wide array of California native plants ranging from desert to wetland and coastal to alpine species. Propagation is done from cuttings, seed, and division. Here, we'll address seed propagation of several high-elevation California natives including: *Artemisia tridentata, Ceanothus cordulatus, C. integerrimus, C. prostratus, C. velutinus, Eriogonum umbellatum, Linum lewisii, Lupinus grayi, Penstemon newberryi, Potentilla glandulosa, Prunus andersonii, P. emarginata, P. virginiana, Purshia tridentata, Ribes nevadense, Rosa woodsii, Sambucus nigra* subsp. *caerulea,* and *S. racemosa.*

SEED PROPAGATION PROTOCOL

Typical Seed Treatments. Many California native plants produce seeds that have complicated and sometimes not-so-complicated dormancy issues. We employ different seed treatments to break dormancy and encourage germination:

1) Hot water treatment: Hot (180–212 °F) water is poured over the seeds and allowed to soak for 24 h. Seeds are then drained.
2) Warm water treatment: Warm (120–140 °F) water is poured over the seeds and allowed to soak for 24 h. Seeds are then drained.
3) Cold Stratification: Seeds are kept in moist media at 40–45 °F, and either removed when germination starts or after a predetermined length of time.
4) Leach: Seeds are leached in running water for a predetermined length of time.
5) No treatment: Dry seed is sown without a pretreatment.
6) Hydrogen peroxide: Seeds are soaked in a solution of hydrogen peroxide for a predetermined length of time.

Seed Sowing Techniques. After the appropriate pretreatment, seeds are either sown individually into the liner or are sown into a seed flat. Seed flats may be covered with sand or vermiculite or may be left uncovered. Generally, size of the seed and sensitivity to transplant determine how they will be sown.

Protocol by Species.

1) *Artemisia tridentata* (big sagebrush): Cold stratify for 90 days in perlite. Flat sow. No cover. Seed flats need to be kept moist until germination. Transplant when first set of true leaves emerges.
2) *Ceanothus cordulatus* (whitethorn), *C. integerrimus* (deerbrush), *C. lemmonii* (Lemmon's ceanothus), *C. prostratus* (mahala mat), *C. velutinus* (snowbush): Hot water treatment. Cold stratify in perlite until germination occurs. Direct-sow seeds that have germinated into liners.

3) *Eriogonum umbellatum* (sulfur buckwheat): No treatment. Sow fresh seed into seed flat. Cover with sand. Transplant when first set of true leaves emerges.
4) *Linum lewisii* (western blue flax): No treatment. Sow seed into seed flat. Cover with sand. Transplant when first set of true leaves emerges.
5) *Lupinus grayi* (Sierra lupine): Warm water treatment. Direct sow seeds that have imbibed water into liners. Treatment can be repeated on seeds that have not been imbibed.
6) *Penstemon newberryi* (mountain pride): Warm water treatment. Cold stratify for 60 days in perlite. Flat sow. Cover with sand. Transplant when first set of true leaves emerges.
7) *Potentilla glandulosa* (sticky cinquefoil): No treatment. Sow seed into seed flat. Cover with sand. Transplant when first set of true leaves emerges.
8) *Prunus andersonii* (desert peach): Soak in water for 8 days. Cold stratify for 150+ days in perlite. Direct sow seeds that have germinated in liners.
9) *Prunus emarginata* (bitter cherry): Leach in running water for 8 days. Cold stratify in perlite until germination starts. Flat sow. Cover with sand. Transplant when first set of true leaves emerges.
10) *Prunus virginiana* (chokecherry): Warm water treatment. Cold stratify in perlite until germintaion occurs. Direct sow germinated seeds into liners.
11) *Purshia tridentata* (bitterbrush): Soak in 3% hydrogen peroxide for 5 h. Flat sow. Cover with sand. Transplant when first set of true leaves emerges.
12) *Quercus vaccinifolia* (huckleberry oak): Warm water treatment. Cold stratify in peat moss until germination occurs. Direct sow germinated acorns into liners.
13) *Ribes nevadense* (Sierra currant): Warm water treatment. Cold stratify for 90 days in perlite. Flat sow. Cover with sand. Transplant when first set of true leaves emerges.
14) *Rosa woodsii* (interior wild rose): Warm water treatment. Cold stratify in perlite until germination occurs. Flat sow. Cover with sand. Transplant when first set of true leaves emerges.
15) *Sambucus nigra* subsp. *caerulea* (blue elderberry), *S. racemosa* (red elderberry): Warm water treatment. Cold stratify in perlite until germination occurs. Flat sow. Cover with sand. Transplant when first set of true leaves emerges. Very susceptible to fungi at all stages of propagation!

QUESTIONS AND ANSWERS

Todd Jones: Are you collecting your own seed or do you purchase them from others?

Neal Funston: We collect many of our own seeds from the American River Parkway near Sacramento or we may collect seeds from the site on which we're going to plant. We buy some seeds from local seed collectors and also a few collectors in the Sierras.

Mike Bone: More of a comment than a question. I've read there seems to be some allelopathy with *Ribes* where seed germination is higher if seeds are sown in individual plugs versus in a seed flat.

Steve McCulloch: I have two questions. First, in your overnight soak using hot water, what is the temperature of the hot water?

Neal Funston: About 160–180 °F.

Steve McCulloch: Second, on what plants do you use hydrogen peroxide?

Neal Funston: I believe only on *Purshia*.

Kathy Echols: What is the reason for the gravel on top of the seed flats?

Neal Funston: It's used to prevent seeds from flushing out with heavy rains.

Kathy Echols: How do you perform your leaching?

Neal Funston: Seeds, wrapped in burlap or similar material, are placed in a bucket in a bath tub and water is slowly applied by a hose.

Douglas Justice: Do you direct-sow any of your seeds into plug trays?

Neal Funston: Yes, we direct-seed *Ceanothus* into plugs. We prefer to only direct-sow seeds that are going to germinate quickly and in high percentages.

Multi-Budded Fruit Trees©

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INTRODUCTION

Backyard fruit trees have always been popular in the residential landscape. Grocery store fruit can be lackluster, to say the least. The health-conscious consumer has become more demanding than ever. Residential fruit tree, vegetable, and herb gardening has become more popular than ever, and it's not just a trend, but a lifestyle change.

With the reality of residential properties becoming smaller and smaller, the popularity of multi-budded fruit trees have increased dramatically. It's common sense; grow three or four successive ripening varieties in the space of one orchard size tree. Home orchardists are not looking for the same yield as commercial growers. In fact, it's just the opposite. They want a little fruit all the time, as opposed to farmers looking to harvest large crops all at once. The multi-budded fruit tree fills this niche.

From the wholesale growers' perspective, with experienced, well-trained propagators on staff, it's no more difficult to grow multi-bud trees, than it is to grow single bud varieties. Multi-bud trees demand a premium price on the wholesale and retail markets. To the nursery professional, multi-bud trees have a desirability and mystique that demands attention and increases marketability.

Considerations for growing quality multi-bud trees are: (1) rootstock selections and cultivation, (2) bud selections chosen for successive harvest, cross pollination, and compatibility, (3) top-working of mature trees, and (4) helpful hints for the home orchardist.

MULTI-BUDDED FRUIT TREE CONSIDERATIONS

Rootstock Selection and Cultivation. Successful rootstock selections should be sturdy and self-supporting, adaptable to a diversity of climates and soils, bud compatible to a wide range of varieties within their genus and species and disease and insect resistant whenever possible.

Young rootstock seedlings or rooted cuttings should be lined out and grown for the first season to a height of 48–60 in. (without topping). Desired size for budding is $^{3}/_{8}$–$^{1}/_{2}$ in. caliper, at a height of 24–30 in. Three to five buds can be inserted into each rootstock. Buds can be set in the fall (Aug./Oct.) and equally spaced around the circumference of the rootstock. Each bud should be given an equal percentage of growing space and not overcrowded. Young buds will heal in to the rootstock and go dormant for the winter season. As trees come out of dormancy the following spring, buds will grow vigorously and should be trained as primary scaffolding structure for future fruit development. Growth should be monitored through this first growing season, to ensure that no variety is allowed to dominate the combination. All buds should be of equal vigor at the end of season to promote a healthy balance of structure.

Bud Selection Considerations. A well-balanced multi-bud tree should consist of varieties that harvest successively. Early, early-mid, late-mid, and late-season varieties should be included so that fruit can be harvested all season long. This successive harvest sequence is crucial to the success of any home orchard; a small harvest of fruit over an extended period, as opposed to a large harvest of fruit all at once. Another consideration is cross pollination. If desired varieties are not self fertile, cross-pollinating varieties should be included in the budded selections. It's a well-known fact that even self-fruitful varieties will produce better crops with cross pollination. It's very important to select compatible varieties for inclusion in the combination, as some varieties may not be compatible to some rootstocks. Vigor is also a consideration, as some varieties can be easily overgrown by more aggressive selections. Remember, first season management practices are important to make sure no varieties are allowed to dominate the combination.

Top Working of Mature Trees. Often, mature fruit trees are unproductive or undesirable. Maybe the variety needs more winter chill than certain geographic areas can provide. Sometimes the fruit quality is undesirable or the tree is just not productive due to lack of pollination. Mature fruit trees of good health can be easily top-worked to change one variety to another, add cross-pollinating selections, or add variety to create combinations. Top working can be easily accomplished by bark grafting during the dormant season, to large caliper scaffolding branches. With bark grafting several two to four bud scions can be inserted under the bark layer at the point of fresh cuts. These scions should be secured with heavy nursery tape and any exposed cut sealed with a grafting wax or pruning seal. Within one season, young grafts can grow out several feet and become productive in the second year. Continue to follow the same basic structure management practices to achieve balance of growth.

Helpful Hints for the Home Orchardists. For long-term success with multi-bud fruit trees a few common sense horticultural practices should be followed. Always consider the planting site. Make sure the tree is in the right soil for the rootstock and the varieties are adaptable to the specific climate. Make sure when placing young trees to angle the weakest grafts toward the southwestern exposure. Never give vigorous grafts the dominant position for exposure. With any young fruit tree, protection against sun burn is an important consideration. Be sure to white wash the trunk and young branch structure with a very light coat of neutral color paint. Remember to prune all varieties to a balance; never let one variety dominate the combination. No graft should be any more vigorous than the weakest graft on the tree. Irrigation should be thorough when applied, and established trees should be allowed to go just slightly dry between watering. Fertilize two to three times per year, from late-winter through mid-summer, with a low nitrogen fruit tree fertilizer. A little more nitrogen for young trees establishing fruiting canopy is acceptable, but after fruiting structure is established, nitrogen just creates more growth, more pruning, and less fruit. A little goes a long way. Be sure to mulch the soil surface under the canopy with bio-diverse large particle wood mulch. Enjoy fresh, tree ripened fruit all season long.

For more information on multi-budded fruit trees and fruit growing in general, be sure to visit us at <www.davewilson.com>.

QUESTIONS AND ANSWERS

Anonymous: What apple rootstock would you use for a wet soil or a dryer, sandier soil?

Tom Spellman: It depends on the kind of tree. There are some great selections for Malling Research Station. M 7 or MM 111 are probably the most popular apple rootstocks in the world at this point. They are very diverse in their adaptability. They'll take a heavy, wet soil or they'll take a fairly dry soil. They're bud compatible will all *Malus* cultivars. They don't sucker very readily after the first year or so. They're fairly resistant (not immune) to *Eriosoma lanigerum* (woolly apple aphid).

Douglas Justice: Can you talk a little about pollinizers?

Tom Spellman: That's a great point for multi-budded fruit trees since it provides an opportunity to include the pollinizers on your selections. Even self-fertile variety of *Malus, Prunus,* or *Pyrus* will always produce a much better crop if they have cross-pollination.

Douglas Justice: When you're selling a tree that has early, mid, and late maturing fruit ripening don't you also have to consider when the timing of the pollinizer?

Tom Spellman: Yes, but with most varieties, especially apple, it's relatively easy to select ones that are compatible both in terms of budding and in terms of pollination.

Patrick Petersen: What is your main method for getting after-care information into the hands of your customers?

Tom Spellman: We're really proud of our website. We put a lot of information there.

David Cain: Do you have one budder do all the buds on one tree or do you have four budders each doing one variety?

Tom Spellman: We use four budders. Each one knows the placement of their particular bud and they just follow each other down the row.

Jack Bennett: What's your opinion of the practice of planting two trees in one hole?

Tom Spellman: I'm all for it. That's an extremely important concept for backyard orchard culture. The goals of a backyard grower are different than those of a farmer. The backyard grower wants a little fruit all the time while the farmer wants a lot of fruit all at once. This can also affect tree spacing considerations. In a backyard, trees can be grown closer together. When you plant multiple plants in one hole you can select which ones are planted. In a multi-budded tree the variety selections have already been made for you.

Charles Brun: In southwest Washington we need a more dwarfing apple rootstock than MM 111. What would you recommend?

Tom Spellman: MM 111 is the most popular dwarfing apple rootstock, but it's only about 15% dwarfing. Absolutely, we need other choices.

Charles Brun: Do you have any plants that use the M 9 rootstock?

Tom Spellman: We use about 12 different apple rootstocks including M 27, M 9, and others that are considerably more dwarfing than MM 111. We don't use those for multi-budded trees since the resulting plants are too slow-growing to produce a quality nursery product.

Charles Brun: In western Washington we're faced with dealing with apple scab, which makes or breaks backyard grower's success and satisfaction. Will you design us a tree that will be resistant to apple scab?

Tom Spellman: I'll get right on that.

Effect of Container Type on the Nursery Growth of Two Palms©

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Palms have a fibrous, adventitious root system where all primary roots arise independently from one another from the base of the stem in an area called the root initiation zone. Because of the nature of this root system, palms are especially amenable to container culture. Commercial growers, collectors, and hobbyists grow palms in containers for potting up, sale, and/or placement in the landscape. Palms are typically grown in traditional, straight-sided, solid-wall containers. Several nontraditional containers with perforated side walls that allow air pruning of roots reportedly to enhance growth of shrubs and trees through development of a stronger denser root system have been introduced to the nursery trade. Fitzpatrick et al. (1994) found that mahogany [*Swietenia mahagoni* (L.) Jacq.] grown in air-root-pruning containers had lower root mass and higher shoot-to-root ratios compared to trees grown in standard black plastic containers while Marshall and Gilman (1998) found that red maple (*Acer rubrum* L.) grown in air-root-pruning containers had reduced root ball mass and fewer roots deflected by the container sidewall compared to trees grown in standard black plastic containers. Would these nontraditional container types be beneficial for nursery container production of palms? We conducted a 2-year study at Keeline Wilcox Nursery in Oxnard, California to answer this question.

In May 2008, using the nursery's standard potting soil, we potted 1-qt kentia palms [*Howea forsteriana* (F. Muell.) Becc.] and 1-gal king palms [*Archontophoenix cunninghamiana* (H. Wendl.) H. Wendl. & Drude] into seven different container types/volumes for each species (four container types, two sizes of three of the types). We used 10- and 14-in. standard nursery containers (Nursery Supplies, Inc., Orange, California), 3- and 5-gal RootBuilder® containers, 10- and 13-in. RootMaker® containers (Rootmaker Products, Co., Huntsville, Alabama), and 12-in. Accelerator® containers (Nursery Supplies, Inc., Orange, California). The study was set up as a randomized complete block with two palm species, seven treatments (container types), and 20 replications for a total of 280 palms/containers. We tagged the newest emerged leaf of each palm and set them out under 50% lath shade. At 6-month intervals we recorded stem diameter, quantity of leaves produced, and overall quality. In April 2010 we harvested the roots, dried them, and recorded their dry weight. Keeline Wilcox Nursery irrigated and managed the palms as they did for kentia palms in adjacent production bays. Because we primarily wanted to compare the container types, we controlled for initial stem caliper and container volume in data analysis.

Results showed that none of the nontraditional container types produced more leaves, greater stem diameters, more root mass, or higher quality than traditional containers. Also, no container produced lower root mass. RootMaker was equivalent to the standard nursery container for growth and quality for both palm species. RootBuilder produced significantly fewer leaves and smaller stem calipers for both species and poorer quality for kentia palms than the standard nursery container, but the same quality for king palms as the standard nursery container. Accelerator produced significantly fewer leaves, smaller stem calipers, and lower quality than the standard and RootMaker containers for both species and smaller stem calipers and lower quality than all other containers for king palms. Generally, palms in larger containers tended to produce more growth and were of higher quality than those in smaller containers. RootBuilder containers had to be assembled and their straight sides precluded stacking empty containers in nested fashion to save space.

Thus, we feel that none of the non-traditional container types were advantageous for growing palms. The generally poorer growth in the nontraditional containers might have been due to the perforated side walls allowing excessive drying out of the potting soil between irrigations, which were scheduled to optimize growth in kentia palms in adjacent production bays. Also, we found that the sidewall-slits in the Accelerator allowed potting soil to be washed out of the container and water lost at each irrigation, exposing the roots and causing excessive drying.

We thank Keeline Wilcox Nurseries for donating the kentia palms and some of the containers, allowing us to conduct this experiment at their facility, and irrigating and managing the palms in the research plot; ABC Nursery in Gardena, California, for donating the king palms; and Nursery Supplies, Inc. and Rootmaker Products Company, LLC for donating containers.

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QUESTIONS AND ANSWERS

Douglas Justice: Were the palms clonal?

Don Hodel: No, they weren't clonal; they were grown from seeds.

Douglas Justice: How uniform were those seedlings?

Don Hodel: They were fairly uniform. There were some differences in stem caliper and the number of leaves they had at the beginning. We compensated for the initial variation when we analyzed the data.

Loren Oki: Do you think the differences might be due more to water relations rather than container architecture? Maybe more water lost through the containers with slots on the side?

Don Hodel: There weren't any significant differences in the root mass in the various containers at the end. It could have been related to the soil drying out faster, perhaps.

Induction of Bud-Break at a Specific Node in Cut-Flower Rose Production©

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INTRODUCTION

It has been shown that apical dominance inhibits axillary bud break and lateral shoot branching in some plant species due to the effects of auxin (IAA) which is biosynthesized in the shoot apex and polarly transported within the plant (Sachs and Thimann 1967; Kitazawa et al., 2008; Leyser, 2003). In rose it has been shown that axillary buds lower on a stem have a higher degree of inhibition then apical buds (Le Bris et al., 1998). The process by which an axillary bud shifts from its dormant state to an actively growing stem is called bud break.

Methods for induction of bud break are commonly used in floriculture to achieve desired plant shape (e.g., to induce branching in potted plants) and for timing of harvests (e.g., cut flowers). The methods currently used on cut flower roses to achieve a particular bud break date, and consequent harvest date, include pinching, pruning, or bending. Pinching involves the removal of the inflorescence to break apical dominance and release the axillary buds below. Pruning is the removal of a large percentage of existing stem tissue to rejuvenate the canopy or create bud breaks at the axillary bud below the cut. During the 1990s stem bending became a commonly used method for timing flower production in cut flower roses. This method has nearly the same effect on the plant as pruning and pinching, in that the axillary buds on the erect portion of the stem near the bend, is allowed to break. In this horticultural method, the stem that is bent ceases to grow and, even if a flower does grow on this bent material, it is not suitable for sale as the stem length is typically too short and flower quality substandard. The carbohydrate production from the bent shoot is available to this new shoot, typically resulting in a stronger shoot then pruning or pinching induced stems (Kim et al., 2004).

Lieth and Pasian (1991) calculated carbohydrate dynamics in growing rose shoots in relation to photosynthesis and respiration over the weeks that were required for a typical cut flower to go from bud break to harvest. They found that halfway through this growth period a luxuriant amount of carbohydrates were available in the lower portion of the shoot, so assimilate resources were available for export from the shoot. This suggested that adequate carbohydrate resources were available to grow a new shoot on a lower node of the flowering rose stem several days before harvest.

Forcing bud break without the loss of a growing flower stem or to induce early bud break on a growing flowering rose stem has been of considerable interest. The use of plant growth regulators (Ohkawa, 1984) and different methods of mechanical manipulation (Orsi et al., unpublished) to the stem have been tried with limited success. To address this, we developed a method that stimulates axillary breaks through mechanical manipulation of the stem by partially compressing the internode above a specific axillary bud. We call this method the “Partial Crush” (PC) treatment. It induces bud break at the proximal node, which will grow to produce

a flower stem for subsequent harvest without harming the current stem or successive growth. The effect on a rose plant was to generate a specific and timed bud break from 7 to 14 days earlier than stem pruning or flower harvesting (Orsi et al., unpublished). Applying this treatment can potentially increase yields of cut flower roses and reduce time between harvests.

Two main experiments were conducted after it was discovered that early bud break prior to stem harvest could be achieved. This method could potentially have various commercial applications and it was necessary to test whether its use in canopy rejuvenation of stock plants was practical and efficient. This experiment tested the effects of the PC treatment on the major rose (*Rosa*) canes that arose from the bud union in an effort to induce new bottom breaks. Bottom breaks or bud breaks that come from lower, older stem tissue on the rose canopy are important to cut flower rose growers in canopy rejuvenation. Bottom breaks are desirable for rejuvenation of the plant canopy because over time flower yields tend to decrease when they develop from older tissue (Kool, 1996). As of now, the only technique available to induce bottom breaks is to severely prune the plant canopy to break apical dominance and force old, dormant axillary buds to break. This can take a significant amount of time for the buds to break and for production to resume. The development of a new treatment that can induce bud breaks prior to pruning for commercial cut-rose greenhouse application could save growers time and money during canopy rejuvenation periods by guaranteeing axillary bud break before pruning.

Additionally, in an effort to maximize application efficiency of the PC treatment the most effective depth and area of compressed tissue needed to induce bud break was tested. The depth of compression at application to the stem, and the height of area crushed on the stem were measured in order to induce uniform axillary bud break before stem harvest.

MATERIALS AND METHODS

Bottom Break Trial. Thirty plants of *Rosa* 'Korlingo', Kardinal® hybrid tea rose, grafted onto 'Natal Briar' rootstock, were grown in 2-gal pots with UC Mix [1 peat : 1 redwood sawdust : 1 sand (by volume)] amended with slow-release Osmocote® encapsulated fertilizer. Plants were established in the University of California, Davis, Environmental Horticulture Complex greenhouses with temperature set points of 20–24 °C during the day and 15.5–18 °C at night. Plants were irrigated with 1,250 mL of amended half-strength modified Hoagland's irrigation solution (Hoagland and Arnon, 1950).

Plants selected for the experiments had 3 to 4 major canes above the bud union. Plants and axillary buds treated for both experiments were chosen at random among the complete block. All data were analyzed with analysis of variance using GLM procedure of SAS (SAS institute, Cary, North Carolina). Means comparisons were done using Student's t-test at the 0.05 significance level.

For the fall trial on 3 Oct. 2008 and 4 Nov. 2008, among 20 plants within the block, all major canes received either the PC or control (CTRL) treatment. The PC treatments were applied 0.5–1.0 cm above the selected node and crushed to 30%–40% of the stem diameter in a few compressing motions. Control-treated buds were flagged for observation. Bud break was recorded when a small bud started to push through meristem. Flowers were continually harvested during this time and measurements were taken for 6 weeks.

For the spring trial, 20 canes were randomly selected to receive either PC or CTRL treatments. Treatments were applied in the same manner as the previous trial. All treatments were applied on 27 Apr. 2009; however, 10 days after treatment the canopy above the selected bud was removed to release apical dominance. Measurements were recorded for 6 weeks.

PC Depth Trial. Three trials were conducted over an 8-month period to test the needed compression depth to induce uniform forced bud break. During the first trial in winter 2009, four treatments were applied randomly within a planting block of 30 roses grown in the same cultural conditions as the bottom break trials. Treatments include compressing the stem 20% (PC20), 40% (PC40), and 60% (PC60) of the stem caliper. Control treatments were flagged at a particular bud. Ten replicates of each treatment for a total of 40 stems treated were applied on 4 Dec. 2009. Digital calipers were used to measure the stem width before the treatment was applied. The caliper of the stem was recorded, the needed depth to compress the treated stem was calculated, and the stem was compressed slowly to that depth in one smooth motion. The treatments were applied 0.5 to 1.0 cm above the most basipetal five-leaflet leaf on the flower stem. The date of bud break and any general observation of the stem growth were recorded. Stems were harvested when all five sepals on the flower were fully extended. Before the stem was removed, its final stem length (cm) was recorded. All harvest dates occurred between 18 Dec. 2009 to 28 Dec. 2009. The average daily greenhouse temperature from the treatment date to the final harvest date was 18.6 °C with a mean PAR of 319.93 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon.

Trial 2 (Spring 2010) replicated Trial 1 at a different time of year. Treatments were applied on 26 Apr. 2010, with the daily average temperature of 22.5 °C and mean PAR of 1027.4 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon from 26 Apr. to 21 May 2010. Stems were harvested on 14 May 14 and 21 May 2010.

Trial 3 (Summer 2010) also replicated the previous trials with the exception of the time of year having higher ambient light levels and with PC treatments being imposed with standard pliers rather than needlenose pliers. The zone of damage induced by the pliers was 12 mm with the standard pliers compared to 3 mm of the stem receiving the crush with the needlenose pliers. Treatments were applied on 16 June 2010. Average daily temperature was 23.9 °C and mean PAR of 1,464.67 $\mu mol \cdot m^{-2} \cdot s^{-1}$ at noon from 16 June 2010 to 6 July 2010. Stems were harvested from 28 June to 6 July 2010. All data was analyzed by means of analysis of variance using GLM procedure of SAS (SAS Institute, Cary, North Carolina); means comparison were by Student's t-test at the 0.05 significance level.

RESULTS

Bottom Break. Forced bud break to initiate bottom breaks prior to canopy pruning occurred only on stems that received the PC treatment. The strong influence of apical dominance was evident because none of the untreated buds had bud break until the upper plant canopy was completely removed as witnessed after Day 10 in Trial 2 and from the lack of canopy removal in Trial 1. During Trial 1 no bud break occurred for CTRL stems and 7 of 37 treated buds in the PC treatment resulted in bud break. Of those 7, 3 resulted in blind shoots. The PC treated buds in Trial 2 broke significantly faster than the CTRL treatment, approximately 10 days earlier (Table 1). The CTRL treatment however had the least amount of time from bud

break to harvest of the secondary stem at 33.0 days and was not significantly different from the PC treatment which took on average, 39.4 days (Table 1).

Table 1. Average days to bud break and harvest after partial crush (PC) treatment application for Winter 2009 and Spring 2010 trials.

Trial season	TRT	Number per TRT	Number per TRT with BB	Mean days from treatment to bud break	Mean days from bud break to mature bud harvest
Fall	CTRL	37	0	---- a	NA
Fall	PC	37	7	16.7 ± 5.3 b	NA
Spring	CTRL	10	10	24.3 ± 1.2 a	33.0 ± 2.5 a
Spring	PC	10	9	14.0 ± 2.5 b	39.4 ± 5.4 a

Data are means ± S.E. Mean separations are within fall and spring trials and were determined by student's t-test. ($p<0.05$).
Note: BB = bud break, TRT = treatment.

PC Depth Trial. In Trial 1, no bud break was observed prior to harvest although several of the PC treated stems had swollen buds at that time. During the second trial, axillary buds broke prior to flower harvest in two of the four treatments: two stems in the PC40 and two in PC60 treatments each had a bud break while PC20 and CTRL treatments had zero pre-harvest bud break. The PC treatments at the different depths did not reduce the time from bud break to subsequent mature bud harvest in all trials (Table 2). The PAR levels were higher for this trial compared to the previous winter trial, which had no pre-harvest bud break in any treatments.

DISCUSSION

In all trials, bottom break and depth compression, it was observed that the PC treatment performed better during periods of higher light intensity and temperature. While we were not able to determine whether temperature or light was the primary cause of forced bud break, it was observed that these cultural conditions played an important role in early bud break.

The lack of efficacy of the PC treatment during the first PC Depth Trial was unusual since all other trials (data not shown) showed significant effectiveness at inducing bud break. It is possible that light is not the only factor that inhibits early bud break as was seen when the area of tissue was compressed from 3-mm-high-light intensity (Trial 2) to 12-mm-high-light intensity (Trial 3) which increased preharvest bud break (Table 2). With an increase in PAR, temperature, and compressed stem area, an increase in preharvest bud break was observed. A replication of this trial at low PAR/high temperature and high PAR/low temperature with standard pliers would allow us to identify whether the causal factors are PAR, temperature, or area compressed or their interaction.

Since cytokinins encourage cell division and have been found to be translocated acropetally within the plant (Sachs and Thimann, 1967) we suspect that disruption in translocation of the growth substances due to the partial compression of the rose stem reduces inhibitory effects of IAA on axillary buds below the compression

Table 2. Average days to bud break, and subsequent harvest after PC treatment at various depths, plier widths, and seasons.

Treatment	Time of year	Plier width (mm)	Number with BB before harvest	Days to BB after treatment	Mean days from bud break to mature bud harvest
CTRL-T1	Winter	3	0	44.2 ± 8.4 a	N/A
PC20-T1	Winter	3	0	41.2 ± 7.0 a	N/A
PC40-T1	Winter	3	0	38.5 ± 5.8 a	N/A
PC60-T1	Winter	3	0	39.0 ± 10.1 a	N/A
CTRL-T2	Spring	3	0	24.1 ± 1.1 a	38.0 ± 1.3 b
PC20-T2	Spring	3	0	22.1 ± 0.4 a	41.4 ± 1.2 ab
PC40-T2	Spring	3	2	21.5 ± 1.5 a	45.0 ± 3.4 a
PC60-T2	Spring	3	2	22.8 ± 2.6 a	43.8 ± 1.7 a
CTRL-T3	Spring	12	0	17.1 ± 1.3 a	37.4 ± 2.1 b
PC20-T3	Spring	12	2	14.8 ± 4.0 ab	52.8 ± 4.8 a
PC40-T3	Spring	12	1	16.7 ± 2.3 a	42.1 ± 4.1 ab
PC60-T3	Spring	12	5	10.1 ± 1.0 b	53.9 ± 7.2 a

Note: CTRL = control; PC20 = partial crush 20%; PC40 = partial crush 40%; PC60 = partial crush 60%; T1 = Trail 1; T2 = Trial 2; T3 = Trial 3; Data are means ± S.E. Mean separations are within trials and determined by student's t-test. ($p<0.05$).

location. Accumulation of cytokinin below/at the wound possibly encourages cell division and bud release. The actual mode of action is currently unknown.

Further research is needed to effectively and uniformly promote bud break and sustain bud growth pre-harvest. At this time the PC treatment does not reduce the time from bud break to harvest. In hard-to-break plants this treatment might be more effective. Exploring the seasonal variation would be an important future line of research as that will have an impact on timing flowers for holiday production. Additionally, plant carrying capacity of PC treatment and its effects on subsequent stem generations needs to be analyzed. Finding the cause of slow bud growth from pre-harvest bud break to stem harvest should be investigated in order to overcome its inhibitory effects and reduce time between production cycles.

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QUESTIONS AND ANSWERS

Anonymous: Can you go back to the last slide that shows how to do the treatment.

Heiner Lieth: You need needle-nose pliers and a strong wrist. Needle-nose vice grips might be the perfect tool to make a more exact crush of the stem. Compress 30%–40% of the stem tissue. Don't pinch the stem so much that it falls over. Give it a good, solid crush. Figure out which axillary bud you want to stimulate to elongate. Crush the stem about 1 cm above that node.

Anonymous: What species of roses did you test this on?

Heiner Lieth: We tested this on *R.* 'Korlingo', Kardinal® hybrid tea rose.

Michael Vietti: After the crushing treatment, did you use any exogenous growth substances like cytokinins?

Heiner Lieth: We did not. So far we've wanted to fully explore this treatment without the use of any other chemicals. Your question brings up an interesting point. Maybe this treatment simply induces a break, but some follow-up treatment is needed to fully realize the effect.

Jim Berganz: Is the length of the stem that's crushed important?

Heiner Lieth: Not sure since we focused on flower stems that already have a terminal, pea-sized flower bud already. It generally doesn't work well on blind shoots, those that never have a terminal flower bud.

The Greening of California Home Landscapes©

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THE ISSUE

Residential landscapes are an essential part of the quality of life we enjoy in California. They can provide refuge, solace, and food. But they also add to demands for scarce water resources. According to a 2010 study for the California Homebuilding Foundation, a new three-bedroom home will use approximately 174,000 gal of water, more than half of it for landscaping annually.

Runoff from landscaping also is a source of environmental pollutants such as pesticides and fertilizers that threaten fish and wildlife in rivers and streams. Faculty members in the College of Agricultural and Environmental Sciences at UC Davis recognized the need to make horticulture research and education more available for Californians to address these concerns.

WHAT WE'RE DOING

The college established the California Center for Urban Horticulture (CCUH) at UC Davis in 2006 to help state residents get the most out of their yards by learning environmentally sound gardening practices and encouraging better plant materials for sustainable urban landscapes. Since opening, CCUH has held numerous outreach and support events for both the industry and the general public.

OUTREACH AND SUPPORT EVENTS

Your Sustainable Backyard. Home gardening has become increasingly popular with Americans. A survey by the National Gardening Association found that 7 million more households planned to grow their own fruits, vegetables, herbs, or berries in 2009 than in 2008, a 19% increase. The CCUH created the "Your Sustainable Backyard" program, an ongoing series of workshops developed with Master Gardeners in mind (Fig. 1). Master Gardeners are public educators trained by University of California experts in horticulture, pest management and related home gardening topics who extend this information to the general public. In its first 2 years, more than 800 people attended workshops on a wide range of horticultural care of fruit trees, roses, and edible plants.

Figure 1. "Your Sustainable Backyard: Roses" partnership workshop series with the Statewide Master Gardener Program.

Arboretum All-Stars. The horticulturists at the UC Davis Arboretum identified 100 tough, reliable plants that are easy to grow, don't need a lot of water, have few problems with pests or diseases, and have outstanding qualities in the garden (Fig. 2). They include

Figure 2. University California Davis Arboretum All-Stars retail display in partnership between the Arboretum and CCUH.

Figure 3. Häagen Dazs Honey Bee Haven garden. Partnership program between the UC Davis Entomology department, Häagen Dazs, and the CCUH. Pollinator garden that provides a year-round food source for honey bees and other bee species.

Figure 4. University California Verde Buffalograss planted at the U.C. Davis Graduate School of Management (GSM). The turf was a component of GSM's LEED certification.

trees, shrubs, vines, groundcovers, and perennials. Many of them are California native plants and support native birds and insects. California Center for Urban Horticulture has been instrumental in promoting these plants, which are available at Arboretum plant sales on campus and at an increasing number of retail nurseries throughout California. Arboretum horticulturists are also testing plant species that have demonstrated tolerance to summer heat and drought under different irrigation frequencies and in a variety of climate zones around the state.

Helping Honey Bees. The CCUH coordinated the design and installation of a demonstration garden called "Honey Bee Haven" with the support of Häagen-Dazs and the UC Davis Department of Entomology (Fig. 3). The half-acre garden and adjacent wildflower meadow on the UC Davis campus provide bees and other pollinators with a year-round food source, raise public awareness about disappearing honey bees, and encourage visitors to plant bee-friendly gardens of their own.

Horticulture Industry Partnerships. Another way CCUH is helping green California landscapes is through its work with industry, such as its "quality tree initiative" to improve nursery stock and promotion of water-conserving *Buchloe dactyloides* UC Verde® buffalograss (Fig. 4). A water wise symposium has helped industry professionals learn new approaches to water management, including planning and designing for water efficiency ordinances and management to reduce water use and runoff.

Research on Runoff. A multi-year study led by UC Davis plant sciences specialist Loren Oki and UC Cooperative Extension water resources advisor Darren Haver found 11 pest control chemicals in storm drain water

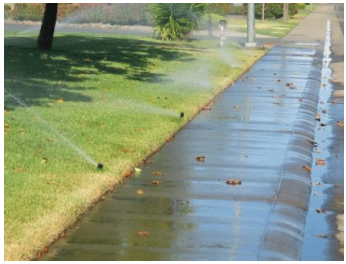

Figure 5. Research partnership with Dr. Loren Oki depicting pesticide and fertilizer run-off due to improper irrigation from residential neighborhoods.

Figure 6. Improper irrigation from residential neighborhoods results in pesticides and fertilizers watershed contamination.

samples from eight selected California neighborhoods virtually year round, including some products no longer commercially available (Fig. 5). The main ingredients of typical lawn and garden fertilizers were also detected in water samples at all sites. Master Gardeners are providing education to residents in the test neighborhoods to reduce both the amount of runoff water and its potentially harmful contaminants (Fig. 6). Computer models of flows and loads from the study will aid future urban planning. The CCUH provides a forum to report on this important research.

To learn more about these projects and other CCUH activities, visit the program's website at <http://ccuh.ucdavis.edu>.

A Shared Vision. The CCUH came about as a result of careful planning and research with UC Cooperative Extension, the UC Davis Arboretum, the Department of Plant Sciences, the Department of Landscape Architecture, and representatives from the horticulture industry and professional horticulture associations.

In just a few short years the power of this partnership is evident in more widely adopted horticultural practices that are conserving water, reducing pesticide and fertilizer use, and introducing Californians to attractive plants better adapted to California's Mediterranean climate.

That's impact — "enhancing urban living through horticulture."

The University of California Nursery and Floriculture Alliance: Providing Technical Education for Growers©

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The University of California Nursery and Floriculture Alliance (UCNFA) provides outreach programs that serve the educational needs of the California nursery and floriculture industry. Providers of these programs include University of California (UC) faculty and UC Cooperative Extension Advisors and Specialists. Outreach is conducted at events including workshops at grower locations, conferences, and seminars throughout California.

The UCNFA leadership includes Loren Oki and Dave Fujino, who serve as Co-Directors. Additional leadership is provided by the Executive Committee: John Kabashima, Mike Parrella, Ken Tate, and the Co-Directors. Cooperative Extension Advisors, Julie Newman serves as the Chair of Educational Programs, Steve Tjosvold is the Newsletter Editor, and Jim Bethke is Chair of Technology. Linda Dodge is the Program Representative and manages the activities of the program.

Programs presented in 2009 were attended by 268 people and consisted of the following workshops and conferences:

- IPM for Bedding Plants and Container Color: Santa Paula, Vista
- Nursery Cost/Profit Estimator Webinar: Internet
- Light Brown Apple Moth Management Regulation Update: Watsonville
- Nursery Pests Workshop: Parlier
- Vegetated Filter Strips to Manage Runoff: Santa Paula
- ABCs of Fertilizer Management (in Spanish): Watsonville
- California Weed Symposium: Watsonville
- ABCs of Plant Pathology (in Spanish): Fresno

California Programs in 2010 were attended by 429 people and included the following events:

- Conference on Water Quality and Treatment: Vista
- Nursery Risk Management Workshop: Vista
- Nursery Risk Management Webinar: Internet
- Greenhouse Management Workshop: UC Davis and Vista
- ABCs of Insect Management (Spanish and English): Tulare and Watsonville
- ABCs of Fertilizer Management (Spanish and English): Ventura and Watsonville
- CA Nursery and Floriculture Insect & Disease Management Symposium: Watsonville

California Programs in 2011 include:

- Risk Management Workshop for Greenhouse and Nursery Managers: Carpinteria
- ABCs of Fertilizer and Irrigation Management in Spanish: Azusa
- Pest Monitoring in Ornamental Plant Production (in English and Spanish): San Marcos
- Scouting and Spray Evaluation Workshop: Watsonville
- Erosion and Pesticide Runoff Management in Nurseries: Ventura
- California Nursery Conference scheduled on 6 Oct. 2011, Etiwanda: Rancho Cucamonga
- Effective Use of Pesticides in Ornamental Plant Production scheduled on 18 Oct. 2011: San Marcos

Events that are currently scheduled include: The California Nursery Conference on 6 Oct. 2011 at the Etiwanda Gardens in Rancho Cucamonga. This program will provide an overview of current issues related to invasive pests and diseases and water runoff and water quality. A workshop on Pesticide Use and Rotation will be provided in Spanish on 18 Oct. 2011 in San Marcos. The Insect Bio-control Symposium, originally scheduled for 3 Nov. 2011 has been postponed until early 2012.

The program has completed a transition in the past few years. In January 2009, the program was known as the California Ornamentals Research Federation (CORF) and programs focused on the floriculture industry. Program management and leadership were assigned to the Department of Plant Sciences and the College of Agricultural and Environmental Sciences Dean's office. Later that year, the new organizational structure was implemented and programs to the nursery industry were included. In January 2010, the name was changed to the UCNFA.

These changes have led to several accomplishments:

- Issues have been expanded to include nursery as well as floricultural production.
- Workshops have been conducted in the Central Valley.
- Workshops have been provided in Spanish.
- The first programs via the internet (webinars) have been conducted.
- Programs have been provided through multi-state partnerships that have included the University of Arizona, the University of Hawaii, the University of Florida, and Texas A&M University.
- Conference sponsors provided financial support for the Insect and Disease Symposium that took place in Watsonville.
- The California Nursery Conference organization moved to the UCNFA.
- A new website appeared at <http://groups.ucnfa.org/UCNFA>.
- A new electronic newsletter appeared at <http://unanr.org/sites/UNFCAnews/> and is available in a downloadable "pdf" format.
- The UCNFA appears on Facebook at: <http://www.facebook.com/pages/University-of-California-Nursery-and-Floriculture-Alliance/172471082771255>.

For the future, events for 2012 will be identified, scheduled, and provided. Funding support is a concern and the UCNFA has secured a grant totaling $296,603 from the California Association of Nurseries and Garden Centers (CANGC) to conduct a study of Best Management Practices (BMPs) that target specific diseases and pests. In addition, a proposal has been submitted to the UC Strategic Initiatives Grant Program for the amount of $575,000 to conduct research and outreach on scouting programs for greenhouses and nurseries. A strategy for the UCNFA program to become self-sufficient through partnerships, grants, program events, and other revenue generating activities will continue.

As the UCNFA provides technical and educational programs to the nursery and floriculture industry, there has been increase in requests for programs by growers. This is a reflection of the high level of service and value that this program has been and is able to provide to the horticulture industry in California.

Micropropagation of Walnut Rootstocks©

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INTRODUCTION

Walnut is a popular crop with 5 million trees annually planted in California. Paradox walnut [*Juglans hindsii* × *J. regia* (Northern California black walnut × English walnut)] is a popular rootstock due to its high vigor. Nurseries often grow Northern California black walnut and a pollinating English cultivar side-by-side to produce paradox walnut. One disadvantage of this un-controlled open pollination is that its success varies from year to year and in some years the success rate is as low as 25%. This leads to a shortage of paradox walnut trees for walnut growers. Another disadvantage is genetic variability from one paradox walnut seedling to another that leads to tree-to-tree differences (disease resistance, vigor, etc.) in the orchard.

Clonal propagation can solve the aforementioned disadvantages of paradox walnut seedlings. However, a major hurdle in adopting clonal propagation for walnuts is that paradox walnut cuttings are much more difficult to root than rootstocks of other fruit and nut crops. The success rate of rooting of hardwood walnut cuttings has been so low that nurseries have not adopted this practice. On the other hand, success in rooting cuttings grown by tissue culture has dramatically increased and is likely to revolutionize the availability of rootstocks that were never available before.

MICROPROPAGATION

New Rootstocks for Micropropagation. University of California, Davis has recently released two new paradox walnut rootstocks, RX-1 and VX211. Rootstock RX-1 provides resistance to *Phytophthora* and VX-211 provides resistance to nematodes. As one can imagine, this genetic resistance is good for the life of the tree in the orchard and provides protection even if the pathogens get introduced in the orchard at a later stage. Rootstock breeding is an active program at UC Davis and a release of more desirable rootstocks are expected. These rootstocks have been released to some laboratories that specialize in micropropagation. Accordingly, the use of clonal rootstock is expected to increase and meet the demand of the California's planting needs.

Micropropagation at Micro Paradox Inc. Although, in principal, walnut micropropagation is similar to other crops, it requires more and longer tissue culture stages, larger facilities, and more tissue culture staff to produce the same number of plants than for other species. The following is a brief explanation of the various stages involved.

Establishment. Establishment of new varieties in culture is difficult for walnuts due to the presence of endogenous bacteria and phenolic substances in the tissue that interfere with culture establishment. Nodal sections from actively growing shoots are surface-sterilized with 1% sodium hypochlorite and planted on DKW medium (Driver and Kuniyuki, 1984) with ½X salts. The tissue is frequently (daily) transferred to new media until no browning of media due to phenolic exudates is detected. The culture is then transferred to full-strength DKW medium and considered adapted for micropropagation after 3 subcultures.

Multiplication. This phase is relatively easy but a very important phase for the success of the project. Growing healthy cuttings insures a balanced root system later. Nodal sections of cuttings are cultured on a DKW multiplication medium. The cultures are maintained in the light for 12 h at 72–75 °F followed by 12 h in the dark at 75 °F. Cultures are visually examined for any contamination and clean cultures are sub-cultured every 3 weeks. On average, a 3X multiplication rate is achieved. Starting with 100 cuttings, 1.4 million cuttings can be produced in 6 months (Table 1).

Table 1. Number of cuttings that can be produced from a starting number of 10 and 100 cuttings (multiplication rate of 3X in 21 days).

Day	Start	21 days
Day 1	10	100
Month 1	49	490
Month 2	240	2,401
Month 3	1,176	11,765
Month 4	5,765	57,648
Month 5	28,248	282,475
Month 6	138,413	1,384,129

Root Induction and Rooting. The cuttings from the multiplication phase are harvested and planted on a DKW root-induction medium. This induction phase is conducted in the dark for most taxa. The cuttings are then transferred to a rooting medium to develop roots.

Greenhouse Acclimatization. The rooted cuttings are transplanted in Anderson pots containing Sunshine mix #4 potting mix. High humidity (>95%) is maintained. The humidity is then reduced to 80% for approximately 1 week and then to normal greenhouse environment. After 2 weeks, plants are moved to a shade house for hardening. During the entire growing process in the greenhouse and shade house, air pruning of the root system is promoted by open-bottom pot design and open-mesh bench design.

Grading and Sorting. Usually, plant growth and height is variable during acclimatization. Plants with bigger leaves restrict growth of smaller plants by shading. Therefore, we frequently grade plants and sort them into two categories: big and small. The smaller plants are then moved to another area to allow their optimal development.

Identity Tracking by DNA Fingerprinting. Since plants go through a lot of handling during various micropropagation phases there is a possibility of mislabeling. Therefore, we test leaf samples to confirm their identity by DNA fingerprinting in our on-site genetic laboratory.

Superior Root Architecture. A key feature of our plants is their superior root architecture. Our plants have 5–8 roots starting from the base of the cutting that span out at a 45° angle (Fig. 1). This balanced root system provides better anchoring upon planting in the soil and the trees do not get blown over by the wind. Roots of our plants do not show defects such as curling and circling due to our practice of air pruning.

Field Experience. During the last 2 years, we have sold 200,000 trees to various nurseries in California. Feedback from our clients indicates that the micropropagated trees are very uniform, show the promised vigor, and have high stands (Fig. 2). All major nurseries agree that dormant micro-trees from our micropropagation program, when planted in February, are vigorous enough to be easily June-budded. This is preferred by nurseries as their production cycle is reduced from 2 years to 1 year resulting in reduced growing costs. We are further partnering with nurseries to study if

Figure 1. Root structure of dormant trees produced by micropropagation.

Figure 2. Growth of micropropagated VX-211 rootstock at Burchell Nursery near Oakdale, California.

September planting of actively growing trees can enhance their root development in winter before dormancy and result in stronger plants for June budding.

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QUESTIONS AND ANSWERS

Mike Bone: What material are you using for explants?

Parm Randhawa: We used clean and sterile cultures we obtained from UC Davis.

Mike Bone: How are you sterilizing your starting material?

Parm Randhawa: We use a soapy water wash followed by bleach when we start cultures from field-grown material.

Production of Permanent Crops Using Tissue Culture Techniques, Does it Make Cents?©

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INTRODUCTION

The term "tissue culture" has come to encompass many different techniques associated with the clonal reproduction of plants. Terms such as somatic embryogenesis, meristem culture, embryo rescue, protoplast fusion and micropropagation are all specialized techniques that are often referred to as "tissue culture" when discussing the propagation of plants. Any one of the above techniques would ultimately give rise to a new plant, but micropropagation has probably come to be the most widely adopted, since its relative ease in training novices in the technique.

At Duarte Nursery, in Hughson, Calif., micropropagation is used primarily to clonally reproduce rootstocks used in the production of stone fruit, nut, and citrus trees for commercial plantings. The technique allows us to produce elite, "clean" plant material, but not without substantial costs and investments.

With that being said, let's look at what micropropagation has to offer the nurseryman and examine the question: "Does it make Cents?"

WHAT IS MICROPROPAGATION?

Micropropagation is a specialized technique used to propagate plants using small pieces of a plant stem, leaf, or growing tip. It is particularly useful on plants that are otherwise difficult to propagate by regular means. The technique generally is performed in a sterile environment due to possible contamination by bacteria, fungi, or insects such as mites or thrips.

There are Four Distinct Stages of Micropropagation:

1) Initiation
2) Multiplication
3) Rooting
4) Acclimatization

Stage 1: Initiation. A segment (explant) is cut from the parent plant, disinfected to kill bacteria and mold spores that may be present, and then placed in sterile medium. During this stage, if the parent plant material is found to contain a virus, the plant could undergo thermotherapy treatment or meristem culture to remove the presence of the virus before being placed in culture.

Stage 2: Multiplication. Explant is placed in a medium containing cytokinins (and maybe auxin) and nutrients to encourage cell division, shoot initiation, and lateral bud growth. The objective is to maximize shoot production.

Stage 3: Rooting. Shoots arising from Stage 2 are transferred to a medium containing auxins to induce roots. During this stage, the correct ratio of hormones and nutrients becomes more precise in order to induce root formation.

Stage 4: Acclimatization. The rooted shoots are removed from the sterile containers, transplanted into cell trays filled with soilless medium, and placed in a greenhouse under high humidity for rooting out. The high humidity is necessary to keep the transplants from desiccation, as the leaves' stomata are not fully functioning like those of plants grown in a natural environment.

Sounds Pretty Straight Forward Doesn't It? So, why aren't we all as propagators using micropropagation? Answer is $$$$$ capital investment!$$$$

To do micropropagation on a commercial scale, you would need to invest in:

- Facility: large enough to fit your needs, with heating and cooling system to keep temperatures fairly constant.
- Specialized equipment: such as autoclaves, laminar flow hoods, instrument sterilizers, dissecting microscope, medium mixer, etc.
- Media components: comprised of macro and micro nutrients, vitamins, amino acids, sugars, agar (solidifying agent), and growth regulators.
- One of the most important factors governing the growth and morphogenesis of plant tissues in culture is the composition of the culture medium. The basic nutrient requirements of cultured plant cells are very similar to those of whole plants!
- Containers: size, shape, and type will be dependent on your individual needs.
- Trained staff: critical that they be trained in proper techniques to minimize contamination, but still work efficiently to keep labor costs down.
- Grow room / lighting: racks to support containers and lights for growth.
- Acclimation area: extracted plants will need a growing environment with adequate temperature, light, and humidity controls for acclimating, rooting, and hardening off.

TRADITIONAL PROPAGATION

Compared to traditional propagation methods where all one needs is an area with a mist bench and mist controller/timer, proper heating and cooling, healthy stock plants, propagation trays with media and various rooting hormones, micropropagation seems expensive. So, what's the advantage?

ADVANTAGES OF MICROPROPAGATION

Clean Disease Free Plants.

- Plants are maintained in a sterile environment.
- Provides an avenue to more easily clean up plants that have virus or disease issues.
- Once plants are certified virus free and disease free, the possibility that they will become diseased while in culture is virtually zero.

Ability to Grow Large Number of Plants in a Relatively Small, Well-Controlled Environment.

- Seasonality issues that normally occur with traditional vegetative propagation are eliminated.
- Currently producing 4,000,000 + plants yearly.

Alternative Clonal Propagation Method for Difficult-to-Propagate Plants.

- Especially useful for hybrids, where propagation by seed introduces a large amount of variability.

A good example is UCB-1 pistachio rootstock, a cross between *Pistacia atlantica* × *P. integerrima*. The resulting hybrid has better cold tolerance, salinity tolerance, better overall disease resistance, and produces higher yields. It is difficult to propagate from cuttings and is thus propagated primarily by seed. The problem with UCB-1 pistachio rootstock grown from seed is the variability that grafted trees exhibit in the field. By making careful selections of seedling performance, a single selection was made of the best performing seedling and is now being sold as the "Duarte clone."

Quicker Response to Market Demand. When new varieties are introduced into the industry, micropropagation allows us to multiply the material much more quickly and made available to growers much sooner.

- Clean, disease free plants that are container grown are available for planting year round, thus giving the grower more flexibility in establishing their plantings.

CONCLUSION

Micropropagation of permanent crops such as walnuts, pistachio, almond, stone fruits, avocado, and citrus, to name a few, have a distinct advantage to the grower over traditionally produced field grown plants. In general, micropropagation allows the nurseryman to make available to the grower, trees free of viruses and diseases. Trees that are clonally produced, eliminate the variability observed in seedling populations and can lead to higher production yields. Coupled with a containerized growing system, new varieties can be brought to the market much sooner in larger numbers and available year round for planting. When you consider the advantages, micropropagation does make "cents" for both the nurseryman and our grower/customer!

Cutting Propagation of Azaleas Using Hot Water Treatments to Control Pathogens©

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Azalea web blight, caused by certain binucleate species of *Rhizoctonia*, occurs yearly on some azalea cultivars during nursery production in the southern and eastern U.S.A. Azalea shoots collected for cutting propagation can harbor the pathogen, thus allowing the disease to be perpetuated during the cutting propagation process. A previous study demonstrated that submerging *Rhizoctonia*-infested stem pieces of 'Gumpo White' azalea in 122 °F (50 °C) water for 21 min could eliminate the pathogen without causing damage to leaf tissue. The present study determined that this hot water treatment can be used safely for cuttings of twelve commonly grown azalea cultivars without causing detrimental leaf damage or adversely affecting root development.

INTRODUCTION

Sanitation is a proven and cost-effective approach for limiting the entry of pathogens into a propagation facility (Daughtrey and Benson, 2005; Jones et al., 2001; William-Woodward and Jones, 2001). Hot water treatment is a method of sanitation that can be used for seeds, bulbs, vegetables, fruits, and other plant products (Lurie, 1998; Miller, 2005; USDA-ARS, 2004); however, the technique has not previously been reported for use with stem cuttings.

In our previous study (Copes and Blythe, 2009), hot water treatment was the only sanitation method tested that eliminated *Rhizoctonia* from azalea stem pieces that had been inoculated and colonized by *Rhizoctonia* AG P; soaking stem pieces in selected chemical disinfestants or fungicides was ineffective. *Rhizoctonia* was eliminated (not recovered) from stem pieces submersed in 122 °F (50 °C) water for 21 min and in 131 °F (55 °C) water for 6 min. In that study, terminal leafy cuttings of 'Gumpo White' azalea were treated with the same hot water treatments to evaluate possible damage to leaf tissue, following the assumption that necrosis of more than 25% of the leaf area would result in reduced rooting and lower plant quality. Minor leaf damage resulted on cuttings for the times required to eliminate the pathogen at 122 °F and 131 °C. However, the margin of error in time between killing the pathogen and severely damaging leaf tissue was narrower at 131 °F than at 122 °F. Severe leaf damage occurred when cuttings were submerged in 131 °F water for longer than 13 min, while only minor damage occurred when cuttings were submerged in 122 °F for 40 min.

The first objective of the present study was to determine if hot water treatment [122 °F (50 °C) water for 20 min] would damage leaf tissue and/or reduce root development on cuttings of twelve commonly grown cultivars of azalea. The second objective was to evaluate effects of this hot water treatment when extended from 20 to 80 min on cuttings of the 12 azalea cultivars.

MATERIALS AND METHODS

Terminal cuttings were collected from nursery-grown container plants of 12 azalea taxa ['Conleb' (Autumn Embers™ Encore azalea), 'Fashion', 'Gumpo White', 'Hardy Gardenia', 'Hershey's Red', 'Macranthum Roseum' (syn. 'Macrantha Pink'), 'Midnight Flare', 'Red Ruffles', 'Renee Michele', 'Roblel' (Autumn Debutante™ Encore azalea), 'Watchet', and *R. formosa*] during May and June 2009. In Expt. 1, cuttings were not treated or treated by complete submersion in 122 °F water for 20 min using a temperature-controlled hot water bath. In Expt. 2, cuttings were submerged in 122 °F water for 20, 40, 60, or 80 min. In both experiments, cuttings were inserted in a peat and pine bark substrate in 72-cell trays and placed under intermittent mist in a greenhouse for approximately 7 weeks. Leaf damage was evaluated within 2–7 days after hot water treatment using a scale of 0 (no damage) to 4 (all tissue damaged). At the end of each experiment, cuttings were evaluated for root development [using a scale of 0 (no rooting) to 5 (full, symmetrical root system covering the surface of the substrate plug)].

RESULTS AND DISCUSSION

In Expt. 1, cuttings of nine of the twelve cultivars exhibited no leaf tissue damage following submersion in 122 °F water for 20 min compared with nontreated cuttings (Table 1). Leaf damage on cuttings of the remaining three cultivars was minor and not associated with reduced root development (Tables 1 and 2). Cuttings of 'Fashion' azalea had slightly less root growth on hot-water-treated cuttings compared with nontreated cuttings, although root systems likely would have been comparable after a few more weeks of growth. There was indication of some greater root development on cuttings of 'Conleb' (Autumn Embers™ Encore azalea), 'Hershey's Red', and 'Midnight Flare' azalea receiving the hot water treatment compared with nontreated cuttings, although increased root development was not a focus of this study.

In Expt. 2, results from submersing stem cuttings in 122 °F water for 20 to 80 min indicated that cultivars do vary in sensitivity of leaf tissue and rooting response to hot water treatment (Tables 3 and 4). As in earlier experiments with 'Gumpo White' azalea (Copes and Blythe, 2009), submerging cuttings in 122 °F water for 40 min did not severely damage leaf tissue (with ratings of mostly less than 3) on any of the twelve cultivars tested. Submerging cuttings for 60 min or longer increased the likelihood that cuttings would be severely damaged or killed (Table 3). Approximately one-half of the cultivars showed no significant reduction in root development with increasing duration of hot water treatment (Table 4).

Since stem cuttings only need to be submerged for 21 min in 122 °F water to eliminate the pathogen, even the most heat-sensitive of the twelve cultivars could be accidentally submerged for 40 min without hurting the cuttings. Based on published (but limited) research, many other pathogens may survive this heat treatment, while only a few pathogens, including some types of propagules of *Pythium* and *Phytophthora*, may be detrimentally affected by this heat treatment. Research would be needed to determine which pathogens can be killed by heat, if the depth

of pathogen structures within plant tissue affects pathogen mortality, and whether different types of heat sources are similarly as effective as hot water.

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Table 1. Numbers of terminal cuttings of 12 azalea cultivars exhibiting no leaf tissue damage when treated or not treated by submersion in 122 °F water for 20 min, inserted in a pine bark and peat medium in plug trays, and placed under intermittent mist (n = 36). Leaf damage was assessed within 2 to 7 days after treatment.[z]

Rhododendron taxa	Nontreated	Treated	*p*-value[y]
'Conleb' (Autumn Embers™ Encore azalea)	36	35	0.5000
'Fashion'	35	32	0.1785
formosa (syn. 'Formosum')	32	31	0.5000
'Gumpo White'	36	34	0.2465
'Hardy Gardenia'	33	30	0.2391
'Hershey's Red'	36	33	0.1197
'Macrantha Roseum' (syn. 'Macrantha Pink')	35	20	<0.0001
'Midnight Flare'	35	31	0.0993
'Red Ruffles'	35	31	0.0993
'Renee Michele'	33	29	0.1535
'Roblel' (Autumn Debutante™ Encore azalea)	33	36	1.0000
'Watchet'	31	29	0.3765

[z]Leaf tissue damage, when it occurred, was minor.

[y]*p*-values for tests of increased leaf damage with use of heat treatment (alternative hypothesis) based on Fisher's exact test (lower-tailed). Small numbers ($p < 0.10$) indicate a statistically significant difference in response between nontreated and treated cuttings.

Table 2. Numbers of terminal cuttings of 12 azalea cultivars exhibiting full, symmetrical root development when treated or not treated by submersion in 122 °F water for 20 min, inserted in a pine bark/peat medium in plug trays, and maintained for 7 weeks under intermittent mist (n = 36).[Z]

Rhododendron taxa	Nontreated	Treated	*p*-value[Y]
'Conleb' (Autumn Embers™ Encore azalea)	29	35	0.9975
'Fashion'	28	16	0.0037
formosa	31	34	0.9467
'Gumpo White'	35	34	0.5000
'Hardy Gardenia'	36	36	1.0000
'Hershey's Red'	7	15	0.9899
'Macrantha Roseum'	35	34	0.50000
'Midnight Flare'	32	36	1.0000
'Red Ruffles'	33	35	0.9427
'Renee Michele'	35	34	0.50000
'Roblel' (Autumn Debutante™ Encore azalea)	34	36	1.0000
'Watchet'	34	33	0.5000

[Z]Root development on all other cuttings was acceptable; no cuttings produced small root systems or failed to root.
[Y]*p*-values for tests of decreased root development with use of heat treatment (alternative hypothesis) based on Fisher's exact test (lower-tailed). Small numbers ($p<0.10$) indicate a statistically significant difference in response between nontreated and treated cuttings.

QUESTIONS AND ANSWERS

Douglas Justice: Were the microorganisms like *Rhizoctonia* actually killed by the hot water treatment? The temperature of the hot water (122 °F) doesn't seem that hot.

Gene Blythe: It doesn't seem particularly hot, but they were completely killed by that treatment. We've tried higher and lower temperatures for the hot water, but water at 122 °F is effective and seems to be the safest to use with most cuttings.

Mike Bone: Could you elaborate on the design of the "tube with holes" used to hold the cuttings and to keep them submerged?

Gene Blythe: We used a conventional, laboratory hot water bath that could keep the water at the temperature we set. The experiment was set up so we were only treating six cuttings of a cultivar at a time. The cuttings were put into the plastic tube. You could probably substitute muslin cloth or something like that. We made holes in the side of the plastic tube to be sure water was thoroughly moving around the cuttings while they were submerged in the hot water bath. In a nursery setting the same equipment used for hot water treatment of seeds could be used for the treatment of cuttings. It's important to carefully monitor the water temperature so it stays at or near 122 °F.

Table 3. Median leaf tissue damage ratings for leafy, terminal cuttings of 12 azalea cultivars submerged in 122 °F water for 20 to 80 min, inserted in a pine bark/peat medium in plug trays, and placed under intermittent mist (n = 12). Ratings were assigned within 1 week after treatment using a 0 to 4 scale (0: no damage; 4: complete damage).

	Duration of submersion (min.)				
Rhododendron taxa	20	40	60	80	*p*-value[z]
'Conleb' (Autumn Embers™ Encore azalea)	0	0	2	3	<0.0001
'Fashion'	0	2	3	4	<0.0001
formosa	2.5	3.5	4	4	<0.0001
'Gumpo White'	0	0	0	1.5	0.0675
'Hardy Gardenia'	0	2	2	3	<0.0001
'Hershey's Red'	0	2	3	3	<0.0001
'Macrantha Roseum'	2	3	4	4	<0.0001
'Midnight Flare'	0.5	2.5	4	4	<0.0001
'Red Ruffles'	0	1.5	3.5	3.5	<0.0001
'Renee Michele'	0	1	2	3	<0.0001
'Roblel' (Autumn Debutante™ Encore azalea)	0	0.5	0	2	<0.0001
'Watchet'	0	0.5	1	2	<0.0001

[z]*p*-values for tests of nonzero correlation (alternative hypothesis) between duration of submersion and response ratings based on Cochran-Mantel-Haenszel statistics. Small numbers ($p<0.10$) indicate a statistically significant change in response with increasing duration of submersion.

John Low: Since you were able to get complete kill after a 20-min exposure of the cuttings to hot water, why did you look at longer time periods?

Gene Blythe: We were curious to see what kind of damage longer time periods caused to the cuttings.

Jim Conner: Is the azalea blight similar to the camellia blight? Does it affect the flowers by turning them brown or are the two diseases totally different?

Gene Blythe: The azalea web blight kills stems. You'll typically find it toward the center of the plant. In humid conditions you may actually see the hyphae growing on the surfaces of leaves. It can actually look like a spider web, thus the name. It will kill the foliage and, eventually, the stems.

Steve McCulloch: Have you considered using a surfactant in combination with the hot water?

Gene Blythe: No, we haven't looked at that at all.

Table 4. Median rooting response ratings for leafy, terminal cuttings of 12 azalea cultivars submerged in 122 °F water for 20 to 80 min, inserted in a pine bark/peat medium in plug trays, and maintained for 7 weeks under intermittent mist (n = 12). Ratings were assigned on a 0 to 5 scale (0: no rooting; 5: full, symmetrical root development).

	Duration of submersion (min.)				
Rhododendron taxa	20	40	60	80	*p*-value[z]
'Conleb' (Autumn Embers™ Encore azalea)	5	5	5	4.5	0.1592
'Fashion'	4	3	2.5	0	<0.0001
formosa	5	4	2.5	0	<0.0001
'Gumpo White'	3.5	3.5	3	3	0.1883
'Hardy Gardenia'	4.5	4	3.5	3.5	0.2158
'Hershey's Red'	3	3	2.5	2.5	0.2581
'Macrantha Roseum'	3	3.5	0	0	<0.0001
'Midnight Flare'	5	5	1	0.5	<0.0001
'Red Ruffles'	3	3	3	1	0.0026
'Renee Michele'	4	4	3.5	3	0.0608
'Roblel' (Autumn Debutante™ Encore azalea)	5	5	5	5	0.1223
'Watchet'	5	4.5	3.5	2	<0.0001

[z]*p*-values for tests of nonzero correlation (alternative hypothesis) between duration of submersion and response ratings based on Cochran-Mantel-Haenszel statistics. Small numbers ($p<0.10$) indicate a statistically significant change in response with increasing duration of submersion.

Nevin Smith: Has anyone looked at the necessary temperatures to kill various common plant pathogens like *Fusarium* and *Botrytis* and *Phytophthora* and *Pythium*?

Gene Blythe: I'm sure that's been done, but I don't have the exact details on that.

A New University Greenhouse From Inception to Completion©

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At our Washington State University Extension office complex known as the Heritage Farm we have 79 acres of county-owned farm ground which includes community garden plots, agricultural research plots, and a collection of older greenhouses utilized by our Master Gardener Foundation. While the individual greenhouses are serviceable they are very dated.

INCEPTION

Washington State University conducted agricultural research at the Heritage farm from 1949 until 2008, at which time Clark County resumed ownership of the property with the intent of keeping it as a working farm. County staff reviewed the assortment of older greenhouses on the farm and determined that they should be replaced with modern structures incorporating the latest in greenhouse technology. In January, 2010, I approached the county with a proposal to build a new 30-ft × 60-ft gable greenhouse (GH). My initial proposal was readily accepted based on a projected cost estimate. In early discussions with staff from Clark County the issue was raised as to whether the new structure would have to meet the standards of the International Building Code for a GH. When I discussed inviting not only volunteers but also the general public into the building the county Building Inspector stated that clearly it had to have a Commercial Building Permit. As such agricultural buildings do not have to meet code as they are not open to the public (Bartok, 2005). Before our GH could be erected it had to have stamped engineering drawings sent by our manufacturer (Conley's Greenhouse Manufacturing and Sales) to the County Building Department. Our GH had to meet the same standards as those for a retail garden center (Humphrey, 2010), including a 25-lb snow load. As for the site for the new GH, the county General Services' staff recognized that the majority of the structures on the site were dilapidated and should be removed over time as opposed to being updated. Any new structure had to be placed on top of previous GH foot print. In addition, the county Fire Department had to review the plans for the entire GH complex. The Fire Marshall determined that no fire flow had been set for the entire GH complex. We could not exceed a total of 9,620 ft^2 of GH without triggering the need to either install sprinklers or put in a new fire hydrant. As our new structure would be open to the public it had to have doors and walkways that complied with the Americans for Disabilities Act (ADA).

PROJECT DEFINITION

The first step in considering what our new GH would include directed us to look at comparable research and public school structures. We reviewed coded houses in northwestern Oregon and southwest Washington. In keeping with the goal of building a structure with a professional appearance we looked at gable truss structures with rigid glazing. County staff members expressed strong support for

a well-designed structure that resembled those found at other public high schools and universities in the surrounding community. We discounted semi-gable (arch) or quonset bow designs as these were so often associated with lower-end facilities. Rather than using the common polyethylene or corrugated polycarbonate for glazing we opted for double-wall polycarbonate as it offered better insulation, durability, strength, and appearance.

For summer ventilation we opted for a design that incorporated both a roof vent as well as side vents. By incorporating a dual venting design we hoped to reduce the summer heat load by both wind pressure and thermal gradients (Buffington, 2010). Our naturally vented GH used less energy and was quieter than one with the traditional intake shutters and exhaust fans. To reduce the apparent heat load during the summer months we looked at a shade curtain system built truss-to-truss in a slope-flat-slope design. This design will enable us to hang plants and horizontal air flow fans from the roof trusses without interfering with the shade panel. A flat panel shade curtain would have been less expensive. During the winter months the shade panel can reduce heat loss significantly. We did understand that natural ventilation may not be enough to keep the interior temperature comfortable during the summer months. Accordingly, we had the engineering plans include space on the end walls for an evaporative pad on the windward wall and two exhaust fans on the leeward side. In our Northwest location this could reduce the ambient temperature by 15–18 °F depending on the relative humidity.

For heating the GH we looked at the newer condensing unit heaters. These units capture and utilize latent heat from the water vapor in the exhaust stream, enabling them to be 93% efficient (Schaffart, 2010). As a backup we had the standard 78% efficient power vented unit heater. Our greenhouse heating was designed to maintain a 50 °F temperature differential. For environmental control in the new GH we looked at electronic controllers that could regulate the heater, vents, shade curtain, and eventually the pad and fan system (Jones, 2008). We selected a Wadsworth EnviroSTEP unit that could manage 12 programmable relay stages. In time we may tie this unit into a personal computer.

For benches we looked at both stationary as well as rolling designs. We settled on five of each, with steel legs and hot-dip galvanized wire mesh bench tops. We discounted plastic bench tops as they did not appear to offer sufficient flex resistance. In order to keep the benches stabile their legs were set into concrete caissons.

For task lighting we had a combination T-5 fluorescent fixtures as well as high-pressure sodium lamps for seed starting. We have already started discussions with a major greenhouse lighting company in our community to donate lights to our new GH.

PROJECT DESIGN

During the design stage we worked with private greenhouse consultants to compare the costs associated with all the different variables we had reviewed. We looked at prices for gable houses from Stuppy (Classic 2000), AgraTech (SolarLite), Nexus (Vail), and Conley (7500 series). We settled on the Conley structure as they could custom design a structure to fit our space limitations. We had considerable input from the Master Gardener volunteers who will utilize the GH. They agreed to contribute $6,000 towards the new benches for the GH. While we were very fortunate to have as many of the advanced features we reviewed, budget limitations pre-

cluded us from having a full concrete pad, a pad and fan evaporative cooling system, and potable water delivered to the new GH. All told the entire project including site improvement cost on the order of $150,000.

IMPLEMENTATION

The GH was ordered from Conley GH in March 2011, and it arrived on 2 April 2011. We next had to develop a Request for Proposal for a contractor to build the structure. We assigned a value of $35,000 to cover construction. Of the three firms we solicited none of them felt they could meet this bid, as the county asked them to pay prevailing wages. During a second round of bids I was able to find a local contractor who would do the work, as long as he had assistance from the county Facilities Management staff.

UTILIZATION

The new GH was set up for teaching as well as raising plants to sell to support the Master Gardener Program. Currently, we raise nearly $35,000 per year from the sale of bedding plants, vegetable starts, houseplants, and herbaceous perennials. As this will be an ADA compatible structure we will be able to offer classes to mobility limited participants.

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POSTER SESSION

2011 Update on All-America Selections: Trialing New Flowers and Vegetables for a New Generation of Gardeners©

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All-America Selections (AAS) was founded in 1932 by W. Ray Hastings as a way for home gardeners to learn which new varieties were significantly improved for better garden performance. The AAS includes a network of over 50 trial grounds all over North America where new, never-before-sold varieties are grown and evaluated by skilled, impartial AAS Judges. Only the best performers are declared AAS Winners. The AAS continues as the oldest, most established international testing organization in North America.

All-America Selections Display Gardens provide the public an opportunity to view the new AAS winners in an attractive well-maintained setting and provide educational AAS programs during "open house" or "field day" events. The network of nearly 200 dedicated AAS gardens includes 55 locations that have served for 25 yr or longer. The earliest AAS garden was opened at Norseco Inc. of Québec, Canada, in 1962.

Figure 1. The new All-America Selections logo features a red winner bar, green leaves, blue letters for the AAS acronym, red letters for All-America Selections encircling the acronym, and a white background.

In Summer 2011, All-America Selections unveiled a new logo with a modernized design (Fig. 1). While there was some brand recognition of the former AAS badge emblem, the organization feels the new logo with the strong use of the letters A, A, and S, along with the red winner bar and green leaves, will quickly become more recognizable as a identifier of plants that are proven garden performers. Mike Murgiano of Syngenta Flowers, chair of the AAS task force responsible for the new image of AAS states, "Our new logo honors the past 80 years of AAS history by maintaining the familiar red, white, and blue, but in updated tones. We also are embracing our future with the strong use of the AAS acronym that represents an easily identifiable connection to our organization and our winning plants and flowers." Diane Blazek, AAS Executive Director, adds "The words 'All-America

Selections' encircling the acronym symbolizes how the organization embraces not only seed annual flowers and vegetables, but how we plan to embrace vegetatively propagated annuals and perennials in the future."

The 2011 AAS winners are:

- *Gaillardia* × *grandiflora* 'Arizona Apricot'
- *Brassica coleracea* 'Glamour Red' (ornamental kale)
- *Salvia coccinca* 'Summer Jewel Red' (F1 salvia)
- *Viola cornuta* 'Shangri-La Marina'
- *Capsicum annuum* 'Orange Blaze' (F1 pepper)
- *Cucurbita pepo* 'Hijinks' (F1 pumpkin)
- *Solanum lycoersicum* 'Lizzano' (F1 tomato)
- *Solanum lycoersicum* 'Terenzo' F1 (F1 tomato)

More information on AAS and AAS winners is available at: <www.all-americaselections.org>.

Habitat Creation and Management for Native Pollinating Insects at the Manhattan Plant Materials Center, Kansas©

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Pollinators are keystone species to which many plants rely on to complete their reproductive lifecycle. Insects are the most numerous group of the pollinators. Some pollinating insects are also considered to be indicator species and can be used to determine ecosystem health. Pollinating insects provide for heterogeneity of the floral gene pool, larger fruit and seed size, and a more even development of fruits or seeds. Bees are often the insect pollinators that are commonly referred to, and they are one of the biggest contributors to pollination, but many other types of insect pollinators are involved in pollinating flora. Due to the role that pollinating insects have in seed production and the increased problems with using domestic honey bees for commercial applications, a great need exists to study and develop better ways to manage native pollinating insects. Pollinating insects will play a vital role in the commercial production of native seed for land reclamation and restoration projects in the future. The increased demand for native plants and native plant seeds for ecological rehabilitation applications increases the need for demonstration projects and research on native insect pollinators and native plant interactions. Projects and studies at the Manhattan Plant Materials Center (PMC) have been implemented to survey for and to create artificial nesting habitat for native pollinating insects that occur at the PMC. Based on the results of these initial surveys and habitat projects, other management may be implemented to target specific species.

The Effect of Healing Chamber Design on the Survival of Grafted Vegetables©

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Successful grafting of vegetables requires high relative humidity (RH) and optimal temperatures for approximately 1 week following grafting to reduce transpiration of the scion until rootstock and scion vascular tissue are healed together and water transport is restored. This study evaluated the effect of three healing chamber designs on the survival of grafted eggplant (*Solanum melongena* L.), tomato [(*Solanum esculentum* (syn. *Lycopersicon esculentum*), and watermelon (*Citrullus lanatus* Thunb.). The three healing chamber designs were: (1) an industry design that was hand misted, (2) a research design that contained a humidifier, and (3) shadecloth only that was hand misted. The research healing chamber had higher mean RH than the shadecloth only healing chamber, but there was no significant difference in mean temperature between the two structures. All plants were self-grafted using the splice grafting technique, placed in the healing chambers for 7 days and evaluated for signs of wilting and graft failure from Day 6 to Day 14 after grafting. The industry healing chamber had higher mean temperature and RH (24.9 °C, 98%) than both the shadecloth only (23.3 °C, 52%) and the research healing chamber (23.4 °C, 81%). Graft survival in the research healing chamber (66%) and industry healing chamber (69%) were similar, and both had higher survival rates than the shadecloth only healing chamber (52%). The three crops all had significantly different survival rates regardless of healing chamber design; tomato had the highest percent survival rate (98%) and watermelon had the lowest survival rate (7%) with eggplant survival at 82%. The very low survival rate of watermelon was most likely due to the grafting technique used in this study, which was not optimal for watermelon. There was no interaction between healing chamber and crop. A healing chamber such as the research design in this study that has a humidifier has higher costs than the hand-misted industry healing chamber and at the same time has equivalent graft survival rates, suggesting that a humidifier is not cost effective for grafting.

Viability of Native Warm-Season Grass Seeds after 35 Years of Storage Under Two Different Environments©

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The ability to store native grass seeds for long periods of time is important to plant breeders, habitat restorationists, botanists, and seed vendors. Seeds stored in hot, humid climates are subjected to wide fluctuations in temperature and humidity. Such conditions are known to reduce longevity of seeds in storage. Seeds of nine warm-season grass species native to North America were stored under controlled and uncontrolled storage environments for 35 years at the Manhattan Plant Materials Center, Manhattan, Kansas. The viability of the seeds was monitored to determine what effect the two storage environments had on longevity of various native warm-season grass species. Seeds under a controlled temperature and humidity environment remained viable for more than 35 years, except for seeds of prairie cordgrass (*Spartina pectinata* Bosc ex Link). The longevity of seeds stored under an uncontrolled storage environment remained viable up to 13 years. The viability of the grass seeds remaining in this study meet or exceed the minimum acceptable level established by Kansas seed certification standards. Trends in longevity for the grass species under the two storage environments makes it possible to predict storage life of seed lots.

The Efficacy of Flower Bud Removal Techniques for Enhancing Growth of Young Blueberry Cultivars©

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In this 2-year study, flower bud removal techniques were tested on young rabbiteye blueberry (*Vaccinium ashei* Reade) plants to determine effects on flower bud mortality and growth parameters. The treatments consisted of no flower bud removal (control), hand stripping, and hydrogen cyanamide applied at 0.75% and 1.5%. Treatments were applied to three different cultivars exhibiting different stages of flower bud development. The cultivars, listed from most advanced to least advanced flower bud development were 'Climax', 'Brightwell', and 'Tifblue', respectively. Both hydrogen cyanamide treatments resulted in higher bud mortality than the control, and the 1.5% treatment was as effective as hand stripping in Year 1 (2009). Except for 'Brightwell' in 2009, leaf area was not affected by treatments. The growth index was not affected by the bud removal treatments in either year of the study. The 1.5% hydrogen cyanamide treatment appeared to be an effective method of flower bud removal, and, as a labor saving practice, could be used as an alternative to hand stripping. However, this study indicates that flower bud removal may not result in increased vegetative growth for field-grown rabbiteye blueberry plants.

King Range Native Perennial Bunchgrass Program©

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Limited stands of historically abundant California native perennial bunchgrass remain in California wild landscapes. Many of these wild landscapes have been subject to a century or more of livestock grazing and decades of fire suppression. The Bureau of Land Management (BLM), in partnership with the Mattole Restoration Council (MRC), has inventoried, mapped, collected, and propagated seed of 11 native perennial bunchgrasses in order to generate enough seed and standing nursery capacity for on-the-ground restoration projects. Through partnership, the BLM has utilized native perennial bunchgrass material to: (1) create an in situ seed bank for study and future seed collection, (2) develop and provide sufficient local seed supply for a hydroseeding project following the 2008 Paradise Fire, and (3) produce nursery capacity to thus far transplant 64,622 plugs of prairie Junegrass (*Koeleria macrantha*), leafy reed grass (*Calamagrostis foliosa*), Pacific hairgrass [*Deschampsia holciformis* (syn. *Deschampsia cespitosa* ssp. *holciformis*)], California melic (*Melica californica*), and Idaho fescue (*Festuca idahoensis)*, following the 2007 Spanish Fire, and also in November of 2009–2010 as part of Paradise Ridge and Prosper Prairie native perennial grass enhancement projects. The BLM is committed to actively managing events responsible for resuming successional processes that may favor colonial establishment of transplanted perennial grasses. The King Range Native Perennial Bunchgrass Program has demonstrated that successful establishment of new native perennial bunchgrass colonies can be accomplished through the propagation of locally collected seed followed by transplantation of plugs.

Hibiscus acetosella 'Sahara Sunset'©

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The Agricultural Research Service, United States Department of Agriculture, has released a new African hibiscus, *Hibiscus acetosella* Welw. ex Hiern., named 'Sahara Sunset' (USPP #21,765). This cultivar, tested as HAC06-11, was selected from a group of seedlings grown at the Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi. Seedlings were produced from seed of open-pollinated purple-leaf *Hibiscus acetosella* which were irradiated with a cobolt-60 source. The original seedling of 'Sahara Sunset' was selected in 2006. It is the first stable variegated form of the purple-leaf form of this species.

'Sahara Sunset' is a tropical shrub (USDA Cold Hardiness Zone 10), grown as an annual for the beauty of its colorful maple-like leaves. Plants of 'Sahara Sunset' are moderately vigorous, have a spreading upright growth habit, and have unique multicolored ornamental foliage. When grown as an annual, it can reach 2 m tall by the end of summer if grown under optimum conditions without pruning. 'Sahara Sunset' has small, insignificant purple flowers induced by short days.

'Sahara Sunset' is well suited to a range of landscape uses such as a specimen plant, a color accent in shrub borders, a contrast plant in mixed annual planters, a background planting in perennial beds, and as a summer hedge. Plants perform best in full sun with moderate moisture and fertility. Its broad environmental adaptation and tolerance of common insects and diseases make it an ideal plant for low maintenance plantings.

Speaking Plant Approach for Highly Sophisticated Intelligent Greenhouse©

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INTRODUCTION

Japanese agricultural sector has a serious problem in the workforce area. The population engaged in agricultural sector has decreased in the last 50 years because of rapid aging, i.e., people over 65 years old occupy 61% of the current agricultural workforce. This situation results in a decrease in self-sufficiency and increase in the dependence on imported food, and threatens the safety and reassurance of food in Japan. As a solution for this problem, the plant factory system attracts much attention as a prospective agricultural production system in Japan. However, at this moment, the plant-factory system does not always produce commercial success. So, further technological development is required.

In April 2011, we established the Research Center of Intelligent Greenhouse Systems (RIGS) in Ehime University, which was supported by the Ministry of Economy, Trade, and Industry and the Ministry of Agriculture, Forestry, and Fisheries of Japan. In RIGS, we are promoting research based on the concept of the "speaking plant approach" (SPA). The SPA concept defines that the optimal crop cultivation conditions should be based on the physiological status of the plants and the concept has attracted a great deal of attention as a highly sophisticated strategy for environmental control in greenhouses. To establish the SPA, we are focusing on information and communication technology (ICT) and robot technology. Our goal is to achieve a stabile supply of high quality agricultural products with SPA technologies.

SPEAKING PLANT APPROACH FOR HIGHLY SOPHISTICATED INTELLIGENT GREENHOUSES

There are two types of plant factories defined in Japan. One is artificial lighting completely closed and the other is intelligent greenhouse. Both are high-performance agricultural production systems, which control environmental factors such as light, temperature, humidity, and CO_2. At RIGS we are especially focused on the intelligent greenhouse. The difference between the conventional and the intelligent greenhouses is characterized by their harvest periods. In the intelligent greenhouse, the environmental factors are intensively controlled to keep the plants healthy based on the SPA concept and it allows year-round production.

INTELLIGENT SYSTEMS FOR SPEAKING PLANT APPROACH GREENHOUSE

The first and important step of the SPA concept is the measurement of plant physiological information and the diagnosis of the plant health status based on that information. Therefore, the "plant health monitoring technique" is very important step in the SPA concept. The SPA basically consisted of three steps: (1) measurement of plant biological information, (2) diagnosis of plant physiological status, and (3) control of environmental conditions optimally. So, we focus on the research topics as follows:

1) Chlorophyll fluorescence measurement to evaluate the photosynthetic functions (Fig. 1). The photosynthetic reaction and chlorophyll fluorescence emission are competitive reactions, so precise measurement of chlorophyll fluorescence allows us to evaluate the status of photosynthetic functions without touching the plant. Figure 1 is a map of the "photosynthetic function index" of an experimental RIGS greenhouse. Tomato plants in the western area of the greenhouse, i.e., non-heating area, showed lower values compare with the plants in the eastern area. This result suggests that significant heterogeneity in the health conditions of tomato plants is detectable by using the chlorophyll fluorescence imaging system.
2) Detection of water-stressed plants under greenhouse conditions. Generally, leaf temperature is relatively low because of the transpiration, i.e., latent heat of evaporation. But, the leaf temperature goes up when the plant is exposed to water stress and the temperature increase of the leaves is detectable with thermal cameras.
3) Quantification of water stress by monitoring the wilting of tomato plants. By taking color images of tomato plants form the top of the canopy, the extent of the water stress can be evaluated as changes in the projected area of the plant. We applied this technique for the irrigation control to produce high-sugar-content tomato fruits.
4) Autonomously controlled plant diagnosis robot (Fig. 2). This robot has CCD camera for detection of abnormal flowers, infrared radiation thermometer for diagnosis of transpiration by measuring the leaf temperature and chlorophyll fluoresce imaging system for diagnosis of photosynthetic functions.

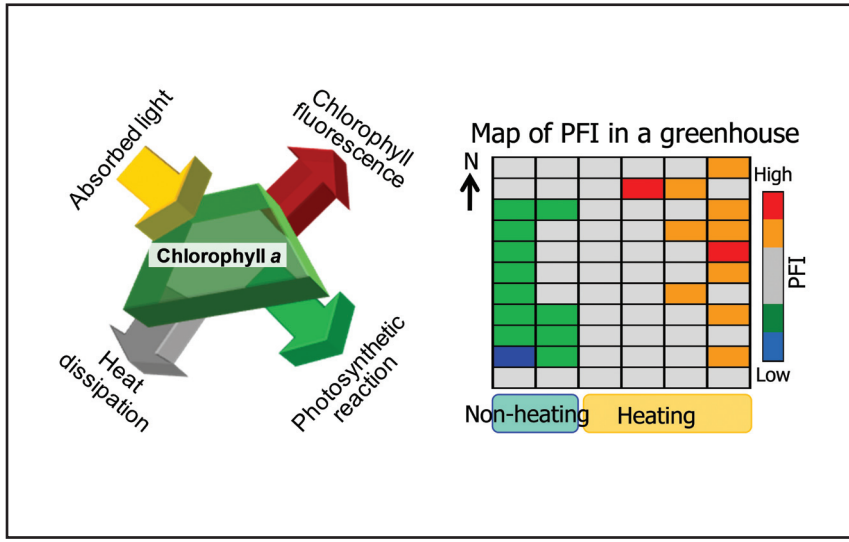

Figure 1. Chlorophyll fluorescence measurement to evaluate the photosynthetic functions and map of PFI.

Figure 2. Plant diagnosis robot.

5) Mapping system of diagnosis information.
6) Root zone and growing tip cooling system, etc.

By using such a plant diagnosis robot, we are developing SPA-based intelligent greenhouse systems. Though the plants are cultivated under strictly controlled environmental conditions, their growth can be varied by not only the genetically based variations but daily operations. Such a destabilized growth is also detectable with the plant health monitoring techniques and the plant health status is able to be evaluated (plant diagnosis). Based on the result of the plant diagnosis, the production management system automatically modifies the settings of the environmental factors. At this step, a knowledge base — which is an accumulation of information on growth, plant diagnosis, and historical log of the environmental control — plays an important role to optimize the control procedure.

Ferrous Ferric Chloride Water Decreases Attachment of Bacteria to Surfaces — Scanning Electron Microscopy Observation and Force-Volume Microscopy Measurement of Titanium Surfaces Immersed in Ferrous Ferric Chloride Water©

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INTRODUCTION

Akatsuka Garden Company has continued research and development on various solutions which accelerate plant growth and activate physiological functions of plants since 1984. We have focused our attention on the behavior of iron ions in water and interaction of iron ions and water. Based on that research we developed a new water improvement device named "Ferrous Ferric Chloride (FFC®) ceramic balls" (Sugi and Yamashita, 1991) in 1995. Water treated with FFC ceramic balls (called "FFC water") possesses specific biological effects such as stimulation of plant growth, especially root growth (Hasegawa et al., 2006). In animals, FFC also possesses stimulative effects on cell growth (Hirobe, 2007). The FFC ceramic balls have been utilized by users in many different fields in primary and secondary industries. Those users obtained many advantages from the utilization of FFC ceramic balls — for example, productivity enhancement, cost reduction, decrease in amount of agricultural chemicals required, etc. (Yokomizo, 2011). In addition, many users have realized that utilization of FFC ceramic balls for production facilities and their water distribution systems can decrease the harmful biofilm formation which can cause contamination and deterioration of facilities and the clogging of drainage pipes. We considered that these beneficial phenomena could be due to physicochemical origins of the FFC water's antifouling property against bacterial attachment. Therefore we established collaborative research with Harvard University from 2004 until today. In this paper, I introduce some of the effects of FFC water to prevent or hinder bacterial attachment using titanium surfaces for this research.

MATERIALS AND METHODS

The control solution was prepared by dissolving 0.22 g of $(NH_4)_2SO_4$, 0.12 g of KH_2PO_4, 0.23 g of $MgSO_4 \cdot 7H_2O$, 0.25 g of $CaCl_2 \cdot 2H_2O$, and 0.05 g of BBL™ yeast extract in 1 L of deionized water followed by autoclave sterilization. The FFC solution was prepared as described for the control solution, but with deionized water first equilibrated with four FFC ceramic balls under vigorous stirring for 1 h.

Sterilized titanium squares (0.5×0.5 cm^2, thickness of 0.5 mm) were immersed in the control or FFC solutions with and without *Pseudomonas aeruginosa* inoculation at 25 °C and 120 rpm. The squares with the inoculation were removed after 4 days of incubation, and the squares without the inoculation were removed after 2 days of incubation. The density of attached *P. aeruginosa* cells to the surfaces

with the inoculation was examined by scanning electron microscopy (SEM). Surface forces (repulsive and adhesion forces) of the titanium squares with and without the inoculation were examined by force-volume microscopy (FVM) (Na et al., 2010).

RESULTS AND DISCUSSION

The SEM observations showed that the densities of attached *P. aeruginosa* were 6.2 (±1.3) × 10^5 cells/cm^2 for surfaces immersed in the FFC solutions compared to 8.7(±0.8) × 10^6 cells/cm^2 for surfaces immersed in the control solution (Figs. 1, 2a). Parallel measurements by FVM demonstrated that regions of elevated interfacial repulsion covered 72±2 % of the surfaces immersed in the FFC solutions, compared to 26±2 % for immersion in the control solutions (Fig. 2b). Additionally, the FVM measurements also indicated that the upper fifth percentile of surface adhesion was 1784±40 pN for surfaces immersed in the FFC solutions compared to 2284±40 pN for the control solutions (Fig. 2c). These results suggested that more extensive regions of elevated interfacial repulsion as well as of decreased surface adhesion provided an explanation for the lower density of attached cells observed for the surfaces immersed in the FFC solutions compared to the control solutions.

Our previous experiments showed that the lower densities of attached cells after using FFC water were observed for surfaces of not only titanium but also steel, plastic, and glass. Thus, we consider that the utilization of FFC ceramic balls for plant production facilities and its water distribution systems may be a worthwhile strategy for preventing or at least hindering bacterial attachment and biofilm formation.

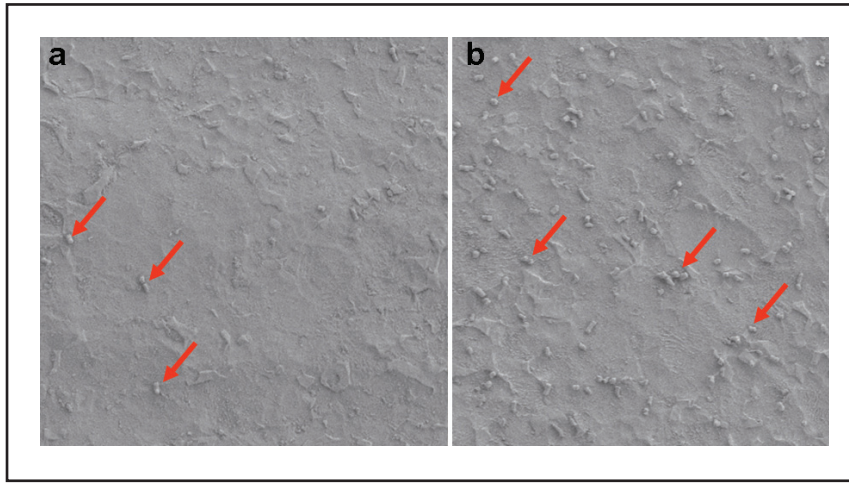

Figure 1. Scanning electron microscopy (SEM) image of titanium surfaces immersed in (A) ferrous ferric chloride (FFC) or (B) control solutions for 4 days. Prior to immersion SEM images showed clean surfaces. Image size: 40 × 40 μm^2.

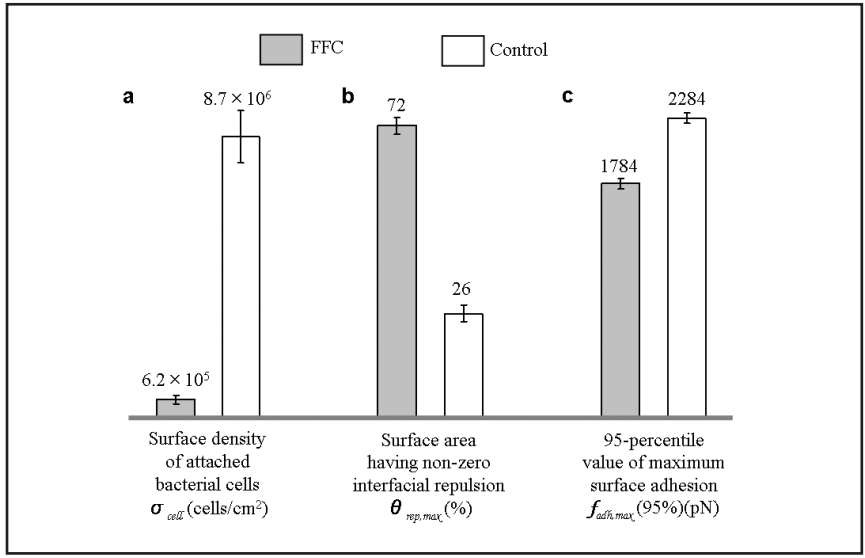

Figure 2. Comparison for ferrous ferric chloride **(**FFC) and control solutions of (A) surface cell density, (B) surface area having non-zero interfacial force, and (C) the 95-percentile value of maximum surface adhesion.

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Use of the Microbial Pesticide Hasumon Killer® Against *Spodoptera litura*©

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The common cutworm, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae) (Fig. 1) is a serious harmful insect because the larvae attacks more than 80 kinds of plants, including vegetables (Fig. 2), flowers, and fruit trees. In Japan, the expanding of the damage started in the second half of 1950s. In the warm area of central Kanto district to the south, it has occurred continually to the present. This causes considerable concern because *S. litura* can overwinter in plastic and glass greenhouses built mostly from the1950s and the increasing temperatures from global warming.

Although many depend on controlling *S. litura* larvae by spraying chemical pesticide, there are many examples of pesticide resistance occurring. In addition, chemical pesticide use may be restricted by the number of spray application times and crops on which it can be used even if it is still effective.

Therefore, if new nonchemical control materials can be developed to replace current chemical pesticide treatments we felt that it could contribute to better farm worker's management of the pest and offer consumers food free of chemical pesticides.

Ibigawa Kogyo Co., Ltd. then developed the microbial pesticide Hasumon killer® from *Spodoptera litura* nucleopolyhedrovirus (SpltNPV) which has a strong insect-killing activity against *S. litura* in collaboration with Gifu Prefectural agricultural technology center.

The SpltNPV is an insect virus and belongs to the genus *Nucleopolyhedrovirus* of the family *Baculoviridae*. It is very stable since the viral particles are occluded in a protein crystal. When *S. litura* larvae ingest it, the occlusion body dissolves in the high alkali conditions of the digestive organs, the cells are infected with the emitted viral particle, so their whole bodies were infected and they died (Fig. 3).

We used a novel SpltNPV isolated in Japan, which has a high insect-killing activity, as the active ingredient of Hasumon killer (Kamiya et al., 2004). Because of this the control effect is higher than conventional insect virus formulations and other microbial pesticides. Regarding this point, it has been shown by studies carried out at examination sites around the country (Kamiya and Sobue, 2007). Viral insecticides such as SpltNPV have the advantage of being safe for humans and non-target insects, such as honeybees, and soil microbes and plants. The safety to humans is also very high from the safety examination studies using mammals, such as mice.

We applied to the Ministry of Agriculture, Forestry, and Fisheries for the agricultural chemicals registration to sell Hasumon killer in March of this year. If everything goes smoothly, we will acquire agricultural chemicals registration for the following five crops: soybean, green soybean, strawberry, perilla, and basil by next year (Table 1).

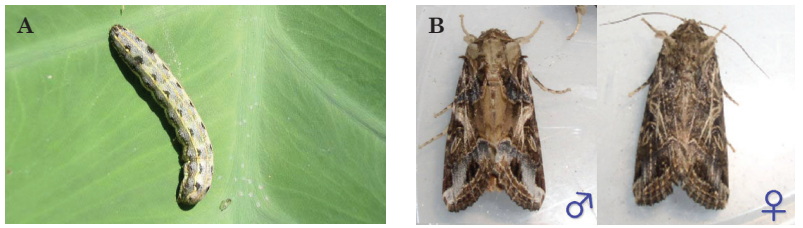

Figure 1. *Spodoptera litura* (Fabricius) A, larva; B, imago male (left) and female (right).

Figure 2. Damaged leaf of kale (*Brassica oleracea* L. var. *acephala* DC.).

Figure 3. Dissolved body of *Spodoptera litura* by Hasumon killer.

Table 1. The range of application disease and insect pest name, and usage.

Crop name	Application disease and insect pest name	Dilution multiple	Operating fluid volum	Use time	Usage
soybean green soybean strawberry perilla basil	*Spodoptera litura*	1,000 times	100~300 L/10 acre	Early stages of larva generating	Spraying

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Effects of an Eco-Friendly Pot Medium "Chaco Ball" on Cuttings of *Ficus benjamina*©

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"Chaco Ball" (Japanese commercial name: Sumi-zutsumi) is an eco-friendly pot medium, and it has a structure of charcoal coated with porous ceramics. In this report, we examined its use as cutting medium. Tip cuttings of *Ficus benjamina* L. with 4 unfolded leaves were prepared from greenhouse-grown stock plants. The cut ends of cuttings were dusted with powder of 0.5% indole-3-butyric acid (IBA). The cuttings were inserted in three kinds of media: Chaco Ball, akadama-soil, and expanded-clay balls (7 mm). They were irrigated by overhead irrigation or subirrigation. Rooting and subsequent growth of cuttings when Chaco Ball medium was used were superior to the other media, regardless of the irrigation method. The cutting root system after 2 months in the Chaco Ball medium was more fibrous and higher in weight than in other media, especially in the case of the overhead irrigation.

INTRODUCTION

"Chaco Ball" (Japanese commercial name: Sumi-zutsumi, which the name means coated charcoal) is a medium developed jointly by Konishi Kohatsu Co. Ltd. (Kagawa, Japan) and Ota Floriculture Research Institute Ltd. (Tokyo, Japan). The Chaco Ball is an eco-friendly medium for pot culture and hydroculture. It was made from charcoal powder derived from saw waste of trees such as Japanese cedars and Japanese cypresses during thinning for forest management. More than 64% of it is carbon. Moreover the carbon was stably fixed in its granules. Therefore, the manufacture and use of Chaco Ball would contribute to reduce waste and carbon dioxide emission into the atmosphere. The charcoal in the Chaco ball is coated with porous ceramics. Their physical and chemical nature has been already examined and become clear—they have good properties such as aeration, drainage, absorption of water, and the ability to absorb toxic substances such as formaldehyde (<http://www.otalab.co.jp>). In this report, we examine the functionality of Chaco Balls as a cutting medium.

MATERIALS AND METHODS

Preparation of Cuttings and Media. Tip cuttings of *Ficus benjamina* with four unfolded leaves and about 6 cm long were prepared from stock plants grown in a greenhouse on 12 June 2011 (Hartmann et al., 1997). The cut end of cuttings was dusted with 0.5% IBA powder [Oxyberon 0.5 (commercial name), Shionogi

& Co., Ltd., Oosaka, Japan]. The respective cuttings were inserted at 2 cm deep in three kinds of media which were contained in 6-cm plastic pots (inner volume 120 mL). The three media were: Chaco Ball (the diameter of about 4 mm, Ota Floriculture Research Institute, Tokyo, Japan), akadama soil (a small granule with a diameter of approximately 5 mm), and expanded-clay balls [with a diameter of approximately 7 mm, Hydroculture (commercial name), Daiso-sangyo Co., Ltd., Hiroshima, Japan]. Akadama soil and expanded-clay balls are generally used in Japan as media for pot culture and hydroculture, respectively. All media were screened with a sieve (with 4 mm openings) to remove dust and small particles before use. One gram of mixed slow-release coated fertilizer [10N-10P_2O_5-10K_2O-10CaO : 10N-18P_2O_5-15K_2O + microelements (1 : 1, v/v), each of high-control, 70-day-release type (commercial name), Chisso Corp., Tokyo, Japan] was added to each potting medium immediately before cutting propagation.

Cultivation and Estimation of Establishment of Cuttings. At first, all potted cuttings were rooted on a greenhouse bench under a 50% shading to avoid excess drying of the cuttings. The shading curtain was removed after the first week. One half of each experimental plot was supplied water by overhead irrigation once or twice a day depending on surface drying of the media. The other half was continually supplied water by subirrigation using trays that maintained the water at a depth of 1 cm. All lateral shoots were removed immediately after visible confirmation during the experimental period in order to simplify the estimation of cutting growth. Two months after cutting insertion (9 Aug. 2011), all plants were harvested and measured for stem length, number and fresh weight of leaves, stem fresh weight, and root fresh weight.

RESULTS AND DISCUSSION

In the Chaco Ball plot, all cuttings rooted and grew regardless of the difference in irrigation method. In the akadama-soil and the expanded-clay ball plots under overhead irrigation 20% of cuttings were not rooted and dropped leaves, and finally died within 3 weeks (Table 1). In the case of subirrigation, there was no significant difference statistically on shoot length, number of leaves, fresh weight of leaves and fresh weight of stem, but the internodal length and leaf lamina in the expanded-clay ball plot were larger than in other plots. Rooted cuttings of the expanded-clay ball plot showed succulent growth to some extent (Fig. 1). Total root fresh weight in the Chaco Ball plot was heavier than in other media plots (Table 1) and the root system developed better than other media (Fig. 2). In the case of overhead irrigation plots, all growth parameters were the largest in the Chaco Ball plot (Table 1, Fig. 3), and its roots were more fibrous when compared with those in other media plots (Fig. 4). One of the main requirements of a cutting medium is that it should drain quickly to admit air to the rooting area but also should retain some moisture, because the property of medium will determine whether root will form and their quality (Rice and Rice, 2000). From the above mentioned results, it was shown that Chaco Ball can function well as a cutting propagation medium.

Table 1. Effercts of media and irrigation methods on the rooting and subsequent growth of *Ficus benjamina* cuttings.

(n = 9. Data were recorded on 57th day from cutting)

Irrigation method	Medium	Survival of cuttings (%)	Stem length (cm)	New growing after cutting		Fresh weight (g/plantlet)	
				Leaf no.	Leaf fr. wt. (g/plantlet)	Stem	Root
Subirrigation	Chaco Ball	100	25.1 a	8.2 a	2.95 a	1.33 a	1.87 a
	Akadama-soil	100	24.6 a	9.1 a	2.53 a	1.24 a	1.23 b
	Expanded-clay	80	23.8 a	7.8 a	2.23 ab	1.17 ab	0.72 cd
Overhead irrigation	Chaco Ball	100	18.9 b	8.0 a	1.79 b	0.86 b	0.86 c
	Akadama-soil	80	13.7 c	5.0 b	0.92 c	0.74 c	0.62 d
	Expanded-clay	80	10.8 d	4.4 b	0.51 d	0.41 d	0.33 e

Means followed by the same letter within column were not significant at 5% level by Turky's test.

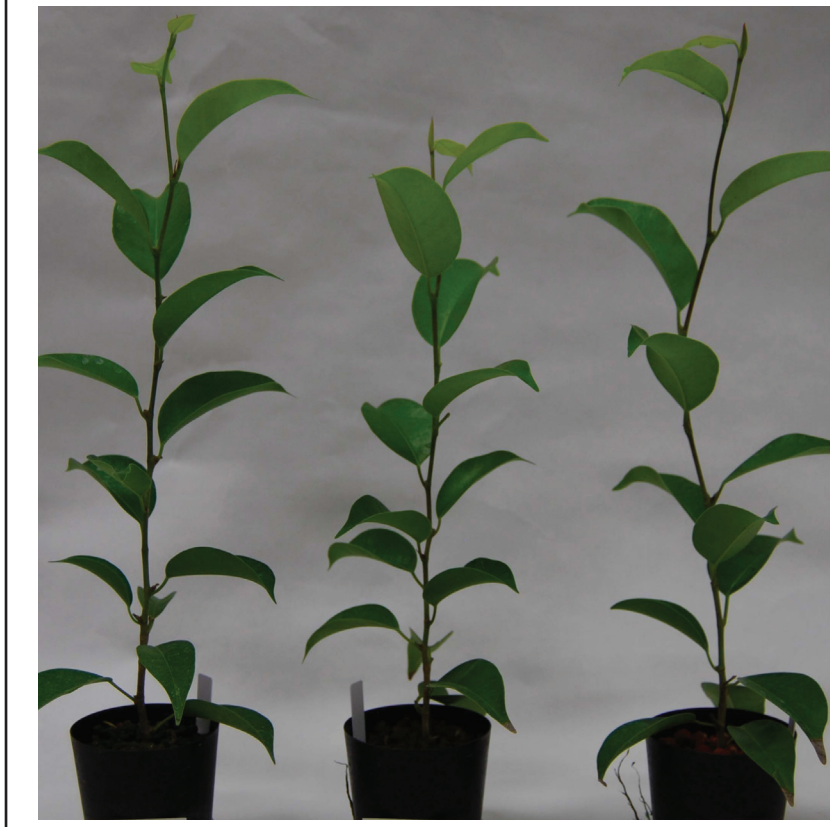

Figure 1. Growth of cuttings in the subirrigation plot (2 months after cutting). Left: Chaco Ball, Center: Akadama-soil, Right: Expanded-clay ball.

Figure 2. Root growth of cuttings in the subirrigation plot (2 months after cutting). Left: Chaco Ball, Center: Akadama-soil, Right: Expanded-clay ball.

Figure 3. Growth of cuttings in the overhead irrigation plot (2 months after cutting). Left: Chaco Ball, Center: Akadama-soil, Right: Expanded-clay ball.

Figure 4. Root growth of cuttings in the overhead irrigation plot (2 months after cutting). Left: Chaco Ball, Center: Akadama-soil, Right: Expanded-clay ball.

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SuiSui System: A Method of Raising Strawberry by Capillary Watering©

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Strawberry (*Fragaria ×ananassa*) is one of the more important fruits eaten in Japan. In commercial production, 8,000 plants per 10 acres is required which is several times that of other fruit vegetables. Almost all strawberry farmers are producing their plants themselves; this increases labor costs and also increases the risk of diseases. In order to reduce labor costs and potential for disease, we developed the "SuiSui system" a method of raising runner plants by capillary watering.

In this system, you grow runner plants by planting the cuttings (runner tips) in a SuiSui pot with capillary watering. The SuiSui pots are placed on trays with special watering mats placed on a bench (Figs. 1 and 2).

The raised bench method will reduce a farm worker's need to bend over. SuiSui pots can secure water supply to the plantlets from the bottom. This method will also greatly increase labor savings during planting because the rooted runner plants can be planted directly without removing them from the pots. In addition, since all the excess water flows out quickly there is reduced risk of damage to the plantlets.

Seedling raised through this method can grow large enough for planting out within 70 days, although there are some differences among strawberry cultivars (Table 1).

In this system the temperature inside of the pot is decreased by evaporation heat. This induces flower bud differentiation and contributes to simultaneous flowering as fast as that of raising plants under nocturnal cooling (Table 2).

You can prevent plant injury caused by *Glomerella cingulata* (Stoneman) Spaulding and Schrenk with usual methods of pest and disease control.

As shown in Table 3, the number of total flowers per plant of this method was larger than that of the plants produced by the normal method. Both apical inflorescences and axillary inflorescences were greater.

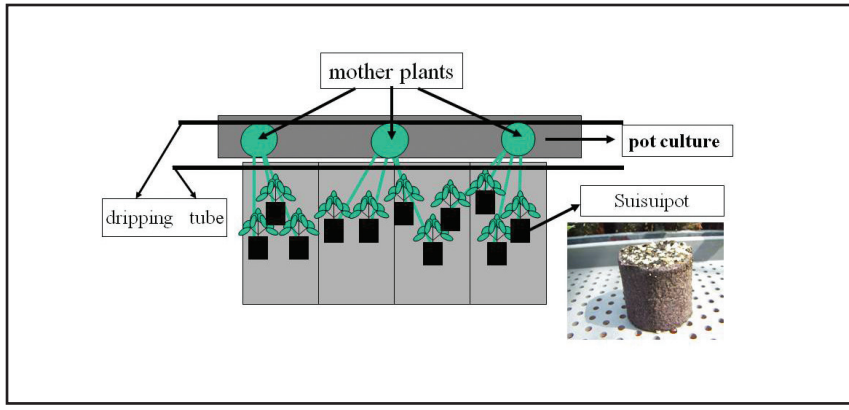

Figure 1. Diagram of the SuiSui system.

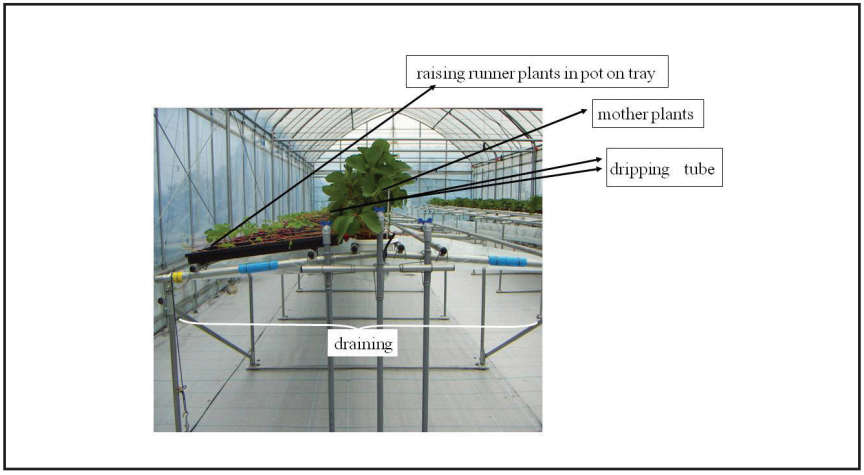

Figure 2. Picture of SuiSui system.

Table 1. Seedling quality of each variety grown in SuiSui pot.

Cultivar name	Number of leaves	Crown diameter (mm)
Toyonoka	4.2	8.4
Akihime	4.1	10.0
Sachinoka	4.6	8.9
Benihoppe	4.3	9.5
Sagahonoka	4.5	9.3
Amaotome	4.6	9.7

Date of planting in pot: July 1
Date of research: September 13

Table 2. Difference of flowering conditions between plants raised in SuiSui pot versus plastic pot.

Pot type	Flower bud stimulation	Number of seedling	Open-flowering	Number flowering	Flowering (%)
SuiSui pot	not	40	26-Oct	33	82.5
Plastics pot	nocturnal cooling treatment	30	24-Oct	20	66.7
Plastics pot	not	40	-	0	0

Data of planting in SuiSui pot: September 23
Date of planting in the plastic pot: September 17
Date of research: November 6
Condition of flower bud stimulation: nocturnal; cooling treatment: 17
Length of daytime: 8 hours per day for 21 days

Table 3. Total number of flowers in SuiSui pot versus plastic pot (variety: S. Achinoka).

Pot type	Flower bud stimulation	Number of seedling	Apical inflorescencs floweres (no.)	Axillary inflorescences		Total number of flowers per seedling
				Flowers per inflorescences (no.)	Inflorescence per seedling (no.)	
Suisui pot	not	40	20.0	14.0	1.8	45.2
Plastics pot	nocturnal cooling treatment	30	15.0	14.0	1.5	36.0
Plastics pot	not	40	14.0	14.0	1.5	35.0

Date of planting and condition of flower bud stimulation are the same as in Table 2.
The number of flowers were researched between November and February.

Approaches to Multiplication and Supply of Virus-Free Japanese Yam (*Dioscorea japonica*) Seed Tubers©

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We are students majoring in biological engineering at Iyo Agricultural High School. Since 2008 numerous attempts have been made by us to provide virus-free Japanese yam (*Dioscorea japonica* Thunb.) seed tubers with the help of the local Japanese yam production guild in Hirota village. In the past the guild had received the seed tubers from the Ehime Prefectural Agriculture, Forestry and Fisheries Examination Institution but they are not now supplied.

In Stage 1 of the original micropropagation method for the production of virus-free plantlets, the shoot apexes were cultured on Murashige and Skoog (MS) medium (Murashige and Skoog, 1962) supplemented with α-naphthaleneacetic acid (NAA) and 6-benzylaminopurine (BA) phytohormones (Table 1). In the current study, however, we used hormone-free medium, because we should not overlook that there is a possibility of epigenetic changes when phytohormones are used. The explants used for the study are not the meristem apexes but larger segments including the meristem. We also need to take measures to prevent a virus from entering these explants.

Table 1. Murashige and Skoog (MS) medium growth regulator and sucrose treatments.

Material	MS strength	NAA	BA	Sucrose
MS	1/1	0.02 mg/L	0.2 mg/L	30 g/L
MS	1/1	0	0	30 g/L
Amaotome	4.6	9.7		

The objective of the current study was investigation into the possibility of producing a stable supply of virus-free (Editor's note: refers to free from Japanese yam mosaic virus) Japanese yam seed tubers from microbulbils by using explants that are not infected with Japanese yam mosaic virus (JYMV) as determined by using the reverse transcription-polymerase chain reaction primers (RT-PCR, Table 2).

From July through August, 160 stem segments with the axillary buds were taken from the vines of one Japanese yam plant. The length of the each segment was about 3 cm. The segments were soaked in the alkaline detergent (MYPET, Kao Co.,

Table 2. Specific primers used in the present study to detect Japanese yam mosaic virus (JYMV).

Target virus	Primer	Sequence	Ampricon size (bp)	Reference or accession
JYMV	125F	5`-TTGGATGATAATTCAATGCAA-3`	241	AB430808
	12345R	5`-GTGGCATATACGCTTTTTC-3`		AB430808

Japan) for 10 sec and washed with water; for surface sterilization, segments were soaked in 10% chlorine bleach (HYTER, Kao Co., Japan) for 10 min and rinsed with sterilized water. The ends of the surface sterilized segments were trimmed (about 5 mm) prior to placing on hormone-free MS medium. To develop micro-bulbils from the shoots, the culture conditions were maintained at a constant temperature of 23 °C under a 14-h photoperiod by white fluorescent lamps.

Some axillary buds became micro-bulbils; the others have elongated shoots with micro-bulbils. Finally, elongated shoots were induced from all segments, 90 elongated shoots out of 160 could have 1 or 2 micro-bulbils each that weighed 0.15 g on average. These micro-bulbils were kept in cold storage, and sprouted after planting.

In conclusion, the reproduction of Japanese yam micro-bulbils is possible by using stems with axillary buds. In addition, micro-bulbils developed on them can be preserved at 4 °C in a refrigerator and they need no acclimatization.

Hirota Japanese yam production guild has a greenhouse (about 1 acre) for seed tubers production. Every spring, the superior seed tubers were cut into pieces of about 10 g each and planted five pieces each into 120 large pots; in autumn, they produce about 60-kg seed tubers in all. The guild supplies these tubers to the farmers.

For our produced micro-bulbils to apply to this seed-tubers production system future research will be needed to examine how large the seed tubers will become from micro-bulbils. In addition, we have been trying to supply virus-free Japanese yams stably by the use of reverse transcription loop-mediated isothermal amplification (RT-LAMP) methods.

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Effects of the Character of Cuttings and the Type of Auxin on Rooting Ability in Dragon Fruit©

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INTRODUCTION

Dragon fruit (*Hylocereus undatus* Britt & Rose), also called pitaya of pitahaya, is a climbing cactus native to the tropical forest regions in Mexico and Central and South America (Mizrahi et al., 1997). Dragon fruit has been cultivated in Vietnam and currently in some countries such as Nicaragua, Columbia, and Israel (Merten, 2003).

In Japan dragon fruit has been cultivated mostly in Okinawa. In 2009 the growing area and amount shipped were 46 ha and 335 t, respectively (Ministry of Agriculture, Forestry and Fisheries, 2011). Dragon fruit can be grown without heating in warm regions; therefore the cultivation has been increasing recently in areas north of Okinawa.

Cutting propagation is the most common method for dragon fruit propagation. Special equipment such as mist for promotion of rooting is not required because *H. undatus* is easy to root. But the character such as age and fresh weight of cuttings is considered to affect rooting. Dragon fruit cuttings root well without auxin treatment, however, rooting is promoted by IBA treatment (Elobeidy, 2006). The effect of the auxin type on rooting is not well known. The objective of the present study was to identify suitable conditions for rooting cutting of dragon fruit.

MATERIALS AND METHODS

This study was conducted from 2006 to 2008, using cuttings collected from 4- to 6-year-old plants cultivated in a greenhouse at the experimental farm of Kinki University.

Cutting propagation was basically conducted in the following way. Herbaceous stems (cuttings) were cut to a predetermined length, sprayed with solution of 500 ppm benomyl, and 150 ppm streptomycin, and placed in a shaded, well-ventilated place for 2 days for healing of the cut end. Then they were inserted to a depth of 4 cm in polyethylene pots (10.5 cm in diameter × 9.0 cm in height) filled with a soil mixture [mountain sand, peat moss, and vermiculite; (2 : 1 : 1, by vol.)], placed in a 50% shaded greenhouse, and irrigated daily with tap water. Auxin treatment was not carried out, except for Experiment 5.

Measurement of rooting of cuttings was performed after 60 days. Cuttings with root growth more than 2 mm were regarded as rooted. Rooting percentage was calculated by dividing the total number of cuttings with the number of rooted cuttings. Cuttings were removed from the pots and washed thoroughly with tap water before root fresh weight was measured.

In Experiments 1 and 2, six cuttings similar to those used in the experiments were prepared, and initial fresh and dry weights were measured to determine initial dry matter percentages. In all experiments, 20 cuttings were used for each

treatment, and three replicates were performed in Experiments 4 and 5. Data on rooting percentage, root fresh weight, and root dry matter percentage were analyzed for significant differences by Tukey-Kramer's multiple range test.

Experiment 1. Effects of the Herbaceous Stem Part on Rooting Ability.

1) *Mature Herbaceous Stems.* One-year-old herbaceous stems (1 year after stopping of stem elongation) of 30-40 cm length was collected and cut into three parts (upper, middle, and basal) each 10–12 cm in length. Cutting preparation was performed in 2 May 2006, and the measurement of rooting was performed in 1 July 2006.
2) *Immature Herbaceous Stem.* Immature herbaceous stem (collected 1–2 months after stopping of stem elongation) of 30–40 cm length was collected, and cut into three parts as previously described. Cutting preparation was performed in 19 June 2006, and the measurement of rooting was performed in 21 Aug. 2006.

Experiment 2. Effects of the Age of Herbaceous Stem on Rooting Ability. Immature, 1-year-old and 2-year-old stems were collected, and cut into 12 cm length. Cutting preparation was performed in 19 April 2007 and the measurement of rooting was performed in 19 June 2007.

Experiment 3. Effects of Flesh Weight of Cuttings on Rooting Ability. One-year-old herbaceous stems of different thickness were collected and cut into 12-cm lengths. After measurement of fresh weight, they were divided into three fresh weight groups: 30–50, 51–70 and 71–90 g. The number of cuttings per group was 22, 23, and 35, respectively. Cutting preparation was performed in 19 April 2007, and the measurement of rooting was performed in 19 June 2007.

Experiment 4. Effects of Length of Cuttings on Rooting Ability. One-year-old herbaceous stems were collected and cut into 8, 12, and 16 cm lengths. Cutting preparation was performed in 30 May 2007, and the measurement of rooting was performed in 4 Aug. 2007.

Experiment 5. Effects of Auxin Type on Rooting Ability. One-year-old herbaceous stem cuttings were collected, cut into 12 cm lengths, and the cutting bases dipped for 10 sec in 2,000 ppm solutions (50% ethanol) of either α-naphthaleneacetic acid (NAA) or indole-3-butyric acid (IBA). The base of each cuttings was then left to dry naturally. The cuttings treated with NAA or IBA were compared with the control not treated with auxin. Cutting treatment was performed in 29 May 2008, and the measurement of rooting was performed in 30 July 2008.

RESULTS

Experiment 1. Effects of the Herbaceous Stem Part on Rooting Ability.

1) *Mature Herbaceous Stem.* Rooting percentage of the basal segment tended to be higher than those of the upper and the middle segments, and root fresh weight of the basal segment was higher than those of the upper and middle segments (Table 1). Dry matter percentage of each segment was not significantly different.

Table 1. Effects of the part of herbaceous mature stem on rooting ability in dragon fruit.

Position	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Upper	75	1.56 b[z]	11.8 a
Middle	85	1.76 b	12.2 a
Base	100	2.25 a	13.1 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

2) *Immature Herbaceous Stem.* Rooting percentage tended to be the highest in the basal segment, followed by the middle, and the lowest in the upper segment. Root fresh weight of the basal segment was higher than that of the upper part (Table 2). Dry matter percentage of the basal segment was higher than those of the middle and upper segments.

Table 2. Effects of the part of herbaceous immature stem on rooting ability in dragon fruit.

Position	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Upper	50	1.02 b[z]	7.1 b
Middle	55	1.48 ab	8.3 b
Base	100	2.34 a	10.7 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 2. Effects of Herbaceous Stem Age on Rooting Ability. Rooting percentages of the 1-year-old and the 2-year-old herbaceous stem cuttings tended to be higher than that of the immature stems (Table 3). Root fresh weights and dry matter percentages of the 1-year-old and 2-year-old herbaceous stems were higher than that of the immature ones.

Table 3. Effects of the age of herbaceous stem on rooting ability in dragon fruit.

Age	Rooting (%)	Root fresh weight (g)	Dry matter (%)
Immature	25	1.42 b[z]	10.9 b
One-year-old	95	2.76 a	14.6 a
Two-year-old	95	2.59 a	15.6 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 3. Effects of Fresh Weight of Cuttings on Rooting Ability. Rooting percentage tended to increase with increase in the fresh weight of cuttings, and similarly root fresh weight increased with increase in the fresh weight of cutting (Table 4).

Table 4. Effects of fresh weight of cuttings on rooting ability in dragon fruit.

Fresh weight (g)	Rooting (%)	Root fresh weight (g)
30–50	81.8	1.34 b[z]
51–70	91.3	2.06 ab
71–90	100.0	2.89 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 4. Effects of Length of Cuttings on Rooting Ability. Rooting percentages of the cuttings of 12 and 16 cm lengths were higher than that of 8 cm length, and root fresh weight increased with increase in length of cuttings (Table 5).

Table 5. Effects of length of cuttings on rooting ability in dragon fruit.

Length (cm)	Rooting (%)	Root fresh weight (g)
8	53.3 b[z]	1.12 b
12	81.7 a	1.48 ab
16	83.3 a	2.73 a

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Experiment 5. Effects of Auxin Type on Rooting Ability. Rooting percentages of the cuttings treated with NAA or IBA were higher than that of the control not treated with auxin, and root fresh weight of the cuttings treated with NAA was higher than that treated with IBA and the control not treated with auxin (Table 6).

Table 6. Effects of the type of auxin on rooting ability in dragon fruit.

Type	Rooting (%)	Root fresh weight (g)
NAA	98.3 a[z]	5.43 a
IBA	91.7 a	3.04 b
Non-treated	78.3 b	2.28 b

[z]Values in a column followed by the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

DISCUSSION

The results of this study indicated that the rooting of cuttings increased by using herbaceous cutting material with solid stems. Rooting percentage and root fresh weigh were higher in cuttings of 71–90 g fresh weigh with 12 cm length than those with lower weight. This corresponds to 6.0–7.5 g per cm of cutting length. In addition, it was considered necessary to require more than 11% dry matter percentage for higher rooting.

Fresh weight and dry matter percentage of the mature herbaceous stem cuttings were higher than that of the immature one. Therefore, rooting of 1- to 2-year-old mature stem cuttings was higher than that of immature cuttings and so are more suitable as materials for cuttings.

With respect to the length of the cuttings, the shorter the length, the higher the reproductive efficiency. Elobeidy (2006) reported that rooting of cuttings of 5, 15, and 25 cm long were tested and 25-cm cuttings rooted successfully, and there was a significant effect of cutting size on rooting. In this study cutting of 8-cm length had low rooting percentage, therefore it was thought that cuttings more than 12 cm long were necessary for effective rooting.

The hormone IBA is an effective growth regulator in promoting rooting (Hartmann et al., 2002). Dragon fruit roots well without auxin treatment because of its high rooting ability, but better and more uniform rooting is promoted by IBA treatment (Elobeidy, 2006). In this study, rooting percentage was increased by treatment with NAA or IBA, but root fresh weight was remarkably increased by treatment with NAA. The NAA may have the effect of speeding up the rooting of cuttings in dragon fruit.

In conclusion, cuttings with high fresh weight per cm or dry matter percentage are suitable for making cuttings, and NAA is more effective in promoting the rooting than IBA in dragon fruit.

SUMMARY

Rooting of the basal segments in both mature and immature herbaceous stems were superior to those of the upper or the middle segments. Rooting of 1- and 2-year-old herbaceous stems tended to be higher than that of the immature ones. Rooting tended to increase with increase in the flesh weight of the cuttings. It was thought that cuttings more than 12 cm in length were necessary for effective rooting. Rooting percentage was increased by treatment with NAA or IBA, but root fresh weight was remarkably increased by treatment with NAA.

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Effects of MKR1, a Dwarfing Rootstock, on Growth of Kaki Scion©

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A dwarfing rootstock, MKR1, for kaki (*Diospyros kaki* L.), is applied to the Ministry of Agriculture, Forestry and Fisheries for cultivar registration. We have intensively investigated the field performance of kaki trees on MKR1 and showed the following characteristics:

- The growth of shoots on MKR1, which used to be named "rootstock-b" or "OD-1," was inhibited and the shoots hardly showed secondary growth (Tetsumura et al., 2010). As a result, the trees are dwarfed (Fig. 1).
- Early fruit drop, which is one of the big problems for kaki growers, was drastically decreased on MKR1 trees (Tetsumura et al., 2011a).
- Efficiency, such as yield per ground area covered by tree canopy and yield per canopy volume, was the best in the trees on MKR1 (Tetsumura et al., 2010).

These characteristics of MKR1 will make this rootstock a preferable alternative for kaki growers. In addition, MKR1 is easy to root if the single-node stem cuttings were collected from root suckers (Tetsumura et al., 2003; 2009; 2011b), while Malling se-

Figure 1. 'Hiratanenashi' kaki trees on MKR1 (left) and free stock (right) 8 years after planting at the orchard of University of Miyazaki. The height of blue sheet is 3 m.

ries apple rootstocks developed by East Malling Research and distributed worldwide, are mainly propagated by stooling because they are not easy to root by cuttings. The grafted unions of some combinations of Malling series rootstocks and apple cultivars are not strong and can be broken by strong winds, whereas the graft union between two cultivars and MKR1 withstood the typhoons (Tetsumura et al., 2010).

However, we are not able to explain the reason why MKR1 gave scions the useful characteristics. Hence, we show all the phenomena observed in the investigation of the field performance and discuss them to find the reason.

'Fuyu', 'Hiratanenashi', 'Soushu', and 'Taishuu' trees on MKR1 bore flowers soon after field establishment (Haranoushiro et al., 2010; Tetsumura et al., 2010). The percentages of flower-bearing shoots of 'Fuyu' and 'Hiratanenashi' trees on MKR1 were the highest every year (Tetsumura et al., 2010).

Leaves of the scion cultivars on MKR1 were smaller (Fig. 2).

These phenomena, including inhibited shoot growth and higher yield efficiency, are similar to those of the kaki trees treated with trunk girdling (Fumuro, 1997; 1998). In fact, the graft union between kaki tree scions and MKR1 swelled (Ishimura et al., 2011; Tetsumura et al., 2010), so phloem transportation might be worse in the graft union. Although numerous studies on apple dwarfing interstocks have shown that the longer the interstock, the greater the amount of dwarfing (Ferree and Carlson, 1987), the length of shank of MKR1 did not affect the growth of 'Fuyu' scion (Ishimura, pers. commun.). This fact also indicates that the cause of dwarfing is at the graft union between kaki scion and MKR1. However,

- The harvest time of trees on MKR1 was not earlier, although the bud break was earlier (Tetsumura, pers. commun.).
- Although the growth of trees on MKR1 was inhibited, they did not become weak and bore many fruit every year (Tetsumura et al., 2010). Kaki trees on seedling stocks often show severe alternate bearing, but the trees on MKR have shown stable harvest.
- These phenomena are different from those of the kaki trees treated with trunk girdling (Fumuro 1997; Harima et al., 2006). If the cause of dwarfing exists only at the graft union, a nursery stock grafted on MKR1 interstock will become a dwarfed tree. The height of nursery stock on MKR1 interstock was lower than that on free stock (Ishimura et al., 2011). However, the swelling at the graft union did not form when MKR1 was used as interstock (Fig. 3).

Figure 2. Leaves of MKR1 (left), 'Hiratanenashi' on MKR1 (upper middle), 'Hiratanenashi' on free stock (upper right), 'Fuyu' on MKR1 (lower middle), and 'Fuyu' on free stock (lower right). The white ruler indicates 30 cm.

- The height of nursery stock on MKR1 interstock was almost the same as that on MKR1 rootstock, but lateral growth of the former was inhibited. That is to say, apical dominance of the latter was lost (Fig. 4). Scions on MKR1 rootstock may produce "knip-boom" tree (Ono et al., 2001). Figure 1 (left) shows a result of the tree growth of weak apical dominance on MKR1 rootstock. These phenomena apparently show that the roots of MKR1 also affected the tree growth.
- Axillary buds on kaki shoots thickened with an increase of leaf primordia, and an occurrence of flower initiation decreased production of new leaf primordia (Harada, 1984). Hence, the size of axillary buds was not correlated with the number of flower buds, generally. However, the size of buds of 'Fuyu' and 'Hiratanenashi' trees on MKR1 was positively correlated with the number of flower buds (Ishimura, pers. commun.).
- In summer, leaves of the trees on MKR1 tended to curl like those of MKR1 (Fig. 2).

These new findings are all interesting because they have not been observed in kaki trees on free stocks. Moreover, most of the phenomena were not observed in other fruit trees on dwarfing rootstocks. We will investigate flower bud initiation, expression of flowering genes, photosynthetic rate, and sap flow, and will treat the nursery plants on free stocks with plant growth regulators to change them to grow like nursery plants on MKR1. These investigations will reveal the mechanism of dwarfing by MKR1, which may be different from the other dwarfing rootstocks.

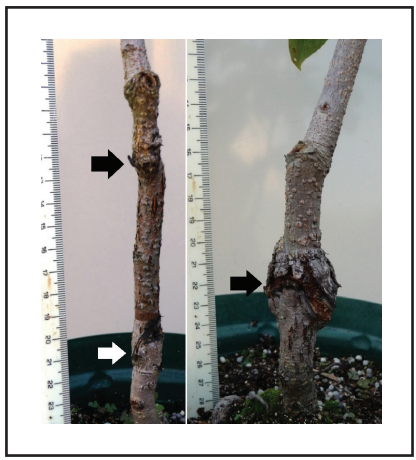

Figure 3. The graft unions between MKR1 and 'Fuyu'. MKR1 was used as interstock (left) and as rootstock (right). Black arrows show the graft unions between MKR1 and 'Fuyu' and a white arrow shows that between MKR1 and free stock.

Figure 4. Two-year-old 'Fuyu' nursery stocks on MKR1 as interstock (left) and as rootstock (right). The white ruler indicates 30 cm.

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Reevaluation of Effects of Aminoethoxyvinylglycine on Growth of In Vitro Pear Shoots©

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INTRODUCTION

Aminoethoxyvinylglycine (AVG), an inhibitor of ethylene, has been used for blocking ethylene biosynthesis and revealing the responses of plants to it. The chemical 1-methylcyclopropene (1-MCP) is able to block ethylene receptors and is functionable at very low concentrations in cut flowers (Serek et al., 1995) and fruits (De Wild et al., 1999). At the end of 2010, 1-MCP was permitted for use as an inhibitor of overripening with apple, pear, and persimmon by Ministry of Agriculture, Forestry and Fisheries of Japan.

Ethylene is said to cause plant tissues responsive reactions at very low concentrations and to be promoted or inhibited by auxin. In in vitro culture, rose shoots required different concentration of ethylene depending on rooting process: an adequate amount of ethylene was needed for root emergence and root formation but more ethylene was necessary for root growth (Kepczynski et al., 2006). In apple microcuttings, it was reported that ethylene was not involved in auxin (IBA)-dependent root formation (Harbage and Stimart, 1996), whereas Ma et al. (1998) reported ethylene inhibited root formation of apple shoots. Ethylene appeared to promote shoot formation in peach rootstocks (Dimasi-Theriou and Economou, 1995) while it inhibited organogenesis and growth of kiwi fruit explants, except for rooting (Arigita et al., 2003).

As mentioned above, even in plant tissue cultures of fruit trees, the conclusions about the role of ethylene differed between the reports. The response to ethylene varied with plant materials, plant sections, developmental stages, and applied ethylene concentrations. It is also unclear whether ethylene is the cause or effect.

Recently, Soeno et al. (2010) reported that AVG was identified as an inhibiter of auxin biosynthesis by a genomics-based approach in *Arabidopsis* and it had a strong anti-auxin activity independently of ethylene biosynthesis. Aminoethoxyvinylglycine is known to inhibit ethylene by inhibiting pyridoxal phosphate (PLP) (Yang and Hoffman, 1984) that mediated the reaction of *S*-adenosylmethionine (SAM) to 1-aminocyclopropane-1-carboxylic acid (ACC). In indole-3-acetic acid (IAA) biosynthesis, tryptophan aminotransferase that converts L-tryptophan to indol-3-pyruvic acid is known to require PLP as coenzyme (Shi et al., 2002), so that the inhibition of IAA biosynthesis is attributable to it.

Many researchers investigating the relations between ethylene and in vitro plant growth used AVG as an ethylene inhibitor, so we think that we should reevaluate an effect of AVG from the point of view of both ethylene and auxin. Furthermore, by using AVG, we are able to make plants defective in auxin and to provide novel insight into auxin biosynthesis and action, and uncover structural characteristics of auxin biosynthesis inhibitors (Soeno et al., 2010). The objective of this study was to reveal whether AVG, 1-MCP, and ACC affected growth and organogenesis of 'La France' pear (*Pyrus communis* L.) in vitro shoots.

MATERIALS AND METHODS

The 'La France' in vitro shoots proliferated by MW medium (Tetsumura et al., 2008), a mixture of equal ratio of MS (Murashige and Skoog, 1962) and WPM (Lloyd and McCown, 1980) was used in this study. All media contained 0.5 μM indole-3-butyric acid (IBA), 10 μM benzyladenine (BA), 0.8% (w/v) agar (Wako Pure Chemical Industries, Ltd., Tokyo, Japan), 2% (w/v) sorbitol. The pH of each medium was adjusted to 5.7 with KOH before autoclaving at 1.1 $kg \cdot cm^{-2}$ for 15 min at 121 °C. The growth regulators AVG and ACC were filter-sterilized and added to the media after autoclaving. The 1-MCP was treated as follows; a microtube with polymer absorbing 1-MCP was kept upright into medium in a conical flask, and 100 μl of water was poured into the microtube for evolution of 1-MCP, and then the flask was immediately sealed with parafilm (Pechiney Plastic Packaging, U.S.A.). The AVG (1 and 100 μM), ACC (1 μM, 10 μM, and 100 μM), and 1-MCP (1 $\mu l \cdot L^{-1}$) were added to the medium or the flask solely or in combination.

After culturing 4 to 7 weeks, the shoots were cut to ca. 1 cm of the apical section containing five to six young leaves, and the three sections were placed on 20 ml MW medium per each conical flask, and then the flasks were covered with aluminum foil. Some conical flasks containing the medium with AVG at 1 μM and 100 μM were made airtight by being wrapped with parafilm. Cultures were maintained under 16-h photoperiod with 80 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD and 25±2 °C. Number of leaves with lamina, >8 mm long, shoot number, and shoot length of the shoot showing the best growth in each flask were recorded every 7 days. The length of the shoot was converted to the point as based on the shoot length conversion table (Table 1).

For ethylene assays, the flasks were sealed with parafilm 24-h prior to the measurement. Subsequently a 1-ml gas sample of the headspace of flask was taken by a syringe and injected into a gas chromatograph (GC-8A, Shimadzu, Kyoto, Japan) equipped with flame ionization detector and stainless steel column packed with 50–80 mesh Porapack Q.

Table 1. Shoot length conversion table.

Shoot length (cm)		Converted value (point)
~ 0.99	⟶	0.5
1.0 ~ 1.19	⟶	1.1
1.2 ~ 1.39	⟶	1.3
≀		≀
1.8 ~ 1.99	⟶	1.9
2.0 ~ 2.19	⟶	2.1
≀		≀

RESULTS AND DISCUSSIONS

The most ethylene production from 'La France' shoots on the control medium was observed at Day 49 (Fig. 1). As active cellular division increased ethylene production (Abeles et al., 1992) and leaf number of the control rapidly increased from Day 49 (Fig. 2). However, the shoot length and the shoot number did not show rapid increases from Day 49. The organogenesis of the control was not associated with ethylene production. Aminoethoxyvinylglycine at 100 μM prevented all organogenesis (Fig. 2).

Little ethylene was detected from the flasks with the medium containing AVG 1 μM and 100 μM. However, a certain amount of ethylene was detected from the airtight flask containing AVG. Hence, it was suggested that covering with an aluminum foil lid kept a little bit of ventilation and ethylene accumulation hardly occurred in the flasks. The greatest leaf number was produced by 1 μM AVG, but the shoot length on the medium with 1 μM AVG was shorter than that of the control. This inhibition of shoot elongation might result from the inhibition of auxin biosynthesis by AVG.

Cultures treated with ACC (1 μM and 10 μM) produced much calluses without decreasing the leaf number, the shoot elongation, and the shoot number. 'La France' shoots are probably insensible to increased amount of ethylene. The shoots in the 1-MCP grew as well as those in the control. The growth inhibition by 100 μM AVG was overcome by neither ACC nor 1-MCP.

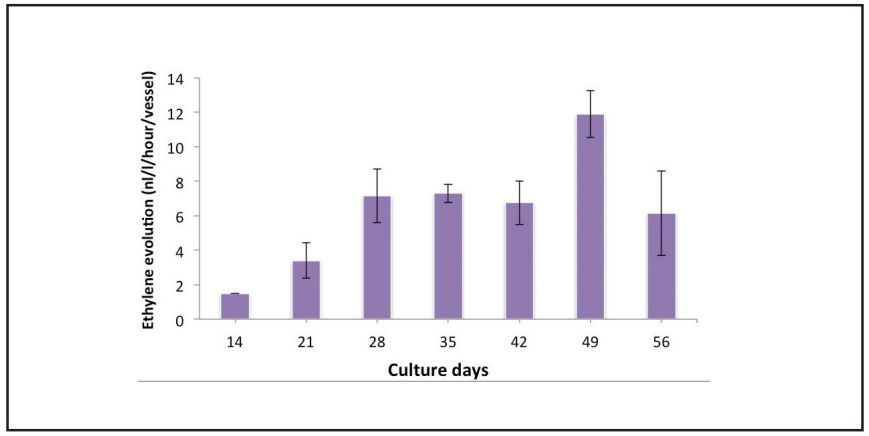

Figure 1. Ethylene evolution from *Pyrus communis* 'La France' shoots on MW medium [a mixture of equal ratio of Murashige and Skoog (MS) medium and Lloyd and McCown (WPM) medium]. Vertical bars represent ± se. N = 5.

CONCLUSION

In conclusion, ethylene had little effect on organogenesis of 'La France' shoots and the effect of AVG on the shoot growth may be caused by the inhibition of IAA biosynthesis. Further investigation, that is, whether an addition of auxin to the medium can overcome the inhibitory effect of AVG on the organogenesis, should be conducted.

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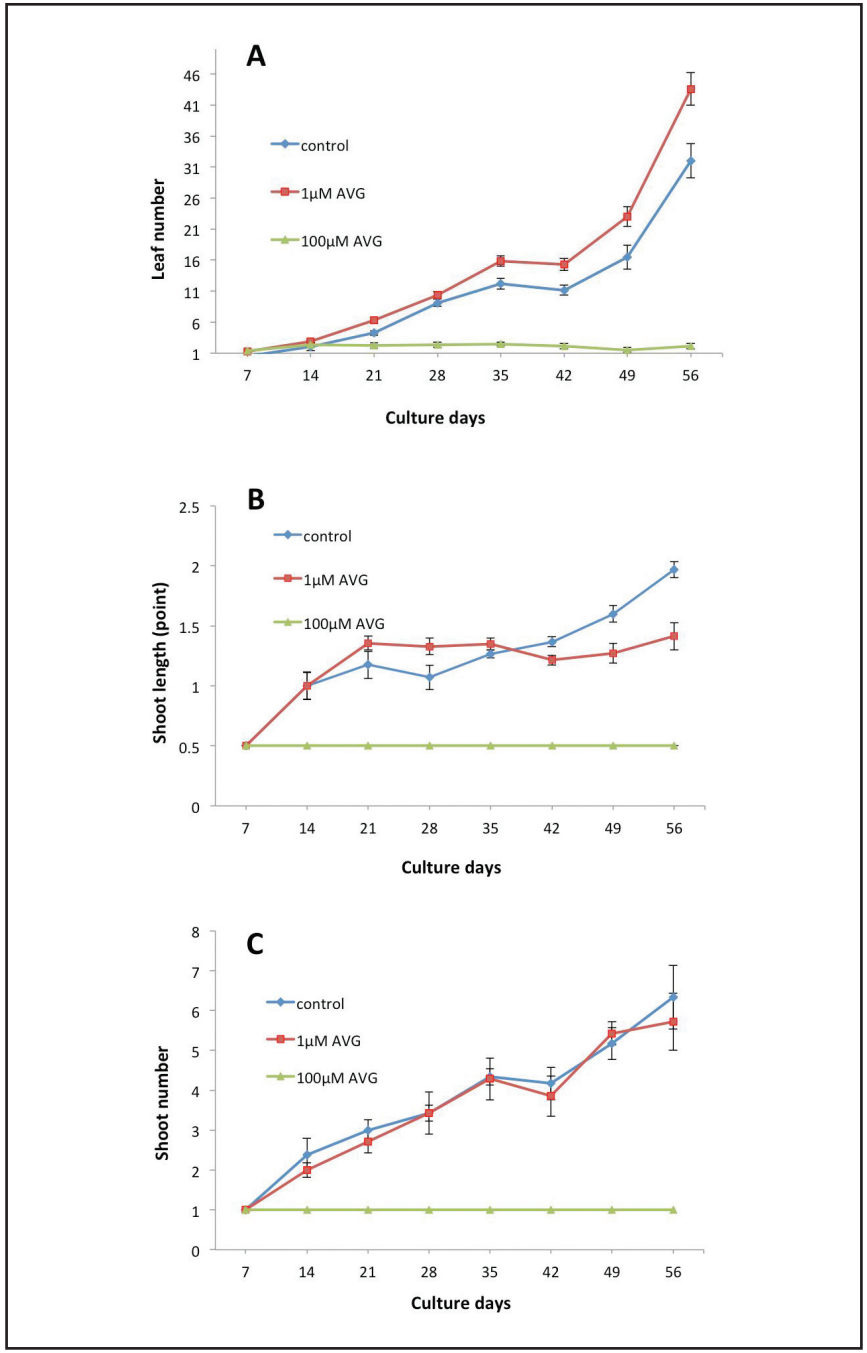

Figure 2. The effect of AVG on leaf number (A), shoot length (B) and shoot number (C) of *Pyrus communis* 'La France' shoots. Vertical bars present ± se. N = 8.

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Propagation In Vitro of *Nothapodytes amamianus* an Endangered Medicinal Tree©

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INTRODUCTION

Wadatsuminoki (*Nothapodytes amamianus* Nagam. & Mak. Kato, Icacinaceae) is an endangered species only naturally found as a new species in 2004 in the southern part of Amamioshima Island located in the south of Japan (Nagamasu and Kato, 2004). It produces a useful alkaloid, camptothecin (Fig. 1), which is a raw material of cancer drug irinotecan. Its related species, *N. foetida*, is currently cultivated for drug raw material production. For application of wadatsuminoki in the commercial usage and species conservation, propagation from limited number of trees is crucial. There are several reports about conservation of endangered species using in vitro culture (Sugii and Lamoureux, 2000; Ishii et al., 2004; and Ishii et al., 2005). So, screening of in vitro culture conditions of this species was carried out for the first time. There is a report about tissue culture of a closely related species *N. foetida* (Sundravelan et al., 2003), however its production of useful chemicals was low. Although several papers have been reported on in vitro culture of camptothecin (Fig. 1) producing plants such as *Camptotheca acuminate* (Jain and Nessler, 1996) or *Ophiorrhiza pumila* (Sudo et al., 2001), this is the first report for in vitro culture of *N. amamianus*.

MATERIALS AND METHODS

Branches from 2-year-old seedlings of *Nothapodytes amamianus* which seeds were collected from the natural mother tree. Surface sterilization of shoot and stem segments was done using 70% ethyl alcohol for 1 min, 0.1% mercury chloride for 10 min, and 5% hydrogen peroxide for 10 min, then washed well twice with sterile water for eliminating surface microorganisms. For initial culture, MS (Murashige and Skoog, 1962), ½ DCR (Gupta and Durzan, 1985), SH (Schenk and Hildebrandt, 1972), and ½ LP (Quiolin and Lepoivre, 1977) media (different in the combination of hormones such as 10 μM BAP or zeatin, and 0.027 μM NAA) were compared. For subculture and rooting of the shoots, ½ LP, CD, and ½ MS media containing 1 μM IBA were used. For habituation, nursery trays were used. Culture condition was maintained at the constant temperature of 25 °C under 16 h photoperiod of 70 $\mu M \cdot m^{-2} \cdot s^{-1}$ by fluorescent lamp. Propagated plantlets were first cultured in the greenhouse then planted out to the field.

RESULTS AND DISCUSSION

In the initial culture, shoots were rooted in the ½ DCR medium containing 3 $g \cdot L^{-1}$ activated charcoal after 2 months (Fig. 2). Shoots were induced from three subcultured root segments out of 15 in the ½ MS medium containing 2 μM BAP (Fig. 3) and further root initiation occurred. Those plantlets grew well in the ½ LP medium containing 5 $g \cdot L^{-1}$ activated charcoal (Fig. 4). Axillary buds were also induced from

the dissected segments (2 cm length) of in vitro cultured shoots of *N. amamianus* in the ½ LP medium containing 10 μM BAP. Regenerated shoots were rooted in the ½ MS medium containing l μM IBA.

Rooted plantlets were further grown in the ½ LP medium containing 5 $g \cdot L^{-1}$ activated charcoal then habituated successfully in the nursery trays at 100% humidity in the covered tray (Fig. 5). Propagated plantlets were grown in the greenhouse for 3 months (Fig. 6) then planted out in the field. From one shoot stem explants, about 50 plantlets were obtained by in vitro culture of *N. amamianus* after 6 months. Improving the propagation rate and selection of trees with higher contents of camptothecin is necessary in the future.

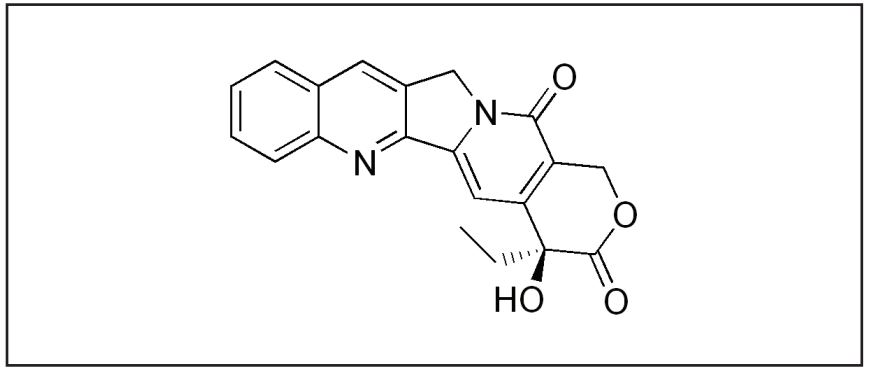

Figure 1. Camptothecin structure.

Figure 2. Rooting of shoot and growth of *Nothapodytes amamianus*.

Figure 3. Shoot induction from root segments of *Nothapodytes amamianus*.

Figure 4. Regenerated plantlet of *Nothapodytes amamianus*.

Figure 5. Habituation.

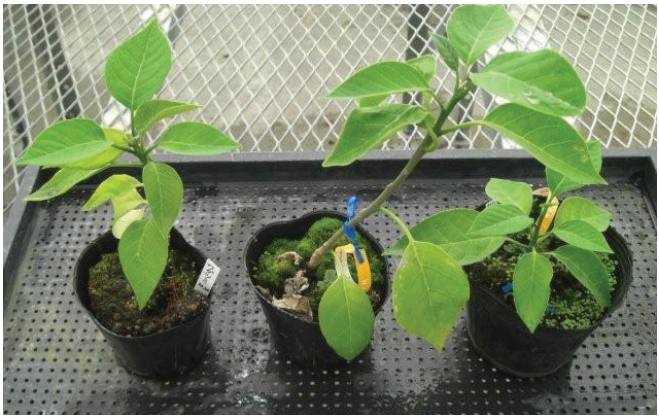

Figure 6. Habituated plantlets of *Nothapodytes amamianus*.

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Micropropagation of *Haworthia cymbiformis* Through Thin-Cell-Layer Tissue Culture©

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Window haworthia [*Haworthia cymbiformis* (Haw.) Duval] was propagated through thin-cell-layer (TCL) tissue culture in vitro. Thin-cell-layer explants were prepared from leaves and stem of offsets. Leaves and stem segments were immersed in 70% ethanol for 10 sec, and then 1% sodium hypochlorite for 13 min. After washing in sterilized distilled water three times, TCL and transverse-TCL (t-TCL) explants were prepared from leaves into 1 mm and 3 mm thickness, respectively. Stem t-TCL explants were dissected to disk explants of 1 mm thickness. Those explants were cultured on the Murashige-Skoog (MS) medium [30 g·L^{-1} sucrose, 8 g·L^{-1} agar (pH 5.6)] supplemented with 0.1 mg·L^{-1} benzyladenine (BA), 0.5 or 1.0 mg·L^{-1} indole-3-acetic acid (IAA) under 24±2 °C and 16-h light with cool white fluorescent lamps (40 µmol·m^{-2}·s^{-1} PPFD) / 8-h dark condition. Only stem t-TCL explants produced adventitious shoots on all media. The maximum number of regenerated shoots was 24.0 per explant on the medium supplemented with 0.1 mg·L^{-1} BA. The respective regenerated shoots produced additional numbers of secondary shoots (7.5 per a divided shoot) and roots after subculture on the growth-regulator-free medium.

INTRODUCTION

Window haworthia [*Haworthia cymbiformis* (Haw.) Duval] produces offsets and is stoloniferous; and its leaves are club-shaped with a separate flattened end area windowed with translucent patches. Although the window haworthia is able to propagate by division of offsets and leaf cuttings, the multiplying efficiency is not that high. In vitro cultures of *Haworthia* plants using inflorescence (Majumdar and Sabharwal, 1968; Kaul and Sabharwal, 1972; Ogihara and Tunewaki, 1978), perianth (Konishi et al., 1982), ovary (Majumdar, 1970), and leaf (Wessles et al., 1976; Beyl and Sharma, 1983) have been reported. However, the main aims of these reports were not the propagation of the true-to-type, and studies were directed at morphogenetic and physiological analysis of *Haworthia* plants. Thin cell layer (TCL) system established and developed by Tran Thanh Van and co-workers (Tran Thanh Van, 1999) has a characteristic point which the accelerative effect of organ formation from various organ and tissue explants prepared as TCL, and the effects have been confirmed in many plant species. It seems that the accelerative effects will effectively act in favor of the micropropagation for the difficult plant species of the increase. In this report, we tried to apply the TCL system for micropropagation of *Haworthia cymbiformis* plants.

MATERIALS AND METHODS

Preparation of TCL Explants from Leaf and Stoloniferous Stem and Their Initial Culture. Thin cell layer explants were prepared from leaves and stoloniferous stems of offsets. Leaves and stem segments (about 1 cm long) were sterilized in 70% ethanol for 10 sec and then 1% sodium hypochlorite for 13 min. After washing in sterilized distilled water three times, TCL and transverse-TCL (t-TCL) explants were prepared from the leaves into 1 mm and 3 mm thickness explants, respectively. The stoloniferous stem were dissected into t-TCL disk explants of 1 mm thickness. Those explants were cultured on the Murashige and Skoog (1962) medium [30 $g \cdot L^{-1}$ sucrose, 8 $g \cdot L^{-1}$ agar (pH 5.6)] supplemented with 0.1 $mg \cdot L^{-1}$ benzyladenine (BA), and 0.5 or 1.0 $mg \cdot L^{-1}$ indole-3-acetic acid (IAA). Ten milliliters of each medium was poured into a 20 × 120-mm glass test tube and autoclaved at 120 °C for 15 min before explant inoculation. All cultures were incubated under 24±2 °C and 16-h light with cool white fluorescent lamps (40 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD) / 8-h dark condition.

Subculture of Regenerated Respective Shoots. The regenerated shoots on each explant in the initial culture were divided into single shoots, and each of them was subcultured on the growth-regulator-free MS medium. Twenty milliliters of the medium was poured into a 40 × 150-mm glass test tube and autoclaved at 120 °C for 15 min before the shoot inoculation. All cultures were incubated at 24±2 °C and 16-h light with cool white fluorescent lamps (40 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPFD) / 8-h dark condition.

RESULTS AND DISCUSSION

Only stem t-TCL explants produced adventitious shoots on all media. Explants of TCL and t-TCL from leaves showed no response. The earliest shoot formation from the stem t-TCL explant was observed on 11th day from the inoculation of the explants and the first root formation from regenerated shoots was observed on the 17th day from explant inoculation. The maximum number of regenerated shoots was 24.0 per explant on the medium supplemented with 0.1 $mg \cdot L^{-1}$ BA (Table 1). The regenerated shoots produced a considerable number of secondary shoots (7.5 per divided shoot) and roots after subculture on the growth-regulator-free medium (Table 2, Fig. 1). Within 6 months, about 160 plantlets could be obtained through the offset-stem t-TCL explant culture from one offset stem segment when those explants were cultured on the MS medium supplemented with 0.1 $mg \cdot L^{-1}$ BA.

The secondary shoot still showed a vigorous multiplication capacity after the second subculture on the growth-regulator-free medium. The capacity was higher in

Table 1. Effects of BA and IAA on the shoot regeneration from stem t-TCL explants.

Growth regulator					Shoot formation	
Chemical name	($mg \cdot L^{-1}$)	Number of explants	Contamination (%)	Callus formation (%)	(%)	No. per explant
BA	0.1	7	14.3	57.1	28.6	24
IAA	0.5	7	14.3	42.9	28.6	7
IAA	1.0	6	33.3	33.3	33.3	11

Figure 1. Shoot multiplication from a regenerated shoot after subculture on the growth regulator-free MS medium in *Haworthia cymbiformis*.

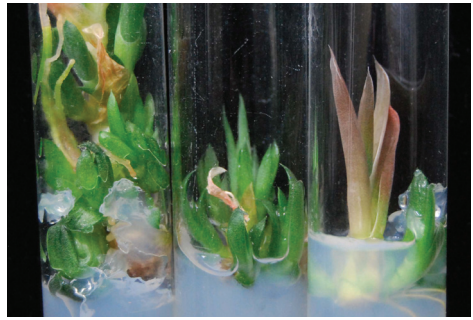

Figure 2. Axillary and adventitious shoot development during the second subculture in *Haworthia cymbiformis*. Left: Axillary shoot development on upper part and adventitious shoot formation on basal part of a whole shoot. Center: Vigorous adventitious shoot formation from the lower half segment. Right: Shoot formation from the upper half segment.

the basal half of the secondary shoots than the upper half. Almost all axially buds of secondary shoots subcultured on the growth-regulator-free medium grew and developed into shoots (Fig. 2 left). The same carrying-over effect of BA was reported by in the inflorescence culture of *H. cymbiformis* (Suzuki and Ijiro, 2011) and shoot culture of *Spathiphyllum wallissii* (Amaki et al., 1996).

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Table 2. Carrying-over effect of BA and IAA on the subcultured shoot multiplication.

Past culture media							
Growth regulator					Regenerated shoot		
Chemical name	($mg \cdot L^{-1}$)	No. of inoculated shoots	Contamination (%)	Callus formation (%)	2nd shoot formation (%)	No. of 2nd shoots	Shoot length (cm)
BA	0.1	7	0	57.1	100	7.5 a	4.5 a
IAA	0.5	7	0	42.9	100	3.1 b	3.3 b
IAA	1.0	6	0	33.3	100	7.5 a	3.0 b

The Report of IPPS International Exchange Program of New Zealand and Japan Region©

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I was very lucky to participate as a supported member of the 40th anniversary conference that was held at Napier in New Zealand (N.Z.) from 5 to 8 May. More than 200 members participated in the memorial conference, from which I learned many things. This report outlined what I learned during my stay in N.Z.

Scott Base Nurseries (Auckland). At first, I visited Scott Base Nurseries, which mainly produced ground cover and shrub plants. I practiced division of *Phormium*, which is one of the most popular plants in N.Z. Large plants of *Phormium* were planted on road slopes and small ones were supplied for gardens. The nursery produced a very beautiful two-colored cultivar, but the sorting operation was difficult because its coloration varied with stock plants (Fig. 1).

Joy Plants (Pukekohe). The nursery mainly propagated and sold rare plants and N.Z. native plants. It was located in a natural environment with old forest plants. The plants preferring shade were placed under the shade of trees, while those preferring wet condition were managed in the vicinity of the swamp (Fig. 2). The environment-friendly nursery did not have any large scale facilities. These efforts were highly praised in the region, and the staff actively gave lectures at schools and held workshops.

Taupo Native Plants (Taupo). Taupo lies in the highlands in a volcanic region and snows occur in winter. There were some geothermal power stations using steams and hot water (Fig. 3) in the area. The nursery used energy from a geothermal well and the greenhouses were heated by steam from a neighboring geothermal heat plant. The nursery mainly produced native plants, fruit trees, and ground cover plants. I went into the old forest and experienced the collection of *Podocarpus*, *Pittosporum*, and *Phormium* seedlings.

Plant Struck Ltd and Copperfield Nurseries (Tauranga). Plant Struck Ltd produced nursery plants and actively bred flowering plants, especially *Altroemeria* 'Alsdun01', Rock and Roll® Peruvian lily a wonderful cultivar because of its beautiful flowers harmonizing with the white variegated leaves (Fig. 4). I practiced planting and digging up *Citrus* at Copperfield nurseries (Fig. 5). All *Citrus* cultivars were grafted onto *Citris trifoliata* (syn. *Poncirus trifoliata*) rootstocks, and I learned that citrus tristeza virus had damaged *Citrus* trees around the world, including N.Z.

Bruntwood Nurseries (Hamilton). Shrubs, flowering plants, and fruit trees were produced at this nursery, which was my last visit in N.Z. and I practiced cutting propagation of *Acca sellowiana* (syn. *Feijoa sellowiana*) (Fig. 6). Feijoa was difficult to propagate by cuttings. For example, the rooting percentage of one of difficult-to-root cultivar was under 30%. I learned lots of techniques of cutting propagation, about which I learned that the number of leaves, collection of plant parts, and cutting period were important.

Figure 1. Division of *Phormium* at Scott Base Nurseries.

Figure 2. Nurturing of *Clivia* at Joy Plants.

Figure 3. Wairakei Geothermal Power Station near Taupo Native Plants.

I would like to express my gratitude for IPPS N.Z. Region's members who welcomed me and for IPPS Japan Region supporting the exchange program. I want to make use of the valuable experience for my work and Japanese agriculture.

Figure 4. *Alstroemeria* 'Alsdun01', Rock and Roll® Peruvian lily (Plant Struck Ltd).

Figure 5. Planting *Citrus* at Copperfield Nurseries.

Figure 6. Cutting propagation of *Acca sellowiana* at Bruntwood Nurseries.

Field Excursion at IPPS Japan 18th Conference in Matsuyama©

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The annual meeting of IPPS-Japan this year was held in Matsuyama City, Ehime Prefecture (please visit <http://www.pref.ehime.jp/index-e.htm>).

The excursion was arranged on 16 Oct. 2011 to visit nurseries, a market, and research institute. In the morning, 30 participants left the Hotel in Dogo Hot Spring Spa, Matsuyama City (<http://www.city.matsuyama.ehime.jp/lang/en/sightseeing/dogo.html>).

The first visit was the Fruit Tree Research Center of Ehime Prefecture (Fig. 1a), which is located northeast of Matsuyama City, where the aim is to breed new citrus cultivars and to establish stable production of high quality citrus fruits. All the participants learned something important about the cultivation of citrus from explanation by research staff (Fig. 1b).

After a short drive, the delegates arrived on the Jaistation Mercato (organic market) and studied how they present and sell their products (Fig. 2). The participants were attracted to the many organic crops and processed goods.

After a lunch break, the trip went southward to visit the Shigematsu Garden in Matsumae Town, where Mr. Shigeru Shigematsu, the owner, has been devoted to the introduction of many taxa from both Australia and South African. Mr. Shigematsu imported and tested in vitro seedlings of over 160 native species and now he propagates commercially about 30 selected species, including *Anigozanthos*, *Banksia*, and *Protea* spp. (Fig. 3).

The last visit was "Takenaka-Engei" (Takenaka Garden), which breeds and produces pot plants, especially many cultivars of cyclamen (*Cyclamen persicum* Mill.) (Fig. 4). Mr. Shuichi Takenaka, the owner, introduced many cultivars from overseas, and has established the techniques for cultivating them well in Ehime prefecture climate, a hot area in Japan.

At around 15:00, the excursion completed the trip, and the participants left for their home from Japan Railway Matsuyama Station.

Figure 1a. The Fruit Tree Research Center, Ehime Prefecture.

Figure 1b. Mr. Yano, Head of research section, who explains citrus cultivars to participants (left).

Figure 2a. "Jaistation mercato" (organic market).

Figure 2b. Display of many processed agricultural foods.

Figure 3. Shigematsu Garden.

Figure 4. Takenaka-Engei.

The Development of Social Media for the IPPS Eastern Region©

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INTRODUCTION

Whether we like it or not, more people, companies, and organizations are joining and using Facebook® each day. After the 2010 Eastern Region meeting, the IPPS Eastern Region created a Facebook page <www.facebook.com/IPPSER> and an informal committee to work on and maintain it. This page replaced an outdated Eastern Region Facebook group.

DISCUSSION

Currently, there are over 800 million active Facebook users in the world, of which about 200 million reside in the United States. Fifty percent of users log onto Facebook at least once each day (Facebook Statistics, 2011). Two-thirds of Facebook users will select a product or company based on a recommendation from a Facebook friend (eMarketer Digital Intelligence, 2010). With companies and other organizations harnessing the power of Facebook, IPPS Eastern Region decided to try to increase awareness of the organization through Facebook updates, notifications, and discussions.

The goal of the IPPS Eastern Region Facebook page is to create a network where members and nonmembers can have year-round connections and discussions. During the 2011 Eastern Region meeting, Eastern Region attendees actively posted pictures of the tours, talks, and other events. Several speakers even commented that they watched and enjoyed seeing what the group was doing through Facebook prior to the speaker arriving at the meeting. Showing what was happening during the meeting gives prospective members an opportunity to see first-hand what they could experience during the annual meeting.

This talk specifically showed how to "like" the IPPS Eastern Region page by clicking on the "like" button underneath the IPPS Eastern Region title once at our page (Fig. 1). Additionally, several of the features along the left hand side of the Facebook page were explained (Fig. 2).

One of the features briefly explained was the wall on our Facebook page. It is an excellent place for posting relevant comments, photos, and questions. One example was from a member located at the U.S. National Arboretum who was looking for suggestions for a research study. This member wanted to start a study on woody plants that readily callus but were slow to root. We posted his message on the Facebook site to try to receive some information from other members. Social media is an excellent place to list questions similar to this to receive instant feedback from fellow horticulturists. In order for social media to work efficiently, it is essential to have a solid database of people who "like" our Facebook page.

Other features that were discussed included the photos link and events link. The photos link allows everyone to see any previously uploaded photos. These photos could be from an area meeting, past meetings, or any other pictures that were add-

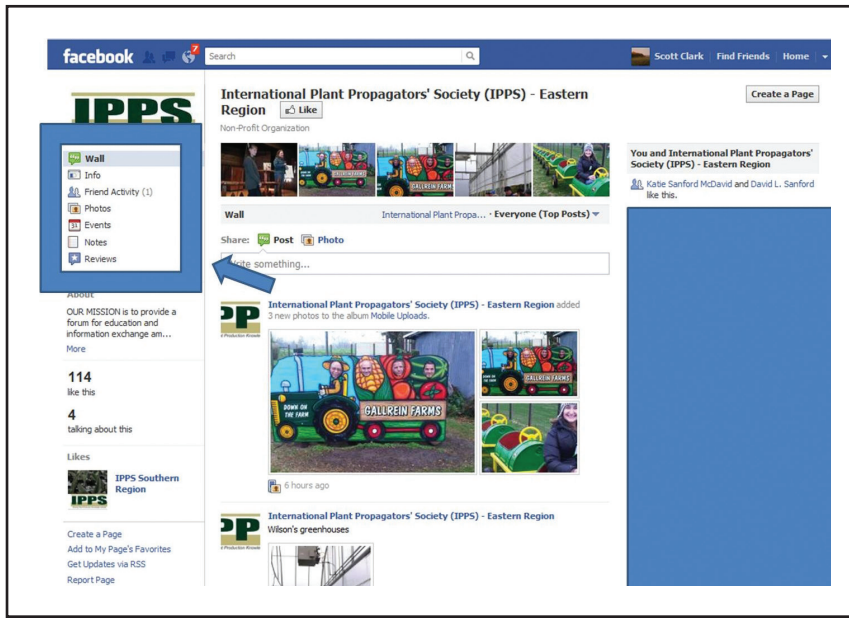

Figure1. From <www.facebook.com/IPPSER>.

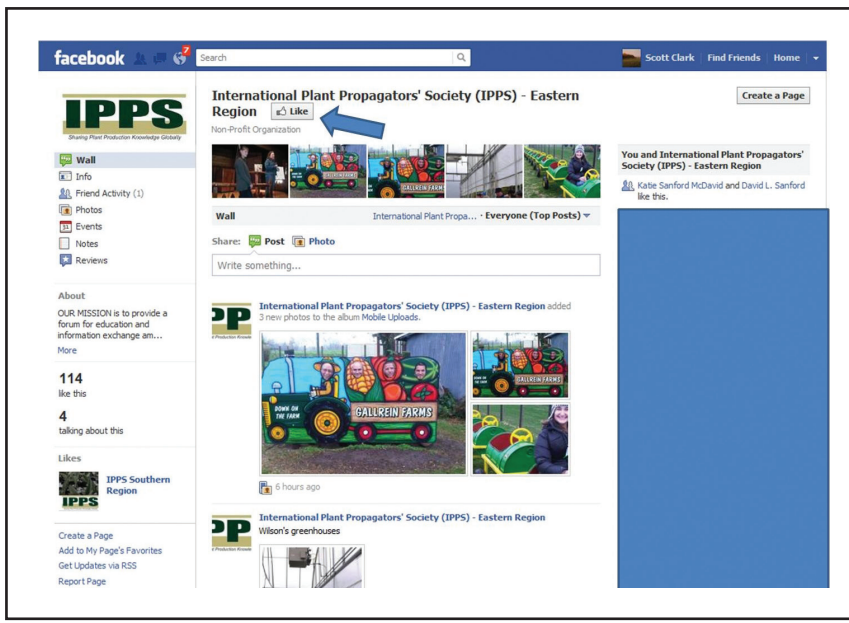

Figure 2. From <www.facebook.com/IPPSER>.

ed to our page. The events link was shown as it is an excellent place to look to see what future events may be occurring through the Eastern Region, such as the annual meeting or area meetings.

CONCLUSION

Facebook is a new feature for the Eastern Region but has the potential to allow interactions between members and prospective members throughout the year. It allows for relevant information and important notices to be posted. By "liking" the IPPS Eastern Region page, it shows each person's Facebook friends that this is an interesting and important organization, which in turn, may lead to their Facebook friends looking into the IPPS organization. In today's technology-fueled world, Facebook is another means for the Eastern Region to spread the word about our organization and goals.

Acknowledgements. Special thanks to Scott Clark for allowing me to use his Facebook account for our screen shot images and the administrator members of the IPPSER Facebook page for their help the past year.

ADDITIONAL READING

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Where Have We Been in 2011 and Where Are We Headed?©[1]

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The green industry is comprised of wholesale nursery and floriculture (greenhouse) growers; landscape service providers (e.g., architects, design/build firms, contractors, and maintenance firms); retail garden centers, home centers, and mass merchandisers with lawn and garden departments; and marketing intermediaries such as brokers and horticultural distribution centers (re-wholesalers). This outlook paper will continue to use the term "green industry" but most of the comments herein refer specifically to nursery and greenhouse growers.

RECENT HISTORY IN THE GREEN INDUSTRY REVISITED[1]

Prior to the recession, total economic contributions for the United States Green Industry in 2007, including regional economic multiplier effects, were estimated at $175.26 billion in output (revenue), employment of 1.95 million fulltime and parttime jobs, labor earnings of $53.16 billion, and $107.16 billion in value added impacts, representing 0.76% of U.S. Gross Domestic Product in 2007.

Economic contributions for the United States Green Industry:

- For the Production and Manufacturing Group, including Nursery and Greenhouse Production and Lawn and Garden Equipment Manufacturing sectors, total output impacts were $52.57 billion, employment impacts were 469 thousand jobs, earnings impacts were $13.14 billion, and value added impacts were $32.13 billion.
- For the Horticultural Services Group, Landscape Services, and Landscape Architectural Services sectors, total output impacts were $92.83 billion, employment impacts were 1.12 million jobs, earnings impacts were $30.15 billion, and value added impacts were $54.52 billion.
- For the Wholesale and Retail Trade Group, total output impacts were $29.86 billion, employment impacts were 358 thousand jobs, earnings impacts were $9.87 billion, and value added impacts were $20.51 billion.
- The largest individual industry sectors in terms of employment and value added impacts were:

[1] Since USDA-ERS discontinued its data collection regarding nursery and greenhouse crops, the only nursery-related data available is the Nursery Crops Survey conducted by USDA-NASS (last conducted in 2006) and the Floriculture Crops survey (conducted annually but only reflecting data collected from 15 states). Another helpful resource is the National Nursery Industry Survey and the Economic Impact Study conducted by the Green Industry Research Consortium, which is available online at: <ellisonchair.tamu.edu> (under the marketing and economics emphasis area).

- Landscaping Services (1,075,343 jobs, $50.28 billion),
- Nursery and Greenhouse Production (436,462 jobs, $27.14 billion),
- Building Materials and Garden Supplies Stores (190,839 jobs, $9.71 billion).

■ Other industry sectors with employment impacts exceeding 10,000 jobs were:

- Miscellaneous Store Retailers (59,829 jobs),
- Landscape Architectural Services (48,085 jobs),
- Lawn and Garden Equipment Manufacturing (32,230 jobs),
- General Merchandise Stores (39,433 jobs),
- Merchant Wholesalers of Durable Goods (19,218 jobs),
- Merchant Wholesalers of Nondurable Goods (15,732 jobs),
- Food and Beverage Stores (14,074 jobs),
- Non-store Retailers (12,170 jobs).

Obviously, these levels of economic contributions by the green industry are impressive. However, nursery and greenhouse growers who experienced remarkable growth in sales and profits for most of the decade prior to the recession now face stagnant demand, with prospective buyers only willing to purchase product only if and when needed. Maintaining liquidity (meaning cash or credit available to handle daily operations) is a key industry challenge. The decline in sales and increased expenses to maintain nursery and greenhouse products combined to reduce cash reserves and forced many growers to attempt to source additional credit from lenders or suppliers.

The USDA/NASS (National Agricultural Statistics Service) has not generated a Nursery Crops report since 2006 and this has left a significant void in the economic data available for the nursery sector. Greenhouse-related data is available, however, with USDA releasing their latest Floriculture Crops Summary on April 21, 2011. The 2010 wholesale sales value increased 3.4% from 2009 for the 15-state survey to $4.13 billion. California was the leading state, accounting for $1.01 billion, or 24.4%, of the total survey sales. California's sales increased 8.1% from 2009. Florida remains state Number 2, with $809.6 million in sales. Florida sales declined 0.7% from 2009. The 2010 survey tallied 6,126 producers in the 15 states. This was down 6.9% from the revised 6,561 total.

Total wholesale value for firms with at least $100,000 in sales was also up 3.3% from 2009 to $3.98 billion. For these firms the wholesale value of bedding/garden plants — including perennials — was up 4.1% from the previous year to $1.91 billion. Sales of flats increased about 3%, sales of potted bedding/garden plants increased about 5% (potted annual sales were up 7%, while potted perennial sales were up almost 3%), and flowering hanging basket sales were up about 1% from 2009 levels.

Sales of potted flowering plants, at $668.5 million, were up 4.0% from 2009. Foliage plant sales were up 2.5% to $571.1 million. Cut flower sales were up 3.8% to $375.2 million. Sales of cut cultivated greens were up 5.8% from 2009 to $78.3 million. Total value of propagative materials and prefinished plants declined 1.2% to $376.4 million. Total finished floriculture sales were up 3.8% from 2009 to 2010 to $3.47 billion, mainly reflecting the strong spring bedding season in 2010.

OUTLOOK FOR THE REMAINDER OF 2011 AND NEXT YEAR

In general, plant availability was greatly reduced going into 2011 from 2010 levels. Because of this, landscape service providers and retail garden centers found that locating material to book for 2011 was more challenging. With the decline in plant inventory numbers, however, pricing is starting to go up.

Plant availability across the industry has reduced for several reasons. First, we are seeing nurseries both large and small going out of business altogether. The ones that remain have planted smaller crops or opted to not plant a crop at all during 2010 and 2011. I have not toured a single nursery/greenhouse grower that has a larger or even an equal quantity of inventory at this point compared to last year. At best, individual nursery inventory is down 25% to 30% and some firms have indicated they are down as much as 80%.

Perhaps of even greater concern is that many plants have remained on the growing location too long and have passed the stage of salable quality. Dumping significant numbers of old material has been common in the last 2 years. In some cases the nursery or greenhouse did not have the labor remaining to dump the plants and have simply turned off the water. Those plants are dead in the growing space. In several nurseries, small areas of ground cloth have been removed and vegetable gardens now occupy that irrigated space. Nurseries that specialize in propagating and selling liners and rooted cuttings for other growers to grow reported lower than expected orders for material that was to be delivered in this year's planting season. This will contribute to a possible continuation of the shortage well into 2012.

As mentioned, plant quality is of a bigger concern. Plants have been held too long in hopes of making a sale at some point in the future. Those plants are no longer viable for the retail trade and in many cases simply need to be dumped. Some growers have planted, yet not fertilized for various reasons ranging from lack of labor to put the fertilizer out to not having the money available to buy the fertilizer. Those plants have grown much more slowly and will not be ready for sale in Spring 2012. Older and unfertilized plant material will result in fewer plants that can be purchased for retail sales. Additionally, some plants cannot be purchased due to the overwhelming weed pressure that has resulted from the lack of labor and money to hand weed and or put out herbicide. All of these factors can be summarized by the following comments that I have heard across the industry this year:

- "I am not going to plant anything until I see the market turn."
- "We are not going to spend the money to fertilize until someone orders the plants."
- "I need several days' notice to load a truck so that I can find some help; we do not have any labor left."
- "I am sorry for the weeds; we just do not have the labor or money to take care of them."
- "We are too late planting anything this year and as a result will be basically out of salable plants during 2011."
- "I went out to tour some of my plant sources and the first three I tried to tour were all closed and out of business."

These quotes and more are quite common this day and age. I have no doubt that in 2012 there will be additional plant shortages. Some plants may not be found at all and for others we may have temporary outages in certain sizes.

The upside of all of this is that some growers are sensing the shortage and are already quoting higher pricing. Usually price increases are a sore topic. In our current economic climate, cost cutting has become a way of life as businesses have fought to conserve cash and preserve margins. The unwelcome news of a price increase from a supplier is usually the last thing a buyer wants to hear.

Of all of the green industry sectors, the ornamental tree sector has been hit particularly hard over the last 2 years. Growers have suffered through a crushing oversupply of trees that was, in fact, developing 6–7 years ago, but was masked by the frenetic pace of construction through the middle part of the decade. When the bubble burst in 2007-2008, the demand for trees was reduced dramatically, beyond what few of us have ever witnessed. Since that time, growers, desperate to maintain market share, reacted by cutting prices for each of the last 3 years to the point where prices, on some items, have reached 30-year lows.

Unlike their perennial and shrub-growing counterparts, tree growers cannot simply downsize their company to a scale that matches their sales. Existing inventory requires upkeep and that costs money. Like everyone else, tree growers have aggressively cut costs to try to offset the effects of multi-year negative flow of cash. That is a tall order in a world where the costs of raw materials such as burlap, diesel, and plastic have only increased. So, in many cases, fertilizer, pesticides, pruning, and staking have gone by the wayside. The results of excessive cost cutting are evident in the marketplace this year and many growers are simply not capable of supplying trees of adequate quality. For most growers, even the cost of culling bad trees is daunting when cash is tight and so the trees sit around, on display in the fields or, in the case of containerized trees, growing increasingly pot-bound.

The other major area of cost cutting has been a sharp decrease in tree planting in nurseries. Many cash-conscious growers have decided that if they cannot afford to maintain what they have, then there is little point in putting more trees in the ground. As a result, tree planting has declined 70%–80% over this period. This reduction occurred progressively: first by about 20% in 2008–2009 and then an additional 30%–40% in each of the two following years. This trend has only just begun to become evident, with many smaller-sized trees and evergreens becoming scarce this spring. Over the next 2 years the breadth of shortages will increase dramatically and progressively, as more gaps appear while the old inventory outgrows the market, becomes ruined from neglect, is cut down to increase spacing, or grubbed out entirely to prepare fields for re-planting.

Growers are watching carefully to see which items are selling out and they will raise prices whenever market conditions allow. This is not a matter of greed as much as survival. Most nurseries are just hanging on and absorbing losses, if they are even doing that. We are all watching while prominent nurseries fail, unable to continue in an economic meltdown that was nearly impossible to predict and one that is particularly harsh on those who are overleveraged.

The shock waves from the subprime meltdown will continue to be felt, but will soon be felt in different ways. The crash of demand will be followed by a crash in supply caused by a reduction in the number of nurseries that have been willing and able to continue to risk investment in the planting and maintenance of quality inventory these last 3 years. And just as the construction boom masked the over-supply of trees 5–6 years ago, the construction bust is masking the currently

developing shortage. When we experience even a modest resumption in new construction, the shortages will be difficult to manage.

It is important for green industry growers to educate their landscape and retail customers for what is coming. There is a special challenge for those who are bidding commercial projects that are further out. There is a shocking gap between the desperate pricing of 2010-11, and the prices of even the over-supplied market of 2007. But when scarcities become prevalent, prices will return to their former levels, and eventually go higher still. That market of shortages may be much closer than most realize. Buyers should be prepared for price increases in fall 2011 and very large increases in 2012 and 2013.

SUMMARY

The current health of the economy is extremely fragile, with some of our leading indicators continuing to be negative, yet some trending positive. Mixed performance in the economy coupled with extreme weather conditions across much of the country makes for a terribly challenging environment. I remain optimistic about the recovery, but then again, I pretty well find the silver lining in most economic storms.

But what if my optimism does not pan out and things do not continue to improve, even modestly? What if Europe's financial market unravels and propels the rest of the world into Great Recession: Part 2? What if the gloom and doom economists are the ones that are right and this is only the beginning of financial Armageddon in this country? Can the green industry make it through another recession like this one?

If I can elaborate on a couple of my earlier comments, I still have reason to believe that the most successful nursery and greenhouse firms in 2012 will be those that are: (a) well positioned with their customers in the marketplace, (b) not overleveraged, and (c) clearly articulating their value proposition. However, those that aren't probably won't be around much longer.

We will likely see continued structural changes across the industry supply chain as we morph into the more compact and efficient industry of the next decade. This will not only mean fewer key players in the industry but deeper, more strategic relationships among those left from the transition. The green industry will not look the same; not even close.

Yes, the industry will still be around (if it maintains value, relevance, and authenticity to end consumers), but the factors that will guarantee success in the future are going to change. Better brand management, more detailed SKU movement and replenishment analysis, greater efficiency in distribution and logistics, closer integration of genetic innovations and supply levels with consumer demand, and the assimilation of innovative marketing technologies (social media and otherwise) are the new key success factors of the future. Notice that growing a quality plant isn't listed; that's because it's a given. Growers will continue to have to have quality to even play in the game. Growers that master these key success factors will not only be postured better for the potential double dip in the short-run (if it does occur), but they will lay the groundwork for solid performance during any future economic downturn.

Finding Your Business Niche©

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THE INHERITED ART OF GROWING PLANTS

I was raised in the greenhouse and nursery business, with overnight, out-of-town trips for plants considered as a vacation. My father, Jack Randolph, started the nursery just after WWII, and my mother, Ruth, joined him as the greenhouse operator, while he pursued landscaping and most of the outdoor production. On family outings, we would trot through botanical gardens and other horticultural businesses, and on our way, we collected plants to bring back for ourselves. The youngest of five, I ended up being the one to stay behind and take over the family business. Beginning in the early 1970s, I have spent most of my spare time searching for new plants to grow and add to our collection. Most of the plants we asexually propagate are tropical, and we add these to annual and perennial container combinations for a colorful effect (Fig. 1).

Our first attempts at container mixes were over 35 years ago, when my mother started making them with the comment that "something in there will like you," meaning that if the customer neglected or stressed the container combination,

Figure 1. Propagation House. This old glass house came with a "boiler" that circulates hot water underneath the benches, making it the ideal house for starting cuttings and seed. Liners are moved out for finishing in other greenhouses as soon as they have established root systems. All cuttings are rooted with very little mist, shaded under newspapers on hot sunny days.

something would survive, leaving the customer with at least one good plant! We would add ferns and ivy to the shady impatiens mixes, and tried a range of goodies in the sunnier mixes. But back then there were not very many variegated or extremely colorful foliage plants on the market, and searching for them, propagating them and producing these unusual plants became our niche.

At Randolph's Greenhouses we discovered the added retail value of having more interesting or unique items in planters. Most of our customers are true gardeners, and really appreciate a well thought out design that includes some dramatically different selections. Many long-term customers educate themselves, as we do, about all the new plant introductions, reading all the best gardening magazines and becoming collectors themselves. People travel for miles, migrating to the plants they search for, and once found, they keep coming back year after year. Adding the newest and best flowers or foliage to your plant pallet will bring in those who are very willing to pay for a unique, colorful, artistically arranged mixed container, especially if it comes in a great pot.

THE "ART" OF COMBINING

The real art to doing container mixes is pairing the plants with others in a complimentary or contrasting manner (Figs. 2A and B), yet keeping an eye out for predictable behavior or growth habits. Your containers may look fabulous at first, but grow into awkward shapes later on in the season. By planning on their predicted growth habits, your mixes will stand a test of time in the garden setting, and require less maintenance. Pruning plants into submission should not be a requirement of the customer! Plan your mixes so that the outstanding feature plants remain domi-

A

B

Figure 2 A and B. Our retail greenhouse benches contain many kinds of plants, and too many choices can intimidate a shopper. Displaying the wide array of plant material in color theory groups makes it easier for customers to appreciate foliage and flowers together and simply choose the colors they are attracted to. Every bench contains "thrillers, fillers and spillers" and plenty of beautiful foliage plants mixed with flowers.

nant, and filler material contrasts with the one next to it, yet cohabitates. An example of this would be alternating flowering plants with foliage color as you work around the perimeter of the container.

Foliage First, Flowers Are a Bonus. Foliage is so important to an arrangement, collection of plants, or a landscape (Fig. 3). With great-looking, interesting foliage that compliments and contrasts, then you and your customers constantly have something great to look at. The flowers then become the bonus. The first thing to go when a container or collection is stressed is the flowers. Lack of fertilizer, water, or being 'bloomed out' flowers must be dead-headed. Outstanding foliage is crucial for consistently good looks.

Another good rule to follow is "break up your large leaves with fine foliage." Fine textured, ferny or needle-type leaves are the glue that hold all your big leaves together. Too many large leaves can look like beautiful colorful puzzle pieces that just don't quite fit together yet. Fine foliage softens the edges and melds it together.

The "WOW" Factor and the Rule of Three. You've undoubtedly heard of the plant design theory; "The Thriller, The Filler, and The Spiller." This term has stuck around for such a long time because its simplicity usually works. This is also known as the "Rule of Three." This and other odd numbers in combinations are often applied to container mixes. One chooses a tall plant, usually of linear-shape, another medium-sized selection that will spread and be bushy, and the third, "spiller" is cascading in nature. Most of our garden center collections can easily fill these roles, and wonderfully profitable designs are achieved in this way. The Rule of Three also works with color choices for your designs, like three primary colors, three colors in a harmony and so on. As primary colors, choose red, yellow, and blue.

Primary colors are pretty lively and exciting. They are usually placed in high-action areas of the garden, or where they need to be seen from a distance. A

Figure 3. Rita doing containers. The days of "a spike in a color bowl" are over. Monochromatic arrangements can still be quite interesting, even if the entire arrangement is green. Whether you are designing container gardens or a landscape, you start combining complimentary plants, separating large leaves with fine textured foliage, and under-plant any areas where soil may show or mulch with gravel or other suitable bark.

harmony would be three of one single color family, or with colors close to each other on the color wheel, for example; purple, violet, and lavender. Another would be red, rose, and light pink. These combinations will sooth and calm you. But even more interestingly, the Rule of Three is also wonderfully helpful in respect to a plant's foliage size and shape.

Containers Complete the Selection: Listen to the Plants. Once you've played around with fabulous plant collections, the container you choose to put them in can mean the difference in a nice mix, and an exceptional grouping.

Many times I have been found to walk around our empty containers with some plants in my arms, holding them up for comparison and compatibility, asking them "… who wants to go with us?" and "What pot do you want to go in?" Listening to the plants is a lot like shopping for fabric, or a searching for a shirt and tie that go together. The same rules of contrast and compliment apply. Even though you may not be able to describe the act of listening, it seems to come naturally the more it is practiced! I heard a phrase once, "What thrills one person, chokes another!" so be prepared for most any reaction to your new container designs, including laughter. We, at Randolph's, believe that great plants deserve great pots, whether it is on a large proportion, or on the smallest scale.

IPPS 2012 Annual Meeting: Brandywine Valley, Pennsylvania©

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CONFERENCE VENUE

Location and Hotel. The 2012 IPPS meeting will take place in the Philadelphia area Oct. 10–13, 2012. The Host Hotel is the Holiday Inn Express in Glen Mills, Pennsylvania (Fig. 1). Room rate would be $109 single/double and includes comp WIFI and hot breakfast buffet. There is a restaurant and bar on site and many restaurants within walking distance or a short drive. Hotel has a free shuttle service. Parking is free. Travel time is 16 min to Winterthur; 11 min to Longwood Gardens.

Travel. Travel time is 25 minutes to Philadelphia airport, half hour to Wilmington, Delaware train station ($46 shuttle; $65 taxi). Hotel has an airport shuttle service that they recommend at a reasonable price also Delaware Express Shuttle Co. We will encourage people flying in to rent a car.

CONFERENCE PROGRAM

Wednesday, 10 October Pretour. Full day with two options; those staying at hotel will eat breakfast there, tour does not include breakfast.

1) **Lancaster Area Tour.** Ron Strasko will be the contact person for this tour and will help organize it.
   - Creek Hill Nursery (Fig. 2)

Figure 1. Host hotel.

Figure 2. Creek Hill Nursery.

- Leola Produce Auction
- Aris / Greenleaf Perennials (Fig. 3)
- Esbenshades Greenhouses

2) Botanic Garden and Arboretum Tour.
   - Scott Arboretum (Fig. 4)
   - Chanticleer Gardens (Fig. 5)
   - Jenkins Arboretum

Welcome Reception. Wednesday afternoon / evening. Pre-tour buses will arrive at Tyler Arboretum for a tour of the arboretum, gardens, and grounds followed by a welcome reception in the barn and tent. The IPPS will supply beverages (BYOB).

Tyler is just 15 minutes from the Holiday Inn Express. People who arrived at the hotel Wednesday would be bused to the reception or they can arrive by car.

Thursday, 11 October Will Feature the Lecture Symposium and Tour at Longwood Gardens. Busses leave hotel at 7:00–7:30 with registration at Longwood Gardens for those not arriving at hotel.

General Session. These will occur in Ballroom. There is the possibility of breakout workshop —"Back to Basics Workshop"— to be determined after speaking with Paul Cappiello (Program Chair). Breakout would require a check off on registration and there will be no moving between the workshop and the general session. Great for students interested in propagation and employees of local nurseries.

Afternoon Tour of Longwood. On your own tour or organized guided tour of Longwood grounds (Fig. 6). Optional behind the scenes tour which would include composting, production houses, and nursery.

Longwood Evening Reception. There will be a cocktail reception in the East Conservatory at the end of the day.

Figure 3. Aris / Greenleaf Perennials.

Figure 4. Scott Arboretum.

Figure 5. Chanticleer Gardens.

Posters Session. Viewing will be available throughout the day and evening.

Friday, 12 October. Full day tours with two options.

1) **Dupont Legacy Tour.** The bus for this tour might leave a half hour to hour after the Nursery Tour. Will need to limit size of this tour due to capacity issues at the gardens.
   - Nemours Gardens
   - Hagley Museum and Gardens

Figure 6. Longwood Gardens.

- Mt. Cuba Center
- North Creek Nurseries

2) **Nursery Tour.**
   - Mt. Cuba Center — First stop
   - W. D. Wells and Sons Nursery
   - Conard Pyle Company
   - North Creek Nurseries (Fig. 7)

Dinner on Your Own — Evening Social Event at Host Hotel. Return to hotel for reception, mixer, garden trivia event, silent and live auction, new plant presentation, and cash bar.

- **Plant trivia, question box, or the return of garden jeopardy.** Cash bar hosted in auditorium of host hotel. This will be a fun and interactive event.
- **Live Auction Will Be a Part of the Evening's Activities.**

Saturday, 13 October Will Feature the Lecture Symposium and Tour at Winterthur Gardens. Lectures at Winterthur Gardens (Fig. 8) through early afternoon followed by afternoon tour of the gardens.

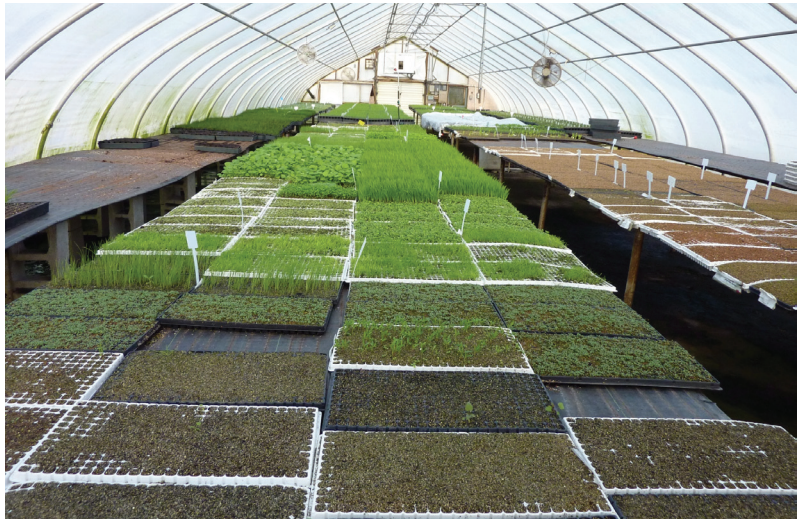

Figure 7. North Creek Nurseries.

Figure 8. Winterthur Garden.

Updating *Hydrangea* Production and Potential Cultivars©

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For the last 12 years of my academic career, I was part of a team which was involved in evaluating woody plants to use as cut stems, flowers, and fruit for use in the florist industry. During that time, *Hydrangea* was one of a number of genera investigated.

In 1996, the first 20 cultivars were planted at the University of Kentucky Horticulture research farm, Lexington, Kentucky. Most were *H. macrophylla* cultivars. They grew nicely each year and died back to the ground each winter. Each summer there was sporadic flower production. Since nurseries were able to produce flowering plants, it was decided to make sure we could get consistent flower production by growing plants in containers and using cold frames for overwintering them. We were able to produce 10–20 usable blooms per plant when grown in a trade size #5 container (Editor's note: container sizes all refer to trade size). Since we could obtain flowering with protection, the next step was to grow the plants in the ground and cover them with a cold frame which could support shade cloth in the summer and poly in the winter.

In total, around 250 cultivars in five species were evaluated under field conditions during the 20 years. Plants were established at three trial sites in the Commonwealth at Lexington, and the two east/west research stations at Quicksand and Princeton. Only about a tenth of the total was evaluated for production under cover.

Highland Moor was established as a nursery about 8 years ago by my daughter. Since retirement in January 2005, I have assisted her as an unpaid volunteer. The following is how Highland Moor has been producing *Hydrangea* in recent years.

Propagation is similar for the four species grown. Rooting hormone is Woods rooting compound, substrate is Barky Beaver pine bark nursery mix, container is Landmark 25-cell propagation tray, mist cycle is 6 sec/15 min, and mist nozzle is a Agridor 809 Mister.

Hydrangea arborescens and cultivar cuttings are taken as softwood cuttings from plants in #1 containers, cut to 2 or 3 nodes with lower leaves stripped, no hormone treatment, and one cutting per tray cell.

Hydrangea macrophylla cultivar cuttings are taken as softwood or hardwood cuttings from June to November from plants in #5 containers. Shoots are long enough to provide 3 or 4 two-node cuttings per stem. Foliage is removed from the lower node and treated as a quick dip with a dilution of one part Woods to 19 parts water.

Hydrangea paniculata cultivars are taken as softwood and hardwood cuttings from plants in #5 containers. Shoots provide several 2- or 3-node cuttings. Foliage is removed from the lower nodes and the remaining terminal foliage is cut in half before being treated as a quick dip with a dilution of one part Woods to 19 parts water.

Hydrangea quercifolia cultivars are taken as softwood cuttings from #1 containers as they are pruned to encourage branching. Cuttings are generally 3-node cuttings where the foliage is removed from the lower nodes and the remaining termi-

nal foliage is cut in half before being treated as a quick dip with a dilution of 1 part Woods to 19 parts water.

Once cuttings are rooted, the flats are sold as liners or are transplanted into #1 or #2 containers depending on market channel. Substrate is also the Barky Beaver pine bark nursery mix. Containers have been from Nursery Supplies Inc. or ITML Horticultural Products. Irrigation is drip with 17-mm supply lines, Netafim 4-way multi-outlet drippers (MOD) using angle arrow drippers and Woodpecker pressure compensating junior drippers. A short angle arrow dripper is used on #1 containers and a long arrow dripper is used on #2 containers.

Trade size #1 containers are transplanted to #3 containers. Irrigation is supplied by Netafim yellow spray stakes. Two different systems are used. One system has lateral lines to the stake coming directly from the supply line without pressure compensation. The other system uses a Woodpecker pressure compensating junior dripper at the end of a lateral line coming from the supply line. This dripper has an MOD with two lateral lines going to individual stakes in adjoining rows.

Trade size #1 containers are transplanted to #5 containers and #2 containers are transplanted to #7 containers. Both the #5 and #7 containers are on a drip system. The system is not pressure compensating and uses the double assembly Agridor 4463 spray nozzles.

Trade size containers #2, #3, #5, and #7 are offered to the retail and landscape trades. Highland Moor cut stem production is in the ground or in #5 containers.

About 15 cultivars from three genera are grown for cut stems. Somewhat unique for Highland Moor, cultivars such as *H. arborescens* 'Hayes Starburst'; *H. paniculata* 'Boskoop'; and *H. macrophylla* 'Oak Hill', 'Decatur Blue', 'David Ramsey', and 'Izu-no-hana' are among those grown for the retail and landscape firms.

Plant Hormones: The Auxins, Points for Understanding Their Actions and Use©

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INTRODUCTION

Whenever I travel to plant conferences — IPPS meetings and IPPS area meetings — I am inevitably asked: "Well what hormone do you use to root this particular plant?" While I might have a ready answer more often than not, I offer "well, it depends." This paper is an attempt to explain some of the things that fall under the category of "it depends."

From a commercial stand point auxins come to us in a variety of forms. There are auxins dissolved in an alcohol solvent to form a concentrate that we in turn dilute with water to the desired concentration. Some auxins come as a talc powder formulation that has a fixed dosage and in the last 10 years or so there are now auxin preparations that are completely water soluble and can be diluted to the desired concentration in the same manner as the alcohol concentrates but without the possible injury from the alcohol.

AUXINS

Natural Auxins. All plants produce natural auxins (Fig. 1) that they use for the regulation of growth, flower formation, fruit formation, fruit abscission and for the initiation of roots (Devlin, 1969; Salibury, 1955). The auxins, indole-acetic acid, indole-3-butyric acid, and indole-4-chloro-butyric acid have specific functions depending on the time of year and the physiological state of the plant. All are manufactured in the leaves and the apical buds and transported basipetally throughout the plant. The natural auxins are under the control of various feed-back and counter chemical relationships so that no particular auxin can get out of control. All indole auxins are under continual degradation by IAA-oxidase and IAA peroxidase enzymes, which breakdown the hormones after they have done their job and prevent an extraneous build up (Kenton, 1955).

In addition to the indole derivatives as auxins, a second class of auxins is found as ethylene gas (Devlin, 1969). It behaves in a similar manner as the indoles but has a different timing sequence and mode of action and a different degradation system. Think of indoles as a heavy truck and ethylene as sports car. Both move down the road but the similarity stops there as each has a different application.

All of the auxins can be thought of as a key that unlocks a particular activity in the cells of a plant.

When the key is inserted into the lock the membrane potential of the cell is changed and allows or forces the cell to start undergoing specific changes (Fig. 2) (Haissig, 1986).

The natural process of auxin action is held in place by regulatory enzymes and counter hormones in the plant such as the gibberellins, cytokinins, and abscisic acid (Jarvis, 1986).

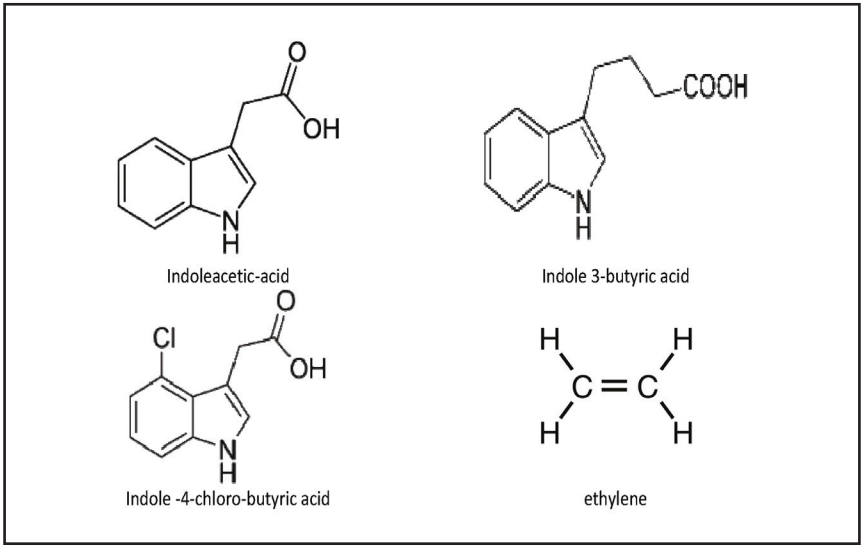

Figure 1. Various natural auxins and their respective chemical structures.

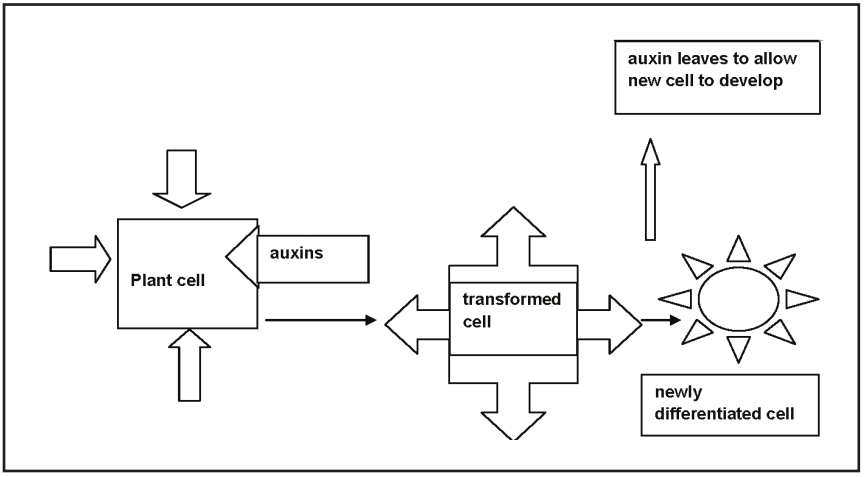

Figure 2. Sequence of auxin-induced events in a cell as it starts to undergo specific changes.

Synthetic Auxins. Synthetic auxins are not subject to many of the regulatory pathways in plants as the regulating auxin degredation/oxidase enzymes do not have an effect on the presence of a synthetic auxin. Accordingly it is much easier to overdose a cutting or tissue culture explant with auxin if a synthetic compound is used. The synthetic auxins with respect to the previous analogy of the lock and key will allow the key to turn the lock but then becomes jammed and will not allow for the normal processes to occur. This can lead to a range of problems. The most

common of the synthetic auxins that mimic the indoles are α-naphthalyene acetic acid, followed by phenoxyacetic acid, 2,4,-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid, and dicamba (3,6-dichloro-2,methoxybenzoic acid) (Fig. 3). Synthetic auxins that mimic ethylene are acetylene, propylene, and carbon monoxide (Fig 3).

The mode of action of the synthetic auxins be they phenolic (NAA, 2,4-D, etc.) or aliphatic (gaseous) is based on the cells of a plant mistaking them for the natural forms based upon the similarity of the molecular structures. However, it is the alteration of the molecular structure that accounts for both their activity in the cell systems as well as their propensity to become toxic to the cellular mechanisms. They trick the lock into action but the key cannot be subsequently removed. A recent development in the creation of synthetic auxins is aminocyclopyrachlor-methyl ester. This chemical was released in 2010 as the herbicide (Imprelis™) by the DuPont Company. It is nontoxic to grasses but it is seriously toxic to conifers and has proven deadly to most of the common genera of conifers (Strachan, 2010).

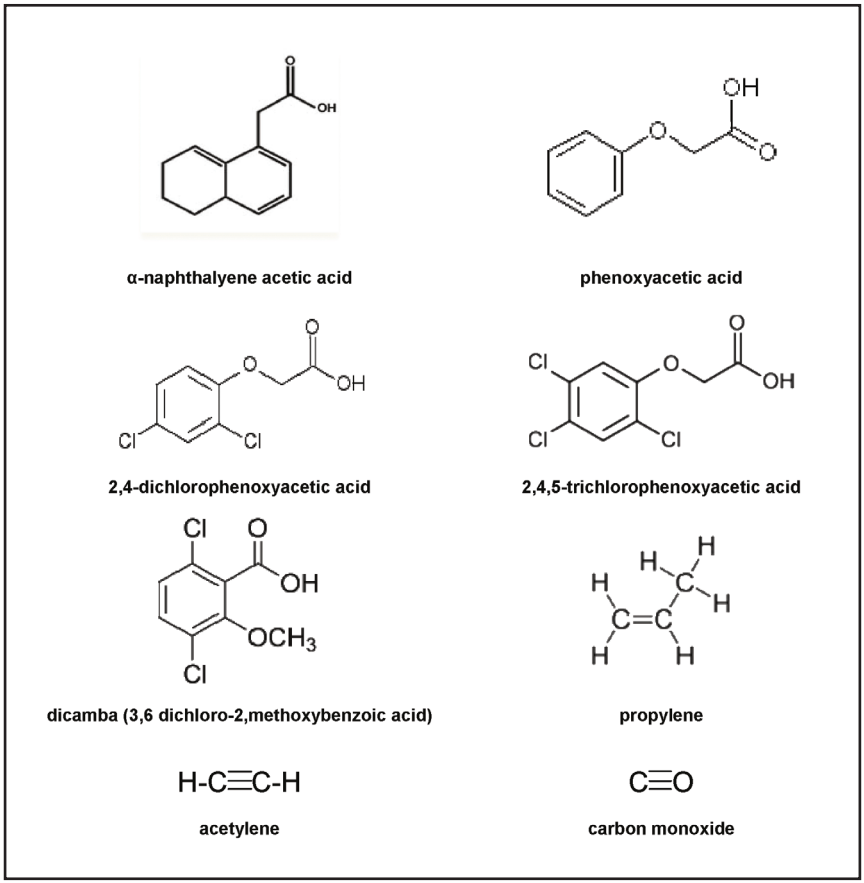

Figure 3. Synthetic auxins.

Commercial Availability of Auxins for Nursery Work. In the commercial world we commonly use IBA, α-NAA, and rarely but sometimes 2,4 D and ethylene. Indoleacetic acid is not used because of its tendency to be broken down before it has a positive effect on the rooting of cuttings. None of the other synthetic auxins are used because they have too great of an effect and cannot be easily administered in useable dosages although this property is exploited when they are used as commercial herbicides. None of the gaseous synthetic auxins are used as they cannot be used in a controlled manner and they all have a propensity to cause epinasty (abnormal leaf formation and development) and subsequent leaf abscission. Some authorities will suggest that auxins like 2,4-D cause plants to grow themselves to death. This is not the case, rather the synthetic auxins disrupt the cellar systems to such an extent that normal function is impaired and halted which results in toxic metabolites that in-turn kill the plant cells.

Commercially IBA and NAA can be found as a concentrate with ethyl alcohol as a solvent up to 10,000 ppm IBA and 5,000 ppm NAA. Dilutions from that point are made with water. The IBA is also available in the talc preparations at fixed rates such as 0.8% or 1.6% by weight. They generally cannot be altered to a lesser dosage. Potassium IBA (K-IBA) was used for a number of years for rooting cuttings but was removed from availability by the U.S. EPA because it was not registered for such use and it has been declared to be illegal to use K-IBA for the commercial rooting of cuttings in the U.S.A. Hortus Products (New York, New York) has a readily available alternative that is water soluble. Jones (2011) has suggested that in a comparison of K-IBA to the Hortus products that the Hortus material works better than K-IBA. The synthetic auxin, α-NAA, while available in the alcohol concentrates is not available as either a talc preparation nor as a water soluble formulation. It is available in the U.K. and presumably Europe but not in the U.S.A.

Other Uses for Auxins. Besides being used as root-inducing substances, auxins are used for a diverse applications such the formation of parthenocarpic fruit in plants such as *Capsicum*, chemical thinning of extra heavy fruit crops (the difference between fruit formation and fruit thinning is one of dosage, the same chemical can be used in either application), and for the suppression of suckering shoots on the rootstocks of grafted plants. It is interesting to note that the insecticide, Sevin (1-naphthyl-N-methylcarbamate), has been used as a chemical thinning agent for apples (Anonymous**,** 2011). The chemical structures found in Fig. 4 shows the similarity between the two chemicals and it is enough to fool the mechanisms in the plant.

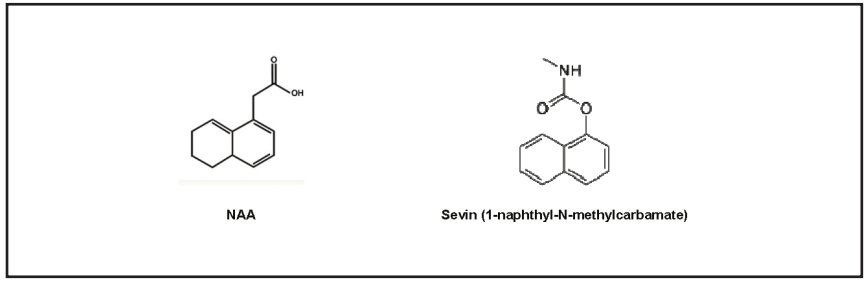

Figure 4. Comparison of NAA and Sevin® (1-naphthyl methylcarbamate), note structural similarities.

Factors Associated with Auxin Use

A perfectly valid debate could be held as to whether to use an auxin or not use an auxin. Many plants will root acceptably without the addition of exogenous auxin and the rooting of plants prior to the commercial availability of auxins is well documented (Burbridge, 1876).

However the presence of an auxin does a number of things to hasten the rooting process:

- Will promote differentiation of tissues and speed up the rooting process.
- Will increase the total amounts of roots formed.
- Many times will increase rooting percentage but not always.
- Always remember that LESS is MORE, doing without is the best course.

The inevitable questions arise, I want to use an auxin but what concentration is the best dosage? This is not an easy answer because a range of factors can intervene and present a multitude of conditions.

Conditions that depend on:

- The plant itself, family, genus, and species, relationship within a kinship tribe.
- Stage of growth of the cuttings.
- Time of year.
- Stock in ground, container.
- Full sun, partial shade, shade.
- Nutrient status of the stock plant (Blazich, 1988).
- Primed or not primed, exposure to cold or other prompting environmental condition.
- Type of cutting, apical or basal.
- Wounded or not wounded.
- Liquid hormone or powder.

Some generalities:

- No auxin: cacti, sedums, sempervirens.
- Wounding without hormone, for easy-to-root tender things (*Impatiens*).
- 500–2,000 ppm IBA (NAA often used in conjunction to IBA at half rate), 5-sec dip for easy-to-root things such soft tips, *Lonicera, Weigela, Salvia.*
- 2,000–5,000 IBA, 5-sec dip, *Viburnum, Potentilla, Spiraea.*
- 5,000–7,000, IBA, 5-sec dip, *Syringa, Quercus, Prunus, Malus, Pyrus, Halesia.*
- 7,000–10,000, IBA, 5-sec dip, *Taxus*, *Juniperus*, *Picea.*

It should be remembered that even by following the obvious rules that not all groups of plants can be tarred with the same brush. In the maples (*Acer* species) for instance using quick dips:

1) *Acer tataricum* subsp. *ginnala*, 1,000 ppm IBA
2) *Acer rubrum*, 2,000 ppm IBA
3) *Acer palmatum*, 3,500 ppm IBA
4) *Acer griseum* × *A. maximowiczianum* (syn. *A. nikoense*), 5,000 ppm IBA

In general some approximations can be determined by following family patterns. A general rule of thumb for quick dips is offered by the following graph (Fig. 5).

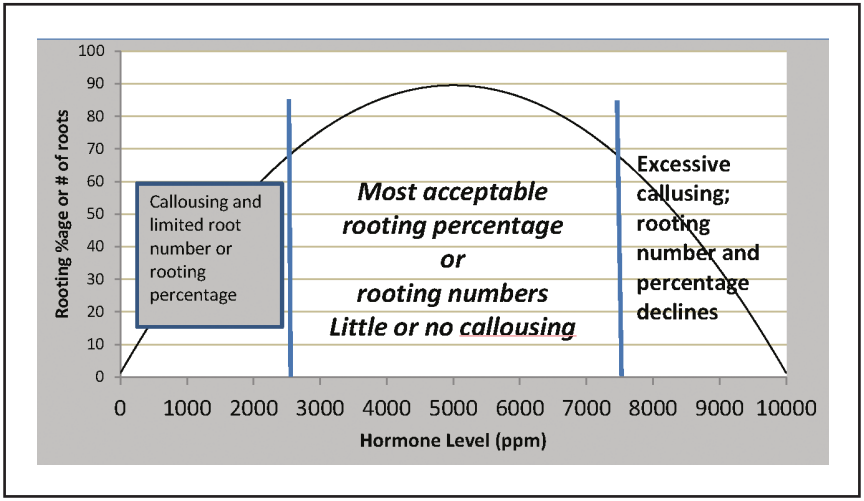

Figure 5. Cutting responses to variations in auxin concentrations.

SOURCES FOR DOSAGE RECOMMENDATIONS FOR QUICK DIPS

For Water Soluble Dips Go To:

- <http://www.hortus.com/Yoder/Yoder_recommendations_2004.pdf>.
- In general water soluble formulations use about 20% higher than acid formulations with alcohol.
- References such as: *Manual of Woody Landscape Plants* (Dirr, 2009), *Reference Manual of Woody Plant Propagation: From Seed to Tissue Culture*, (Dirr and Heuser, Jr., 2006); *Hartmann and Kester's Plant Propagation, Principals and Practices* (Hartmann et al., 2002).

Powder Formulations:

In many respects the use of rooting powders has diminished significantly. This is largely due to the fact that quick-dips are much more thorough to use and are more efficient. However, rooting powders do have a place in modern propagation. Some plants are ethanol sensitive and rooting powders can be used to overcome this difficulty although it should be noted that the water soluble quick-dips can also be used to circumvent the alcohol toxicity problems. So why use powders?

In some instances they are quite reliable and effective. They are somewhat cumbersome to use but they are not complicated. Many directions for using quick-dips suggest using xxxx ppm but the starting place for the alcohol dips is 1% IBA and 0.5% NAA. Some people have trouble going from % to ppm. To set the record straight 1% is 10,000 ppm. 0.5% is 5,000 ppm. However, people with limited English skills or folks just not familiar with the techniques might find powders to be that much more user friendly.

In general dosage requirements of powders follow the same pattern as quick-dips but with a different set of units. A dosage of 0.8% powder is equivalent to 2,500 ppm IBA quick dip. A dosage of 0.4% is approximately to 1,000 ppm IBA quick dip. Alternatively a 4% IBA powder has a rooting potential of a 10,000 ppm IBA quick dip. Older volumes of the Combined Proceedings of the IPPS offer the most reliable

references to using powders, as the quick dip methods did not really become commercially available until the 1970s.

WHICH IS BETTER?

To effectively decide what to do, requires planning and an understanding of both the materials being used and of the plants being treated. Some of the pros and cons of the various formulations can be found in Table 1.

Table 1. Comparisons of various commercial auxin formulations.

Formulations	Pro	Con
Alcohol dips	Contains IBA and NAA	Alcohol toxicity
	Easily tailored to specific plants	Limits of solubility of both IBA and NAA 10,000 ppm, 5,000 ppm, respectively
		Not effective for all plants
		Fumes can be problematic
		Concentrate is flammable
Water soluble dips	Contain IBA	No alcohol toxicity
	Tailor made concentrations up to 20,000 ppm	Does not contain NAA
	No harmful fumes	Not effective on all plants
	Safe for many soft cuttings	Need about 20% more hormone than with alcohol dips
Talc preparations	Contain IBA	Do not contain NAA
	No alcohol toxicity	Limited effectiveness
	Safe on many types of plants	Cumbersome to use

Some Key Points for Consideration.

- Alcohol- and water-soluble formulations overlap in usage.
- Each method needs to be applied with respect to specific plant.
- Not all plants respond to either formulations, alternative formulations might be needed.
- Water-soluble formulations based on K-IBA reagent grade chemicals deemed illegal.
- Exact nature of new water-soluble forms not published.
- Barnes (1990) in unpublished work showed Rubidium salts of IBA just as effective as K-IBA, which indicates that the auxin is the majority player in the water-soluble formulations.
- Jones (2011) in a personal communication, says that Hortus products work better than K-IBA.
- Remember active ingredient is the auxin, not the solubility factor, unless alcohol solvents are involved.

Special Considerations with Auxins.

- Byrnes (2002) (pers. commun.) showed that IBA alone is preferable to IBA/NAA combinations for the rooting of *Quercus*.
- *Platanus* and some *Vaccinium* are generally rooted without auxins, because auxins will inhibit rooting in some taxa of these plants.
- Monocots: *Hemerocallis, Hosta*, Graminacae do not respond to auxins, but will root from cuttings.
- *Magnolia virginiana* and *M. grandiflora* show marked preferences for either IBA or NAA but not both in conjunction (Dirr, 2009; Martin and Ingram, 1989).
- Plants with high levels of manganese (Mn) are negatively affected with regards to rooting (Andersen**,** 1986).
- Boron at 2.5 ppm with auxins shown to be positive for rooting (Blazich, 1988; Haissig, 1986; Jarvis, 1986).
- Acidic pH for dipping solutions sometimes beneficial (Jarvis, 1986).
- Bottom heat and light shown to make significant contributions to the overall rooting success (Andersen, 1986; Burbridge, 1876).

CONCLUSION

Auxins are positive tools for the accomplished propagators. The variations in formulations and methods of applications can often spell success or failure. Other factors besides auxins can often contribute greatly to the overall effort. It is not prudent to assume that auxins alone will be sufficient to accomplish the largest amount of rooting that is possible for a given plant.

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Mobilizing Resources to Conserve Ash Species in Response to Emerald Ash Borer

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AN INTRODUCTION TO ASH AND EMERALD ASH BORER

Ash (*Fraxinus*) consists primarily of temperate, deciduous trees and shrubs, with ±60 species native to the Northern Hemisphere. Ash diversity is highest in China (22 species) and the U.S.A. (16 species). In Eastern North America, six native ash species are under threat of functional extinction by an exotic insect pest, emerald ash borer (EAB; *Agrilus planipennis*), introduced from Asia to southeastern Michigan, probably in the 1990s. Emerald ash borer adults feed on ash leaves, females lay eggs exclusively on ash, and larvae feed on cambial tissue in ash stems and trunks. There is no documented resistance to EAB among these six ash species, and larvae commonly infest and kill healthy and stressed mature trees and juvenile saplings alike. This severely reduces opportunities for the evolution of increased tolerance to EAB and may hasten extinction.

Native species under threat include *F. americana* (white ash) and *F. pennsylvanica* (green ash), which are widely used as stress-tolerant landscape trees, and often planted as monocultures along the streets of many communities (Fig 1). These species are also commercially harvested for timber and wood products, as are two other natives, blue and pumpkin ash (*F. quadrangulata* and *F. profunda*), that also grow to substantial size (Fig 1). Ash wood is strong and flexible, making it

Figure 1. Ash species occupy a wide range of ecological niches in eastern North American forests. White ash has a broad native range from Minnesota south to Texas and east to the Atlantic Coast, most commonly in fairly well-drained, mesic forests where it is most obvious in autumn (left image). Blue ash is associated with alkaline or calcareous soils, in a more limited geographic range in the central U.S.A. with outliers in Ontario, typically in rocky, limestone woodlands (right image).

ideal for specialized uses, including tool handles, baseball bats, artistic furniture, and bowls, and black ash (*F. nigra)* has long been used by Native Americans to make utilitarian and decorative baskets. Carolina ash (*F. caroliniana*), the sixth species native to Eastern North America, is a small tree restricted to very wet areas in the Southeastern U.S.A.

Native ash trees also provide food and shelter for wildlife, supporting a suite of at least 70 native specialist arthropods, including 21 species of North American butterflies and moths. These insect species are now being negatively impacted by EAB's spread and the resulting demise of ash trees.

THE SPREAD OF EMERALD ASH BORER AND ITS POTENTIAL CONTROL

Since its North American introduction to Michigan in the 1990s, EAB has expanded rapidly via natural dispersal and human assistance, decimating native ash trees in its path. Human-mediated dispersal (including the movement of nursery stock, wood products, and firewood) is the primary means of rapid long-distance movement, and has resulted in many new infestations. Today, firewood movement is the most serious concern. The spread of EAB is diligently tracked by an extensive trapping network and regularly documented through the publication of online maps at <www.emeraldashborer.info>.

In EAB's wake, tens of millions of ash trees have been lost, with billions of dollars invested in tree removal, disposal (to prevent EAB reproduction), and replanting. For example, nearly 10 years ago the Nichols Arboretum at the University of Michigan suffered scientific, ecological, and aesthetic losses as EAB spread rapidly through Ann Arbor. An important experimental plantation of controlled crosses of native ash species developed by Dr. Sylvia Taylor for long-term genetic and taxonomic studies was destroyed by EAB, necessitating expensive removal work. [Loss of this collection was reported in the Fall 2008 *Public Garden*, Vol. 23(3).] Simultaneously, extensive native stands around Nichols Arboretum and the University's other key garden, Matthaei Botanical Gardens, were decimated. But this is only the beginning; future costs may be enormous, considering the estimated number of remaining ash trees (as high as 8 billion). Facing such huge losses, efforts to slow the spread of EAB are needed to help limit annual economic burdens while buying time to develop and deploy biological control strategies, new treatments, and potentially resistant/tolerant ash trees. Many EAB-response strategies are already being implemented, which, if successful, provide hope for a revival in planting ash as a landscape tree and re-introducing ash to native forests where it has been lost.

THE NEED FOR ASH GERMPLASM

Prior to EAB's arrival in the U.S., ash species were considered relatively common and, as a result, ex situ ash germplasm collections were poorly developed. In 2002, as EAB spread and losses mounted, there were no recognized ash collections among North American botanic gardens in the North American Plant Collections Consortium; ash provenance collections previously assembled by foresters were neglected or entirely abandoned; and the U.S. National Plant Germplasm System (NPGS) conserved only a few ash collections. In order to provide a critical safety net against extinction, as well as to aid in research to identify and develop potentially EAB-resistant ash trees, there was an urgent need to rapidly develop well-documented and genetically diverse ex situ ash collections.

After 2002 numerous agencies began working to build ex situ collections of ash. The NPGS began working with other researchers and agencies; the USDA-Natural Resources Conservation Service began mobilizing volunteers to collect ash seeds in Michigan; the U.S. Forest Service National Seed Laboratory initiated seed collections within its agency and with numerous partners; and the Canadian Forestry Service expanded efforts to collect native ash seeds for the National Tree Seed Centre. As the NPGS curator for *Fraxinus*, I began planning a series of domestic seed-collection expeditions and established contacts with the Morton Arboretum and Beijing Botanic Garden to plan Chinese collection trips to sample potentially EAB-resistant ash populations. In addition, other botanic gardens, state forestry and natural resource agencies, and Native American communities became involved. There was a clear need for these often disparate efforts to be coordinated and use limited resources as efficiently and effectively as possible to ensure development of robust ex situ ash collections. Thus, in 2009, I agreed to coordinate this interagency effort. This was a logical move for the NPGS, the lead organization within the U.S.A. for ex situ conservation of economically important plants and their relatives.

ASSEMBLING AND CONSERVING ASH GERMPLASM COLLECTIONS

Fortunately, ex situ collections of ash can be maintained long-term in seed banks and as cryogenically preserved dormant buds. Ash can also be preserved in living collections, as long as the collections are not exposed to EAB and/or if they are able to be treated systemically with proper insecticides. Because seed banking allows large amounts of genetically diverse seed to be stored long-term at relatively little cost, our primary efforts have been to assemble comprehensive ash seed collections. We focus on developing collections with proper taxonomic identity, good initial seed quality, complete passport data, and sampling strategies that maximize the capture of genetic diversity in well-established natural populations distant from large plantings of cultivated ash trees. For each native ash species, we focus on collecting and banking seed from areas being colonized by EAB, and aim to collect from populations representing the full range of habitats where the species occurs. A website describing all aspects of this conservation project, including details about the sampling strategy and current seed-collection protocols, can be found at: <www.ars.usda.gov/sp2UserFiles/Place/36251200/Ash_Project/HomePage.html>.

Since 2007, the USDA-ARS Plant Exchange Office has supported yearly ash seed-collection trips in New England, Missouri, Illinois, Wisconsin, Minnesota, Kansas, Missouri, and Arkansas. Upcoming trips are planned for Pennsylvania and New York (in collaboration with the Arnold Arboretum). Wide year-to-year fluctuation in local seed production has slowed assembly of genetically diverse collections, particularly in areas where EAB is the greatest threat. However, summer reconnaissance trips have improved our success by helping identify sites where fall seed collections can be most effectively made. These collections, and those of many collaborators, are being incorporated into the NPGS. The majority of ash collections will be maintained at the North Central Regional Plant Introduction Station in Ames, Iowa, and collections with sufficient seeds are also backed-up at the National Center for Genetic Resources Preservation in Fort Collins, Colorado. As of 15 March 2011, our active collection included 310 accessions representing 24 taxa, with 71% of those collections from the U.S.A. and 14% from China. Currently, 116 accessions have sufficient quantities of seed or scionwood to make them available.

And consistent with NPGS policy, these collections are freely available for bona fide research and educational purposes.

HOW BOTANIC GARDENS CAN HELP AND INFORMATION ABOUT THE AUTHOR

There are many ways that botanic gardens can assist in ash conservation. Through public education, garden visitors and students can be taught about the importance of ash and its preservation, its vulnerability to EAB, and how to recognize and slow EAB's spread. Curators can identify all *Fraxinus* accessions among their holdings and develop management plans to protect key trees with systemic insecticides. Lists of unique taxa and clones as candidates for cryogenic storage can be compiled. And, for those gardens with expertise in seed collection and/or access to natural ash populations well removed from cultivated ash in the managed landscape, garden staff can directly participate in our efforts by monitoring seed production and collecting seeds.

Mark P. Widrlechner was a horticulturist within the National Plant Germplasm System (NPGS), in Ames, Iowa, where, until his retirement in September 2011, he curated collections of herbaceous and woody ornamentals and medicinal/aromatic plants and conducted research on germplasm management, plant-climate interactions, and risk-assessment for invasive species. The NPGS has extensive collections of agronomic and horticultural crops and their wild and weedy relatives, supporting considerable research on germplasm evaluation and conservation. As noted above, NPGS collections are freely available for research and educational purposes worldwide, and information about its collections is accessible online through the Germplasm Resources Information Network database at <www.ars-grin.gov/npgs>.

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The willingness of the American Public Garden Association to allow me to reprint this paper from the Summer 2011 issue of Public Garden, Vol. 26(2) is much appreciated.

ADDITIONAL READING

In addition to the websites noted in article, here are a few more on-line resources for ash, EAB, and related topics.

Lists of alternative shade trees as replacements for ash.

Canadian Food Inspection Agency. <http://www.inspection.gc.ca/english/plaveg/pestrava/agrpla/rple.shtml>.

Indiana Department of Natural Resources. <http://www.in.gov/dnr/forestry/files/Alternatives_to_Ash.pdf>.

Iowa State University. <http://www.extension.iastate.edu/pme/EAB%20other%20forms/ShadeTreeAlt07.pdf>

Michigan State University. <http://www.emeraldashborer.info/files/e2925.pdf> .

University of Wisconsin. <http://www.entomology.wisc.edu/emeraldashborer/Alternatives%20to%20Ash%20for%20Homeowners.pdf>.

Other Websites.

Continental Dialogue on Non-Native Forest Insects and Diseases. A national efforts to communicate the advantages of using local firewood. <http://www.dontmovefirewood.org>.

Herms, D.A., D.G. McCullough, D.R. Smitley, C.S. Sadof, R.C. Williamson, and **P.L. Nixon.** 2009. Insecticide Options for Protecting Ash Trees from Emerald Ash Borer. North Central IPM Center. <http://www.emeraldashborer.info/files/Multistate_EAB_Insecticide_Fact_Sheet.pdf>.

Knight, K.S., R.P. Karrfalt, and **M.E. Mason.** 2009. Methods for Collecting Ash (Fraxinus spp.) Seeds. USDA Forest Service General Technical Report. NRS-55 <http://www.nsl.fs.fed.us/gtr_nrs55_AshSeedCollection.pdf>.

Smith, M. 2011. Waging war on a voracious pest. Agricultural Research April 2011:18-21. <http://www.ars.usda.gov/is/AR/archive/apr11/pest0411.pdf>.

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Growth of Cane (*Arundinaria sensu stricto*), the Mysterious Native Bamboo of North America©

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INTRODUCTION

In recent years, the generic name *Arundinaria* has become restricted in usage to the native "cane" species of eastern North America: *gigantea* (= *macrosperma*), *gigantea* subsp. *tecta* and *appalachiana* (Triplett et al., 2006, 2009, 2010). The closest living relatives of these bamboos are in East Asia, where they are now classified into several distinct genera (Li et al., 2006; Triplett and Clark, 2010). The purpose of this paper is to summarize what is known, superficially, about the biology of *Arundinaria*, as applied to problems in horticulture, restoration, and ecology.

Arundinaria has several unusual or unique characters, when compared to other native plants of eastern North America. These characters are also typical of many bamboos in temperate regions of East Asia. In flowering behavior, however, species of *Arundinaria* differ from most of their long-lost East Asian cousins, which generally exhibit gregarious flowering over many hundreds or thousands of acres or even whole regions, after nonflowering periods of several decades. Flowering is generally rare and sporadic in *Arundinaria*, with no evidence of such widespread gregarious events.

The following review is based partly on literature, meetings, and conversations with growers. It also draws on 20 years of personal experience in Kentucky trying to grow and establish cane, especially transplants into restoration sites and, more recently, seedlings. My associates at Roundstone Native Seed Inc. (in Hart County, Kentucky), John and Randy Seymour, have also become much involved, and they are also working with Mark Smith at Auburn University in Alabama. I do not deal here with tissue culture and micropropagation, which is being studied by Baldwin et al. (2009), Margaret Cirtain (University of South Carolina, pers. commun.), Sharon Kester (University of Kentucky, pers. comm.), and others. Moreover, Susanne Lucas (Pioneer Plants LLC, Plymouth, Massachusetts), in partnership with Oprins Plant NV in Belgium, is developing the market for mass production of selected bamboo clones.

FLOWERING, SEEDING, AND GERMINATION

Essential sources of information on flowering of *Arundinaria* are the many herbaria, with dried specimens dating back to the earliest periods of botanical exploration (Campbell, 1985). In recent decades, there has also been some useful accumulation of records from propagators (e.g., Betty Shor, American Bamboo Society, pers. commun.; B. Baldwin et al., 2009; and pers. commun.) and ecologists [e.g., Marsh (1977), Gagnon and Platt (2008), Mathews et al. (2009)]. There appears to be some tendency for more frequent flowering in some years in some regions, with clusters of records covering hundreds or thousands of square miles. But even this clustering generally includes no more than 1%–10% of the plants within those regions. There may

be weak association between flowering frequency and years with sun-spot maxima and wetter periods, but deeper analysis is needed.

There is virtually no definitive documentation of life-span for individual clones of *Arundinaria*. A few horticultural observations indicate that as little as 3–15 years can sometimes elapse between seed germination and flowering, but these plants are probably aberrant individuals within seed lots [observations of myself, G. Cooper, G. Lundquist, and others compiled by Betty Shor (pers. comm.)]. Long-term observations of particular cane patches in the wild suggest that the lifecycle is usually at least several decades. In an early account, Neisler (1860) indicated that ca. 25 years was typical in *A. gigantea*, but longer periods are generally suspected today. There are only two flowering records for *A. appalachiana* (1956 and 2006). Whole clones of *Arundinaria* usually die after flowering and seeding but sometimes death is delayed for 1–3 years. Stephen Breyer (pers. commun.) has reported recovery of *A. gigantea* without producing seed at Tripple Brook Farm in Massachusetts.

Potential problems from inbreeding might occur if flowering is somehow decoupled from regular gregarious behavior. Research of Franklin (2004) on a bamboo species in northern Australia has shown much higher rates of cross-pollination, seed-set, and regeneration among plants in peak flowering years, versus precocious or straggling plants. Baldwin et al. (2009, and pers. commun.) suspect similar problems based on initial observations of low seed set in Mississippi, with much more viability after artificial cross-pollination. However, I have got good germination (ca. 80%–100% of sound fresh seed) with several batches of seed that were probably self-pollinated in Kentucky.

Seed of bamboos generally dies after drying out at ca. 60–80 °F (15–25 °C) for 2–4 months, and is thus considered recalcitrant (McClure, 1966; Stapleton, 1987, 1994; Bellairs et al., 2008). Drying in some sun for one day is generally considered useful, in order to slow immediate germination and reduce microbial attack, but several days may be damaging. Germination usually occurs within a few days if seed are kept in a continually moist state after shedding. However, a few reports indicate that germination by some East Asian species of colder zones may occur after 1–5 years of "dormancy" on the forest floor or similar storage (Qin, 1985; Taylor and Qin, 1988; Stapleton, 1994; Wang et al., 2007). Stapleton stated: "Seed of the smaller subtropical and temperate bamboos may have substantial dormancy, and it might germinate more quickly after a period of cold pretreatment, such as stratification or refrigeration at 5 °C [41 °F]."

Recent research on seed of *Arundinaria* by myself at the University of Kentucky (in the lab of Carol and Jerry Baskin) and Mississippi State University (Baldwin et al., 2009; Neal et al., 2011) has confirmed that even in cold storage at ca. 32–35 °F [0–2 °C], germination of seed (when warmed-up and wetted for 14 days) gradually declines to zero after 1–2 years, with considerable variation between seed lots. Zero germination is observed after seeds drop below ca. 6%–8% moisture content. To date, no freezing treatment has been found to preserve viability for longer periods. But after cold damp storage, with or without slight freezing, there was faster germination in some seed from Kentucky, as compared to cold dry storage. After wetting and maintaining sound seed at ca. 70–80 °F [25–30 °C], germination generally starts within a few days, and the first leaves appear at 1–4 weeks. Older seed tends to be slower, with leaves sometimes not appearing until 2 or even 3 months. If seed

does not start to germinate within a few weeks, it is almost certainly dead — or perhaps fatally infected by microbial growth.

Like other bamboos (Janzen, 1976), cane seed is consumed by a wide range of pathogens, pests, and herbivores. For example, much fungus and other microbial growth often occurred in petri dishes used for 14-day germination tests by myself. However, there was significantly less microbial growth after seed had been stored in cold damp versus cold dry treatment; seeds lost weight during cold damp storage, presumably exuding anti-microbial compounds. Sharon Kester (pers. commun.) has had great difficulty extracting sterile material from seeds for tissue culture. It is likely that cane seed in the wild is generally threatened with excessive drying and microbial attack. Cane seed often does not mature due to attack of flowers by weevils, which need to be identified. Due to such insects, several patches of flowering cane in Hart County have failed to produce any mature seed within the past decade, before they die (R. Seymour, pers. commun.). However, an initial flowering patch in 2000 did produce much seed, which was used by Cirtain et al. (2004, 2009) to grow seedlings for their experiments. Small mammals are avid eaters of cane seed — it is usually essential to protect flats of germinating seeds using wire mesh or other means.

GROWTH, PROPAGATION AND ENVIRONMENTAL FACTORS

Based on general horticultural experience, bamboos in general are known to be particularly sensitive to interruptions in moisture supply, poor aeration of roots, and other physical stresses. For example, Stapleton (1987) found that division and repotting in hot dry nurseries was risky, "thus it seems division of seedlings is only suited to cooler or more humid nursery locations." Thanks especially to experienced growers like Bill Hendricks (Klyn Nurseries, Perry, Ohio), Ned Jacquith (Bamboo Garden, North Plains, Oregon), and Nevin Smith (Suncrest Nurseries, Watsonville, California), it is possible to gain some general insights into the best physical conditions for growing temperate species. From varied successes and failures, it appears to me that stresses often cause plants to go into physiological "shock" — presumably involving growth-suppressing hormones, and sometimes aggravated by microbial problems. With return of good conditions, it can take up to a year for plants to resume rapid growth. In containers, much more stress can occur with smaller sizes, especially if exposed to extremes of temperature and moisture during daily or seasonal cycles. Study of hormones in bamboos is a promising field that will eventually help in understanding of how these plants deal with stress (e.g., Zhang et al., 2011).

The obvious unusual feature of *Arundinaria*, compared to associated plants in North America, is its long spreading rhizome system, allowing clonal growth for 100–1,000 m or more during its sexual life cycle. Brian Baldwin (pers. commun.) has evidence from DNA markers that one clone of *A. gigantea* has spread over 1–2 km at Dahomey National Wildlife Refuge in Mississippi. Another unusual feature is the concentration of extension growth by new culms during just 1–2 months in the summer, usually when soils are still damp after spring rains. It is likely that the extensive rhizome system allows rapid supply of moisture for such growth. Moreover, on less well-drained ground, the air-canals in rhizomes of *A. gigantea* subsp. *tecta* (and sometimes *A. appalachiana*) are presumed to enhance oxygen delivery for the rapid extension of culms (McClure, 1963; Triplett et al., 2006). Similar air-canals are known in some East Asian species (e.g., *Phyllostachys atrovaginata*, *P.*

heteroclada, *P. nidularia*). New culms are protected by leathery sheaths, which are shed within a year or so, especially when upper nodes develop branches. There is one dominant branch per node, like most temperate bamboos of eastern China and Japan, but in marked contrast to most Sino-Himalayan and tropical bamboos.

Arundinaria is sometimes assumed to be a plant of wetlands — the USDA has misleadingly listed it a "facultative wetland" species (Griffith et al., 2009). Although sometimes flooded for short periods in the wild, these bamboos do not have optimal growth on saturated soils, but *A. gigantea* subsp. *tecta* is more tolerant (Baldwin et al., 2009; Milles et al., 2011). Like most bamboos, *Arundinaria* is moderately "mesophytic" — easily stressed by droughts or floods during the growing season, especially if the rhizome system is reduced or cut. Cirtain et al. (2004) found that *A. gigantea* seedlings on well-watered but well-drained soil had more 1-year growth (ca. 28-cm shoots) than periodically dried or periodically flooded (ca. 20-cm shoots). However, transplants or cut rhizome sections do best when humidity is maintained at high levels. Adam and Sue Turtle (pers. commun.) recommend that during the growing season, transplanted bamboos in general should be regularly soaked and kept in shade for a month or so before planting out. Baldwin et al. (2009) showed that the vascular system of *A. gigantea* is sensitive to embolism (cavitation) when rhizomes are cut. These researchers also recommend soaking root-rhizome systems of larger plants for a month or more, or enclosing plants with leafy tops in plastic bags, before they are set out in the field.

If care is taken, at least 50% success rate is expected with transplants of *A. gigantea* from existing stands. The best season for transplanting is probably Feb. – March, based on much experience in Kentucky. When digging plugs from the wild, it is important to select 1–3 good culms for each unit and to retain an approximate cylinder of at least 6–9 in. of soil — in depth and width — together with the rhizome and root system. It is important to dig straight down with a long heavy sharp spade (e.g., the King of Spades™ made by W.W. Manufacturing, Bridgeton, New Jersey) — and to dig all around the culms, not angling down into the plug or otherwise reducing or damaging the transplanted rhizome sections. However, even with much care, loose soil often falls off roots, and tying plants up with burlap (or similar material) could be useful in some contexts. To reduce transpiration, it is often important to cut off the top 30%–70% of leafy material when digging transplants, especially if plants are large and soil falls off. It is also important to keep transplants cool and cover them with wet blankets (or similar material) when transporting them, then settle them gently into their new homes within a day or so. And pray for as much rain as possible, but without severe floods or winds, for the next few months.

Propagation from rhizome sections is somewhat erratic, but reliable methods can probably be developed and have being actively sought in several studies (Sexton et al., 2003; Zaczek et al., 2003, 2009; Hartleb and Zaczek, 2007; Brendecke and Zaczek, 2008; Baldwin et al., 2009; Schoonover et al., 2011). Based on these studies (especially Baldwin et al., 2009 and pers. commun.), the source and initial condition of material can be a significant factor. Larger containers or trays with at least 2–3 nodes are recommended, especially sections closer to culms of origin (proximal); diameter of rhizomes appears to have little or no effect on success. A misting system can probably enhance success rates, but rooting hormones may not be particularly useful. Zaczek et al. (2003) achieved more success when rhizomes were planted shallow, exposed to sunlight. Bill Hendricks (pers. commun.) has suc-

cessfully grown many rhizome sections in the spring by enclosing them in a humid polyhouse. Chuck Rhodes (pers. commun.) has observed reliable rooting by floating rhizome sections in full sunlight. Paul Capiello (pers. commun.) is currently comparing rhizome cuttings in fall versus spring, since other bamboos have show more successful rooting in the fall. In the field, rhizomes simply cut and transplanted during the growing season tend to die much more readily than if some leafy tops are retained, even if watered regularly. Schoonover et al. (2011) have shown that in-leaf containerized stock is clearly superior for field plantings than just rhizome sections — but there is much potential for mortality of rhizomes in the greenhouse while developing that containerized stock.

Like many bamboos, *Arundinaria* can grow well in full sun, if soil conditions are suitable, but some shade is tolerated well and may be beneficial for reducing temperatures and resulting moisture stresses. Cirtain et al. (2009) found that *A. gigantea* — in growth chamber and woods — did best in full sun, and there was a positive interaction with N level in their growth chamber. Baldwin et al. (2009; and pers. commun.) grew *A. gigantea* with a shaded pot-in-pot system, regular watering, and NPK amendments; they found that total growth increased in full sun, but above-ground growth alone was maximal under 60% shade. Smith (2011) has shown that *A. gigantea* is a relatively light-demanding bamboo, compared to some of its East Asian relatives, including smaller bamboos like *Sasa* species which did not increase photosynthetic rates when grown in less shade. But she also showed that *A. gigantea* is relatively sensitive to moderate drought, displaying signs of wilting or cavitation before any of the Asian species that were compared.

At Roundstone Native Seed, we suspect that hot summer temperatures can be highly detrimental, especially when black pots are exposed to full sun or within trays on greenhouse benches. In several cases, we have observed much better survival and growth, above ground at least, where containers remain below ca. 75–85 °F (25–30 °C) — experimental work is needed to determine the exact response. For example, large freshly transplanted, potted plants did much better when placed along the north side of a barn but still receiving skylight from above. Even with drip-fed irrigation and a sunken pot-in-pot system, similar plants in full sun mostly died above ground during 2011. In an experimental planting of 150 cane seedlings at Griffith Woods (Harrison Co., Kentucky), survival after 3 years was correlated with an index of cool (N/NE-facing) aspect.

Bamboos are generally considered to be relatively nutrient-demanding plants (Lawson, 1968; Lucas, 2008). Relationships of nutrient levels to *Arundinaria* — especially nitrogen (N) — have been studied in a few, varied contexts. Cirtain et al. (2004, 2009) found that N amendment did not improve growth of *A. gigantea* seedlings until after their first year. With transplants of *A. gigantea* into an old field, Datillo and Rhoades (2005) found that fertilizer and manure both increased culm numbers by ca. 10%–40% after 2 years, but there was less effect on height. With transplanted rhizomes of *A. gigantea*, Zaczek et al. (2010) found that NPK increased survival after 2 years, but it did not offset short-term reductions of above-ground growth due to fire. Blattel et al. (2009) surveyed soils across riparian buffers with native (unplanted) *A. gigantea* at three sites, and found 80%–95% decreases in nitrate from field to interior (downslope) soils at one site, in ammonium at another site, and no significant trends at the third sites. Griffith et al. (2009) found that *A. gigantea* in western North Carolina is associated with well-drained

sandy soils, relatively low nutrient levels, but low C : N ratios and pH of 5–6.6. A partner of Roundstone Native Seed grew seedlings of *A. gigantea* in 2 × 2 × 5-in, cells on acid soils with unusually low Ca level, using standard medium for loblolly pine seedlings. These developed much less rhizome growth after 6 months, with virtually none escaping the containers. In better soil with the same cell size (PRO-MIX™ plus clay and nutrient amendments), leafy shoot growth was similar after the same period but several rhizomes usually appeared out of the bottom of each cell. There is obviously a need for broader experimental studies of growth under a range of nutrient conditions.

COMPETITORS AND CONSUMERS

Some observations, including mulching studies, may indicate effects of competing plants with similar or shorter stature. In their field of *A. gigantea* transplants, Datillo and Rhoades (2005) found that mulch (with or without extra nutrients) increased culm numbers by ca. 40%–60% after 2 years, but there was less effect on height. Using various manipulations, Cirtain (2009), Hartleb and Zaczek (2007), Osland et al. (2009), and Schoonover et al. (2011) found that *A. gigantea* transplants were not much reduced by dense competition in the ground vegetation, such as Japanese grass (*Microstegium vimineum*). However, Baldwin (pers. commun.) found that after 1 year of experiments, transplanted rhizomes of *A. gigantea* grew much less among rhizomatous alien grasses (Johnson grass and Bermuda grass) than among native deep-rooted clumpers (big blue-stem and Indian grass). Reduction of this competition by tilling or herbiciding increased cane growth among the alien grasses, but reduced it among the natives — might these grasses have protected the cane from hot dry air? I found that establishment of *A. gigantea* transplants was virtually all prevented by the densely rhizomatous quackgrass (*Elymus repens*) at Griffith Woods, in Harrison County, Kentucky, but it was often partially successful with much taller but thinner competition including ironweed (*Vernonia gigantea*) and even poison hemlock (*Conium maculatum*). Tall associates may be beneficial in some cases, by reducing hot sun and drying out of the soil surface (see previous section).

There has been virtually no systematic study of consumer relations — herbivores, pests, and pathogens — but there have been varied initial anecdotal observations. In petri dishes used for my germination tests with *A. gigantea* seed, fungal growth became severe in several cases, but was much less after cold moist storage of seeds (unpublished data). In the greenhouse at Roundstone Native Seed, *A. gigantea* seedlings suffered greatly from fungal infection of leaves during the hot humid conditions of Summer 2010. In my garden, a patch of cane grew to 10–20 ft across in a decade then gradually declined in the subsequent decade without any flowering, and no obvious reduction in light or other resources — I suspect fungal accumulation in the plants, as evidenced by blackened twigs and leaves. A new genus of rust-like fungus has been discovered on *A. gigantia* subsp. *tecta* in Alabama (Olive, 1945); see also Hyde et al. (2002). Rabbits caused repeated significant damage to my planting of 7-year-old *A. gigantea* seedlings at Cane Run (Fayette County) during 2000–2002, but the plants finally prospered. Mammalian herbivores in general can have significant effects on cane. Cattle have often browsed it back in Kentucky, and continuous grazing appears to kill the plants after a decade or so. On the uplands of central Kentucky, most remaining cane has survived in old fencerows,

wherefrom it locally recovers into rights-of-way (especially along interstate highways) and other abandoned land that is no longer grazed or mowed.

ECOLOGICAL NICHES, HABITATS, AND RESTORATION

As outlined above, *Arundinaria* is generally typical of edges and other transitions from deep woods to full sun, probably with repeated disturbance rather than a simple "successional" niche after catastrophic disturbance. Within this broad zone, the three species have somewhat distinct habitats along the gradient in moisture conditions: from subhydric (*A. gigantia* subsp. *tecta*) to submesic (*A. gigantea*) to subxeric (*A. appalachiana*). In addition, *A. gigantea* tends to occur on more base-rich soils, especially alluvial soils in the Mississippi Valley. The spread of *A. gigantea* onto some calcareous uplands, such as the Bluegrass Region of Kentucky, may be a relatively recent phenomenon. Triplett et al. (2010) have not yet detected consistent genetic differences between upland and lowland plants, but *A. gigantea* from the Mississippi Valley does appears somewhat distinct in DNA from *A. gigantea* of Atlantic states. Hybridization does appear to occur between *A. gigantea* and *A. gigantia* subsp. *tecta* — the geographic and ecological context of any intergradation will deserve deeper study.

In nature, there has been little experimental work into what disturbance regimes are optimal. Hughes et al. (1960; Hughes, 1966) showed that burning or other intense disturbance at intervals of about 10 years was probably optimal for *A. gigantia* subsp. *tecta*, and that the cane could be successfully browsed by cattle in alternate years, especially during the winter. Gagnon and Platt (2008a; Gagnon 2009) found that *A. gigantea* grew more in a blow-down area, compared to deeper woods, and much more (× 2) with fire as well as blow-down; but growth was less with fire alone. They also found (Gagnon and Platt 2008b) that sown seed did less well on bare burned ground than with regular leafy litter. Zaczek et al. (2010) planted rows of *A. gigantea* rhizomes then observed effects of prescribed fire, which increased culm density and rhizomatous spread 2 years later but with reduced culm sizes and reduced overall leafy cover.

On relatively uniform base-rich soils, Fig. 1 presents a conceptual model for the original "niche" of *A. gigantea* within the dynamics of native woodland, based on much general observation and historical data from the Bluegrass Region of Kentucky. In addition to the general gradient from deep shade to full sun (left to right), one can envisage an independent gradient related to browsing by generalist herbivores. Before excessive human influence, large animals such as giant bison and mastodons probably were significant browsers in woodland with cane. Similar patterns do occur in modern vegetation, though they have been fragmented and any ancient migrations are now of course lost. In the original woods, it is suggested that there was a messy (highly stochastic) cyclical tendency, counterclockwise on the diagram. This concept is allied with Vera's (2000) hypothesis concerning the ancient role of herbivores in the woodlands of central Europe.

Focus on cane in conservation deserves much more effort, given this plant's historical abundance in some regions, its potential role to counter invasive alien shrubs (Osland et al., 2009; Brand, 2010), its potential role in nutrient uptake and reducing erosion, especially along riparian zones and headwater streams (Schoonover et al., 2005, 2011), and its potential role as a perennial forage for wildlife (McHargue, 1941; Platt et al., 2001) or even livestock in some contexts (Biswell, 1941; Hughes et al., 1960; Smart et al., 1960; Halvorson et al., 2010).

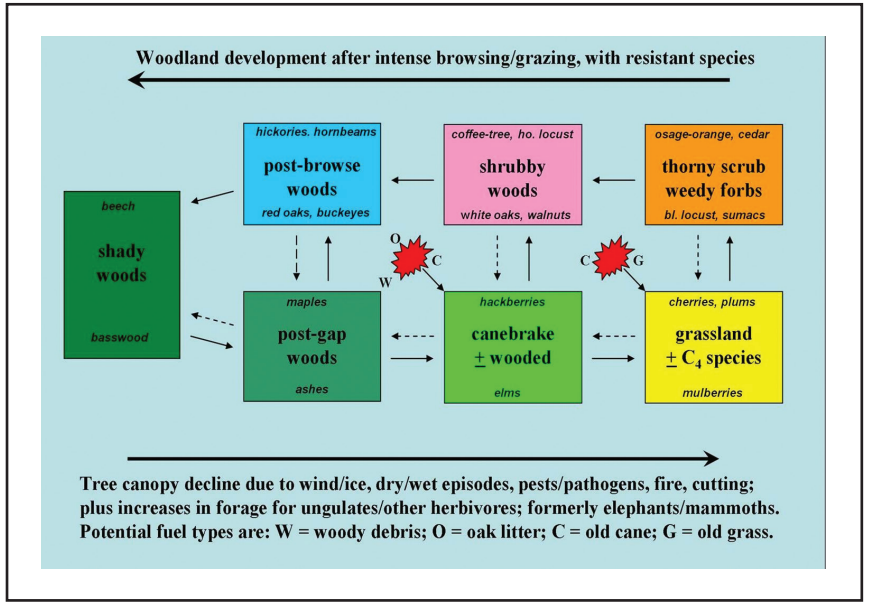

Figure 1. Diagram of ecological concept for dynamic variation in woodland of the central Bluegrass (assuming uniform eutrophic soil).

Griffith Woods (Silver Lake Farm), covering 750 acres in Harrison County, provides an excellent site for deeper study of cane in the Bluegrass Region of Kentucky. In addition to patches of ancient woodland, including the world champion chinquapin oak, there are many old fields where cane can be established. Several general goals can be set: (1) genetic collection, with varied uses; (2) comparative study of growth rates and responses to site types; (3) experimental management — browsing, burning, cutting, chemical, competition, other consumers; (4) studying effects of cane (compared to other vegetation) on soil, plants, animals, etc. Now transferred from The Nature Conservancy and University of Kentucky to the Kentucky Department of Fish and Wildlife Resources, this old farm should become the center for restoration of Bluegrass woodlands, their canebrakes and their wildlife, together with associated research and education.

DISCUSSION

So what generally characterizes the growth form, life cycle and ecology of temperate bamboos, and does *Arundinaria* have any special distinction?

Bamboos in general have a unique "punching and branching" ability to send up rapidly growing culms through brush and vines in transitions from shady woodland to more open vegetation. After escaping herbivory in tender young stages, and growing through any competing thickets, culms then branch out into spaces above. In species with running rhizomes, large areas can be colonized, especially on gentle uniform slopes and plains without excessive droughts or floods. Disturbances of varied kind, when repeated at intervals of ca. 5–25 years, probably provide the optimal habitat for bamboos.

Arundinaria is similar in these respects to its East Asian cousins, with a somewhat similar range of habitats from low, seasonally damp plains to drier, broad ridges in the mountains. The loss of large canebrakes from more fertile lowland plains and some calcareous uplands presents a significant problem for conservation and restoration, since the plant has not yet been propagated in large numbers (Platt and Brantley, 1997; Stewart, 2007). East Asian people have cultivated many species of temperate bamboo for millennia, but the many Native American uses of cane were interrupted (Platt et al., 2009). There was little initial adoption of these plants by the settlers from Europe or even by their slaves from Africa, except for some local uses as fishing-poles, bean-stalks, and the like.

Bamboos in general, especially running temperate species, tend to develop dense competitive stands that can generally prevent seedling survival except after parental death. As discussed previously (Campbell, 1985), their "monocarpy" (death after flowering) could have been selected partly by such need for parental death, assuming that occasional sexual reproduction is essential. Other evolutionary forces favoring infrequent or gregarious flowering could include selection for "satiation" of seed consumers when large seed crops are produced (Janzen, 1976), and selection for association with particular phases of environmental cycles — perhaps allowing seedlings to renew the population in rainy periods after parents decline in drier periods, or after fire (Keeley and Bond, 1999). The rare flowering, poor dispersal, and frequent self-pollination of bamboos pose special problems for maintaining genetic diversity.

The much reduced extent of observed gregarious flowering in *Arundinaria*, compared to its East Asian cousins, suggests possible decoupling of a more regular ancestral life-cycle from environmental cues. Such decoupling might have developed as climatic patterns became less predictable during the Quaternary era, including severe disruptions during glacial periods. Problems for cross-pollination and genetic conservation may be particularly acute in these bamboos. Nevertheless, I am confident that more concentrated attention by horticulturalists and biologists can refocus North American effort on this worthy cause.

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Yoshino and Beyond: Exploring the History and Diversity of Flowering Cherries in the U.S.A.

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The year 2012 marks the 100th anniversary of the planting of the historic flowering cherry trees around the Tidal Basin in Washington, D.C. These trees, a gift of friendship from Japan, have become synonymous with springtime in D.C. and have been the inspiration behind festivals, landscapes, artwork, and merchandise throughout the U.S.A. Given the popularity and notoriety of flowering cherries in the U.S.A. today, it is remarkable to think that they were almost unheard of in the U.S.A. just over a century ago.

Flowering cherries have been an important part of Japanese culture for at least a thousand years. The beauty and ephemeral nature of the blossoms is evident in historic and modern Japanese literature, art, language, and culture, as well as in landscapes. Flowering cherries were brought to the U.S.A. sometime in the mid-1800s, as evidenced by mention in several nursery catalogs from that time, but they were not well-known or widely grown. This status changed in the early 1900s when David Fairchild, head of the USDA's Office of Foreign Seed and Plant Introductions, helped introduce 30 taxa of cherry trees into the U.S.A. Fairchild also took a personal interest in flowering cherries, and planted over 100 trees on his property in Chevy Chase, Maryland. The beauty of these trees became well-known to local individuals and organizations, who decided to plant cherry trees in nearby towns, schools, and parks. Soon the first lady of the U.S.A., Helen Taft, was enamored by the trees, and, with assistance from David Fairchild and others in the USDA, made plans to beautify Potomac Park with mass plantings of flowering cherry trees.

The plans to plant cherry trees in Potomac Park reached the highest levels in the U.S. government, and in 1909, the U.S. Department of State received an offer from the city of Tokyo to donate 2,000 trees as a gesture of friendship between the two cities. This shipment arrived in Washington, D.C. in early 1910 and was inspected by entomologists and pathologists from the USDA to ensure that the trees didn't harbor disease or insect pests that could pose a threat to U.S.A. agriculture. Unfortunately, a number of potentially damaging insects and pathogens were discovered that necessitated destroying the entire shipment of plants. Undeterred by this setback, the City of Tokyo prepared a second shipment, this time taking careful measures to ensure that the plants were disease-free. In 1912, a second shipment of 6,000 trees (3,000 for Washington, D.C. and 3,000 for Central Park in New York City) arrived in the U.S.A. where they passed inspection. First Lady Taft and the wife of the Japanese Ambassador, Viscountess Chinda, planted the first two trees on 28 March 1912 (Jefferson and Fusonie, 1977).

Since that historic planting, flowering cherries have become popular plants for street, commercial, and residential landscapes in the U.S.A. Over one million plants

are sold wholesale each year at a value of more than $22 million [United States Department of Agriculture (USDA), 2001]. Despite the large number of *Prunus* species with diverse origins and ornamental traits, the most widely cultivated flowering cherry trees planted in the U.S.A. represent only a few species, primarily *P. serrulata*, *P. subhirtella*, and *P.* ×*yedoensis*. The United States National Arboretum (USNA) has an ongoing breeding program aimed at broadening this base by developing new cultivars of ornamental cherry with disease and pest resistance, tolerance to environmental stresses, and superior ornamental characteristics. This breeding program began in the 1980s and includes a diverse ornamental *Prunus* germplasm collection, consisting of over 1500 trees representing at least 30 diverse taxa. Many of these taxa were collected by Roland Jefferson in Japan, Korea, and Taiwan in the 1980s.

Flowering cherries are most recognized and appreciated in the spring during their spectacular but relatively short-lived bloom period. However, traits available from other species could be used to develop trees that have year-round interest or that can broaden the use of these plants in the landscape. Traits such as ornamental bark, plant size and architecture (shrubby, columnar, weeping), flower color (white to deep rose), and fall color can be combined using traditional breeding to create novel combinations of desired traits. In addition, tolerance to biotic and abiotic stresses such as wet soils, cold climates, and diseases and pests, can also be bred into new cultivars.

Breeding of many woody ornamental crops is often difficult because of the lack of previous research in the area. Because flowering cherries share the genus with several economically important edible species (for example, peaches, plums, and cherries), many breeding and research tools are available that might otherwise take years to develop. For example, molecular markers developed for peach and cherries can be readily applied to ornamental *Prunus* taxa to determine genetic diversity or verify parentage (Ma et al., 2009). Tissue culture technologies for propagation or biotechnology (Scorza et al., 1995) can also be modified for use in ornamental taxa. Rootstocks developed for specific purposes such as dwarfing or tolerance to pests or stress, may also be useful for ornamental taxa. Even cultural information such as orchard management and grafting may be applicable to production of flowering cherries (Westwood, 1988).

Two flowering cherry cultivars have been introduced by the breeding program at the National Arboretum. *Prunus* 'Dream Catcher' (Fig. 1), released in 1999, is an open-pollinated seedling from *P.* 'Okame'. It has an upright vase-shaped habit (Fig. 1) with large single clear pink flowers. It blooms approximately a week after 'Okame'. *Prunus* 'First Lady' is a backcross of *P.* 'Okame' with *P. campanulata* and is best recognized for its deep pink blossoms and upright, almost columnar habit (Fig. 1). It was released in 2004. 'Dream Catcher' can be readily propagated from softwood or semi-hardwood cuttings under mist using 1,000–3,000 ppm IBA in talc. Propagation of 'First Lady' is usually done by budding or grafting, although softwood cuttings from juvenile plants will root occasionally. Propagation from mature plants is challenging.

Figure 1. *Prunus* 'Dream Catcher' (left) and 'First Lady' (right, photo supplied by Phil Normandy, Brookside Gardens).

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How Perennials Are Born©

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INTRODUCTION

I'm going to spend some time today giving a brief overview of how perennial plants come to market. This will include definitions of what a perennial plant is, history of plant introduction and cultivation, and modern-day examples of plants and techniques used to develop new perennials.

Perennial Definition:

- Any herbaceous plant that survives multiple flowering cycles over multiple years.
- Darwin Perennials definition: plants hardy to USDA Zone 6 or colder.

Why are perennials such an important class? Perennials continue to grow in popularity and are one of the fastest growing categories in the five-billion dollar green industry. Perennials are important because they are/have:

- Excellent landscape feature and transition plant between woody ornamentals and lawn.
- Long lasting.
- Diverse texture, habit, and colors.
- Very early to very late flowering species.
- Many native cultivars.

History. Plant collection for food and medicinal purposes has been documented by the ancient Egyptians back to the 14th century BC.

Our modern era of plant collection and cultivation for ornamental uses is well documented in the 15th century and really blossomed in the 17th and 18th centuries. The earliest plant catalogues date back to the early 17th century.

American botanist John Bartram was collecting, cultivating, and selling North American native plants to customers in England in the 1700s.

Some examples of early traded perennial plants we still enjoy today:

- *Hosta* — Asia late 1700s
- *Baptisia* — North America 1758
- *Iris sibirica* — Cultivated since the 1500s, introduced in North America in 1796

How was this made possible? Through the naturally occurring diversity in plant populations.

Historically and even to this day, plant collectors, hobbyists, and plant professionals use observation and collection as a tool for discovering new and exciting plants for cultivation. Some recent examples are:

> *Rudbeckia fulgida* var. *sullivantii* 'Early Bird Gold' — Dupont Nursery. The folks at Dupont Nursery noticed a plant among a population of *R. fulgida* var. *sullivantii* 'Goldsturm' that was flowering several weeks earlier than all the rest. Normally, *R. fuldiga* flowers after a certain amount of long days; usually by July to August. 'Early Bird Gold' is

truly a new and unique *R. fuldiga* that doesn't require the same number of long days to flower. This one individual plant was then multiplied and clones are sold into the market today.

Echinacea purpurea 'Magnus' — Nurseryman Magnus Nilsson set out to make improvements on the North American native, *E. purpurea*. He made crosses and selections over a 10-year period and finally introduced 'Magnus' in 1982. 'Magnus' is characterized by its compact habit, rich pink flowers, and excellent landscape performance making it one of the most popular seed-raised *Echinacea*.

BREEDING

Natural Pollination. There are a number of ways perennial plants are pollinated in cultivation and in the wild. The most common is with insects, primarily bees and wasps. These insects are excellent pollen carriers. Their territorial nature helps maintain a set population and many "open" pollinated perennials rely on this method.

Other natural pollinators include:

- Wind
- Butterflies and moths
- Hummingbirds

Focused Breeding. Although natural pollinators are responsible for many of the perennials currently on the market, professional breeders employ more focused breeding techniques to help direct the outcome and products they hope to bring to market.

The first step in the process is to set breeding objectives. These may include:

- Market objectives
  - What does the market have?
  - What does the market need?
  - Flaws in market leader?
  - Market size?
  - Market potential?
- Plant characteristics
  - Size
  - Color
  - Disease resistance

These objectives are critical to good breeding resource utilization. Modern breeding facilities are typically sophisticated greenhouses with educated breeders and technicians. A breeding project can take many years; often 5 or more, to start delivering income from the project. For this reason, breeders have to be very focused on achieving the objectives established at the start of the project. Also, it is difficult for them to respond to constantly changing objectives so it's critical that the objectives be well researched, clearly defined, and potentially attainable.

One of the most common techniques is hand pollination. In this method, male (M) and female (F) parents are selected by the breeder based on traits that, when combined, will bring about progeny that exhibit the best of both parents. In the case of M × F, the pollen is collected from the M parent. The F parent is emasculated (male flower parts are removed to avoid self-pollination) and the pollen from the M parent is applied to the F. The F flower is then covered to avoid wind or insect pollen contamination.

Another common technique is one M parent and multiple F parents. In this case, no emasculation takes place however; there is one specific M parent and multiple F parents. This is also a common production technique to produce true lines of perennial seed. Breeders and producers accomplish this by creating breeding cages where there is one M plant and multiple F plants and where pollinators, usually bees, are maintained. The cages ensure that the bees stay put and do their work and that other sources of pollen don't contaminate the area.

SELECTION AND TRIALING

Once seed has been collected from the breeding crosses, seedlings are grown and planted in fields or containers for evaluation. This is another critical phase. The breeder and product management team are looking for the plants that have developed the attributes set out in the breeding objectives.

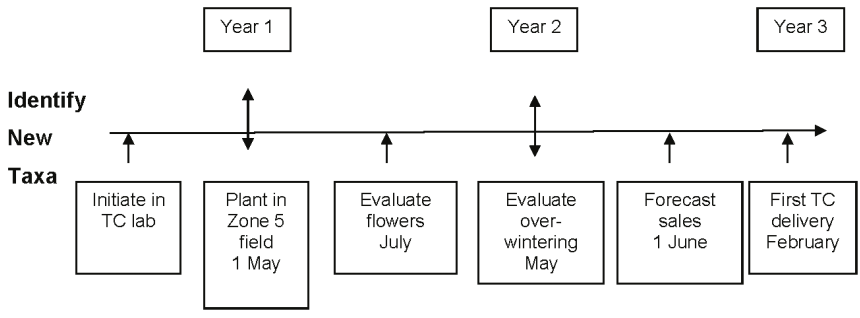
Typically, this work is done in a field setting. For Darwin Perennials, our initial trials are conducted in north eastern Illinois in a Zone 5 environment. We examine the plants for the following traits:

- Cold hardiness
- Heat tolerance
- Disease resistance
- Bloom time
- Color
- Flower size
- Ease of production
- Traits of differentiation from competing genetics

Data is collected from each group of seedlings. This data is used to make selections of the best progeny that will be trialed further. In most cases, fewer than 10% pass the first phase of trialing and less than 1% becomes market-worthy perennials.

After plants have passed field and container trials, they must also pass commercial production trials. These trails ensure that the plants can be produced in the lab as tissue culture plants or in the nursery as cuttings or as seed. Because most perennials are self-incompatible, the majority of taxa are produced by vegetative cloning as cuttings, divisions, or tissue culture plantlets. Professional perennial companies must have reliable supply of plants they introduce to the market and this production trialing step is a key link in the supply chain.

Here is an example of a typical introduction timeline for an *Echinacea* produced from tissue culture (TC) plantlets:



WHAT ABOUT THE FUTURE?

The future of the perennial market is very good. Despite the current economic conditions, the market is still growing. More new cultivars are being added. Perennials are bred to flower longer and are becoming "annualized"; used in mixed containers and as patio accents. The large plant retailers are doing a better job of displaying and marketing perennials and the heavier flowering and better habits of new cultivars add to the impulse appeal that drives sales in these outlets. Growers have more options for sourcing inputs than ever before. Breeders are continually refining production techniques to develop more perennials from seed.

How We Graft Japanese Maples©

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INTRODUCTION

My name is Larry Walsh and I have worked at Prides Comer Farms in Lebanon, Connecticut for exactly 12 years as of this week. I have been involved in running our grafting program at Prides Comer Farms since 2003. In 2003 we grafted a total of 8,800 plants with a total of 13 taxa of plants, eight of them being *Acer* taxa. In 2011 we grafted over 15 taxa of *Acer* and a total of more than 30 different plants for a combined total of 31,000+ actual grafts. The most popular plants we do by grafting are *A. palmatum* 'Bloodgood', *A. palmatum* var. *dissectum* 'Tamukeyama', *Pinus strobus* 'Soft Touch', and *Cornus kousa* 'Wolf Eyes'. We also graft some selections of *Hamamelis*, *Magnolia*, and *Larix* that are much harder to do and we limit these to just a few thousand or so every year.

THE GRAFTING PROCESS

Starting the Process. We buy in our understock for grafting in the spring and fall. The *P. strobus* will come in during May in a 51 cell plug and is then typically transplanted into a larger pot size in June. Our *Acer* and *C. kousa* understocks arrive as bare-root understocks in October and November after they are graded and dug from field-grown beds. These are potted up immediately after arrival within a week or so. Evergreen Nursery supplies our *P. strobus* and Heritage Seedlings supplies our *Acer* and other taxa such as *Magnolia*. Akerboom Nurseries supplies our *C. kousa* and some other species such as *Hamamelis*. We try to stick with an understock that is at least $^{3}/_{16}$-in. to $^{1}/_{4}$-in. caliper on all taxa we purchase. Anything less in caliper size will be too small to graft onto for the coming grafting year.

Potting the Understock. We use the same soil mix that we use for our container trees and shrubs in the nursery that we would do by grafting. Our container soil mix consists of 72 pine bark : 17 peat moss : 5.5 sand : 5.5 coarse perlite (by volume). We also add some Micromax®, RootShield®, lime, and some Harrell's 15N-6P-12K at half the normal rate that we normally use during the propagation season during the summer months. We predominantly use three different pot sizes:

1) A smaller 3.25 in. by 3.5 in. pot for small caliper plants.
2) A 3.5 in. by 5 in. pot for bareroot material, like $^{1}/_{4}$-in. caliper *Acer* understocks that we get in.
3) We also use a quart pot that we like to use for our biggest bare-root plants like *C. kousa* and *M. kobus* that will root quickly and give us a well rooted plant by the end of the springtime or early summer. This quart pot is also 5 in. in depth. Some taxa just cannot fit into the smaller pot sizes, and we don't struggle with potting them and cutting off too much of their root systems.

The Grafting House. We started to use a Jaderloon greenhouse structure for our grafting program in 2003. We only used one half of a bay with only two benches in 2003 and now we have expanded to two full bays with up to eight full benches

being used with an additional four that can be utilized for grafting. We are now able to break the house into two sections by rolling down a poly wall in the center of the house to seal off the back half from the front half benches. We can keep the back half very cool and the plants dormant from November to January or right up until they are grafted during the January and February time period. This area is kept at 60–65 °F or less during the daytime and above 32 °F during the nighttime. We can use the roll-up sides on the greenhouse during warm days to keep it cooler and oil heaters to keep it from freezing at night. We use bottom heat in the 2 weeks prior to grafting a taxon to activate and awaken the root systems to stimulate some white root activity on them before they are brought to the front benches for grafting. Trying to keep the other benches as dormant as possible also, without the plants waking up too much before they are grafted. Not an easy thing to do when you are turning on the heaters to warm up the front bays of the Jaderloon structure.

Grafting Techniques. The techniques and tools that we utilize to make us more successful with the three major groups we graft, *Acer, Pinus,* and *Cornus*, will next be presented.

- We use a folding grafting knife by Victorinex.
- Medical tape is used for the grafters to protect their fingers.
- Buddy tape, rubber bands, and grafting wax are used for our side veneer grafts.
- A crockpot to maintain the wax at a constant temperature, along with small 1- to 2-in. paint brushes for applying the wax.
- Peat moss on top of the soil layer inside the tents on *P. strobus* grafts to keep the humidity high.
- A 12 in. measuring stick to maintain the proper height and keep them uniform for all *A. palmatum* var. *dissectum* selections.
- A side veneer graft is used for all *A. palmatum* selections at 10–12 in. for all dissectum selections and 2–3 in. for all our non-*A. palmatum* var. *dissectum* cultivars.
- *Pinus* and *Cornus* will be grafted at 2–3 in. except for *Cornus* which can be grafted at 6 in. on very straight understock to create a taller plant much faster.
- All plants are then placed inside a tenting system after they are grafted.

Inside the Tents. We use a couple different sizes and types for our tenting system. These include:

- A 3-mil 55% white poly for our *Pinus* to keep it cooler, keep a higher humidity, and more constant at night.
- A clear 3-mil poly for most tents.
- A new tent with clear 6-mil poly for a more permanent structure with roll-up sides that we will have for many years to come.

The tents are kept closed for the first 2 weeks to maintain high humidity levels and promote good healing of the grafted unions. Maintain a temperature of 80–90 °F during the daytime and at least 55–60 °F at nighttime for the air and a constant temperature of 68–72 °F for the soil temperature. Watering in the tents is usually started after the initial 2-week period. Only putting some water on the benches to maintain high humidity levels in the mornings and then again in the

afternoon before we leave. Do not let plants dry out; this will dramatically reduce percentage take on almost all grafts. Drying creates a wicking effect on the grafting union. Venting to control the temperatures begins, as the grafts leaf out. Venting can reduce pressure from leaf diseases and maintains good airflow throughout the tent. Keeping it in the 80 °F range will make a huge difference on quality. The bottom heat also increases humidity levels so needs to be watched and backed off a bit at times. Using temperature and humidity digital meters will increase your awareness for each bench. We also use different sized watering nozzles for the different sized plants on the benches to help maintain the right soil moisture.

Future Grafting Plans. Goals for coming years include:

- Having all tents with roll-up sides with 6-mil clear poly for longer lasting and more permanent structures.
- Using a stir plate to keep the grafting wax at a constant temperature throughout the day so as not to "burn" the graft union and to apply the right amount to seal the wound.
- Growing our own understock from small plugs in the springtime to have for grafting the following winter.
- Using Jiffy® pots to get a more expansive and well-rooted understock and reducing the need to use plastic pots and trays.
- Lastly and the most importantly to continue and improve upon our grafting lean flow system that we implemented this year and promoting it to all our new grafting personnel during the coming winter.

Plant Exploration — Why Is It Important?©

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INTRODUCTION

As universities throughout the world eliminate classes and programs in plant breeding, this discipline is becoming a dying art and science. Instead, genetic engineering and molecular sciences are being touted as the future for new plant development. However, as the world climate changes, and as new pests and diseases damage and destroy commercially valuable plants, it is critical that new plants are found, evaluated, hybridized, and introduced. Novel genetic resources, that are adaptable, valuable, and ornamental, are critical for the future. Plant exploration, collection, and breeding are as important as ever to meet the new challenges of the green industry because germplasm is a vital resource for the generation of new plants (Chang, 1987).

There are three main reasons that plant exploration is important: To find and collect new plant material, to breed and develop new and valuable commercially acceptable plants with the collected germplasm, and to educate future plant breeders.

FINDING AND COLLECTING NEW PLANT MATERIALS

Plant collection and introduction is a valuable process because plant genetic resources are the basis for sustained plant improvement. Crop plants have been bred and hybridized for the past 10,000 years. The improved selections that have resulted from all of this work have eliminated the resource from which they were originally based — this is called "genetic erosion." The genetic diversity that was supplied by landraces of ancient agriculture has been replaced with a relatively small number of selection that were bred for high yields and other adaptations that are necessary for high input agriculture. The genetic reservoir that is necessary for further improvement has been lost in cultivation. The good news is that in many situations, the original and wild progenitors of these crops still exist. However, as natural habitats disappear and land use increases, there is urgent need to collect and conserve the diverse genetic resources that remain.

The collection and preservation of the world's plant genetic resources have been given high priority by both the developed and developing countries. There is a large array of genetic diversity that is available in native landraces, primitive cultivars, and their wild relatives. Plant genetic resources are the most valuable and essential basic raw materials to meet the current and future needs of crop improvement. The collection and conservation of these resources in a systematic manner is a responsibility that cannot be neglected.

There are several advantages to collecting native species.

1) The natural gene pool of plants will be preserved by protecting them in secondary locations like botanic gardens and national collections. Extinction of certain species will be avoided because there are sources to reintroduce these plants if necessary.

2) The plant breeder benefits from collecting plants because new germplasm and genetic resources are available for breeding. Plant introductions expand the availability of high-quality, improved plants for breeding.
3) As new plants are collected from their native habitats, the genetic base will be widened.
4) Science benefits from these plant collecting expeditions because there is valuable information that is learned about the plants and the new genetics that are obtained.
5) New and creative ideas are generated when seeds and propagules are collected. As new locations for these plants are identified, there is an increased awareness of and understanding about plants and their communities.

Once new plants are discovered and collected, the procedures for the proper introduction and exchange of these new genetic resources should be followed. The import and export of plant genetic resources should strictly follow phytosanitary conditions. Inventories of these new plant genetic resources should be assembled and their availability should be shared with scientists and germplasm banks around the world. The new collection of plants should be preserved in a viable manner either through live collections or seed collections.

BREED AND DEVELOP NEW PLANTS

Agriculture has witnessed spectacular advances in both production and productivity of ornamental and food crops during the past 100 years. These advances are due to successful programs in plant breeding that have hybridized new crops and released valuable plants. Much of this research was achieved because of the realization that indigenous germplasm offered new genetic resources that widened the genetic base that is required for crop improvement.

The ultimate goals of plant breeding are to change the genetics of plants and to meet the demands of consumers who want new and novel plants. Modern plant breeders aim to improve native plants and provide new plants for cultivation or newer forms of plants that are currently in cultivation. Plant breeders want to produce improved plants with unique characteristics such as disease resistance, increased length of flowering, stress tolerance, variety diversity, and better postharvest life, etc. (Bridgen et al., 2002, 2009; Cadic and Widehem, 2001). In order to accomplish these goals, breeders must explore the potential value of under-appreciated and under-utilized plants, use modern breeding techniques, and improve scientific research.

Classical plant breeding is time-consuming and tedious but very rewarding. There are multiple plant breeding methods that can be used in a traditional program. These include mass selection, pure line selection, hybridization of inbred lines, backcross breeding, and recurrent selection. Genetic engineering is a new type of genetic modification that can physically remove the DNA from one plant and transfer it into another without concern if these plants have the ability to cross hybridize. The potential now exists to transfer almost any trait from any living organism into a plant.

It does not matter if classical breeding or genetic engineering is used; the ultimate test of successful breeding programs is if new plants are produced, evaluated, and introduced. This requires time to grow and evaluate plants in sufficient numbers.

EDUCATE FUTURE PLANT BREEDERS

The process of collecting plants and breeding them is not only valuable and necessary for the survival of the world, but it is also fun and educational. It is a way to learn about new plants, generate new ideas, develop new research endeavors, and improve science. In addition to the professional advantages, personal development from traveling the world, obtaining new experiences, facilitating collaborative relationships, and meeting new people and making new friends cannot be measured. It is important that the training and educating of new plant breeders continues.

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Tapping the Underappreciated Plant Diversity of the Eastern United States©

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INTRODUCTION

The romance and intrigue of plant discovery and acquisition continues to entice plant explorers, most often to remote and exotic places far away from the United States. Though early explorers and botanists including the Bartrams, the Michauxs, Nuttall, Torrey, Gray, and Harper described the vast richness of eastern North America's flora, the range of diversity and adaptability continues to be underappreciated to this day. In efforts to more fully document and explore its potential, we have continued to explore and promote this rich flora.

PLANT EXPLORATION WITH PURPOSE

The forests of eastern North America are replete with a remarkable array of plant communities, habitats, and plant species, particularly, Virginia, the Carolinas, Georgia, Alabama, and western Florida. We sometimes forget that the U.S.A. has some of the richest temperate flora found anywhere and far greater than the diversity found on the European continent (Table 1). Throughout the southeastern U.S.A. we have discovered that there is an enormous reserve of genetic diversity worthy of greater study and appreciation.

Table 1. Plant diversity comparisons.

Plant type	China	United States of America	Europe
Plant families	260	211	152
Pteridophytes	2,600	440	160
Gymnosperms	200	100	40
Angiosperms	28,500	19,000	10,600
Total:	31,300	19,540	10,800

Many fine species and cultivars of plants found in the prairies, forests, and marginal ecotones of the eastern U.S.A. have been introduced during the past century. Both woody and herbaceous plants are a part of the array of excellent plants available in the marketplace. Just a few include *Amsonia tabernaemontana*, *Baptisia* species and hybrids, *Chelone lyonii*, *Cornus florida*, *Ilex verticillata*, *Itea virginica*, *Physocarpus opulifolius*, *Rhus typhina*, and *Spigelia marilandica*. There are many others that have become common garden plants (Fig. 1).

Additionally, despite our fascination with plants and our thorough knowledge of the flora of the eastern U.S., new or previously under-utilized plants occasionally provide opportunities to expand the commercial availability of native plants. Just a few of these include *Acer saccharum* subsp. *floridanum* (syn. *A. barbatum*), *Acer*

Figure 1. Examples of taxa of plants found in the prairies, forests, and marginal ecotones of the eastern U.S. that have been introduced during the past century. Left image: *Itea virginica* 'Henry's Garnet'; *Physocarpus opulifolius* 'Mindia', Coppertina ™ ninebark; *Rhus typhina* 'Bailtiger', Tiger Eyes™ staghorn sumac; *Ilex verticillata* 'Winter Gold'; Right image: *Chelone lyonii* 'Hot Lips'; *Spigelia marilandica*; *Baptisia* 'Carolina Moonlight'; and *Amsonia hubrichtii.*

saccharum subsp. *leucoderme*, *Bigelowia nuttallii*, *Delphinium alabamicum*, *Rhododendron colemanii*, and *Spigelia gentianoides.*

Plant exploration remains an essential component for broadening the availability of plants in addition to large scale nursery production and selection practices. Tapping the diversity of nature offers unique opportunities for broadened adaptability of native plants for horticultural use. In addition to enriching gardens with documented, wild-collected, seed-grown plants from a range of provenances, detailed field data gathered from observing plants in natures provides us with a greater understanding of habitats, distribution, and plant associations. This information has potentially far-reaching implications for horticulture, landscape design, and conservation.

During the past 11 years, I have had the good fortune to conduct nearly 80 field expeditions in the eastern and southeastern United States in 11 states. Over 1,150 documented collections have been made, representing 619 taxa of herbaceous and woody plants. Regular collaboration with numerous partners — including other public gardens, universities, state and federal agencies, industry, conservation organizations, and private individuals — has afforded us the opportunity to observe and sample plant diversity in a wide range of habitats.

In addition to broad-based sampling of herbaceous and woody taxa, my field work in recent years has also focused on sampling specific taxa in order to obtain broader genetic diversity, obtain taxa from the edges of their ranges or from disjunct populations, and assess potential variation of selected plant species for wider landscape use. Some of the highest priority taxa for targeted sampling have included: *Aesculus parviflora*, *Amsonia ciliata* var. *tenuifolia* (Fig. 2), *Clinopodium georgianum*, *Dodecatheon meadia* (Fig. 3), *Fothergilla gardenii*, *F. major*, *Gaylussacia brachycera*, *Halesia carolina*, *H. diptera*, *H. tetraptera* (see *H. carolina*), *Hymenocallis occidentalis* (syn. *H. caroliniana*), *Illicium floridanum*, *Kalmia latifolia*, *Leucothoe axillaris*, *L. fontanesiana*, *Rhododendron arborescens* var. *georgianum*, *R. catawbiense*, *R. colemanii*, *R. minus*, *R. prunifolium*, *Silene regia*, *S. virginica*, *Stewartia*

malacodendron, *S. ovata*, *Styrax americanus*, *Trautvetteria* sp., *Vernonia angustifolia*, *Veronicastrum virginicum*, and *Viburnum acerifolium*.

Figure 2. Dwarf fringed bluestar (*Amsonia ciliata* var. *tenuifolia*).

Figure 3. Shooting-star (*Dodecatheon meadia*).

Figure 4. Florida anise-tree (*Illicium floridanum*).

Figure 5. Catawba rhododendron (*Rhododendron catawbiense*).

ON THE EDGE

Unfortunately, much of our pre-conceived bias about plant adaptability is based upon limited experiences with plants from their core ranges. Assumptions about adaptability become rules regarding how plants perform in the landscape; however, these "rules" are not always correct. In eastern North America, the range of many species is frequently broader than we know and is not fully represented in cultivation.

An excellent example includes *R. catawbiense*, a broadleaved evergreen shrub typically considered native to the high elevations of the Blue Ridge Mountains (Fig. 5); however populations of this species extend well into Alabama at elevations below 1,000 ft. *Halesia diptera* on the other hand is considered a species of the Gulf Coast region, yet, populations of this widely variable species occur well into the Piedmont of central Alabama. *Kalmia latifolia* is another species with a range that quite literally covers most of the eastern part of the U.S.A. Yet, few have grown or assessed the adaptability of populations from the hot, humid climates of the Deep South.

The flora of the eastern United States still has much to offer horticulture. The plants mentioned here are just a few of the many that deserve broader assessment and study. I hope that a broader segment of this flora will be appreciated and used by the gardening public through the efforts of industry and public gardens.

ADDITIONAL READING

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A to C: From the Adventure of Plant Exploration to Consumers©

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WHERE ARE WE NOW?

The global market for horticultural products has decreased. The shrinking horticultural market is due to the housing market contraction, over production of horticultural products (too many commodity products which were grown for the expanding housing market), and loss of consumers (especially young people) due to them not gardening. The reduction in plant sales per nursery as well as the closure of nurseries in North America is evident. We have seen several nurseries that serviced the national sales in the United States go bankrupt in the past several years.

Between 1999 and 2010, the average dollars spent per household on Do It Yourself "Lawn and Garden" fell from $532 to $355 USD. This precipitous plummet was not just a result of the recession. Even in the "boom" year of 2007, the 1999 figure dropped more than $100 to $428 per year. The fact is that today's shoppers want simplicity when they shop, emotional value when they buy, and success when they get home (Baldwin, 2011).

There are fewer students studying horticultural production and plant propagation in college. We see this in the change in membership of the Eastern Region International Plant Propagation Society — diversification of the membership with growers, production managers, propagation managers, garden center employees. This diversification is positive for the Society because, over time, we learn from others that are within the overall supply chain.

Another aspect of the global 21 century life is the rate of change. Everything is changing faster. There has been significant change in the U.S.A. nursery market in the past several years. The rate of change is speeding up. Companies and individuals that can change will be the winners in the future. The rate of change is getting faster — all of us — both professionally and personally, are feeling the pressures. Helping and supporting your staff with these changes is a key attribute of a successful company.

PLANT EXPLORATION

Many of the plants commercially sold have been found as branch sports and seedling variations. Professional breeders of woody ornamentals were few. In the past 15 years, as the globalization of woody plants has increased, more companies are focusing on professional breeding of woody trees and shrubs. This is exciting time to be participating in these endeavors. Plant characteristics such as improved flower, new colors, and disease and/or insect resistance can now be developed. The manner in which these substantial costs are paid for are to have the breeders work with the supply chain. An increase use of plant patents in the United States is occurring for woody ornamentals (Foley, 2006).

Development of a breeding program must have written goals for the outcome of the program. Have the goals written down. This will help to define and focus your

efforts. These programs cost a significant amount of money. The biggest expense is in the costs after the trip — growing out, space allocation, and time. Collecting plants in the wild sounds glamorous, but, the fact is it is very hard work.

SUPPLY CHAIN

The supply chain is the overarching view of the product (Fig. 1). The integration of the products into the supply chain is a critical step to long term sustainability. There is a balance between the two extremes of new product introduction. On one hand you have the "spaghetti model" which states "throw it on a wall, if it sticks, it is good." This is a model that several successful companies employ to introduce new products into the market. If the market accepts them, than the product must be good. On the opposite extreme is the "test to death" model. This states "we test and trial until the product is tested in for all possible uses." In the middle is the best of both worlds — test the product with predetermined time line for completion. This keeps the focus, keeps you honest with yourself, and will not clog up the overall supply chain.

There are many attributes of a product of which can be used for an evaluation of the product. Such attributes such as suitability of the product for production performance; suitability for intended use (garden, patio container, cut flower, etc.). The time to gather this information costs money. These costs should be included in the initial development of the breeding program.

Another significant cost, which must be understood as part of the budgeting process is the cost of buildup of stock (URC supply, liner supply, retail ready materials, products at retail, products with consumers, support of Retail Garden Centers to purchase the products). Trees and shrubs can take 3 to 7 years from initial build up until the first sales of the product.

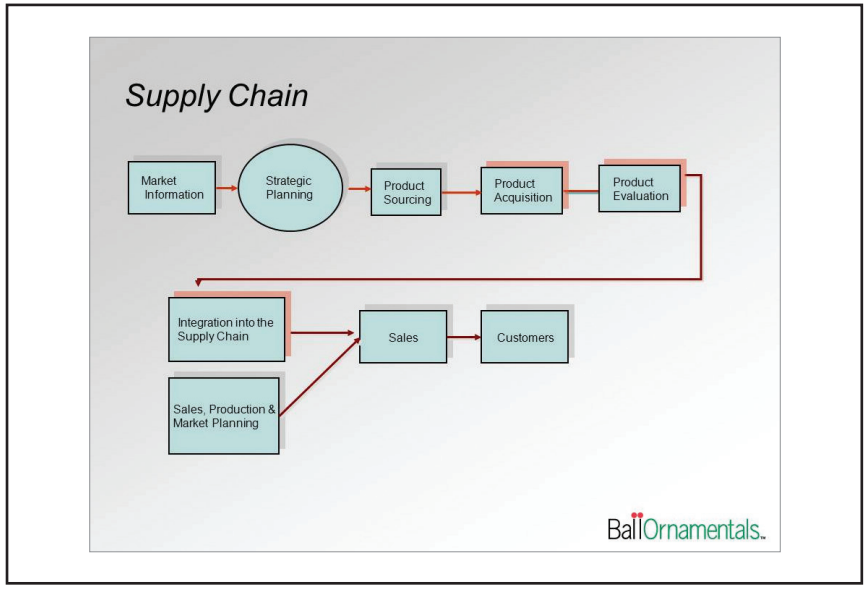

Figure 1. Supply chain flow chart.

MARKETING

Gen X and Boomers perceive gardening as a hobby, to be fun. This group of people has a high degree of pride in showing off the garden. They have a high degree of knowledge in plants and horticulture. They enjoy sharing the garden with family, friends, and neighbors. Spending time in the garden is fun; it is time to relax. The garden for Generation X and Boomers is fun to look at and enjoy.

The next generation coming into the market now is the Echo Boomers. They see gardening as a hobby. Plants are a low priority. They are interested in plants for curb appeal. The look of the home is more important than the hobby. Echo Boomers are unfamiliar with our products. They are insecure with the plants — they are accustomed to first success (think of an IPhone). They are networked people. They may or may not have children. Gardening is a function. The garden is to be lived within.

To communicate with these up and coming retail shoppers your sales activities, retail support, POP, must be focused to service them. Consumers are fickle people. The nursery industry people are fortunate that they buy any plants — they want solutions; easy, easy, easy plants; success the first time; no maintenance; color rules; flower, foliage, texture.

The "DECIDERS" — these are the people that make or break a new product — propagation management, nursery growers, sales representatives, garden center buyers, landscape architects, designers, garden writers. Each of the Deciders are your customers. Working with them to get your product into the consumers hands is critical for success.

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How *Cornus* 'KN30-8', Venus® Hybrid Dogwood Made It to Europe©

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BACKGROUND

Realistically, Dr. Elwin Orton should stand here and make this presentation to you, as all the honor goes to him.

I am really happy having been invited and would like to thank you all, especially my friend Susanne Lucas. I am here to let you know how *Cornus* 'KN30-8', Venus® hybrid dogwood made it from Rutgers University to Germany.

"The best service you can render a culture is to add a new plant to its horticulture."

The quote by Thomas Jefferson (Hatch) is exactly what Dr. Orton did.

Many of you will remember that Dr. Orton has worked successfully with many species of holly (*Ilex*) since 1960. In 1965, he also started assembling many different cultivars of three major species of large-bracted dogwood (*Cornus florida*, *C. kousa*, and *C. nuttallii*) to add another project to his program of inter- and intraspecific hybrids of woody ornamentals. The generation cycle in such plant material can be frustratingly long but by 1990 and 1991, the now well known five F1 interspecific hybrids of his Stellar® Series (*C. kousa* × *C. florida*); i.e. Aurora®, Celestial®, Constellation®, Ruth Ellen®, and Stellar Pink®, had been patented and introduced to commerce. During the same time period, Orton successfully crossed plants of *C. kousa* with plants of *C. nuttallii* and named two of the hybrids as members of Rutgers University's Jersey Star® Series of hybrid dogwood; namely, 'KN4-43', Starlight® and 'KN30-8', Venus®. 'KN4-43' is an F1 interspecific hybrid of *C. kousa* 'Simpson's No.1' × *C. nuttallii* 'Goldspot'. 'KN30-8' resulted from a backcross of [*C. kousa f. chinensis* × *C. nuttallii*] × [*C. kousa*] so, loosely speaking, is genetically $^{3}/_{4}$ *C. kousa* and $^{1}/_{4}$ *C. nuttallii* and, as would be expected, is more winter hardy than 'KN4-43'.

From that day on it was dogwoods. Dogwoods were here to stay. Nobody at that time was much aware that the *Cornus florida* f. *rubra* started to have massive problems with anthracnose and mildew, especially on the East Coast.

Dr. Orton worked with the dogwoods for 16 years. It was a long period of time but not much if you consider that Venus® hybrid dogwood is not the result of a seedling selection, as most of our flowering dogwoods are, but a true hybrid. Venus® hybrid dogwood is a cross between *C. nuttalli* and *C. kousa* var. *chinensis* and then backcrossed with *C. kousa* var. *chinensis* again; or say: East meets West (Fig. 1). There is also *C.* 'KN4-43', Starlight® hybrid dogwood pp#16,293, another one with less *C. kousa* var. *chinensis* blood. And Dr. Orton believes it is less hardy since the buds are more exposed. Starlight® hybrid dogwood flowers a good week earlier and has a more upright shape.

WOLFGANG EBERTS AND VENUS® HYBRID DOGWOOD

After 29 years of breeding and extensive testing, when Dr. Orton was satisfied with the outcome, he gave trial plants to Don Shadow, which must have been

Figure 1. *Cornus* Venus® hybrid dogwood with Dr. Orton and Wolfgang Eberts.

around 2002. In those days I was still deep in my interest of bamboo, even had a position on the Board of Directors of the American Bamboo Society, and came to a meeting in New Orleans.

If you always do what you always did you will always get what you already got: So, I went up to Tennessee to visit Don Shadow's nursery.

After letting me choose some of his wonderful arrowheads, he got me in his pickup and off we went. Several times Don would slow down, lower the window and give orders to his men working. But one time, he came to a full stop and we got out of the truck. Don showed me his new dogwood, a dogwood he had received from Rutgers. Vigorous growth, shiny leaves. Don told me it had bracts three time the size (Fig. 2) of what we normally know. Woooah! This was in August, not a single flower was to be seen. Only by listening to Don`s description, I became fascinated. Don't ask me what happened then but something within me must have made a "click." It was not in my head and it was not me, I had no control over it. I repeat: not a single flower. It is like judging the beauty of a woman when she is just getting out of bed in the morning.

You need more than just good eyes. Back home in Germany, I called Rutgers and found out they had contacts with Andre Briant, a French nursery at the time with a plant hunter traveling the globe. The good news, no contract was signed yet.

I told them that I was interested in getting the license and it worked out. I met Dr. Orton for the first time; we got along very well with each other, the people in the University office typed up a contract. We discussed it, made a few changes, looked it over again and then signed.

Then I received the first plants. I knew from the beginning that we could not do the grafting ourselves. We had found a nursery in Belgium to do it for us. At the beginning, the road was quite bumpy; I remember the first winter our plastic greenhouses were torn to pieces by a storm. Then we had quality problems and switched

to a German grower. He is near Westerstede Oldenburg; he grafts in August on *C. kousa* var. *chinensis* understock, the latter having been potted earlier in spring (Fig. 3). We receive our 2.5-inch liners 7 months later, by the end of March.

When you grow a plant, you can compare it with the bringing up of a child.

Everything should be perfect from the beginning. When you buy a new car, especially if it is a European one, you don't want to bring it back to the dealer. What do you need when you introduce a new plant? A banker as a friend, lots of endurance, passion, and good contacts to the press and to television.

Figure 2. Close-up of flower of Venus® hybrid dogwood.

Figure 3. Production of Venus® hybrid dogwood.

In the meantime we had plants growing to a good size. We went to a plant fair in the Netherlands and got our first gold medal. You can imagine Dutch nurserymen coming up to us and showing their interest. We soon found out they were mainly after getting a sublicense from us, which of course we denied. The news of the gold medal quickly spread amongst professionals in all of Europe.

We needed partners in the various European countries to grow our Venus® hybrid dogwood, that took us a while but now it works well.

A good instrument to prevent cheating is our numbered color tags. When a contract nursery gets our 2-L starter plants, the tags go with the shipment and we take a note of the numbers. While the plants are cultivated , in 7.5-L containers mostly, the tags don't need to be on.

When Venus® hybrid dogwood is shipped to garden centers (the final destination) they need the tag. The tag also indicates the planting instructions. No matter where we see a plant, with the number on the tag we can backtrack its origin. In July we were in the north of Scotland, very windy place, in fact the color tags had blown off but the white string remained.

We have no restrictions when it comes to markets. Vannucci, Pistoia (Italy) our best customer, can sell his plants to the U.K., to France, etc. In fact most of Vannuci's plants come back to Germany.

When we knew that we would participate at the Chelsea Flower Show, we worked hard on luring Dr. Orton and his wife, Portia, over for a visit. It was a hard job but we finally succeeded. Several weeks prior to the show two men came to choose which plants would be on display. In mid May 2010, Dr. Orton and his wife came. Elwin was thrilled to see his baby having grown into a beautiful teenager. All four of us flew to London.

The Chelsea Flower Show, no doubt, is the finest plant show on Earth. Again we were awarded a gold medal. Getting a gold medal at Chelsea is like getting the gold medal at the Olympic Games. Back in Baden-Baden, Dr. Orton confessed that this was a true highlight, some of the best moments he has had in his life. At home we had organized another event with press people, the mayor, city council, etc.

Sales started to increase, also due to the spread of the news on the internet and various articles appearing in magazines and newspapers.

The plant is one of the best novelties we have seen in years. You can introduce a new *Hibiscus*; a *Rhus typhina* 'Bailtiger', 'Tiger Eyes'® staghorn sumac PP#16185; a new red *Magnolia* from New Zealand; the *Echinacea* Tomato Soup PP #19,427; but Venus® hybrid dogwood beats them all. Talking "tomato soup," a good brand name is very helpful when you introduce a new plant. Thank you, Elwin, well done!

Venus, the Greek Goddess, or one of the brightest planets in the sky, is also called the morning star or the evening star. We call her the "Diva."

I was asked to give some figures. What I can say is we paid more than $20,000 to U.S.A. lawyers and therefore agree with Shakespeare who in his play King George VI said: "Let's kill all the lawyers." The cost with CPVO (Community Plant Variety Office) in Angers, France, was considerable, too. So far, we have paid $84,000 in royalty to Rutgers. That includes both Venus® hybrid dogwood and Starlight® hybrid dogwood.

SUCCESS WITH THE PUBLIC

We had professional and other garden magazines write about Venus® hybrid dogwood, we helped with pictures and text. When you have a real sensational product the media will jump on it.

This spring we have taken several platforms, places where a lot of plant interested people come to, just to make Venus® hybrid dogwood known. Quite an effort and you do not always see an immediate result, more likely it is an investment in the future. One such event was EUROPA-PARK, sort of a Disneyworld. We had 150 6-ft high plants there. Venus® hybrid dogwood, the Diva, was also presented at PalmenGarten in Frankfort, at Wilhelma in Stuttgart, and on Mainau Island in the Lake Constance (Konstanz). Most of the time, Venus® hybrid dogwood was there for official openings and with good press coverage. If you think that this big mouth German is bragging, go ahead and Google, find out yourself. Südwestrundfunk (SWR) TV station announced in their breaking evening news "Baden-Baden has snow in May" showing the pictures of fully blooming Venus® hybrid dogwoods.

German National Garden Exhibit 2011 Koblenz, was our highlight this spring. It was overwhelming to see how Venus® hybrid dogwood conquered the hearts of the visitors.

On two weekends Wibke and I answered questions of thousands of visitors. The frequently asked questions were:

- Is it winter hardy? Yes.
- When does it flower? Mid-May!
- For how long will it flower? 2 to 3 weeks.
- Does it get diseases? No, it does not.
- How high will it grow? 20 to 30 ft.
- Can you prune it? Yes, you can — and you can even put branches in a vase when you cut these at the right moment.
- What soil does it require? A well drained and slightly acid soil.
- Do you plant it in the sun or shade? Sun or part shade is good, not under a tree.
- Can Venus® hybrid dogwood stay in a pot on the terrace? Yes, it can, at least for a couple of years.

Besides having to answer the same questions all day long, we handed out 8,000 postcards to a great public. One of the nicest compliments we received comments like, "just getting to know this wonderful new plant — seeing was worth the trip to Koblenz." Koblenz will close this weekend and instead of reaching 2 million as projected, 3.3 million visitors came.

Talking compliments: a lady from Luzerne Switzerland called: Their VENUS blooming in front of the house, no fence between the road and the front door. A man rang the doorbell at 6.30 on a Sunday morning; the husband got up and went to the front door. The person bowed and asked the owner for the name of the plant. In order to avoid such disturbance in the future the lady wanted to know if they could transplant it to the backside of the house. I agreed, however suggested she just leave it where it is and put a big sign up: *Cornus* Venus® hybrid dogwood.

We found out that a branch cut at the right moment and put in a vase will hold 2 weeks. If a few high-class florists will appreciate the value of Venus® hybrid dogwood there will be an extra market for it. Venus® hybrid dogwoods can also be of interest for "Rent a Plant" gardeners.

We had Venus® hybrid dogwood at a prominent spot in town, when they were gradually fading we exchanged them unnoticed and put plants we had kept in the cool storage. That made a flowering period of 6 weeks instead of 3 weeks.

Making publicity for such a unique plant when it is flowering is so easy. Plant lovers cannot hold back their fascination. If we would be in New York City we would

put 30 full flowering 6-ft high plants at the beginning of High Line Park and again 30 at the end of it. Can you imagine what impact that would provoke? Wibke would stand on the one side, give away postcards and answer questions and I would do the same on the other end. Of course we would not charge, we would do it for free. Who doubts that we would get permission?

Cornus Venus® hybrid dogwood has good chance with the mail-order business, also.

I say to my people: If we can't grow a plant better, in a more sustainable manner, then why grow it at all? The big challenge is the setting of flowering buds at an early stage. We haven't quite discovered that trick but we are getting better. You have to be friends with Venus® hybrid dogwood and you will find it very cooperative.

So now, I tell Elwin, you have to work on a red one! What I hear then is: don't you worry. Considering the time it took him to bring out Venus® hybrid dogwood Dr. Orton will be close to 100 years of age. If Portia watches and prevents her husband from climbing up (and falling off) the garage roof, there is good chance we will get there.

Dr. Orton is realistic and has handed his research over to Dr. Tom Molnar. The latter and our company Eberts Baumschule will be together with my son Frederic.

***Cornus* Venus® hybrid dogwood Features.**

Description:	*Cornus* Venus® hybrid dogwood is an improved dogwood hybrid with superb resistance to anthracnose and powdery mildew. Venus® hybrid dogwood explodes in early spring with large, 6-in. pure-white blooms with green centers. This Rutgers introduction has clean foliage and a fast-growing, full, low-branching habit. *Cornus* Venus® is part *C. kousa* × *C. nuttalli* (the Pacific dogwood) and part *C. kousa*. Plant this cold-hardy creation as a specimen in good well-drained soil. Grows 25 ft H × 25 ft W in full or part-sun.
Hardiness Zones:	6 to 8
Sun/Shade Preference:	Partial
Soil Condition Preference:	Moderate
Special Attributes:	Disease resistant, fall foliage color, frost tolerant
Plant Height:	20–35 ft
Bloom Time:	Early spring
Flower Color:	White
Foliage Color:	Dark green
Fall Color:	Orange
Plant Uses:	Specimen, Urban Park, Border
Awards Won:	2007 Pennsylvania Horticultural Society Gold Medal, U.S.A. 2007 Plantarium, Netherlands 2008 IPM Essen, Germany 2009 Grower of the Year Award, Most Success New Plant, U.K. 2010 Royal Horticultural Society, Chelsea Show Gold Medal, U.K.

LITERATURE CITED

Peter Hatch, Director of Gardens and Grounds, Monticello. <www.pbs.org/jefferson/archives/interviews/Hatch.htm>

In the Company of Plantsmen©

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INTRODUCTION

In a recent talk in Raleigh, North Carolina, Tony Avent of Plant Delights Nursery described those of us, who are obsessed with plants and gardens, as being a little "odd." George Mitchell of Woodlanders Nursery in Aiken, South Carolina told me, at the same symposium, about the story of the nurseryman who had died, and met St. Peter at the Pearly Gates. They had a cordial chat and St. Peter finally asks the new arrival what he'd done for a living. He said he had spent his career as a nurseryman. St. Peter says, "Oh my God, you've lived your life in Hell."

George Mitchell's business partner, Bob McCartney, tells the interesting story about how *Amsonia hubrichtii* came into the trade. "… a teenage Ken Wurdack, who now works at the Smithsonian, was doing a lot of research on rare plants and travelling all over the South following up on old records, herbarium collections, etc. in the early 1980s. He shared a lot of material with us including *A. hubrichtii* that he had collected in Arkansas. Woodlanders first offered it, I think, in 1982." It took nearly 30 years before *A. hubrichtii* was awarded the Perennial Plant Association's 2011 Plant of the Year

So, we are odd and have demanding careers but I doubt too many of us would trade our careers for another. Another friend succinctly described heaven and hell, "Heaven is where you go for the weather. Hell is where you go for the company." I have kept wonderful company for a long time. Rather than being so odd and indifferent, the many men and women I have known in the plant world have shared their time, wisdom, and plants. They don't seem so odd at all — at least not to me. My life has been enriched enormously by their generosity. They embody the IPPS motto: To Seek and to Share.

HERE ARE A FEW STORIES…

But, by all means, don't pass-up a trip to Hell if you get the chance. I'm speaking of Hell, Michigan. I'd first recommend you see the nearby bog for some extraordinary botanizing with Bob and Brigitta Stewart of Arrowhead Alpines. They can point out skunk cabbages and terrestrial orchids and will remind you to look out for rattlesnakes sunning on dry hummocks. But after mucking around for a couple of hours in the bog, on a hot August day, you'll want to cool off with a cold beer at the Dam Site Inn in Hell, Michigan.

Most of my life has been spent living in Louisville, Kentucky, or in the mountains of North Carolina near Fletcher, North Carolina. You'd need to travel to southwest China to find an area as rich as what's represented in the southeastern U.S.A. mixed mesophytic hardwood forests.

Wes Cowan was a college roommate at the University of Kentucky who, following graduation, made a remarkable archaeological discovery in the Red River Gorge. It was first presumed those seeds found in Kentucky had been domesticated, selected over millennia for improved performance, by indigenous people. But according to

research published in the Journal of Ethnobiology by C. Wesley Cowan and Bruce D. Smith (1993), these were wild seed and represented one of the most eastern U.S.A. locations of *Cucurbita pepo* var. *ozarkana*. Carbon dating tests confirmed that the Kentucky discovery of the Red River Gorge material was 4,500 years old. (The trail diverges here: More recent mitochondrial DNA studies suggest the possibility that var. *ozarkana,* may have been the progenitor for subsp. *ovifera*. And subsp. *ovifera*, according to mitochondrial DNA, could have given rise to the pumpkin. It's all a guessing game of haplotypes. In all likelihood, there were two probably distinct genetic lines.)

Well, alright. The pumpkin probably took shape in Mexico, and not Kentucky. But at least we had a historic role, as small as it may be, along a long trail of pepos. And Kentucky can lay claim to being the Lord of Gourds. And the important discovery of prehistoric seeds of Kentucky's native gourd predated the domestication of gourds by 2,500 years. Kentucky was at the center of early plant domestication. And another interesting bit of archaeological lore placed Kentucky in the top world centers of center of that early plant domestication Mesoamerica was renowned for corn. Kentucky became famous for lambs quarters, (*Chenopodium* species) not quite the big deal as corn.

During the time Wes and I lived together in Jessamine County, Kentucky, in the early to mid 1970s. We were taught how to garden by Elsie Lowery, a tobacco farmer, who patiently helped us with our first vegetable garden. What we learned from this experience was that I liked gardening — a lot! (And Wes Cowan found a new niche, a few years ago, on Public Television's The History Detectives.)

It was a few years before I met Clarence "Buddy" Hubbuch at Bernheim in 1978. By this time the intrigue of vegetables had given way to wildflowers and ornamentals. And Buddy was the local go-to expert who pursued his love of trees and shrubs with devotion and a renowned lack of ego. He seldom traveled to visit nurseries or gardens much beyond a day's drive from Clermont, Kentucky (across the road from the Jim Beam Distillery). But Buddy never had a dull day; he could entertain himself and never feel the need to wander far afield.

By the late 1970s I knew that plants, somehow, would be my life's work. I was fortunate to be able to spend a year in England at the Royal Botanic Gardens at Kew and would be from — that point — forever spoiled. I've kept in touch with a few from that year in 1978-79, but none is more fascinating than Tony Hall. Hall has retired — sort of. He was for nearly 30 years the Manager of Kew's Alpine Unit, caring for the alpine plants and bulbs and overseeing the Alpine House and Woodland Garden. Hall, renowned for his knowledge of Iris, is the leading authority on Juno Iris and working toward a botanic monograph. Kew continues to provide facilities for Hall's Juno Project.

Tony buzzed me in late May 2010. He was eager to get moving. A special package had just arrived: four bulbs and nearly fifty seeds of the very rare *Iris stocksii*.

Juan Piek, a South African, working for Security Forces in Afghanistan, found the juno iris in Kajaki, Helmand Province, and told Hall that he would put the collection in the mail. A month went by and Tony worried that it had gotten lost, but, fortunately, Piek had waited until he was safely home before posting the rare species. Piek was, according to Hall, "…a lover of plants, especially proteas…not especially junos."

In a battled scarred desert landscape, Piek ran the risk of landmines and avoided the crosshairs of feuding warlords and resurgent local terrorist networks. At stake in Helmand is the rich opium crop; 40% of the world's production comes from the Province, an area described by *The New York Times* as: "…Afghanistan's most dangerous land."

There may soon be a land rush there, too, since an internal Pentagon memo recently suggested Afghanistan might become the "Saudi Arabia of lithium." (Lithium is used to power laptops.) General Petraeus, Commander of U.S. Central Command (and just recently promoted), cited this vast reserve and other rich mineral deposits for its "stunning potential."

Not quite lost in this land grab has been Piek's prize, *I. stocksii*, whose vital DNA is being mapped at Kew. The "stunning potential" of this species will soon power-up the fertile imaginations of a few talented botanists, molecular scientists, and horticulturists, and, worldwide, there are a handful of us who can't wait to see what happens. We may have to wait awhile.

Tony Hall will try to try to mimic conditions indigenous to the dry, stony slopes of central and southern Afghanistan and neighboring Baluchistan, around Quetta, in western Pakistan — an elevation range between 1,150–2,700 m (3,773–8,858 ft). He'll grow the Iris in special glass frames for many years to come, trying to coax them into bloom. In nature, *I. stocksii* endures cold, dry winters and emerges with spring snowmelt, or the first rains, between March and April. After producing seeds, the plants soon go dormant again, surviving the intense summer heat (45 °C /113 °F) and prolonged dry period with the aid of fleshy roots and bulbs.

The connectedness of so many is my reward for showing-up year after year at the annual meetings of wonderful groups like the IPPS. But, now at age 60, I am looking for a new generation. When I joined the Eastern Region in 1983, there were names in propagation like Flemer, Cross, Fordham, Shugert, and Mezitt. They seemed so old and I, now, realize I am that old. I look around, now, and see young plants people — the next "odd" generation — and I like what I see. Kelly Norris goes plant hunting in South Dakota in 2011 and finds 13 different forms of *Monarda fistulosa*. Jared Barnes continues his ascent in the doctoral program at North Carolina State University. And Hillary Nichols who has worked at the Atlanta Botanical Gardens is now working at Tony Avent's Juniper Level Botanic Gardens. These young folks ask a lot of questions and I always remember: To Seek and to Share.

Portions of this paper were previously published on the Human Flower Project's blog.

Appeal of the Aberrant©

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Discovering or creating a new form is fabulous. Successfully propagating it is immensely satisfying. Getting the public interested is sometimes the more difficult key to success.

While there is a growing percentage of savvy gardeners hooked on looking for unusual plant selections, there are lots who have no inkling. How to hook them?

One avenue is to make gardening unintimidating. At conferences I often listen to talks by garden designers or landscape architects who trot out lofty principles or rules, striking fear into listeners that they might do something tacky.

A few "rules" we should help to expunge:

- Never put a plant in the ground until you have a plan laid out on paper.
- Never buy a plant unless you know where it will go in your plan.
- Use plants with variegated or golden foliage minimally and with discretion.
- Plant in drifts, or at least in groups of threes or fives.

While there is a fine line between tacky and whimsical, playing with this line removes some of the fear factor that discourages the novice gardener, or even the experienced but "proper" gardener.

Turn the tables. Before the proper gardener can scorn the adventurous, poke (good hearted) fun at the proper gardener. Again, a fine line, because certain principles of design are found in any art form. When I teach landscape design, I make analogies to music. It is good to recognize a line of melody (a sort of structural unity) but too simplistic and repetitive is boring. Too much improvisation is irritating and disconcerting (jazz that gets so far from the original theme that nothing resembling it remains). Having some strong line and a few geometric structural elements will allow them to improvise to their heart's content and still look "landscaped".

Good ideas to promote experimentation:

- "Recycled" or inexpensive garden art (bicycles, old furniture, unusual use of paint, etc).
- "New plant" forums at varying events, both industry level and consumer level.
- Teach some master gardener classes, and influence will spread from them.

After all, it should be apparent that experimenting with new plants is much more fun!

"Without deviation from the norm, no progress is possible." Frank Zappa, 1940–1993. American musician, composer, satirist.

New Plant Forum©

Compiled and Moderated by Jack Alexander
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Cercis canadensis 'Vanilla Twist' ppaf
Pinus strobus 'Stowe Pillar'

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Agastache aurantiaca 'Tango'
Agastache cana 'Bolero'
Eritrichium canum 'Baby Blues'
Trollius ×*cultorum* 'New Moon'

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Bouteloua gracilis 'Blonde Ambition', blonde ambition blue grama
Tradescantia roseolens 'Morning Grace' morning grace piedmont roseling
Viola walteri 'Silver Gem', silver gem prostrate blue violet

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Hydrangea quercifolia 'Ruby Slippers'
Hydrangea quercifolia 'Munchkin'
Camellia japonica 'Anacostia'
Loropetalum chinense 'Snow Panda'
Styrax japonicus 'Spring Showers'

Agastache aurantiaca 'Tango'

Agastache species have been a recent target for breeders who have developed interesting seed strains and cultivars. The hummingbird mints, bred principally from species native to southwestern U.S.A. and northern Mexico, have attractive features that appeal to growers and home gardeners.

'Tango' will add more fuel to the fire. Funnel-shaped blooms of fiery orange, on dense terminal spikes to 35 cm (14 in.) tall, stand out in a crowd. But don't forget the other fine selling points. 'Tango' has attractive, aromatic-scented, grey-green foliage

that blends magnificently with the orange blossoms. And growers will also appreciate the more compact habit and the short time — as little as 12 weeks — it takes to produce finished pots of this first year flowering seed strain. Hardy in Zone 5–10.

'Tango' is a magnet for hummingbirds and butterflies from June through October in full sun and well drained soils. Honeybees love it, too. Lovely perennial companions include *Callirhoe involucrata*, *Eriogonum allenii* 'Little Rascal', and *Lavandula angustifolia* 'Hidcote Superior'.

The name *Agastache* is derived from Greek and refers to the many flowering spikes. *Agan* means: much and *stachys* means ear of grain or spike. There are over 20 *Agastache* species, principally from Western U.S.A. and northern Mexico. But there are, also, a few species from the Eastern U.S.A. and Asia.

***Agastache cana* 'Bolero'**

The mosquito hyssop, *Agastache cana*, was the modest starting point for this breeding project. It didn't stop there. (It could have if we'd been badly bitten by mosquitoes...)

Add a couple of other southwestern U.S.A. species, spend years evaluating seedlings — throwing out many more than are kept — for further trials — and wait to see what the stork brings — or doesn't. Breeding efforts don't always end-up where the guiding hand wants to take it. But this new seed strain is impressive.

Agastache 'Bolero' has a compact habit, grows to height and spread of 40 cm (16 in.), and is covered with rose-purple tubular blooms with purple calyxes above mounds of aromatic dark colored foliage. Ninety-nine percent of the slug-resistant plants have bronze-colored leaves — considerably darker than lesser strains.

'Bolero' is reliably first year flowering, tolerant of dry conditions, hardy in Zones 5–10, and magnificently suited for container production or dry gardens. This combines beautifully with *Delosperma cooperi*, *Kniphofia hirsuta* 'Fire Dance', and *Penstemon* 'Sunburst Ruby'. 'Bolero' attracts hummingbirds, butterflies, and honeybees during its flowering period from June through October.

***Bouteloua gracilis* 'Blonde Ambition', blonde ambition blue grama**

Where low maintenance meets garden whimsy, 'Blonde Ambition' is sure to turn heads. Airy, chartreuse flowers float horizontally amidst blue-green foliage from mid-summer into fall. Seed heads extend the season providing unique winter appeal. Extremely cold hardy and adaptable to various soil types, use in sweeps for a dramatic effect. Unlike any other ornamental grass in cultivation, discovered and introduced by David Salman of High Country Gardens.

***Cercis canadensis* 'Vanilla Twist' ppaf**

A new selection of weeping redbud with white flowers developed by Brotzman's Nursery, Madison, Ohio, by combining the weeping characteristic of *C. canadensis* 'Covey' (Lavender Twist® redbud) with the white flowers of *C. canadensis* 'Royal White'.

This is an F2 selection of (*C. canadensis* 'Covey' × *C. canadensis* Royal White) × (*C. canadensis* 'Covey' × *C. canadensis* 'Royal White'). The initial F1 reciprocal crosses were done about 1999 in a caged environment using natural insect pollinators. Seed was collected from both *C. canadensis* 'Covey' and 'Royal White', kept separated from each other and in time approximately 20 siblings from each parent were planted close together, keeping the two groups at a distance from each other. None of the F1 plants in either group exhibited white flowers or weeping habit, all being lavender colored and upright in habit.

Seed from open pollination within each group were sown from which nearly 900 seedlings resulted; these were outplanted together for evaluation. Approximately 175 weeping plants were produced of which approximately 17 bore white flowers. In 2008 three of each of these were budded and planted out for evaluation in 2010. Along with their respective mother plants, these were compared for growth rate, flower color and size, habit, and vigor. In 2011 'Vanilla Twist' was selected and first commercial propagation was made.

Other than having white flowers, 'Vanilla Twist' appears to be very similar to its weeping parent, 'Covey', in growth rate and leaf characteristics. However, there is suggestion that the weeping characteristic may be a little bit more "broad shouldered," and it appears lateral branch development might result in branches arching upward in an antler-like manner. Covey does not exhibit this trait.

Plant Patent protection has been sought and contracts for licensed propagation will be authorized.

***Eritrichium canum* 'Baby Blues'**

The heavenly blue flowers on 'Baby Blues' took us by surprise and won our hearts. We've fallen in love with this lovely scree plant. This short-lived perennial (best grown as an annual) will become a valuable substitute for the powdery mildew–plagued *Myosotis* species, forget me nots. 'Baby Blues' flowers more abundantly than the wild species and has dozens of intense blue corollas with throats of soft heavenly blue on evenly compact stems to 25 cm (10 in.) tall.

'Baby Blues' is a relative of the luscious *E. nanum*, a native of the European Alps. This highly desirable species was described by Will Ingwersen as "…one of the most supremely beautiful of all alpine plants…" And, as experienced growers will also admit, it is very difficult to grow in cultivation. *Eritrichium nanum* shouldn't be confused with 'Baby Blues', which can be easily grown, even as an annual, in full sun in climates with cooler summers and in soils that are gritty and well drained. One of the parents, *E. canum* var. *canum* originates on hillsides of grit, gravel, or sandy riverbanks. 'Baby Blues' is a fast germinator and can be brought to flower in 3 to 4 months.

Eritrichium is a name of Greek origin — *erion* translating to wool; tricha to hair. The leaves on many of the species are soft and fuzzy.

***Hydrangea quercifolia* 'Ruby Slippers'** (USDA Zones 5–8)

This oakleaf hydrangea resulted from a cross between 'Snow Queen' and 'Pee Wee' and was selected for its large flower panicles that emerge white but turn pink and then deepen to a rose color. It is a small rounded shrub that reaches a size of 3.5 ft high and 5 ft wide after 7 years of growth. An excellent choice in the shrub border, deciduous hedge, or mass planted in larger areas. Released in 2010, 'Ruby Slippers' can be propagated by softwood cuttings under mist with 4,000 ppm IBA. Expected retail availability in 2012. For more information on these and other cultivars, visit our website at <http://www.usna.usda.gov/Newintro/index.html>.

***Hydrangea quercifolia* 'Munchkin'** (USDA Zones 5–8)

As the name implies, this oakleaf hydrangea is smaller than the species, making it ideally suited for use in small residential landscapes. It reaches a size of 3 ft tall by 4.5 ft wide in 9 years of growth. It originated from an open-pollinated population from 'Skies Dwarf'. The abundant flower clusters are held upright above the foliage open white and gradually turn medium pink. It was released in 2010 with expected

retail availability in 2012. For more information on these and other cultivars, visit our website at <http://www.usna.usda.gov/Newintro/index.html>.

***Camellia japonica* 'Anacostia'** (USDA Zones 7–9, possibly into Zone 6b)
Selected for its abundant, large, semi-double medium-pink flowers and dark glossy evergreen foliage, this hybrid was created in the 1960s from a cross between a white-flowered selection of *C. japonica* and *C. japonica* 'Z' (a cultivar with reportedly increased cold tolerance). It reaches 12 ft high and 7 ft wide in 30 years, making it suitable as a specimen plant, hedge, or mass planted in larger areas. It has survived several harsh winters at the National Arboretum. 'Anacostia' can be propagated from semi-hardwood cuttings taken mid- to late summer, or by grafting. Released in 2010, it has limited availability. For more information on these and other cultivars, visit our website at <http://www.usna.usda.gov/Newintro/index.html>.

***Loropetalum chinense* 'Snow Panda'** (USDA Zones 7–9)
'Snow Panda' originated from seeds collected near Yan Chi He, Hubei, China in 1994. The seedlings were grown out at the National Arboretum and this plant was selected for further evaluation in 2006. It reaches 10 ft high by 8 ft wide in 15 years, with an evergreen, loosely vase-shaped habit. The leathery foliage is medium green, and flowers are creamy white with 5–8 flowers in a cluster. 'Snow Panda' is suitable as a sheared evergreen hedge, foundation plant, container, plant, or espalier. Softwood or semi-hardwood cuttings dipped in 1,000–3,000 ppm IBA will root readily under mist in 4–6 weeks. Released in 2011, it has limited retail availability. For more information on these and other cultivars, visit our website at <http://www.usna.usda.gov/Newintro/index.html>.

***Pinus strobus* 'Stowe Pillar'**
A very narrow selection of white pine found in Vermont by Greg Williams of Kate Brook Nursery and named by Bob Fincham. Original tree was approximately 33 ft tall × 10 ft wide. This is narrower than the two other common commercial selections, *P. strobus* 'Fastigiata' ('Columnaris') and 'Bennett's Fastigiate'. In addition, 'Stowe Pillar 'has a slower growth rate and denser form than either of these.

Greg told me that there were a total of three narrow pines at this location and he shared scions from two of them with me. My labeled selection "Williams' #2" is what has been called 'Stowe Pillar'. "Williams' #1" is also a very fine plant, superior to 'Fastigiata' and similar to 'Bennett's Fastigiate'. It remains unnamed at his time.

On the plants I have propagated by grafting, both 'Stowe Pillar' and Williams' #1 exhibit a characteristic I have never seen before. These are goiter-like swellings that occur on the trunk and branches at the branch unions. Cutting into them reveals a hard woody structure, not pithy or hollow. It does not appear to be caused by insects or any exterior influence.

***Styrax japonicus* 'Spring Showers'** (USDA Zones 5–8)
Selected and evaluated by the Arboretum's breeding program in McMinnville, Tennessee, this plant has a delayed bud break that allows it to be successfully grown in areas frequently subject to late spring freezes. It reaches a height of 12 ft and a width of 8 ft after 10 years. It is a small tree with a tight conical habit that leafs out 2–3 weeks later than most cultivars. Softwood cuttings root in 4 weeks under mist with 3,000 ppm IBA. Released in 2011, it has limited retail availability. For more

information on these and other cultivars, visit our website at <http://www.usna.usda.gov/Newintro/index.html>.

***Tradescantia roseolens* 'Morning Grace'**, Morning grace piedmont roseling
A beautiful cultivar that comes to us from Michael Jenkins. 'Morning Grace' has a dainty garden stature reaching just under 1 ft in height. Thin, strappy foliage remains a clean, medium green throughout the growing season. A very long bloom period, the triangular, light pink flowers have attractive gold stamens and rest just above the foliage. Flowers are very attractive to pollinating insects.

***Trollius* ×*cultorum* 'New Moon'**
Trollius ×*cultorum* 'New Moon' has a long and distinguished history. We received seed from the nurseryman Coen Jansen of the Netherlands who had been working with the legendary 'Alabaster' that originally came from the famous Georg Arends Nursery in Wuppertal, Germany. Arends, going back as far as the 1930s, had been the source of many outstanding perennial introductions including *Astilbe*, *Primula*, and *Saxifraga* taxa. *Sedum* 'Herbstfreude' ('Autumn Joy'), one of the most popular perennials of all times, originated at the Arends Nursery.

Although 'Alabaster' has an extraordinarily beautiful creamy-yellow blossom, it has not been a strong grower and has been a challenge to propagate vegetatively. Still, the majestic blooms proved irresistible to anyone who saw it. Jelitto experimented with plants grown from Jansen's seed with the desired goal of producing a seed strain with bigger blooms and more vigor. 'New Moon' is a Jelitto seed strain success!

Few wildflowers in native habitats are as endearing as globe flowers when discovered — sometimes in abundance — in the cool, moist meadows of Europe, Asia, and North America. We are certain that growers and home gardeners will find 'New Moon' just as beautiful.

'New Moon' is hardy in Zones 3–7 and looks wonderful in a cool, humus-rich garden combined with *Deschampsia cespitosa* 'Pixie Fountain', *Viola sororia* 'Dark Freckles', and *Alchemilla sericata* 'Gold Strike'.

***Viola walteri* 'Silver Gem', silver gem prostrate blue violet**
From the gardens of Mt. Cuba Center, North Creek, is delighted to introduce this tough native groundcover. This selection is easily identified by trailing stems and delicate lavender flowers, 'Silver Gem' forms a dense, tidy mat of attractive silver foliage. Flowers appear in March and persist into autumn. Our plant trials have proven 'Silver Gem' to be exceptionally drought tolerant and happiest in part to full shade.

How to Improve Cuttings Propagation Using Water-Based Indole-3-Butyric Acid Rooting Solutions©

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INTRODUCTION

The present studies were done to guide growers on successful cutting propagation from cuttings using water-based indole-3-butyric acid (IBA) rooting solutions. The following four studies: (1) the time of foliar treatment after sticking, (2) the effect of alcohol or wetting agents in the solution, (3) the effect of cold temperature at time of treatment, and (4) the use of basal long-soak method on cuttings which are seasonably difficult to root. The present studies used two foliar and one basal method to apply aqueous IBA rooting solutions. Foliar application is only done to leafy cuttings taken during the growing season.

HORMONE APPLICATION METHODS

Spray Drip Down (SDD) Method. In this method:

- Cuttings are inserted into the propagation medium.
- Cuttings are hydrated and misted as required.
- Misters are turned off.
- The aqueous IBA rooting solution is sprayed onto the leaves until the liquid drips down with solution on both the top and bottom of the cuttings.
- Misting is resumed after the solution dries on the leaves or after about 45 min and misting is done as required.

Total Immerse (TI) Method. In this method:

- Leafy cuttings are totally immersed in the aqueous IBA rooting solution for about 5 sec.
- The cuttings are drained and kept hydrated until sticking.
- Cuttings are inserted into the propagation medium.
- Misting is done as required.

Basal Long-Soak (BLS) Method. In this method:

- Aqueous IBA rooting solutions are made and put into a tray with hormone solution about an inch deep.
- The basal ends of cuttings are immersed in the solution for 12–24 h.
- Cuttings are inserted into the propagation medium.
- Misting is done as required.

Questions to Be Answered

Timing of Foliar Application. The first study addresses treatment of cuttings soon after sticking with cuttings treated 0 (at sticking) 3, 5, or 7 days after sticking. When using the SDD method growers usually stick during the same day. After the production staff leaves the propagation area one person does the treatment. The question asked is what happens if the cuttings are not treated the same day?

Alcohol and Wetting Agents in the Rooting Solution. The second study addresses the inclusion of alcohol or wetting agent in the hormone solution. Two questions are addressed: (1) What happens to the cuttings, using the SDD method, if the IBA rooting solution is made with alcohol and does the alcohol cause toxicity? (2) What happens to the cuttings, using the SDD method, if the aqueous IBA solution includes a wetting agent and does the cutting better absorb the solution?

Temperature at Time of Sticking. The third study addresses treatment of cuttings at cold (45 °F) compared to warm (78 °F) temperatures. The question asked is what happens when propagation, using the SDD method, is done in a cold versus warm propagation area?

Foliar Versus Basal Long-Soak Application with Difficult-to-Root Cuttings. The fourth study addresses treatment of cuttings with an aqueous IBA solution (at a moderate concentration) using TI method compared to a low concentration BLS-treatment method. The question asked is can cuttings be successfully rooted at a time of the year when they are normally considered difficult to root? Can cuttings which are difficult to root by other methods be better treated?

RESEARCH STUDIES

Trial 1. This study compares foliar treatment of cuttings at time of sticking (Day 1) with a one-time treatment at either 3, 5, or 7 days after sticking.

Foliar applied aqueous IBA rooting solutions are used to propagate annual, perennial, and woody leafy cuttings during the growing season. Growers often stick cuttings and foliar treat in sequence. Scheduling may require treatment done at a later time. The current study compared untreated (control) cuttings with treated cuttings using a single aqueous IBA rooting solution treatment at time of sticking (Day 1), versus Day 3, Day 5, or Day 7 after sticking.

Plant Material and Dates. Plant cuttings: *Begonia ludicra* "red wing"; leafy cuttings from actively growing plants; dates: 21 July–21 Aug. 2010 (duration 31 days).

Hormone Treatment. The aqueous IBA rooting solution used Hortus IBA Water Soluble Salts (Hortus USA. Source: Hummert International, 800-325-3055) dissolved in water to make a rooting solution at 100 ppm IBA.

Procedure.

- All cuttings were inserted into the propagation medium at the same time to eliminate sticking time solely being responsible for treatment effect.
- Foliar-treated cuttings had aqueous IBA rooting solutions applied by the SDD method.

Treatments included the following: untreated control cuttings, Day 0 (at time cuttings are inserted into the propagation medium), Day 3, Day 5, and Day 7.

Comparative Trials. Dr. Fred Davies performed plant physiology studies on *Ficus pumila* that included foliar application of aqueous IBA rooting solutions at time of sticking and a few days later. Studies included the plant physiology. Dr. Davies' results, as shown on the attached chart, are consistent with the present study. (Davies, 1978; Davies and Joiner, 1980; Davies et al., 1982; Davies, 1984).

Observations. In this study, and prior studies, foliar applied aqueous IBA rooting solutions were useful for the propagation of leafy cuttings during the growing season. Results from the aqueous IBA foliar treatment applied at time of sticking or later days is shown in Tables 1 and 2.

- In this study all foliar-treated cuttings had the highest number of roots and greater root mass compared with untreated control cuttings.
- Cuttings foliar treated near the time of sticking produced better rooting compared with untreated control cuttings.
- Rooting was diminished for cuttings foliar treated on the 3rd day after sticking but slightly increased on cuttings foliar treated on the 5th or 7th day.

Table 1. Foliar-applied IBA rooting solutions used to propagate plants from cuttings as affected by treating once at time of sticking, at 3, 5, or 7 days after sticking (duration 31 days).

Group treatment	Roots/cutting (avg. no.)	Root quality	Leaf observation	Results
		Untreated cuttings		
Untreated control	18.9	Good	New leaf shoots	Lower number of roots formed compared to all foliar treated cuttings
		Time of foliar treating cuttings		
At time of sticking	27.2 *	Good	New leaf shoots	Highest number of roots and root mass
Day 3 after sticking	20.7 *	Thin	Original leaf loss. No leaf shoots.	Lowest number of roots and root mass
Day 5 after sticking	22.0 *	Thin	Original leaf loss. No leaf shoots.	Lower number of roots and lower root mass compared with cuttings foliar treated at time of sticking. Higher number of roots and greater root mass
Day 7 after sticking	22.1 *	Thin	Original leaf loss. No leaf shoots.	compared with day 3 foliar treated cuttings.

*Treated cutting groups had higher number of roots and greater root mass compared with un-treated control cuttings.

Table 2. Foliar-applied IBA rooting solutions used to propagate plants from cuttings as affected by treating once at time of sticking and at several days after sticking. Comparison of present *Begonia ludicra* trial with *Ficus pumila* (Davies and Joiner, 1980).

	Begonia ludicra (present study) at 100 ppm IBA		*Ficus pumila* (Davies and Joiner) Juvenile at 1000 ppm IBA		Mature at 3000 ppm IBA		
Day Foliar Treated	Roots/cutting (avg. no.) (Day 31)	Root quality (Day 31)	Roots/cutting (avg. no.)	Root quality**	Day foliar treated	Roots/ cutting (avg. no.)	Root quality**
Untreated cuttings							
Untreated control	18.9	Good	0.8	Poor	Untreated control	1.5	Poor
Time of foliar treating cuttings							
At sticking	27.2	Good	11.9	Good	At sticking	13.3	Good
Day 3 after sticking	20.7	Poor	9.5	Good	Day 3 after sticking	13.1	Good
Day 5 after sticking	22.0	Poor	11	Good	Day 9 after sticking	8.6	Good
Day 7 after sticking	22.1	Poor	10.3	Good	Day 15 after sticking*	2.7	Poor

*Root quality note: "Application at Day 15 was beyond the "optimum application window," and there was a deterioration of percentage rooting, root numbers, root length and root quality." (Davies person. correspon.).

**Notation: "Root quality" was standardized between the two studies.

Trial 2. The current study compared untreated control cuttings with foliar-treated cuttings using aqueous IBA rooting solution (IBA dissolved in water only), aqueous IBA rooting solution (IBA dissolved in water only) with a wetting agent added, or IBA rooting solution with 20% isopropyl alcohol content.

Plant Material and Dates. *Ficus benjamina.* Leafy cuttings from the growing season. Dates: 9 Feb–3 March 2011 (duration: 22 days).

Procedure.

- All cuttings were inserted into the propagation medium.
- Foliar-treated cuttings had IBA rooting solutions applied by the SDD method as per group. (One-time foliar treated by the SDD method.)
- All cuttings had leaves water rinsed at 1½ h after treatment; this was done to assure there was no residual effect of the rooting solution remaining on the leaves.
- Trial groups:
  - Untreated control cuttings.
  - Rooting solution at 300 ppm IBA. Aqueous IBA rooting solution with wetting agent (Gordon's spreader sticker at ½ tsp per 5 gal).
  - IBA rooting solution with 20% isopropyl alcohol content (rooting solution at 300 ppm IBA dissolved in water was used to make a rooting solution and adjusted to 20% isopropyl alcohol).

Results. Results from IBA foliar treatment applied with and without wetting agent or alcohol (Table 3, Fig. 1)

In this study cuttings foliar treated with aqueous IBA rooting solutions with wetting agent had similar root formation compared with cuttings treated without the wetting agent.

In this study cuttings foliar treated with IBA rooting solution containing 20% alcohol had high death compared will all other trials. The small percent of rooted cuttings had low root numbers and mass.

Likely alcohol dehydrated the plant cells, thereby causing cutting death.

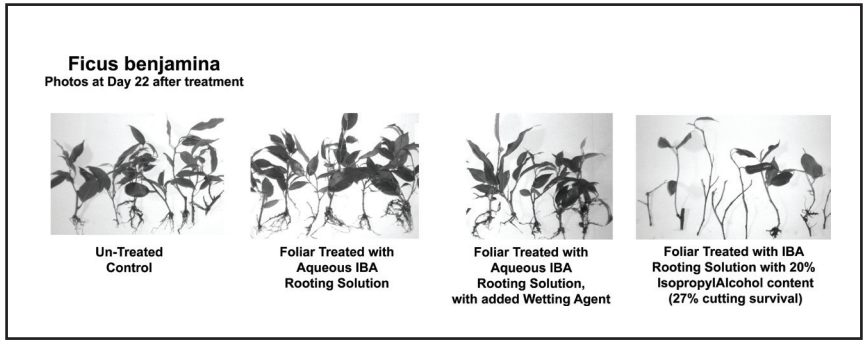

Figure 1. Effect of water wetting agent and alcohol on root initiation.

Table 3. Foliar applied IBA rooting solutions used to propagate plants from cuttings as affected by using an aqueous solution (water as solute only), an aqueous solution with wetting agent, or solution with 20% alcohol content (duration 22 days).

Treatment	Rooting (%)	Roots/ cutting (avg. no.)	Roots on rooted cuttings (avg. no.)	Root quality	Leaf observation	Results
			Untreated cuttings			
Untreated control	100	7.6	7.6	Good	New leaf shoots	Lower number of roots formed compared to water and water with wetting agent foliar treated cutting
			Foliar treated cuttings			
Aqueous IBA rooting solution (water only)	100	9.4	9.4	Good	New leaf shoots	Highest number of roots and greater root mass
Aqueous IBA rooting solution with wetting agent	100	8.9	8.9	Good	New leaf shoots	Similar to an aqueous IBA rooting solution (water only)
IBA Rooting solution with 20% alcohol content	27	0.5	2.0	Thin	Most leaves lost and cutting fatality	Lowest number of roots and lower root mass

Trial 3. This study compares foliar treatment of cuttings at 78 °F (nominal "room temperature") with treatment at 45 °F ("cold temperature"). Cuttings are sometimes put into cold storage before sticking or may be propagated in cold winter houses and greenhouses. Cuttings shipped from off-shore plantations are also refrigerated in transit. The current study compared untreated control cuttings kept at nominal room temperature (78 °F) with cuttings kept and foliar treated at (78 °F) or at 45 °F.

Plant Material and Dates. Plant material: *Impatiens* New Guinea Group (unnamed cultivar), leafy cuttings in the growing season; dates: 27 April–16 May 2011 (duration: 20 days).

Procedure. The aqueous IBA rooting solution used Hortus IBA Water Soluble Salts dissolved in water to make a rooting solution at 100 ppm IBA.

- All cuttings were put into cold storage at 45 °F for 24 h. This was done to ensure cold temperature at time of treatment was the solely limiting factor.

- All cuttings were inserted into the propagation medium.
- After 24 h cuttings lots used as untreated control cuttings and those to be foliar treated at 78 °F were brought up to 78 °F.
- Foliar-treated cuttings had one-time aqueous IBA rooting solutions applied by the SDD method.
- Trial groups:
  - Untreated control cuttings (cuttings kept at 78 °F).
  - Cuttings foliar treated at 78 °F had solutions applied at 78 °F.
  - Cuttings foliar treated at 45 °F had solutions applied at 45 °F. Cuttings were kept at 45 °F for an additional 1½ h, and then brought to 78 °F.
  - At approximately 1½ h after treatment all lots had leaves water rinsed at 78 °F. This was done to assure there was no residual effect of the solution remaining on the leaves.

Results. Aqueous IBA foliar treatment applied at warm or cold temperatures (Table 4) (Fig. 2).

In the warm temperature at time of treatment study (cuttings foliar treated at 78 °F) had the highest number of roots and root mass when compared with untreated cuttings. They had much higher survival rates compared with cuttings treated at 45 °F.

In the cold temperature at time of treatment study, cuttings had substantial death. Surviving cuttings had low root formation compared with untreated and 78 °F-treated cuttings.

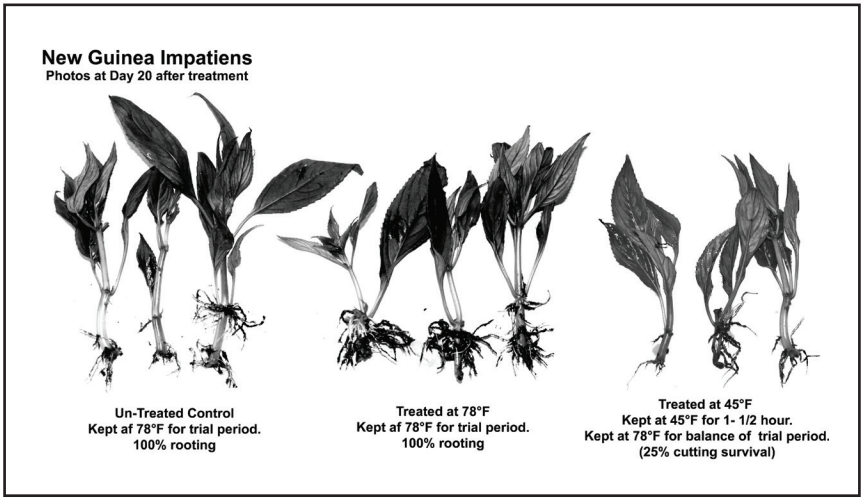

Figure 2. Effects of aqueous IBA foliar treatment applied at warm or cold temperatures on *Impatiens* New Guinea Group (unnamed cultivar).

Table 4. Foliar applied IBA rooting solutions used to propagate plants from cuttings as affected by treating at 78 °F or 45 °F (Day 20).

Treatment	Rooting (%)	Roots/ cutting (avg. no.)	Roots on rooted cuttings (avg. no.)	Root quality	Leaf observation	Results
Untreated cuttings						
Untreated control	100	12.5	12.5	Good	New leaf shoots	Lower number of roots formed compared to 78 °F treatments.
Foliar treated cuttings						
Treat at 78 °F	100	24.1	24.1	Good	New leaf shoots	Highest number of roots and greater root mass
Treat at 45 °F	25	2.4	10.6	Poor	Most leaves lost or cutting fatality	Lowest number of roots and lower root mass

Trial 4. This study compares springtime propagation of *Buxus sinica* (a difficult time to root) by the BLS method with the foliar TI method.

Successful cutting propagation often requires overcoming seasonal variation in rooting. This trial compared the TI and BLS methods on the rooting of cuttings. The current study used cuttings of *B. sinca* from the prior season growth taken in May.

Plant Material and Dates. Plant material: *B. sinica* 'Nana' leafy cuttings from the previous season growth, taken in North Carolina in May 2011. Dates: 20 May–22 July 2011 (duration: 63 days).

Procedure. The aqueous IBA rooting solution used Hortus IBA Water Soluble Salts dissolved in water to make a rooting solution at stated rates.

Trial Groups.

- Untreated control cuttings inserted in propagation medium.
- The TI method:
  - Cuttings immersed in the rooting solution (500 ppm IBA) for 5 sec.
  - Cuttings inserted in propagation medium after treatment.
- The BLS method:
  - Immerse cutting basal end 1 in. in the rooting solution (100 ppm IBA) for 24 h.
  - Cuttings inserted in propagation medium after treatment.

Results. This study compares springtime propagation by the BLS method with the foliar TI method (Table 5) (Fig. 3). On the basal-long-soak cuttings root formation started after 5 weeks. Up till about 7 weeks, all lots had no leaf loss. At 7 weeks root formation started on the TI treatment and control cuttings. After 7 weeks some leaves on the rooted cuttings started to decay possibly from high humidity. Unable to selectively reduce humidity, the cuttings were pulled on the 8th week.

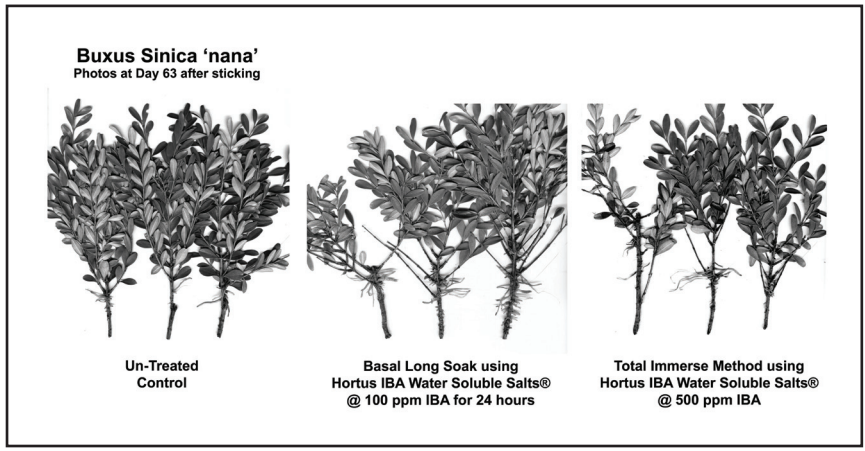

Figure 3. Propagation results of *Buxus sinica* 'Nana' cuttings comparing foliar application by the total immerse method with basal application by the basal-long-soak method

RECOMMENDATIONS

For Foliar Application.

- Apply aqueous IBA rooting solutions to propagate leafy cuttings during the growing season.
- Apply aqueous IBA rooting solutions to cuttings close to the time of sticking in the propagation medium because cuttings treated several days after sticking have reduced adventitious root formation.
- There is no benefit to adding a wetting agent to aqueous IBA foliar applied rooting solutions.
- Do not use alcohol in IBA rooting solutions. It contributes to cutting death.
- Do foliar apply aqueous IBA rooting solutions at nominal room temperatures (such as 78 °F).
- Do not foliar apply aqueous IBA rooting solutions to treat cuttings at a cold temperature (such as 45 °F).

For Hard-to-Root Cuttings. Woody plant cuttings from the prior year growth, taken in early spring may be difficult to root. Also many other types of plants there may be seasonal variations in the ability to form roots, even when applying rooting hormones.

- Do use the BLS method as an effective way to stimulate root formation on hard-to-root cutting even at non-ideal rooting times.

Table 5. Propagation results of cuttings of *Buxus sinica* 'Nana' taken in early May from prior year growth using aqueous IBA rooting solution treatments. Trials comparing foliar application by the total immerse method with basal application by the basal-long-soak method for 24 h (Day 63).

Treatment	Rooting (%)	Roots on rooted cuttings (avg. no.)	Root quality	Results
		Untreated cuttings		
Untreated control	40	4.0	Fair	Lowest number of roots on rooted cuttings. Lowest number of cutting rooted. No significant difference compared to foliar treated cuttings
		Foliar treated cuttings		
Aqueous IBA rooting solution using Total Immerse Method	80	5.25	Fair	Second highest number of roots on rooted cuttings. Same number of cutting rooted compared to Basal Long Soak Method No significant difference compared to un-treated control cuttings
		Basal treated cuttings		
Aqueous IBA rooting solution using Basal Long Soak Method for 24 h	80	14.9	Good	Highest number of roots. Same number of cutting rooted compared to Total Immerse Method.

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Cold-Hardy, Non-invasive Bamboo via Tissue Culture Propagation©

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INTRODUCTION

This poster outlines the basic steps of producing cold-hardy non-invasive bamboo via tissue culture propagation. Exact protocols are not included, as this poster is introductory in nature in effort to simplify the process for interested parties. Lab preparation and tissue culture propagation of the BambooSelect® line is conducted via an exclusive propagation license with North American Plants, LLC located in Lafayette, Oregon.

Tissue-culture propagation of bamboos leads to very uniform, vigorous, and robust liners. The protocols ensure the plants are disease-free and true-to-type propagation. Crop time is greatly reduced compared to traditional vegetative division or from seed. Micropropagation (in-vitro tissue culture) of cold-hardy non-invasive bamboo via axillary branch cuttings is the best method for mass production of uniform, vigorous clones with unique landscape potential as an evergreen grass as an elegant specimen, privacy screen, or hedge.

STEPS IN THE PROCESS

Step One. This shows a photograph of the mother plant field trials (Fig. 1-1). The BambooSelect line produced in the United States results from selection of elite clones from field trials conducted in Belgium by Jan Oprins of Oprins Plant NV during the 1990s. (Some of these came from seed, others from various importations from China.) The plant line in the U.S.A. is exclusively from the genus *Fargesia*. Selection of superior clones is an important accomplishment of BambooSelect, as several genotypes of the various species have been introduced with no known origin.

Step Two. This shows a photograph of a branch with multiple branch compliments (Fig. 1-2) of *F. rufa* 'Oprins Selection', Green Panda™ hedge bamboo. Propagation begins with cuttings selected from axillary buds. This is also a very important aspect of the process, as somatic embryogenesis is another option but leads to genetic diversity in the resulting crop. The advantage of clonal material (via axillary buds) is that the crop is uniform and predictable, sharing the same characteristics as the superior mother plant (clonal fidelity as well as true-to-type propagation).

Step Three. Here we show a photograph of the young cuttings in sterile media in jars in the environmentally controlled growth chamber (Fig. 1-3). This is the stage (typically called Stage 2) where a myriad of conditions are controlled for reliable, reproducible results. Temperature, light intensity, hours of light, media recipes, transplant days, etc. are all vital aspects of protocols that lead to success in multiplication and subsequent rooting (credit goes to Johan Gielis and Jan Oprins for their team research at the University of Gent, Belgium).

Figure 1. Cold hardy, non-invasive bamboo via tissue culture propagation.

Step Four. This shows a photograph of the rooted plug (Fig. 1-4). The protocols of successful rooting also depend on specific cultural conditions, some aspects of which vary from species to species. Some are rooted while still in-vitro, others are rooted directly in the peat-mixed media.

This crucial step is essential to potting success, as the liners are ready to expand into larger soil volumes and display the incredible vigor of juvenile plants. Especially so since they have been growing for approximately 4–5 months in jars with everything they need for maximum health. By the very nature of the in-vitro process, the bamboo plug liners are disease-free and genetically identical to the parent plant. The resulting potted plant develops uniformly and vigorously, greatly reducing crop time compared to traditional vegetative division or from seed.

Step Five. This step shows a photograph of the finished product, a uniform crop of vigorous dense clumps of dark green foliage in nice proportion to the pot size (Fig. 1-5). Short dense clumps have the benefit over taller, fewer stemmed plants by having reduced risk in shipping.

Pot size can be variable depending on the end-user; larger containers up to 15 gal (or up to 40 L) can be produced for landscape clients, whereas smaller containers ranging from 1- to 3-gal pot sizes (5 to 10 L) are more desirable for garden centers and box stores. Obviously larger plants have a longer crop time and demand a larger price tag; smaller plants can be finished relatively quickly (within a year) and fall into a more comfortable price range for the average homeowner (and still be profitable for the grower). Step Five also shows the inclusion of the finished product bearing the BambooSelect label, which is colorful and informative for both the employee at the point-of-purchase, and for the shopper needing cultural information. The marketing partnership is a very important one, and the team behind BambooSelect strives to connect the growers, buyers, sellers, and homeowners with everything to ensure success in growing these non-invasive clumping bamboos.

Step Six. This shows a photograph of a sample residential front entrance-way displaying a beautiful *F. robusta* 'Pingwu', Green Screen™ hardy blue bamboo in an appropriate landscape setting (Fig. 1-6). Simply as a specimen plant, these bamboos are a step above hardy grasses — they are evergreen and shade tolerate. As a hedge, they have a unique and attractive texture, moving with the slightest breeze. They create a green, lush privacy screen. Unlike the ubiquitous arborvitae, yew, or hemlock hedge, these bamboos are not a favorite food of deer or prone to insect infestation. Once established, they are drought-tolerant and do not require pruning or chemical applications. Heavy snows may weigh down snow-laden stems, but bamboos bend rather than break. We are confident the demand for these plants will only grow as architects and homeowners see the advantage of this evergreen grass as a specimen, as a screening plant, or as the "not your average" hedge.

Utilizing Large Nursery Containers for Herbaceous Root Production©

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INTRODUCTION

Propagating and growing plants in containers, in this case herbaceous perennials for the purpose of producing rootstock or root mass divisions, can be a straight forward and effective low-tech method of propagation. This presentation describes the process used to produce several types of perennials for landscape use.

METHOD AND MATERIALS

It has been said, the simplest idea is often the best. With that in mind, I sought to devise a method for producing herbaceous root stocks of various perennial plants. The goal would be to minimize stress to stock plants, and to have minimal steps in the production process.

At the 45th annual meeting of the Eastern Region, Mr. Peter Del Tredici presented a paper on the propagation of hardy, woody plants from root cuttings (see additional readings). At that time, I was aware of using this propagation method for trees and shrubs. I learned a great deal more on this subject from Peter's presentation and subsequent paper published in the Combined Proceedings of the International Plant Propagators' Society (Del Tredici, 1995).

I have over the years employed root-cutting propagation in various containers to produce both woody and herbaceous plant materials. Herbaceous plants are readily adaptable to container growing, not only in a production situation, but also in ornamental situations as well (Kolaczewski, 1995).

One of the problems with leaving plants in the same container for any length of time is that eventually the root(s) will bottom out and also become tangled and malformed in the container. I have for many years used Anderson Die and Manufacturing® band pots, and the deep propagation flat to grow root cuttings of perennials, as well as seedlings and simple plant divisions.

I looked at expanding this method to employ a larger container, whereby I could have an alternative method to growing plants in the ground. Obviously, living in a temperate climate, USDA Zone 5 means we have winter conditions that limit one's ability to work outdoors for months at a time. Winter conditions can, and do, cause soil to freeze to considerable depth, limiting harvesting of roots, to either before or after the winter months.

I decided to use a much larger container, such as shrub or tree pots to grow perennials in, thereby enabling me to have the ability to grow plants in several ways. I could either employ a pot-in-pot method, or grow containerized plants outdoors in three seasons, and place them in a poly-house environment, for the winter season. I could overwinter them in a moderated climate where the plants would be dormant, but not frozen, facilitating fall through winter propagation.

When harvesting roots, for either cuttings or simply to divide the root stock into manageable pieces, removing the plants from the pots is straight forward. The damage to the plant is minimal, the plant is dislodged from the pot, shaking the media free is not complicated. I employ a pine bark, rice hull, and peat compost mix as the nucleus for growing the majority of my plants. There can be other components or less or more of one item or another, depending on what it is I am growing.

The first plants I chose to use with this container method were *Rheum palmatum* var. *tanguticum*, Chinese or Tibetan rhubarb, and *Acanthus mollis*, and *A. spinosus*, bear's breeches. *Rheum* taxa grow to be impressive specimens, this particular plant has a deep red color in the leaf veins, which adds to its ornamental value. They are also a garden substitute for *Gunnera*, which is not hardy here in USDA Zone 5 conditions of Chicago, Illinois. *Acanthus* offers both foliage and floral display as elements to the garden setting. Both of these plants can produce extensive root systems, which make them good candidates for this trial.

I decided to trial two containers for growing these plants. I chose Anderson Die and Manufacturing Nursery cans, The Polycan #6, which is 12-3/4 in. wide, and 11-1/4 in. deep. I also used the Polycan #4 deep pot, which is 10-1/2 in. wide, and 12 in. deep. One plant of each type was planted into each respective size container. These containers would allow for more or less, normal root development. I wanted to compare a somewhat narrower container versus a squat container. The object being to allow for roots to "fill out" a pot if you will, and diminish the chances of roots spiraling and being malformed. The plants were shifted from standard 1-gal nursery containers, into the larger containers in the spring of the year. Fertilizer was incorporated into the mix prior to planting, at a rate of 3 lbs to a yard^3 of mix. Supplemental liquid feeding was applied when needed, about five times during the first season of this trial. No fungicide was applied to the containers; insecticide was only applied if monitoring showed evidence of activity. Slug activity was minimal.

Plants were not disturbed throughout the first growing season. In about mid-September, the plants were dislodged from the containers to inspect their growing progress. The *Rheum* had produced a number roots that were over 8 in. in length, and about a 1/4 to a 1/2 in. in diameter, and about twice as many that were slightly smaller than the largest ones. The *Acanthus* produced about a half a dozen roots that were about a 1/2 in. in diameter. At this junction, the plants were repotted, removing only roots that potentially could interfere with others in close proximity.

These plants were left outside until the end of October, and then were put into a polyhouse for the winter. In early March, the *Acanthus* was dislodged and about half of the roots were removed for propagating cuttings. These were potted into 1-gal containers and left in the polyhouse until mid April. No cuttings or division of the *Rheum* took place at this time.

Once danger of frost had passed, all plants were returned to outdoor growing conditions, and the growing regime from the previous season was repeated. During the second fall season plants were not dislodged from their containers, and put into winter quarters, once they started going into dormancy. During March of the second season, the plants were all removed from the containers. About 2 dozen cuttings were taken from the *Acanthus*, and 14 root sections were taken from the *Rheum*. The remaining rootstock was then potted into a more appropriate size container.

CONCLUSIONS

Obviously, growing perennials in containers has been the norm for some time. This method reduces if not eliminates damage done to the rootstock by digging larger plants out of the ground. Overwintering plants in protected facilities can start or extend production methods that are not tied to weather conditions associated with outdoor production methods. There was no appreciable difference in growth between the different size containers. Costs can be controlled with potting media that can be recycled, and the longevity of better quality growing containers. Several more plants will be added to the program, with the intention of producing additional propagation materials. The accompanying photos show some of the methods and materials contained in this presentation. I hope you have found this information useful; it has been my pleasure to share my horticulture experiences with you.

ADDITIONAL READINGS

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Rooting Success of Summer Softwood Cuttings of Box Huckleberry (*Gaylussacia brachycera*)©

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INTRODUCTION

The box huckleberry (*Gaylussacia brachycera* (Michx.) Gray) is a slow-growing, dwarf evergreen woody groundcover that is native to both the mountains and coastal plains of Pennsylvania, Virginia, Kentucky, Tennessee, West Virginia, Delaware, and Maryland (USDA, NRCS, 2002), and North Carolina (Wilbur, 2004). It has glossy, dark green, fine-textured foliage. New growth may have a deep red to maroon coloration as may older foliage under conditions of high light intensity or stress. Box huckleberry suffers from no known serious disease or insect pests. The box huckleberry's global conservation status is listed as G3 (NatureServe Explorer, 2001), and the state listing for Delaware, Maryland, and Pennsylvania is S1 (critically imperiled). In Maryland, there is only one plantlet left of the known wild population. In Delaware, only three wild populations have been found. In the seven states in which it is native, there are less than 20 known populations of this species.

Gaylussacia brachycera has potentially high ornamental value as a woody, evergreen groundcover. Large-scale, commercial propagation of the box huckleberry could result in the introduction of a valuable new native landscape plant that grows well in dry shade. A limited number of plants are currently sold by a small number of specialized nurseries. Propagation and evaluation of plants from wild collections offers the opportunity to extend the range of use and ease of production of this plant. Identification of best production methodologies could increase the plant's potential as a nursery crop.

Under permit, plants of box huckleberry have been collected from 14 native habitats in six states. Most of these plants have been established in a protected site at the National Arboretum. We hope to use these plants to achieve the following objectives.

OBJECTIVES

- Examine the effect that cutting month has on the rooting and subsequent growth of box huckleberry.
- Examine differences in rooting and subsequent growth in containers between selected clones.
- Subsequently determine optimum production methods so that this species may be evaluated by commercial nurseries as a slow-growing, native, evergreen landscape plant.

METHODS

Established plants are growing at the U.S. National Arboretum under wooden lath in beds containing Fafard Nursery Mix seeded with a small amount of soil and organic matter taken from the same general area where the Maryland plants were

growing. This was done based on the hypothesis that *G. brachycera* may have a mycorrhizal association in the wild. At the time of establishment, compost was incorporated and plants were mulched with a layer of shredded leaves collected from the arboretum's woods.

Cuttings were taken from selected clones each month starting in May 2011. The newest growth was targeted for cuttings each month. Each cutting was approximately 7 cm long and included 10 to 14 leaves. The lowest 4 to 5 leaves were removed and cuttings were dipped in Hormodin 3 (8,000 ppm IBA-talc) and placed in flats containing 1 milled spaghnum : 1 coarse perlite (by volume). Flats were placed on a mist bench in a greenhouse with 50% solar shade at temperatures between 75 °F and 80 °F. After 6 weeks, cuttings were evaluated by counting and measuring roots that had formed. After 9 to 10 weeks, previously unrooted cuttings were evaluated for rooting,and rooted cuttings were transplanted to 1-L pots containing 1 screened Fafard Nursery Mix : 1 coarse sand (by volume). After 14 to 18 weeks, previously unrooted cuttings were evaluated for rooting.

PRELIMINARY RESULTS

In May – August 2011 (Fig. 1), softwood cuttings were a successful method to propagate box huckleberry. Six weeks after cuttings were taken each month, clonal rooting percentages ranged from 0% to 100% and averaged 64%. Nine weeks after cuttings were taken, an average of 74% had rooted. Eighteen weeks after cuttings were taken, 96% had rooted.

In July 2011, the wrong hormone (Hormodin 2 at 3,000 ppm IBA-talc) was mistakenly used, which makes interpretation of rooting results for that month difficult.

Although softwood cuttings were largely successful, the largest differences in rooting success for early summer cuttings were between clones. The West Virginia and Tennessee clones averaged 95% and 91% rooting, respectively, after 6 weeks for May, June, and August cuttings. The first Kentucky clone (KY1) averaged 55% rooting after 6 weeks and the second clone (KY2) averaged 71% rooting after 6 weeks. The Maryland clone averaged 8% rooting after 6 weeks. Although the vast majority of all cuttings rooted after 18 weeks, some did so in half the time of others. This may have implications for production costs associated with mist bench space.

These results are preliminary as they represent about one-quarter of the data to be taken during this experiment. When complete, this experiment will provide information about how to best propagation practices for box huckleberry.

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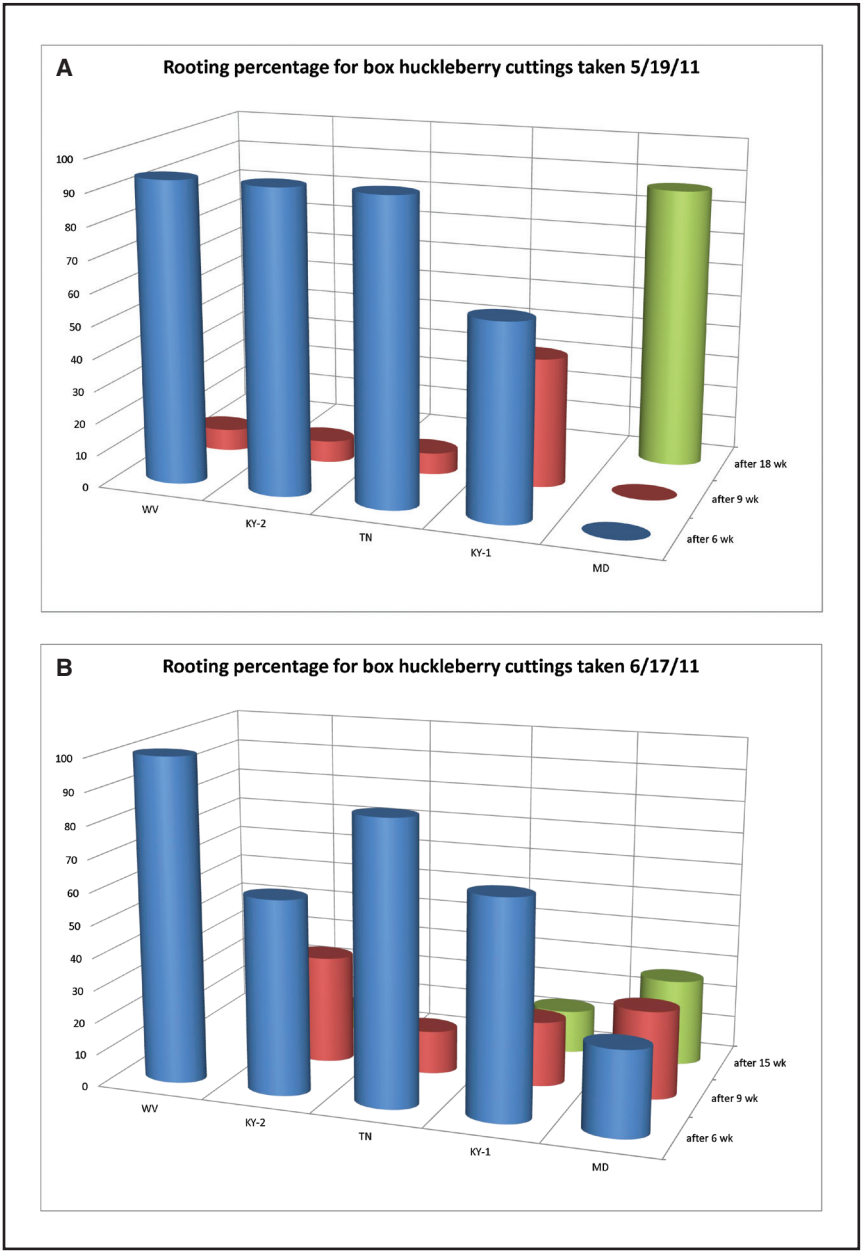

Figure 1 A and B. Rooting percentages for box huckleberry cuttings taken during four months in 2011. *The wrong rooting hormone (Hormodin 2) was mistakenly used for the 15 July 2011 cutting date; therefore results cannot be compared with other cutting dates.

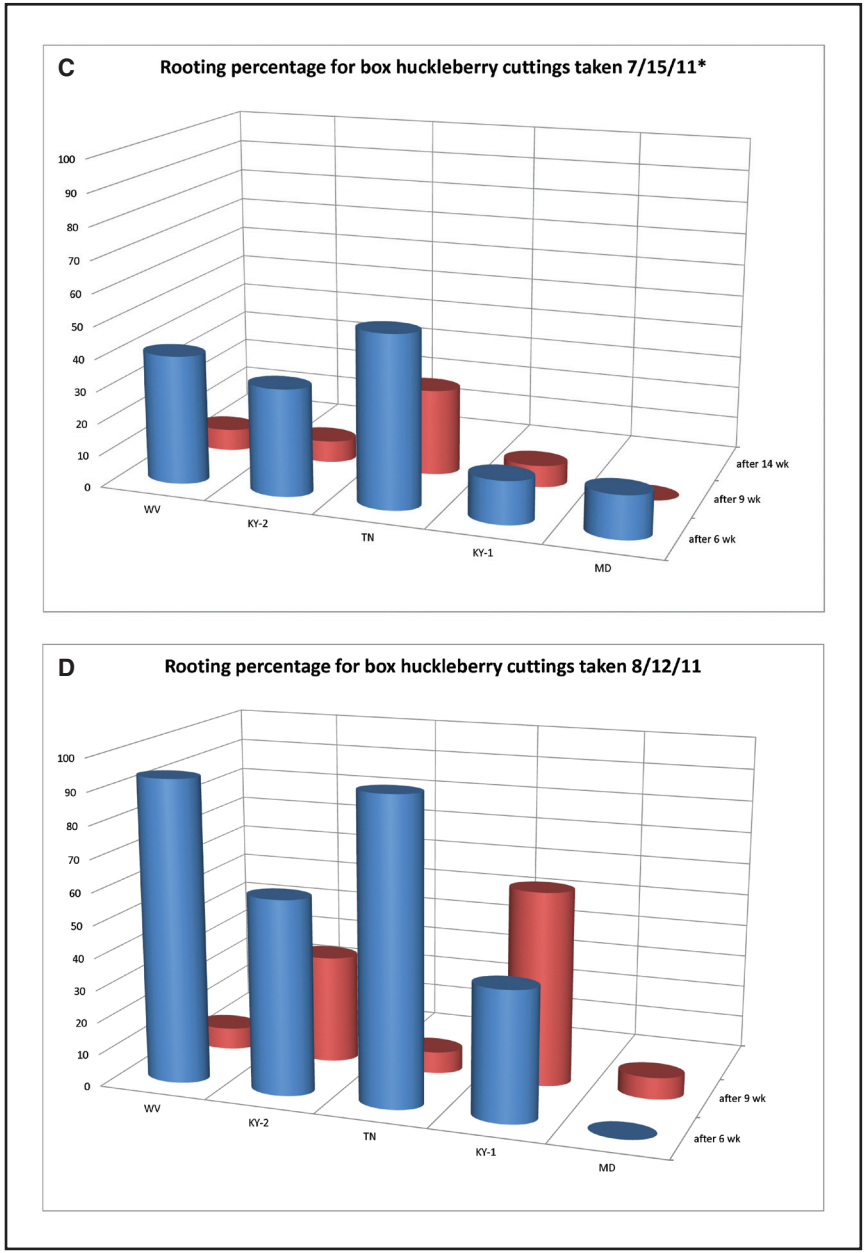

Figure 1 C and D. Rooting percentages for box huckleberry cuttings taken during four months in 2011. *The wrong rooting hormone (Hormodin 2) was mistakenly used for the 15 July 2011 cutting date; therefore results cannot be compared with other cutting dates.

TECHNICAL SESSIONS©

MONDAY MORNING, 24 OCTOBER, 2011

The 36th Annual Meeting of the International Plant Propagators' Society-Southern Region of North America convened at 7:45 AM at the Rainwater Conference Center, Valdosta, Georgia, with President Donna Fare presiding.

PRESIDENT DONNA FARE

President Fare welcomed everyone to Valdosta, Georgia, for the 36th Annual Meeting of the International Plant Propagators' Society-Southern Region of North America. She thanked Local Site Committee Chair, Stewart Chandler, and Co-chairs Kay Phelps and Fred May, and their committee for the long hours in arranging the excellent tours, hotel, and other planning activities and all their attention to detail. Dr. Fare thanked the Executive Committee and Tom Saunder's Sponsorship Committee, which raised $27,850 in cash sponsorships, which was outstanding with the challenging economic times. She encouraged all members to make new members and attendees feel welcome — share with them and seek from them. She asked for all first-time attendees, new members, and students to stand and be recognized. She then asked attendees to stand and be recognized who have been here 5 years, then 10 years, than 20 years, 30 years, 35 years — and who were original members of the IPPS-SRNA. She acknowledged and congratulated Charles Parkerson, Bill Barr, and Dick Marshall as IPPS members for 36 years. Fare also thanked Program Chair and 1st Vice-President, Bob Black, for the excellent program and slate of speakers he assembled. She mentioned that on Wednesday at the annual business meeting, we will be voting on changes in the proposed international bylaws, which was previously emailed to all members, and hard copies are available at the registration desk.

LOCAL SITE CHAIR STEWART CHANDLER

Local Site Chair, Stewart Chandler welcomed everyone to Valdosta. He then recognized the Co-chairs, Kay Phelps and Fred May, and his committee members for all of their efforts. Chandler remarked that this was a 6-year planning process for the site and tours. He commented on the nursery tours and having access to the new Rainwater Conference Center, which is a wonderful facility with adjacent hotels.

PROGRAM CHAIR BOB BLACK

Program Chair Bob Black welcomed all members, guests, and students. He thanked the membership for the opportunity to serve them, and then reviewed the scheduled program, including the silent and live auction, new comers' reception, and banquet. The Question Box scheduled for Tuesday evening was to be tri-chaired by Dr. Cheryl Boyer, Dr. Christine Coker, and Jeff Howell. He thanked Scott Langlois for his work setting up the audiovisual. He thanked Dr. Gary Knox for his leadership and dedication in setting up the auction. He then introduced the first moderator, Dr. Cheryl Boyer.

New Ideas on Growing and Handling Container Trees©

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INTRODUCTION

Worthington Farms uses fabric containers to grow trees. These fabric containers air-prune roots and keep root temperatures cool in the summer. Worthington Farms is located in eastern North Carolina (USDA Plant Hardiness 7b). Windy conditions, high summer temperatures, and hurricane preparedness are primary issues that affect container tree growing. While pot-in-pot production is utilized by the company, the rising costs of plastic for socket pots, drainage pipe, and the labor to install the system is beginning to make the system less cost effective given the stagnant price of trees. Fanntum™ containers offer an option to pot-in-pot production where plants need marginal winter protection <http://www.fanntum.com/>.

FANNTUM™ CONTAINERS

The Fanntum container consists of a wire basket covered on the outside with a fabric bag. The bag is attached to the top ring of the basket with C-rings. The sidewall of the fabric sleeve is made of 3-ounce, high-UV woven polypropylene and the bottom is made of 8-ounce nonwoven polypropylene. The woven sidewall breathes which keeps heat from being trapped, keeping the roots as much as 20 °F cooler than those grown in traditional black plastic containers (grown above ground). The porous sidewall also dries the edge of the growing media. This gives the container an "air-pruning" effect, minimizing root circling and keeping roots from growing next to the sidewall of the container.

In the nursery, trees are grown on bare ground. The bottom has some ability to conform to the undulation of the ground, increasing stability. The nonwoven fabric bottom allows fine roots to grow through while impeding root caliper development. These small roots further improve stability in windy conditions allowing for less rigid staking and guying. If the escaped roots are ever detached from the soil, such as during a severe storm, they do not ever reestablish significant contact. Roots are able to mine phosphorous and available moisture for the soil underneath. The close interface between the soil, fabric bottom, and roots improves cold tolerance for a limited duration.

Fanntum™ containers can be potted similarly to plastic containers. Trees are potted on the perimeter of the growing blocks using a portable pot filler, then moved into the blocks by hand after potting.

STAKING

Metal T-stakes are used to guy the trees. Each tree shares a stake with the next plant in the row. Trees are guyed from opposite sides only. Two separate 2.1-cm (0.5-in.) seatbelt (mule tape) loops are tied loosely around the lower branches. Poly twine connects the mule tape to the T-post. Trees are not tied tightly to keep the mule tape from growing into the bark. This staking system was selected to minimize rubbing damage and allow narrow-width tractors and a scissor lift access for

weed control and pruning. This method is sufficient for up to 30-gal shade trees and shorter growing evergreens and flowering trees in larger containers. An aircraft cable system is used for bigger trees.

HARVEST

An attachment called the Fanntum Grabber can be used at harvest. The Dingo 525 mini track loader, on which it is mounted, can drive between the rows with little ground disturbance. The attachment hydraulically swings outward, is actuated to grip the tree with quarter-moon shaped paddles, and retreats with the tree. If needed, an individual can harvest trees without assistance.

PLANTING

At planting, the fabric bag is cut from the basket. Using bolt cutters, the top ring of the wire basket is cut on each side of the basket loop. C-rings are not used under the loops of the baskets, and pieces of the top ring are now detached. A vertical slice of the sidewall allows the fabric to be peeled downward from the top. The tree is laid down and the fabric is ripped from the bottom. The tree can be lowered into the planting hole using the loops of the basket. The wire loops can be folded downward into the hole or cut from the remaining basket.

ADDITIONAL BENEFITS

Fanntum containers are produced with 10% of the petroleum for traditional plastic containers. Fabric bags can also be disposed at the job site, reducing the need to transport and store used plastic containers.

Mixing Up Your Marketing©

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INTRODUCTION

In today's economy you might ask, "how can my business afford marketing?" After all, every expense has been minimized and the pie that is our market has not increased in size. Despite the bleak outlook, what should be asked is "how can my business afford not to market itself?" Nurseries that are increasing sales are doing so by gaining market share. Essentially they are getting a larger piece of the pie while others' pieces are shrinking or going away all together. Market share is gained through successful promotion of products that exceed competitors' quality and are backed by excellent customer service.

MIXING MARKETING STRATEGIES

Marketing is a strategy that involves communication and development of relationships with customers. The goal is to identify the customer, satisfy their needs, and keep them coming back for more. Not everyone responds to every channel of marketing. To reach the maximum audience for your products you need a mixture of marketing strategies. A person's generation has a lot to do with what type of marketing works for them. Older generations prefer relationship marketing involving face time and personal interaction. Newer generations thrive on technology and immediate information. Keep in mind that there are crossovers between generations. For example, a large portion of older generations has been quick to adapt to new technology. The main idea is that there is no single marketing strategy that will serve all of your potential customers. A multi-faceted approach is necessary to have an impact on your market. That is why there is advertising via TV, radio, print, billboards, and the Internet.

After the economic downturn there was a resounding theme in the seminar circuit. That theme was: Do not cut marketing. That is a hard pill to swallow when everything else is being cut. At Bennett's Creek Nursery we kept our marketing going and actually increased our efforts while keeping a tight budget.

A few years ago, the marketing at Bennett's Creek Nursery consisted of the standard green industry mix. We had a catalog, a website with pictures and availability, we went to tradeshows, and we were offering a simple label to garden centers with their price and logo. We sent out availabilities via email and fax to those who requested it.

In the past few years, many changes have been made to how Bennett's Creek Nursery is marketed. No outside marketing or P.R. firm has been used. All concepts and designs came from our staff and myself. The following information is a summary of what has been utilized during this down economy to maintain sales. The key to justifying marketing expenditures is to track the results of your marketing. With each facet of our marketing I will touch on how we track the results.

WEBSITE

Our website is aimed to be an information source. It has the basics including locations, directions, hours, personnel, and policies. We have links to PDF versions of all of our print media such as catalogs, posters, and brochures. The site also includes a database of our products updated daily including descriptions and photos. When logged in a customer can view prices and availability. Availability can be viewed online by an individual item, a group of items, or a location. Customers can also choose to download an easy-to-read PDF availability or an editable Excel® availability.

When maintaining a website it is important to keep content fresh. It is disappointing to see old specials and past announcements. Since we are in a seasonal business, parts of a website should change to feature items that go with the season. A big part of keeping things fresh is maintaining a marketing calendar of what should go up and come down from the site at different times. Check for past dates and dead links on a regular basis.

The web content should look professional. The person taking photos should be competent in proper exposure (not too dark or bright), composition (the way the subject is aligned and how it fills the frame), and focus. If you decide to include videos use a tripod and an external microphone. Shaky videos with poor audio are not watched for very long.

VIDEOS

Videos can be hosted for free on YouTube. Once a video is uploaded you can either link to it or embed it in your web page which allows visitors to view the video without leaving your website. YouTube tracks the number of views and allows viewers to post comments. That data can be used to determine the effectiveness of your video content. Our videos get embedded on our website and links are included in our emails and on our Facebook page. The videos have been plant oriented and focus on what is currently looking good and the basic characteristics of the plants.

GOOGLE ANALYTICS

To track the effectiveness of your website, Google offers a free service called Google Analytics <http://www.google.com/analytics/> that tracks your website's usage. You can see the number of visits, where visitors are from, what search terms brought them to your site, how long they visited, and more. Visit the Google site to learn more.

CONSTANT CONTACT — TRACKING EMAIL USAGE

Previously, we would only email availability to the customers who requested it. We have since subscribed to Constant Contact <http://search.constantcontact.com> and added our entire email list from our database. We send out weekly availabilities to all of our customers. Constant Contact gives customers a chance to opt out if they choose. We have the ability to track how many emails were opened and what links were clicked all the way down to an individual email address. Constant Contact gives you full control of tracking your email effectiveness. It is an ongoing experiment to include different content and subject lines to see what gets more people to open your email.

SOCIAL MEDIA: FACEBOOK AND TWITTER

To further our online presence we have setup Facebook and Twitter pages. These social media outlets give customers quick access to updates and information about our business. We coordinate specials and announcements that are put on our website along with our social media. It allows our customers to find out information how they want to find out about it. Our twitter page is setup to tweet any posts that go on the Facebook page. Facebook also has advertising opportunities where you pick your spending limit and how much you are willing to pay per exposure or click with the ability to track the results. As with the website you need to keep content fresh.

DISPLAYING AT MANTS SHOW

At the MANTS show in Baltimore each January we setup a 6.1 m × 6.1 m (20 ft × 20 ft) display that reaches 3.7 m (12 ft) tall. The display utilizes larger than life images to catch attention. We have kept the same structure for several years, but we update the graphical look every 2 or 3 years. For smaller shows there is a 3-m-wide (10-ft-wide) backdrop that features our house brand. Tradeshow success is tracked by booked orders. Rather than asking if we should continue to go to tradeshows, the question is typically "Can we afford not to be there?"

At the shows we have some handouts that help us to build visibility in the marketplace. We give out bags with our name and logo on them, note pads, and rulers. The results of these cannot be tracked other than all the show attendees that stop by to pick up a bag resulting in our bags are carried all around the tradeshow.

MOBILE SHOWROOM IN A DODGE SPRINTER VAN

We setup a mobile showroom in a Dodge Sprinter van. The idea came from the Snap-On tool truck that would stop by and visit our mechanic on a regular basis. There is floor space and shelving for the plants. Fluorescent lights are on the ceiling and under the shelves. We used a van instead of a box truck because we can keep the showroom somewhat cool with the air conditioning.

The van travels around our local region and visits retailers showing what is looking good for the week. We make it possible for the buyers, who cannot leave to visit our farm, to see our plants. Customers generally make notes, then they turn in an order to our inside sales staff. The inside sales staff keeps track of orders that are influenced by visits from the van. We have seen a direct correlation between orders and visits from the van with some, but not all, customers.

To increase brand awareness in the local area we have put graphics on a couple of our vehicles. One of our local delivery trucks has our brand name on the side with a photo on the rear door that looks like the door is open and the truck is full of plants. Our mobile showroom van is also a rolling billboard.

POINT-OF-PURCHASE MARKETING MATERIALS

To assist retailers in selling our products we offer an assortment of point-of-purchase (POP) marketing materials. Our first piece of visibility in a garden center is 1.8-m (6-ft) banners that has our brand and lets customers know that our plants are locally grown. When customers enter a garden center we have an A-frame sign that tells them too look for our tag. The sign features a brochure box with pamphlets that tell about our brand.

As retail customers shop they will find our branded tag with a picture of the plants' distinguishing features and descriptive information. The tag also includes a price and a barcode.

We print the tags ourselves using a Xerox color laser printer. The tag media comes from GrowTech Solutions (<http://www.growtechsolutions.com/>). We print tags that are six per page with a perforated stub where the price and barcode is printed. The tags are printed on demand, usually the day before the truck is loaded. The order pullers attach the tags with garment guns using a double-tee v-fastener. The tags cost us approximately 11¢ each.

Employees that help customers are instructed to dress professionally to appropriately represent our company. Sales related staff wears collared shirts embroidered with our logo and khaki shorts or pants. Shirt tales are tucked in and a belt is required. We also have all of our employees wear nametags. We order embroidered shirts in the spring and the fall. Half of the cost is shared with the employees.

WHAT TO GROW AND WHAT QUANTITY?

What to grow and how much is the most challenging part of marketing. This is further complicated by the length of time to produce many of our products. Looking to the past can show us where we missed the mark, but it is not the entire basis of our product mix. The quantities sold are analyzed as well as the quantities dumped. If an item is dumped it needs to be looked at to whether it was from overproduction or quality or disease issues. If an item sells out and you could have sold more, then you have lost sales. If you track what you could have sold but did not because your supply ran out, then you have a better idea of what to produce for the future.

It is also important to analyze items that need a lot of care without much of a return. You may not be making as much as you think. We call these items dogs. It is necessary to accept that there are plants out there that we may not be good at growing, and we need to move on to other things. In contrast, there are items that can be grown easily, but have been commoditized to the point that the profitability is not as high as we would like. These items are used as order starters. Customers will first order the commodity items then add on other things to reach a minimum order amount. Product mix is evaluated in meetings that involve both sales and production.

SUMMARY

This has been an overview on marketing strategies implemented by Bennett's Creek Nursery. Marketing varies according to what you grow, who your target customer is, where your target market is, and what your financial abilities are. The important thing is to always be on the lookout for ideas in our industry and outside of the industry. Take ideas and start on a small scale. Experiment, measure the results, and make changes as necessary. For maximum impact keep your marketing mixed with multiple strategies.

Mitigating Irrigation Pathogens Without Water Treatment©

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INTRODUCTION

Irrigation is where agricultural water security meets plant biosecurity. In light of global water scarcity, capture and reuse of runoff water for irrigation is of strategic importance to the sustainability of ornamental nursery and greenhouse industry. Without water no plant can be grown nor can existing plants survive. However, this practice could potentially recycle and spread destructive plant pathogens from isolated infections to an entire production facility and from a single facility to all sharing the same water resources, wiping out entire crops within weeks or even days.

Pathogen diversity in water and evidence of their economic significance has been mounting in recent years. According to a recent review (Hong and Morman, 2005), the diversity of plant pathogens found in water include 17 species of *Phytophthora*, 26 of *Pythium*, 27 genera of fungi, 8 species of bacteria, 10 viruses, and 13 species of nematodes. There is a growing body of evidence indicating that contaminated water is a primary, if not the sole, source of inoculum for a large number of destructive diseases on ornamental crops (Stewart-Wade, 2011).

The current approach to pathogens in irrigation water and their associated crop health risk focuses on chlorination (Hong et al., 2003b) and other water treatments (Fisher, 2011). Based on the latest research advancements, here I propose an improved version of a system approach for pathogen mitigation in irrigation water (Hong, 2008). Our ultimate goal is to move ornamental production towards a more sustainable industry.

A SYSTEM APPROACH TO PATHOGEN MITIGATION IN IRRIGATION WATER

A recycling irrigation system typically consists of three components: (1) production areas, (2) reservoirs including runoff water containment pond, and (3) pump house (Fig. 1). Runoff water from irrigation and rain events returns to the containment pond through ditches and/or underground drainage systems. Water is pumped out from reservoirs and treated in pump houses before being delivered to crops through PVC pipes.

Corresponding to the three components are three critical control points for plant pathogens in recycling irrigation systems (Fig. 1). Water treatment in the pump house is an important critical control point to prevent pathogens from reaching crops. The other two critical control points are to (1) prevent pathogens from reaching pump inlet, and (2) reduce pathogen entry into the irrigation system and negate its dissemination power. The following discussion will focus on potential mitigation strategies that may be implemented at each of these two critical control points.

PATHOGEN MITIGATION BY LOCATING PUMP HOUSE AWAY FROM RUNOFF ENTRANCE

Although aquatic biology of plant pathogens is largely unknown, there are several lines of evidence indicating that most pathogens including *Phytophthora* species,

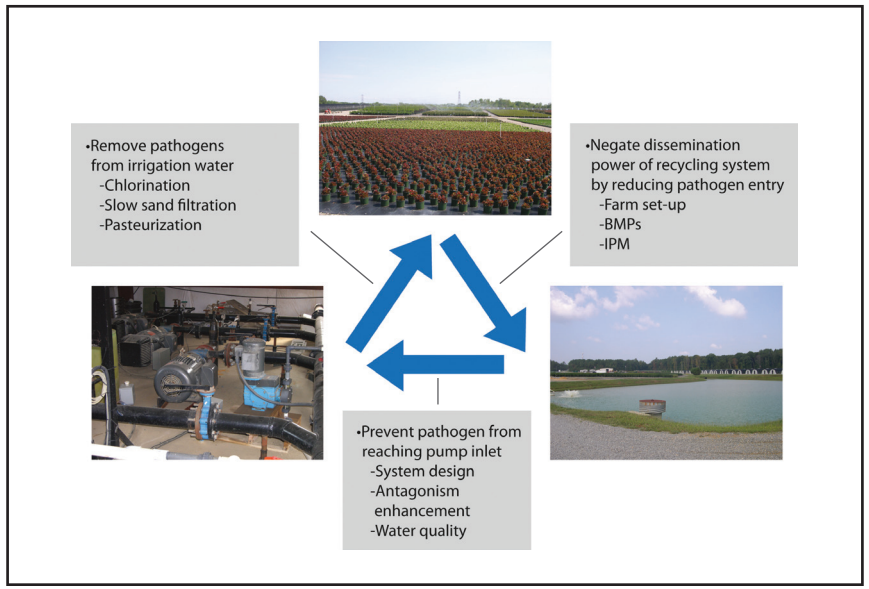

Figure 1. Illustration of three components of a nursery recycling irrigation system and three corresponding critical control points for pathogen mitigation.

commonly known as water molds, are not as adapt to agricultural water environments as previously perceived. First, the population of *Phytophthora* species consistently declined with increasing distance from runoff entrance in two containment ponds (Ghimire et al., 2011; Hong et al., 2003a). Specifically, in the pond with a single runoff entrance at one end and a pump inlet and an outlet at the opposite end, *Phytophthora* recovery at 100 m away from the runoff entrance decreased by 92% (Ghimire et al., 2011). Second, irrigation reservoirs are considered rather harsh environments for wildlife including plant pathogens. Water quality in this aquatic system periodically undergoes dramatic changes (Hong et al., 2009). For instance, water pH fluctuated from 4.5 to 10.5 in one of the ponds monitored and it was mostly above 7. Third, in a recent study evaluating the impact of water pH with Hoagland's solution as base medium, the vast majority of zoospores from five of the seven *Phytophthora* species died off within the first day (Kong et al., 2009). The only exception was *P. megasperma* which survived a broad range of pH from 3 to 11 for the entire experiment period of 7 days. It is anticipated that many other water quality parameters also could limit the survival of plant pathogens in irrigation reservoirs. These latest studies suggested that the risk of pathogen recycling through irrigation systems is inversely related to the runoff water turnover time.

Any considerations that prolong runoff water turnover time will contribute to pathogen mitigation. For single pond recycling systems, these may include (1) digging a curve-shaped reservoir with "speed bumps" in the bottom to slow water movement, (2) channeling runoff water from all production areas to a single runoff entrance at one end, and (3) locating the pump house as far away from the runoff entrance as possible. The bottom line is to settle pathogens out along the water path (Hong and Kong, 2003). This settling effect may be enhanced by adding a second

or more ponds to existing recycling systems. To maximize this benefit, these new ponds and the existing pond should be built with a stepwise water flow to capture runoff from all production areas in the top pond and water for irrigation pumped out from the bottom pond (Hong, 2002).

PATHOGEN MITIGATION BY DESIGNING GOOD DRAINAGE AND CONVEYANCE SYSTEMS

The sharp decline of *Phytophthora* populations along the water path from runoff entrance (Ghimire et al., 2011) indicates that most pathogens in that irrigation pond originated in production areas. These pathogens could have been from direct wash-off from diseased plants or leachate from infested potting mixes and containers on the production beds. They also could have entered runoff when it runs through contaminated sidewalks, roads, and open ditches.

One mitigation strategy is to reduce pathogen movement from production areas to the containment pond by building good drainage and conveyance systems. By functionality, such systems should be set to (1) mitigate direct contact of runoff water with diseased plants, contaminated substrate, containers and areas, or (2) settle pathogens out before reaching containment ponds.

Mitigating direct contact of runoff water with diseased plants, contaminated substrate, containers and areas may be accomplished making the right choices during the design of production beds and drainage systems. For instance, a variety of materials are used for production bed surfaces. These include gravel, seashells, and porous polypropylene ground cloth. Those that enhance infiltration and drainage reduce direct contact of runoff water with diseased plants and infested substrate/containers. Similarly, production beds could drain water to one, two, or four sides. Assumingly, those with a four-sided drainage dry most quickly, reducing pathogen growth and minimizing direct contact of runoff water with diseased plants and infested substrate/containers. Runoff water is commonly channeled through open ditches along sidewalks and roads. This drainage system is prone to cross contamination as discussed above. An alternative for risk mitigation is use of an underground drainage system with large diameter pipes that traverse underneath production areas. Such a drainage system not only reduces the risk of runoff water picking up pathogens along its path but also provides a foundation for a clean and dry production environment. An underground drainage system also opens an additional possibility for effectively draining water within the production bed. Runoff water may be directed to the center of production beds connected to a underground drainage system, so that no runoff water leaves the production beds, thus, completely eliminating pathogen entry from contaminated sidewalks and roads.

As an extension of open ditch or/underground drainage systems, the conveyance system delivers runoff water to containment ponds. Any conveyance system design that slows water movement, promotes sedimentation, and prolongs runoff water turnover time will reduce the diversity and level of pathogens returning to containment ponds. Examples include (1) use a J-shaped system to route water along the side of the reservoir to the opposite end from the pump house, and (2) add gravel with "speed bumps" along the water path.

PATHOGEN MITIGATION THROUGH BEST MANAGEMENT PRACTICES

An irrigation system is a powerful means by which pathogens spread to an entire nursery or greenhouse from isolated infections. However, this dissemination power may be further negated through best management practices to reduce the sources of inoculum for water dispersal. These practices may prevent pathogens from entering production systems or create suppressive environments. One example is to schedule irrigation events during daytime instead of night hours where *Phytophthora* and *Pythium* pathogens are of primary concern. It has been demonstrated that this practice alone reduced spread of these pathogens by more than 80% (Nielsen et al., 2006). This is due to the nocturnal nature of their production of zoospores, the principal dispersal structures and infective propagules. Zoospore populations began to increase at the start of the dark cycle and peaked sharply at Hour 4 (Nielsen et al., 2006). Additional examples include, but are not limited to, use of clean propagating and planting materials and sanitation practices. Some of these best management practices have been recently compiled (Griesbach et al., 2011).

SUMMARY

Plant pathogens in irrigation water present a growing threat to ornamental crop health as the horticultural industry increasingly depends on recycled water for irrigation. To counteract this emerging crop health issue, a system approach was proposed along with three critical control points and several pathogen mitigation strategies. These strategies are based upon good system design from production beds to drainage, conveyance, containment and recycling systems, and upon best management practices. Building new production facilities with good system design and implementing best practices is a matter of making informed choices. Such choices may not necessarily cost even an extra dime but surely their pathogen mitigation benefits will be ever-lasting, giving growers an competitive edge in the global market. Some of these designs prevent infective propagules from reaching pump inlets. Other designs and practices mitigate pathogen entry into recycling irrigation systems by reducing the source of inoculum in production areas and curbing movement to containment ponds. Altogether they provide long-term solutions to pathogens in recycling irrigation systems. The major principles of these designs and practices are to reduce inoculum source and contact with runoff water, and prolong turnover time. Examples used in this work were to illustrate these principles. Growers are encouraged to apply the same principles, make informed choices and build new production facilities with designs and practices that deter pathogen entry, reducing the risk of recycling and disseminating through an irrigation system. As our understanding of water quality dynamics in irrigation reservoirs and pathogen aquatic biology advances, growers should not have to choose between agricultural water security and plant biosecurity. Together we can and will build a more sustainable ornamental horticultural industry.

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Propagation of Pecans and Japanese Persimmons by Grafting and/or Budding©

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INTRODUCTION

Compared to the propagation and sale of pecan trees (*Carya illinoinensis*), which goes back to Simpson Nurseries' inception in 1902, Japanese persimmon (*Diospyros kaki*) propagation is fairly new, going back only approximately 30 or 40 years. Another difference is that we only graft pecans, while we both bud and graft persimmons. In 2006 (Covan), I presented a paper which described field grafting of pecans and persimmons, and so, will address only bench grafting of pecans for containers, as well as bench grafting and chip budding of Japanese persimmons for containers.

BENCH GRAFTING PECANS

Understock Preparation. Starting with the understock, we plant seed of the pecan cultivars 'Elliott' and/or 'Candy' in 1.2-m (4-ft) raised field beds. The seed are planted end to end in rows of three, 38 cm (15 in.) apart. They are grown in the beds for 1, sometimes 2, years. In December or January, which is when they go dormant in Monticello, Florida, we dig them with a Fobro 1500 HD bed digger. The digger is set to undercut them leaving a tap root 25.4 cm (10 in.) to 30.5 cm (12 in.) long. The seedlings are then stored in our drive-through-cooler until we are ready to graft.

Graft Storage Bed Preparation. During early winter we prepare 2-m-wide (6.6-ft-wide) coarse sawdust beds where we will store the grafts for 30 days. The bed is prepared by putting 5 cm (2 in.) to 6.5 cm (3 in.) of sawdust down. We then run two sets of heating cables side by side for the length of the 30.5-m-long (100-ft-long) bed. The double set of cables is 127 cm (50 in.) apart and 35 cm (14 in.) from the sides of the bed. One of the heating cables is the primary cable and the other is a backup in case of malfunction of the primary cable.

Scion Wood Preparation. The scion wood is cut from our stock trees or purchased and shipped in to the nursery. Once the wood is cut into 20-cm-long (8-in.-long) pins and tied in bundles, it is stored in our drive-through cooler until bench grafting begins. In Monticello, Florida, we begin bench grafting in February.

Whip Grafting. We trim the tops off of the understock approximately 5 cm (2 in.) above the original soil line. The bench grafter selects scion wood to match the diameter of the understock as closely as possible so the cambium layer can be lined up on both sides. Ideally one smooth sloping cut should be made ranging in length from 3 to 4 cm (1 to 1.5 in.). The surface on the understock and scion should be flat and, preferably, the same length. A second cut, the tongue, is made on both pieces starting about one-third of the way down from the tip on both pieces so the tongues will interlock tightly and as smoothly as possible. If the diameter and the cuts on both the scion and the understock are exactly the same the cambium layer

will line up perfectly on both sides. If that is not possible the cambium layer should be matched on at least one side. The graft is then passed to the "wrapper," who will wrap the graft union with "Buddy Tape," a very stretchy, translucent tape. At the end of the day the grafts are placed in the sawdust beds with the graft union placed on top of the heating cables. Sawdust is sprinkled around and on top of the grafts to cover them. The bed is then watered and covered with black plastic, and the heating cables are plugged into the thermostat with the temperature set at 25.6 °C (78 °F). The grafts will remain there for approximately 30 days, with the graft union being checked occasionally as the heat dries the union out. After 30 days the graft should be knit together nicely. At that time the root can be trimmed to fit whatever container is being used. For our 5-gal pot 30.5 cm (12 in.) of root is fine, but if we pot the grafts in 10.2 × 10.2 × 25.4 cm (4 × 4 × 10 in.) deep tree bands the understock will have to be trimmed to fit. They are now ready to grow.

PROPAGATING CONTAINER JAPANESE PERSIMMONS

Understock Preparation. The understock is grown from common persimmon (*D. virginiana*) seed. We collect our own fruit and clean the seed, as well as purchase clean seed. After moist stratification of the seed we plant some in Whitcomb #18 trays, some in 10.2 × 10.2 × 25.4 cm (4 × 4 × 10 in.) tree bands and the balance in 1.2-m (4-ft) raised field beds. We also purchase bare root seedlings as needed. By the time we are ready to graft or bud the seedlings we want them established in the 25.4-cm-deep (10-in.-deep) tree bands. The ideal diameter for the seedlings is pencil width and larger.

Whip Grafting. I will not discuss the details of whip grafting persimmons as many of the procedures are the same as those used for pecans. The differences are that we graft persimmons later, in March and April, and we use 3-mil opaque plastic tape to wrap the grafts. After 30 days the graft union should be knitted together.

Preparation for Budding. Collecting bud wood begins during dormancy, January in Monticello, Florida. The bud sticks are cut from our stock trees or purchased, bundled and stored moist in our walk-in cooler at 2.2 °C (36 °F). Chip budding does not start until the understock in the containers begins to break dormancy. We look for the first sign of bud swelling as well as some color. When we observe approximately 40% of the seedlings beginning to show some slight green in the swelling buds we are ready to start. Some prefer to determine start time with what is called "slipping bark" on the understock, while others look for what is called "pipping."

Chip Budding. Remember that we are putting a dormant chip into an understock that is coming out of dormancy. A chip of bark is removed approximately 7.6 to 10.2 cm (3 to 4 in.) from the soil line of the understock and replaced by a chip from the bud stick containing the desired cultivar. The closer the two chips are to the exact same size the greater the "live" percentage is. Both chips are cut using the exact same technique. The first cut is made just below the bud and barely down into the wood at a 30 to 40° angle. The second cut starts approximately 2.5 cm (1 in.) above the bud. The cut is made inward and downward behind the bud until it meets or intersects the first cut. The chip is left in the understock until the chip

is cut from the bud stick and we are ready to replace it. It is important that the budder be careful not to cut any deeper than necessary. Just as is done in grafting, it is important to match the cambium layer of the chip with that of the understock. When the budder is able to make similar cuts in similar sized scion and understock, the cambium layer on both sides of the chip will line up with the cambium layer of the understock and, if that occurs, you have a perfect bud. If the fit is not exact, then one side should be lined up. The "wrapper" should follow closely behind, as the next step is to wrap the bud. It is very important that the chip bud be wrapped to seal the cut edges as well as to hold the chip tightly in place. We use a translucent 1-mil tape that completely covers from below the chip all the way up above the chip. After 2 to 3 weeks, depending on the weather, we cut the stem of the understock off just above the chip bud to force the dormant bud to grow. At this point we remove suckers and stake the central leader.

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Post-Distilled Cedar as an Alternative Substrate in the Production of Greenhouse Grown Annuals©[1]

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INTRODUCTION

Peat moss is the main component found in soilless greenhouse substrates today and is thus in high demand commercially. Due to the increasing demand for peat moss; the issue of peat bog preservation has been brought to light. Another concern associated with peat moss production is the cost of shipping from Canada or Europe and the economic strain it puts on growers. Perlite, another common media component, is also experiencing increased demand. Perlite is not only expensive to produce; there are also high amounts of energy required for both the production and shipping processes. Perlite is considered a nuisance, causing lung and eye irritation in cases involving over-exposure (Du et al., 2010). Due to these concerns, growers have been engrossed in finding replacement substrate options for both peat moss and perlite. In recent years research regarding alternative substrates has steadily increased; with an emphasis on local and regional sources of materials which are considered to be more sustainable. Numerous types of alternative substrates have been tested in greenhouse crops. Recent examples include the research initiatives on Clean Chip Residual (CCR), WholeTree (WT), and Pine tree substrate (Boyer et al., 2008; Fain et al., 2008; Wright et al., 2008).

Clean chip residual is a by-product of thinning pine plantations composed of about 50% wood, 40% bark, and 10% needles. In a study by Boyer et al. (2008), two CCR particle sizes were used alone or in combination with varying peatmoss rates and planted with three annual species. The study demonstrated that CCR is a viable alternative substrate in greenhouse production of ageratum, salvia, and impatiens.

WholeTree is a biomass derived from processed whole pine trees (above-ground portions). WholeTree substrates were compared to a standard peat-lite (PL) mix (Fain et al., 2008). A WholeTree and peat-lite mix [WT : PL (1 : 1, v/v)] was found to have similar growing qualities when compared to the standard mix. Also, a WT ratio of 8 : 2 [WT : PL (8 : 2 v/v)] was found to be similar to the standard mix when amended with 0.907 kg• m^{-3} 7N-3P-10K fertilizer.

Pine tree substrate (PTS) is made from loblolly pine logs. A 100% PTS substrate was compared to a treatment containing a standard peat, perlite, vermiculite, and pine bark industry mix (9 : 3 : 3 : 5, by vol.). Nitrogen was applied at an increasing ppm for each substrate. The PTS substrate required a 100 ppm rate of nitrogen to be comparable to the standard mix (Wright et al., 2008).

In recent years an interest in using *Juniperus virginiana* (L.) as an alternative substrate component for peat moss has risen. Research has shown that plants grown in substrates amended with cedar tended to be equivalent to those grown in a traditional PL mix. Murphy et al. (2011) indicated greenhouse producers could amend standard greenhouse substrates with up to 50% cedar with little to no difference in plant growth. Starr et al. (2011) indicated that *J. virginiana* chips could be used as a substrate for container-grown *Rudbeckia,* with chips at 0.476 cm screen

[1]First Place – Graduate Student Research Paper Competition

size performing the best when compared to a pine bark substrate. In addition to the replacement of peat moss, the physical nature of cedar tends to add substrate porosity normally achieved with the addition of perlite. Therefore, we believe a reduction or elimination in the need for perlite might also be realized with the use of cedar as a substrate component.

The cedar used in this study was obtained from CedarSafe, a company located in Huntsville, Alabama. It is unlike cedar found in other substrate research projects. This cedar is a by-product of cedar oil production at the CedarSafe facilities. The cedar logs (*J. virginiana*) are first shaved and then sent through a hammer mill. It is then conveyed to a set of boilers, where the material undergoes a steam distillation process, which extracts a percentage of the cedar oil. CedarSafe currently has no market for the post-distilled cedar biomass. Our project was to incorporate this cedar into a substrate to determine if it had suitable properties for use as a greenhouse substrate component.

MATERIALS AND METHODS

Cedar (C) was used alone or in a volumetric combination with an industry standard peat-lite base mix (80% peat : 20% perlite). There were six treatments implemented (Table 1).

Table 1. Treatments implemented in experiment.

Treatment	Substrate
1	Industry standard peat-lite (PL)
2	C:PL (1 : 4, v/v)
3	C:PL (2 : 3, v/v)
4	C:PL (3 : 2, v/v)
5	C:PL (1 : 4, v/v)
6	Cedar (C)

The varying cedar treatments were compared to a 100% PL base mix. Substrate treatments had the following amendments added per cubic meter at mixing: 2.26 kg lime (added only to PL base); 0.907 kg starter nutrient charge (7N-3P-10K, Greencare Fertilizers Inc. Kankakee, Illinois), 0.45 kg Micromax (The Scott's Company LLC. Marysville, Ohio), 0.45 kg gypsum (added only to 100% cedar), and 2.72 kg slow-release fertilizer (13N-6P-16K, Harrell's LLC. Lakeland, Florida). Aqua-Gro L was added at 118.3 $mL \cdot m^{-3}$. Containers (1.8 L) (Dillen Products Middlefield, Ohio) were filled with the substrates and two plugs (200 cell flats) of either *Impatiens walleriana* 'Extreme Violet' or *Petunia* Celebrity Series Blue were planted into each container. Containers were placed in a twin-wall polycarbonate greenhouse on elevated benches and hand watered as needed. Containers were arranged in a randomized complete block with 12 blocks per treatment. Species were arranged as separate experiments.

Data collected included pH and EC using the pour-through method (Wright, 1986). At termination all plants were measured for growth index (GI) and bloom count (BC). Roots were visually inspected and rated on a scale of 0 to 5 (RR). At termination shoots were removed at substrate surface, oven dried, and weighed to determine shoot dry weight (SDW). Initial substrate airspace (AS), container capacity (CC), total porosity (TP), and bulk density (BD) were determined using the NCSU Porometer method, as well as particle size distribution (PSD) (Fonteno Harden, 1995). Data was analyzed using Tukey's Studentized Range Test ($P \leq 0.05$) (SAS Institute version 9.1, Cary, North Carolina).

RESULTS

Substrates containing higher amounts of cedar had greater AS and a lower substrate CC (Table 2). Starr et al. (2011) concluded that substrates containing cedar tended to have a higher AS and lower CC than PBS. Substrate TP was similar amongst all the treatments. Substrate PSD (data not shown) showed that cedar substrates contained a higher amount of medium and coarse particles and fewer fine particles. The larger particle size of these treatments explains, in part, the greater AS and lower CC.

At 0 days after planting (DAP) pH and EC were similar amongst all the treatments. Substrate EC at 14 and 28 DAP showed that substrates containing higher amounts of cedar had a lower EC than those containing higher amounts of peatlite. At 14, 28, and 35 DAP substrates containing higher amounts of cedar had a higher pH than the PL substrates. At 35 DAP the EC of all the substrates was similar (Table 3). It can be determined that, as we have seen from other experiments, substrates containing cedar had higher AS and therefore the leaching of nutrients would be greater in those substrates. This would result in a lower EC overtime for those substrates.

Petunia GI and SDW were similar among Treatments 1, 2, and 3. Petunia BC was also comparable among Treatments 1, 2, and 3. Similarly, the GI, BC, and SDW of the impatiens were similar between Treatments 1, 2, and 3 (Table 4). The weakest treatment was that of the 100% cedar. From this data we can conclude that the lower water holding capacity along with lower cation exchange capacity (data not shown) of cedar resulted in poor nutrient retention and thus reduced growth.

Table 2. Physical properties of cedar-amended substrates.[Z]

	Air space[Y]	Container capacity[X]	Total porosity[W]	Bulk density[V]
Substrates	---------- (% vol) ----------			(g/cm^3)
100% Peatlite	8.1 dc[u]	76.1 a	84.2 ab	0.11 b
20:80 Cedar : Peatlite	4.4 d	76.1 a	80.5 b	0.15 a
40:60 Cedar : Peatlite	12.7 c	70.1 b	82.7 ab	0.15 a
60:40 Cedar : Peatlite	20.3 b	65.0 c	85.4 a	0.15 a
80:20 Cedar : Peatlite	23.9 b	60.3 d	84.2 ab	0.16 a
100% Cedar	35.9 a	50.1 e	85.9 a	0.16 a

[Z]Analysis performed using the NCSU porometer.
[Y]Air space is volume of water drained from the sample ÷ volume of the sample.
[X]Container capacity is (wet weight – oven dry weight) ÷ volume of the sample.
[W]Total porosity is container capacity ÷ air space.
[V]Bulk density after forced-air drying at 105 °C (221 °F) for 48 h (1 g • cm^{-3} = 62.4274 lb/ft^3).
[U]Tukeys Studentized Range Test (P≤0.05, n = 3).

Table 3. Effects of substrate on pH and electrical conductivity of greenhouse grown *Impatiens walleriana*.

	0 DAP[Z]		14 DAP		28 DAP		35 DAP	
Substrates	pH	EC[Y]	pH	EC	pH	EC	pH	EC
100% Peatlite	4.98 ab[X]	2.27 a	5.12 bc	9.79 a	5.10 d	2.21 a	5.09 bc	0.94 a
20:80 Cedar : Peatlite	4.99 ab	2.55 a	5.01 c	8.30 ab	4.98 d	2.51 a	4.73 d	0.89 a
40:60 Cedar : Peatlite	4.83 ab	2.40 a	5.31 b	4.58 cd	5.21 cd	2.69 a	4.83 cd	0.82 a
60:40 Cedar : Peatlite	4.65 b	2.29 a	4.99 c	5.31 cd	5.44 bc	2.19 ab	4.89 cd	0.84 a
80:20 Cedar : Peatlite	4.73 ab	2.03 a	4.90 c	5.89 bc	5.63 b	1.39 ab	5.40 b	0.54 a
100% Cedar	5.10 a	1.98 a	5.62 a	2.99 d	6.19 a	0.59 b	5.82 a	0.34 a

[Z]Days after planting.
[Y]Electrical conductivity (dS/cm) of substrate solution using the pourthrough method.
[X]Tukeys Studentized Range Test (P≤0.05, n = 4).

Table 4. Use of cedar as an alternative substrate component.[Z]

	Growth index[Y]	Bloom counts[X]	Root rating[W]	Shoot dry weight[V]
Substrates		*Petunia*		
100% Peatlite	35.8 a	60.1 b	4.1 a	12.2 ab
20:80 Cedar : Peatlite	35.4 a	69.7 a	4.1 a	12.9 a
40:60 Cedar : Peatlite	33.6 ab	63.6 ab	3.8 a	10.6 b
60:40 Cedar : Peatlite	30.9 bc	49.5 c	2.6 b	8.3 c
80:20 Cedar : Peatlite	29.2 cd	42.0 cd	2.8 b	7.1 cd
100% Cedar	27.6 d	36.9 d	1.3 c	5.7 d
		Impatiens walleriana		
100% Peatlite	28.3 a	68.3 a	4.5 a	13.3 a
20:80 Cedar : Peatlite	28.6 a	68.0 a	4.9 a	12.9 a
40:60 Cedar : Peatlite	28.0 a	63.9 a	5.0 a	11.8 a
60:40 Cedar : Peatlite	26.9 a	49.0 b	4.9 a	9.2 b
80:20 Cedar : Peatlite	24.1 b	41.7 b	3.9 b	6.5 c
100% Cedar	22.1 c	28.8 c	3.4 b	4.6 d

[Z]Experiment installed at the Paterson Greenhouse Complex on 15 April 2011.
[Y]Growth index = [(height + width1 + width2)/3] (P≤0.05, n = 12).
[X]Bloom count = number of blooms or buds showing color at 35 days (P≤0.05, n = 12).
[W]Root ratings 0–5 scale (0 = no visible roots and 5 = roots visible on the entire container substrate interface) (P≤0.05, n = 8).
[V]Shoot dry weight measured in grams (P≤0.05, n = 8).
[U]Tukeys Studentized Range Test (P≤0.05, n = 12).

DISCUSSION

The data provided indicates that both petunias and impatiens grown in substrates containing 20% and 40% cedar were of equal, if not greater, marketable value than that of those grown in the standard peat-lite mix. The cedar provided by CedarSafe would be a sustainable alternative component for greenhouse substrates replacing portions of peat and perlite.

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Pre and Post Application Moisture Levels and Formulation Affect Preemergence Control of Spotted Spurge (*Chamaesyce maculata*) and Hairy Bittercress (*Cardamine hirsuta*) with Flumioxazin©[1]

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Two experiments were conducted to evaluate pre and post application moisture levels effect on preemergence control of spotted spurge (*Chamaesyce maculata*) and hairy bittercress (*Cardamine hirsuta L.*) with flumioxazin in two different formulations. BroadStar™ 0.25G was applied as granular, and SureGuard 51 WDG (water dissoluble granular) was sprayed. In Experiment 1, three pre-moisture substrate levels (wet, medium, and dry) were treated with BroadStar and SureGuard® at 0.25 and 0.375 lb ai/A on 7 Sept. 2010. Four irrigation volumes were applied immediately after herbicides application, including 0.6, 1.3, 2.5, and 5.1 cm (0.25, 0.50, 1, and 2 in.). Each pot was overseeded with 25 spotted spurge seed the next day. Results showed that both main effects, formulation and herbicide rate, had significant influence on spotted spurge control. The only significant two-way interaction was formulation × rate. Granular was less effective than spray formulation, and low rate was less effective than high rate. Conversely, spray formulation provided 100% control at both 0.25 and 0.375 lb ai/A. In Experiment 2, the experiment was repeated with hairy bittercress on 1 March 2011. Each pot was overseeded with 25 hairy bittercress seed 1 week after treatment. Results showed formulation significantly influenced weed control; irrigation was slightly significant at 2 weeks after seeding; pre-moisture and herbicide rate did not influence bittercress germination number. The only two-way interaction of formulation × irrigation was slightly significant. When irrigation volume was 0.6 cm (0.25 in.), granular formulation had lower control of hairy bittercress germination at 2 weeks after seeding. Spray formulation at both rates provided excellent control of hairy bittercress.

INTRODUCTION

Preemergence herbicides have to be activated by water. For most herbicides, irrigation [0.6 to 1.3 cm (0.25–0.5 in.)] is needed after treatment. Based on previous studies, moisture is one factor affecting the absorption of herbicides by germinating weeds (Menges, 1963). Previous researches in the 1960s demonstrated how irrigation volume affects effectiveness of preemergence herbicides with different ingredient and volatility (Knake et al., 1967). As pointed out by Audus (1964), the relationship between soil moisture and absorption of herbicides into the soil ex-

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change complex may affect the availability of herbicides for uptake by the plant. Other research with diuron on cotton (*Gossypium hirsutum L.*) showed that diuron was more toxic under high moisture conditions than under low moisture conditions (Upchurch, 1957). In a study on foxtail control with 25%, 31%, and 37% moisture (Stickler et al., 1969), the effectiveness of atrazine and ethyl N,N-dipropylthiocarbamate (EPTC) increased with increasing soil moisture. In reviewing the literature, little or no research has been conducted since cited research from the 1960s. Nursery production had changed dramatically since the 1960s. Potting media in the 1960s had high soil content; today most media are completely soilless. Growers need solid information about how to best manage moisture levels for the best weed control. Therefore, the objective of this research was to evaluate the influence of pre-application moisture levels and the initial post-application irrigation levels on the preemergence control of spotted surge (*Chamaesyce maculata*) and hairy bittercress (*Cardamine hirsuta L.*) with flumioxazin.

MATERIALS AND METHODS

Experiment 1. On 3 Sept. 2010, trade-gallon pots were filled with pine bark and sand (6 : 1, v/v) substrate previously mixed with 15 lb/yd^3 of Polyon (17–5–11) control-released (7–8 months) fertilizer, 5 lb/yd^3 of dolomitic limestone, and 1.5 lb/yd^3 Micromax. Pots were separated into three moisture levels and container weights and container metric water content for each moisture level were measured with 10 samples for each moisture level before herbicides were applied. We used a Decagon® Soil Moisture Sensor to measure volumetric water content. For low moisture, no water was applied 4 days before treatment. The average weight of whole pot was 1.18 kg, and water content was 20%. For medium moisture, no water was applied 1 day before treatment. The average weight of whole pot was 1.36 kg, and water content was 26%. For high moisture, all pots were watered to saturation immediately before treatment. The average weight of whole pot was 1.60 kg, and water content was 34%. On 7 Sept. 2010, herbicides were applied to the pot surface. Treatments included BroadStar™ 0.25G at 0.250 and 0.375 lb ai/A and SureGuard® 51WDG at 0.250 and 0.375 lb ai/A. Both herbicides have the same active ingredient: flumioxazin. BroadStar was applied with a hand-shaker, and SureGuard was applied by an enclosed-cabinet sprayer which has been calibrated to deliver at 30 GPA (gallon per acre) with Teejet 8002 flat fan nozzle. After treatment, 4 overhead irrigation volumes were applied, including 0.6, 1.3, 2.5, and 5.1 cm (0.25, 0.5, 1, and 2 in.). Each pre-moisture level received four herbicides treatments and four irrigation volumes with six replications per treatment. Nontreated control group was also included. All pots were completely randomized and maintained outdoor with 1.3-cm (0.5-in.) overhead-irrigation daily. Spotted spurge was overseeded 25 per pot the next day (8 Sept. 2010) after treatment. Weeds number was counted weekly and fresh weight was collected at 9 weeks after seeding (10 Nov. 2010). Data subject to ANOVA and variable means separated using Duncan's multiple range test at $P \geq 0.05$.

Experiment 2. A similar experiment was conducted on 25 Feb. 2011 with hairy bittercress. Pots were filled with the same substrate as in Experiment 1. Container weights and container metric water content were measured before herbicides were applied on 1 March 2011: low pre-moisture 1.58 kg, 16%; medium pre-moisture

1.73 kg, 22%; and high pre-moisture 1.88 kg, 30%. Herbicide treatments, irrigation treatments, and experimental designs were identical to that previously described for the spotted spurge experiment. Bittercress was over seeded 25 per pot at 1 week after treatment. Weed numbers were counted weekly. Fresh weights were collected at 10 weeks after seeding (10 May 2011). Pairwise comparisons were performed for each growth stage using a generalized linear model using Duncan's Multiple Range Test at $P \geq 0.05$.

RESULTS

Experiment 1. For spotted spurge emergence counts at 2, 6, and 9 weeks after seeding (Table 1), all three evaluations were influenced by the main effects of formulation and rate. The main effect irrigation was slightly significant at 6 weeks after seeding. Conversely, the main effects pre-application media moisture and post-application irrigation volumes were not significant. Only herbicide formulation affected spotted spurge fresh weights at 9 weeks after seeding. For the two-way interactions, the interaction of herbicide formulation × rate was also significant for weed counts. Conversely, all other two-way interactions were not significant. No two-way interaction affected spotted spurge fresh weight. Individual means of formulation and rate review showed the spray was consistently more effective than granular. There was no significant difference between the two rates of spray formula on spotted spurge germination and fresh weight (Table 2). Because the spray formula is so effective, even low rate (0.25 lb ai/A) can also achieved almost 100% control. In contrast, for the granular formulation, low rate achieved 73.9% control, and high rate achieved 82.4% control.

Table 1. ANOVA of spotted spurge (*Chamaesyce maculata*) data (Fall 2010).

	Weed counts (WAS[Z])			
Source of variation	2	6	9	F.W.[Y]
Main effects	----------probability----------			
Formulation (form.)	<0.0001[X]	<0.0001	<0.0001	<0.0001
Rate	0.02	0.01	0.02	0.14
Pre moisture (moist.)	0.70	0.57	0.61	0.33
Post irrigation (irrig.)	0.24	0.06	0.11	0.47
Two-way interactions				
form.*rate	0.02	0.02	0.02	0.15
form.*moist.	0.70	0.47	0.78	0.32
form.*irrig.	0.24	0.07	0.09	0.46
rate*moist	0.81	0.96	0.95	0.91
rate*irrig.	0.56	0.42	0.64	0.89

[Z]WAS = weeks after spotted spurge was seeded.
[Y]F.W. = fresh weight of spotted spurge at 9 WAS.
[X]P-value form general linear model of the weekly data.

Table 2. Pertinent treatment means for spotted spurge (*Chamaesyce maculata*) (Fall 2010).

Experimental variable		Weed counts /pot (WAS[Z])			F.W.[Y] (g/pot)
Fomulation	Rate (lb ai/A[W])	2	6	9	(% control[U])
Spray[X]	0.250	0.00a[V]	0.01a	0.04a	0.02 (99.9)a
spray	0.375	0.00a	0.00a	0.04a	0.00 (100.0)a
Mean		0A	<0.01A	0.04A	<0.01 (100.0) A
granular	0.250	1.00a	1.54a	1.84a	9.90 (73.9)a
granular	0.375	0.51b	0.90b	1.16b	6.69 (82.4)b
Mean		.76B	1.22B	1.51B	8.43 (77.8)B
Non-treated control		7.83	8.17	8.33	38.00 (0.0)

[Z]WAS = weeks after spotted spurge was seeded.
[Y]F.W. = fresh weight of spotted spurge at 9 WAS.
[X]spray = SureGuard; gran. = granular = BroadStar.
[W]lb ai/A = pounds active ingredient per acre.
[V]Means separated using Duncan's multiple range test at P = 0.05; lower cases within formulation; upper cases mean comparison.
[U]% control = 100 - (weed fresh weight/ control fresh weight)*100.

Experiment 2. For hairy bittercress emergence weed count, formulation was always a highly significant main effect (Table 3). Irrigation was slightly significant in weed count at 2 and 10 weeks after seeding. The main effects of both rate and moisture were not significant. Only the two-way interaction of formulation × irrigation was significant on germination. For all response variables (Table 4), the spray formulation was more effective than the granular formulation. Post-application irrigation levels had no effect on efficacy of the spray formulation. All spray formulation treatments achieved about 100% control with four post-irrigation levels. Conversely, with the granular formulation at 2 weeks after seeding, irrigation at 0.6 cm (0.25 in.) was less effective than the higher irrigation levels. There results indicated the importance of adequate irrigation to activate BroadStar; however, at 6 and 10 weeks, the weed counts in different irrigation volumes were not significantly different. For the fresh weight, irrigation at 0.6 cm (0.25 in.) provided 92.4% control, which was similar to irrigation at 5.1 cm (2 in.) of 91.3%. Irrigation at 1.3 cm (0.5 in.) provided 96.6% control, which was similar to irrigation at 2.5 cm (1 in.) –96.8%. Therefore, the irrigation treatments at 0.6 cm (0.25 in.) and 5.1 cm (2 in.) were less effective than irrigation at 1.3 cm (0.5 in.) and 2.5 cm (1 in.).

DISCUSSION

In summary, formulation was always the most highly significant main effect in both spotted spurge and hairy bittercress control, while pre-moisture substrate levels

Table 3. ANOVA of hairy bittercress (*Cardamine hirsuta* L.) data (Spring 2011).

	Weed counts /pot (WAS[Z])			
Sourse of variation	2	6	10	F.W.[Y]
Main effect	probability			
Formulation (form.)	<0.0001[X]	<0.0001	<0.0001	<0.0001
Rate	0.58	0.34	0.34	0.08
Moisture (moist.)	1.00	0.76	0.87	0.29
Irrigation (irrig.)	0.06	0.09	0.06	0.43
Two-way interaction				
form.*rate	0.58	0.47	0.46	0.12
form.*moist.	0.52	0.58	0.81	0.24
form.*irrig.	0.05	0.06	0.04	0.33
rate*moist.	0.63	0.58	0.90	0.26
rate*irrig.	1.00	0.73	0.62	0.44

[Z]WAS = weeks after hairy bittercress was seeded.
[Y]F.W. = fresh weight of hairy bittercress at 10 WAS
[X]P-value form general linear model of the weekly data.

were not significant at any time. Spray formulation of flumioxazin always provided excellent control at all irrigation levels and rates. The effectiveness of granular formulation increased with the increasing rate. However, post-irrigation volume did affect hairy bittercress emergence with the granular formulation. Irrigation volume at 1.3 cm (0.5 in.) and 2.5 cm (1 in.) provided better control than irrigation at 0.6 cm (0.25 in.) and 5.1 cm (2 in.). When preemergence herbicide flumioxazin is applied, the media moisture before treatment does not affect the herbicide effectiveness. However, irrigation at 1.3 cm (0.5 in.) to 2.5 cm (1 in.) is recommended to activate the granular formulation of flumioxazin.

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Table 4. Pertinent treatment means for hairy bittercress (*Cardamine hirsuta* L.) (Spring 2011).

Experimental variable		Weed counts (WAS[z])			F.W.[y] (g/pot)
Fomulation	Irrigation (inch)	2	6	10	(% control[v])
spray[x]	0.25	0.00a[w]	0.00a	0.00a	0.00 (100.0)a
spray	0.50	0.00a	0.00a	0.00a	0.00 (100.0)a
spray	1.00	0.00a	0.03a	0.03a	0.59 (99.5)a
spray	2.00	0.00a	0.00a	0.00a	0.00 (100.0)a
Mean		0.00A	<0.01A	<0.01A	0.15 (99.9)A
gran.	0.25	0.78a	0.36a	0.47a	8.63 (92.4)b
gran.	0.50	0.17b	0.11a	0.11a	3.84 (96.6)a
gran.	1.00	0.25b	0.06a	0.11a	3.64 (96.8)a
gran.	2.00	0.22b	0.39a	0.47a	9.80 (91.3)b
Mean		0.35B	0.23B	0.29B	6.47 (94.3)B
Non-treated control		11.17	15.67	16.50	113.22 (0.0)

[z] WAS = weeks after hairy bittercress was seeded.
[y] F.W. = fresh weight of hairy bittercress at 10 WAS.
[x] spray = SureGuard; gran. = granular = BroadStar.
[w] Means separated using Duncan's multiple range test at P = 0.05; lower cases within formulation; upper cases mean comparison.
[v] % control = 100- (weed fresh weight/ control fresh weight)*100.

The World Is Run by Those Who Show Up©

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INTRODUCTION

The title of my talk is a quote that Dr. Burl Long from the University of Florida told our class at my first meeting with the Wedgworth Leadership Institute. The intent of the Wedgworth Leadership Institute for Agriculture and Natural Resources (<http://wlianr.ifas.ufl.edu/>) is to develop and refine the leadership capabilities of young leaders who, in turn, will be prepared to become increasingly involved in policy formation on behalf of agriculture.

THE PROGRAM

Let me start by explaining a little bit about this program, and add that there are programs very similar to this one in other states in the Southeastern U.S.A. The program consists of class members, similar to a school class, except that each class is selected once every 3 years. Each class consists of up to 30 people, between the ages of 25 and 50, who make the majority of their income from agriculture, natural resources, or other related industries. The class is a state-wide mixture of individuals from different sectors of agriculture, including ornamental horticulture, timber, cattle, citrus, vegetables, row crops, fertilizer producers, etc.

Over the course of 2 years, our class met together for 1 week, every other month, usually in a different city, and with a different purpose and format for each meeting. The program begins with an introspective evaluation of oneself, and expands outwards to explore local, then state, national, and international governments — and how policy is formed and influenced. At the end of the 1st year, the class takes a national trip to Washington, D.C., and another area of the U.S.A. In 2008, energy was the big issue and our class went to the U.S.A. Midwest to explore "green energy." The current 2011 class just returned from a trip to New Mexico and Arizona to survey life along the border with Mexico. The final seminar for each class includes an international trip. When my class went to China and Vietnam in 2009, China was "taking over the world". So, we traveled to Asia to see what was happening. The class that is preparing for their international trip next summer will travel to France and the Netherlands. I assume it relates to the economic meltdown in Europe and fiduciary issues facing the European Union (EU).

THE SEMINARS

The first seminar focused on personal behavior, attitude, problem solving, and individual growth. It included doing a rope course, taking a number of personality tests, and focusing on interactions between individuals.

The second seminar was in Miami. We spent a week looking at the issues that major metropolitan areas face. We went from the Port of Miami to the Everglades to Little Havana, and from the Miami Herald newspaper to a homeless shelter, and all points in between. We were there in the Winter of 2008, and did not realize that we were witnessing the beginning of the economic meltdown. Some of the people

we talked to in Miami were commenting on an odd problem of not being able to sell some of the new condos that had just been built downtown. This was a problem that nobody in Miami could ever remember experiencing in recent times.

Next we were off to Tallahassee. There we spent several days meeting with folks at the Florida State Capitol. We sat in on an Ag Coalition meeting where lobbyists from the Florida State Associations for Forestry, Florida Nursery Growers and Landscape Association (FNGLA), Farm Bureau, citrus and cattle industries, and the University of Florida - IFAS, met to resolve the different problems that they were facing in an attempt to help each other with the issues during the current legislative session. From there we "shadowed" lobbyists from our respective associations as they crisscrossed the capitol for meetings with legislators, cabinet members, or their aides. We had a meeting with the Florida Commissioner of Agriculture. Some of the commissioner's hot topics were invasive pests, including citrus canker and sudden oak death.

Two months later we were in the Florida Panhandle to learn about small, rural cities and communities. We visited timber operations, the Buckeye Cellulose Mill, and an ocean biology / seafood testing lab. We spent a day in the Apalachicola Bay learning about the science of oyster farming, including actually harvesting oysters. During this period in 2008, we were in the middle of a multi-year prolonged drought. We had meetings with several environmental groups, the Apalachicola River Keeper (a nonprofit organization made up of professional staff, volunteers and members who monitor the Apalachicola), and oyster farmers who had one issue: Force Atlanta to stop using water out of Lake Lanier. Now to most of the folks in our group, this meant nothing. But to me it was like a blow to my stomach. Water in Lake Lanier, as most of you know, is what keeps the landscaping business afloat in Atlanta! My customers need that water…therefore I need for them to have it! Yet to most of the people around me, even agriculturally minded people in a state with limited water supply, the solution was simple: Make them stop…right? This is the problem with one-sided arguments!

Next, we began preparing for our national trip for Fall 2008. Our first stop was Washington, D.C., where we spent 5 days. We met with representatives; senators, their aides; lobbyists; activists; and one self-proclaimed radical. One of the unwritten goals of the leadership program is to see various sides of different arguments. The class is not about specific issues per se. Rather it deals with how to manage and address different issues. Part of that process is gathering information and learning what is behind the opposing side. The goal of our director, Dr. Hannah Carter, was to take the class out of their comfort zone as frequently as possible. That was a very effective learning tool, but hard to swallow at times.

One morning in Washington we met with a labor organizer whose first word to our group of farmers was: "Liberals are too conservative for me. I am a radical, and if I could have 10 min in front of your labor crews, I would have your entire organization unionized before you went home that night." You should have seen all the good ol' boys in the room squirming in their chairs as we listened to this man talk for 20 min.

We talked with environmentalists who want genetically modified crops banned and organic crops mandated nationwide. We heard from animal rights groups that wanted dairy farms, feed lots, and hog farms outlawed. On the flip-side, we visited the U.S. Chamber of Commerce who showed us how they were fighting for legal reforms, expansion of domestic energy, tax reform, and more.

From Washington we flew west to Des Moines, Iowa, to watch corn and beans being harvested, and subsequently processed not for food, but rather for fuel. It was staggering. Ethanol manufacturing plants are strategically located all across the U.S.A. Midwest in an effort to capture as much of a corn harvest as possible. Specifically we toured two ethanol plants, and one of the most striking contradictions I saw throughout my experience with the Wedgworth Leadership Institute was the sight of three semi-loads lined-up, waiting to dump their coal load into the on-site power-plant. That is correct! Ethanol plants use thousands of loads of coal to make "clean" fuel. Go figure! We also visited a wind farm, a hog farm, and several corn and bean farms.

The stock market began to crash while we were in Des Moines, and it continued to get worse as we toured the Chicago Mercantile Exchange a few days later. Oil was falling. Corn prices were falling, stocks were falling. It was certainly an interesting time to visit the trading floor of the Chicago Mercantile Exchange!

INTERNATIONAL SEMINAR

Preparation had begun for our international seminar to China, Vietnam, and Hong Kong. A 13-h flight was followed by 3 weeks of chopsticks and questionable meals — three times a day. We started off in Shanghai then an overnight train-ride to Beijing. From there we took a flight west to Xi'an, home of the Terra Cotta Soldiers, and down to tropical Nanning. There we crossed the border on foot into Vietnam and took a bus to Ha Long Bay. Next was a bus ride south to Hanoi and a flight to Hong Kong. During all of this time, we visited the U.S.A. embassy, went to a silk factory, met rice and citrus farmers, and visited their villages and homes. We saw the Great Wall…which was one of the largest failures in the history of mankind and pretty much sums up the senseless excess of previous Chinese regimes. They build things that they do not need, just for the sake of saying that they built it, and it is still continues.

OBSERVATIONS OF CHINA, VIETNAM, AND HONG KONG

I will share a few observations about China, Vietnam, and Hong Kong. First of all, we should thank the Lord that we live in America. We are very fortunate. The people of China are still oppressed, and much of their news and influence is heavily censored.

Secondly, the communists are very good capitalists. They do not let pesky issues, such as human-rights and pollution get in the way of making money. There is smog everywhere — and it is constant. Everyday felt like a cloudy day, but if you looked up, there was not a cloud in the sky.

China does not have trees like we do in the U.S.A. Virtually every tree in China was cut down during the 1950s to fuel the steel mills — not because China needed steel, but because Mao wanted to exceed the United States in steel manufacturing, just to say he had done it. All of their mountains that I saw must have been completely logged and replanted within the past 40 years.

The landscaping in China was comical by our standards. We would consider most of their street trees as trash trees: camphor, sycamore, China berry, *Koelruteria* — rain tree, *Ailanthus* — tree-of-heaven, etc. Vegetable gardens are everywhere, in ditches beside the interstate, completely surrounding most apartments, on roofs, and patios. One gets the feeling that China has trouble feeding itself.

The size and scope of population is staggering. The city of Beijing has 20 million residents, while Shanghai has 23 million, and that is just within the city. To put this into perspective, the entire state of Florida has a population of about 18 million. Construction is everywhere in China, but mostly in the form of government apartment housing. Much of China seems to be new and shiny.

Conversely, construction appeared to be non-existent in Vietnam. Vietnam seems old and crumbling. The country of Vietnam is beautiful with great food, very friendly people, and ironically, all items priced in U.S.A. dollars.

While most of my photos are from the international trip, I will let the images speak for themselves, while I try to stay on message. The fact that you all are here at IPPS tells me a couple of things about you. Look around you. We are survivors — so far. Not only are we survivors, but we are willing to make the sacrifices necessary to make our businesses better. Nurseries do not develop on their own. It takes hard work, constant supervision, and the need to adapt to changing times. And the times are changing faster now than ever. We have to continue to pursue greatness, and we have to keep learning. Learning about new trends, plants and technologies — and learning from our mistakes. We can never stop learning! Ask Charlie Parkerson if he thinks he has learned enough to settle down and stop all this dang learning.

LISTEN TO WHAT I AM SAYING

If you are still willing to learn, then listen to what I am about to say. There are people out there who want you to go out of business!! There are organizations with deep pockets and offices next to the White House who want nothing less than a socialized, organic, utopia — and you are in their way! Or if you are not in their way, you need to be!

Sometimes it is hardest for a business owner to "see the forest for the trees." While you are lying in bed at night trying to figure out if your business is strong enough to survive the economy, you should also be wondering if you can withstand the U.S. Federal Government. There are people trying to figure out how to clean-up the Chesapeake Bay. Or they might just need Atlanta to stop using water. Or else they wonder if we could just fence off the border with Mexico once and for all — so their brother-in-law might find a job. It is starting to feel like those Tea Party folks might not be quite as level headed as we initially thought!

IMMIGRATION AND UNEMPLOYMENT ISSUES

Halsey Beshears of Simpson Nursery is the current President for FNGLA and also a graduate of the Wedgworth Leadership Program. Let me tell you a story from his latest monthly letter to the FNGLA membership. On a recent trip to Washington, he was fortunate enough to sit in on a U.S. Congressional hearing on immigration and unemployment. Three of the people testifying were business owners including one nurseryman, while the fourth was a labor lawyer. When the lawyer was asked how Congress could change and get unemployed Americans to work in the agricultural industry, he responded by stating it was simple: growers just need to pay higher wages and provide better working conditions and Americans will do the work. He argued that by increasing our labor costs and passing it onto the consumer, American agriculture would have a consistent and steady labor force. This is the type of advice that Congress routinely hears.

My point is not to scare you specifically. It is to inform you that we are fighting a battle whether you are engaged or not. "To those whom much is given, much

is expected" — This quote has been used by many Presidents, including John F. Kennedy and George W. Bush.

You might ask what you have been given? First of all, we have a great industry to work in — even if we might be limping on a broken leg right now. The business might have been given to you by an older generation, or it might have been developed by a younger version of yourself who worked hard to build the life that you have now. More than that, we have been entrusted with the future. If you are nearing retirement and you do not have a succession plan, then you probably are not at this IPPS meeting. If you want to see your business succeed after you, if you want the nursery industry to thrive once again, if you have hope for the future, then you have an obligation to see this through.

SO WHAT DO WE DO? WHERE DO WE START?

Begin at home by becoming a member of your state nursery association. It is not very expensive, and they go to bat for you every day, whether it is for some permit fee or storm water run-off code that they stop before you ever hear about it, or they manage to keep onerous immigration law pushed off a little longer. George Hackney told me that he fully believes that one of the things that kept Florida from hammering us with an immigration law this year was from information the FNGLA received from the Georgia Green Industry Association (GGIA) after they lost their battle in Atlanta. Volunteer at your State Association — they always need help.

Next, you need to be a member of the American Nursery and Landscape Association (ANLA). I know that it is expensive. May Nursery has been paying those dues for longer than I have been alive. But it's important! Some folks might visit Washington, D.C. once a year to "make the rounds on Capitol Hill," but ANLA is there every day — as are your congressmen and senators, environmental groups, and labor unions. It's important to have someone there standing up for *us*! ANLA is helping you right now, today, whether you are a paying member, or riding other Nurseries' coat-tails.

Join the Southern Nursery Association (SNA). The SNA is back in operation with its research conference, and plans for the state officers conference, as well as a "State of the Industry" workshop this winter. If you can afford it, join them all — including other states' associations. Our nursery is a member of more than ten state associations east of the Mississippi River. Is it important to May Nursery what happens in Pennsylvania, Virginia, Ohio, Georgia, or Alabama — absolutely! We are in this fight together. If my customers depend on it, then we depend on it too.

Other organizations that fight for us are the state Farm Bureau, the American Farm Bureau, your local, state, and national Chambers of Commerce, and the National Federation of Independent Business.

Get to work!

- Become knowledgeable of the issues.
- Be engaged and immersed in the policy process.
- Be open minded about solutions.
- Make things happen rather the watch things happen…or worse yet, wonder what happened.
- Understand that it is "not all about you." However, nobody is better prepared to fight this battle than you!
- Get off the bench and be a player. Do not trade a walk-on part in the war for a lead role in a cage.
- You are either at the table, or on the menu.

Selection and Production of Mexico Oaks©

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INTRODUCTION

With 161 species, Mexico has the greatest number and diversity of oak species of any country in the world (Valencia, 2004). Of these, 36 are listed as globally threatened (Mendoza, 2007). In Mexico, oak and pine forests occur mostly in mountainous regions with temperate and semi-humid climates. These temperate forests cover 21% of the country and include 24% of the recorded flora. Unfortunately, biodiversity losses from these forests have been severe, and 25% of the original temperate forests have been converted to agriculture or livestock use (Rzedowski, 1998). These forests have been determined to be vulnerable to long-term climate changes. It has been predicted that an additional 13% of the temperate forests will be lost because of the effects of climate change (Villers and Trejo, 1998). There is scant literature available on performance of Mexico oaks in Southern U.S.A. landscapes, but there is a reasonable body of anecdotal information suggesting that the oaks of Mexico deserve further evaluation and perhaps promotion north of their accepted range.

TOP PERFORMING MEXICO OAKS AT STEPHEN F. AUSTIN GARDENS

Nacogdoches is Zone 8 with an average annual rainfall of 1219 mm (48 in.). June through August is characteristically hot and dry. In 2010 and 2011, Nacogdoches experienced all-time record drought and heat. In recorded history, 1 Sept. 2000 was the record high, 44.4 °C (112 °F), and 23 Dec. 1989 was the record low –17.8 °C (0 °F). In 2005 and 2008, Nacogdoches was damaged by hurricanes with winds in excess of 139 km/h (100 mph) that toppled many large trees in our region. Lynn Lowrey (1940–1997) had much to do with many of the early plantings at the Stephen F. Austin (SFA) Mast Arboretum in the mid and late 1980s. Lynn was the consummate plantsman (Grant and Creech, 1997), quick to share plants, and the first Texan to seriously promote *Quercus polymorpha*, *Q. canbyi*, and Q. *rysophylla*. His visits to Mexico were during a different era. The countryside was friendly, the forests less disturbed, and the paperwork to move plants across the border less strident. Things have changed. While Lynn collected a wide array of plant materials, oaks held a special place in his heart. Carl Schoenfeld and John Fairey of Yucca Do Nursery also introduced many Mexican oak species to the nursery world in the late 1980s and 1990s. Beginning in 1986, a wide range of Mexico oaks were planted in the landscape of the SFA Mast Arboretum. The following represents those that have performed well for many years, organized in order of my own personal preference.

***Quercus rysophylla,* loquat leaf oak.** Our original tree was planted in 1988 as a 1-gal container and is now over 18 m (60 ft) tall, a striking specimen in full sun. Two years after establishment, the tree survived the 23 Dec. 1989 freeze [–18 °C (0 °F)], two hurricanes (2005 and 2008), and the record heat and drought in 2010 and 2011. Evergreen in our climate, the thick, rough leathery leaves are dark green and glabrous, 6 to 22 cm (2 to 8.2 in.) long, elliptical to oboval-lanceolate. New growth varies from copper to salmon color and old leaves are shed quickly in the spring. The

tree has never been affected by tent caterpillars, which have occasionally ravaged the nearby native oaks in the garden and on our campus. Loquat leaf oak is very drought resistant. Native to Nuevo Leon, Tamaulipas, and San Luis Potisi, this species is usually encountered in the mountains at mid to lower elevations. A tall tree, this species can reach over 25 m (82 ft) in height. Acorns are small, 1 to 1.5 cm (0.4 to 0.6 in.) long, pointed, in singles to several on a stout peduncle with the cup enclosing about 1/3 to 1/2 of the nut. In our region, the tree performs best in a well-drained soil and full sun. While often spelled *rhysopylla* or *risophylla*, we have chosen to reflect the original spelling by Weatherby (Weatherby, 1910), *Q. rysophylla*.

***Quercus grisea,* gray oak.** This is a rarely encountered Mexico oak with Christmas tree form to 4 to 7 m (13 to 23 ft), sometimes to 10 m (33 ft), but generally smaller in cultivation. Our oldest tree is 4.6 m (15 ft) tall in 16 years and is clean, dense, and well branched to the ground. While yet to bear acorns, this tree has weathered heat, drought, and heavy rains and remains essentially evergreen, shedding leaves as new growth begins in the spring. Two freeze events in 2010 and 2011 with temperatures both years dropping to –12 °C (10 °F) caused some leaf shedding at the top of the tree, but no stem or bud damage was evident and new growth resumed normally in the spring. Bluish-gray leaves are 2 to 8 cm (0.8 to 3.1 in.) long and 1 to 4 cm (0.4 to 1.6 in.) wide, entire, oval elliptic, with base rounded and a modestly pointed apex. Range is described as southwest Texas, Arizona, and Northern Mexico and the species prefers dry, rocky soils. Acorns are 1.2 to 2 cm (0.5 to 0.8 in.) long, usually singly or paired on a short peduncle with the cup scaly, half-round and enclosing 1/3 to 1/2 of the nut.

***Quercus canbyi,* Canbyi oak.** This is a mid-sized semi-evergreen oak that can be found in the Texas nursery and landscape trade. Our oldest specimen was planted in 1986 at the front of the SFA Mast Arboretum along Wilson Drive. It has never received irrigation and features attractive glossy foliage. It has proved to be very drought and alkaline tolerant in Texas. Sometimes referred to as the chisos oak, slender oak, or graceful oak, the range includes Nuevo Leon and Tamaulipas in Mexico, and the Chisos Mountains in Texas. The species is encountered in rocky canyons and is rarely abundant. Growth habit is 4 to 15 m (16 to 50 ft) tall and long branches are somewhat drooping, with a graceful form. Shiny green leaves are 7.5 to 10 cm (2.9 to 3.9 in.) long and 2 to 3 cm. (0.8 to 1.2 in.) wide and are lanceolate to narrowly elliptical with apex pointed. Acorns are 1.5 cm (0.6 in.) long, somewhat narrow and without a significant peduncle. The cup is shallow and covers only 1/4 to 1/3 of the cup. The nomenclature of *Q. canbyi* is complicated and there are a number of synonyms. It has been described as a variety of *Q. graciliformis* in the south of its range, northern Mexico, but most authors consider *Q. gracilformis* as a form of Canbyi oak. It is also associated with *Q. langtry*, which is also thought to be a form of *Q. canbyi* found near Langtry, Texas.

***Quercus polymorpha*, Monterrey white oak.** A medium-sized Mexico oak that is popular in Texas landscapes. The species enjoys a wide range in Mexico on the Atlantic slope and can also be found in Guatemala. In 1992, *Q. polymorpha* was discovered in a small isolated box canyon along the Devil's River near Dolan Falls in Val Verde County, and can thus be now considered a Texas native plant. In cultivation, the tree reaches 10 to 20 m (32.8 to 65.6 ft) tall and usually features an irregular form. Leaves are 6 to 13 cm (2.4 to 5.1 in.) long and 3 to 6 cm (1.2 to

2.4 in.) wide, and leaf shape can be highly variable. Acorns are 2 to 2.5 cm (0.8 to 1.0 in.) long, 1.2 cm (0.5 in.) in diameter, oblong, and are presented singly or paired on a short peduncle. Tolerant of a wide range of soil conditions, this species is now in cultivation in Europe. Monterrey white oak is closely related to *Q. splendens*, which can be found on the Pacific slope of Mexico.

***Quercus germana*, royal oak.** This cloud forest, Mexican oak is rarely encountered in the U.S.A. It is native to east and northeast Mexico, usually found at 800 to 1,800 m (2,625 to 5,905 ft). The species reaches 25 m (82 ft) tall, but should be much smaller in cultivation. We have two royal oaks over 10 years old and have been distributing acorns to interested nurserymen. Leaves are lustrous, green, and glabrous, 9 to 13 cm (3.5 to 5.1 in.) long and 3 to 5 cm (1.2 to 2 in.) wide. Leaves are persistent or semi-evergreen, oblong to oboval or oblanceolate. Acorns can be up to 4 to 5 cm (1.6 to 2.0 in.) long and 2 to 3 cm (0.8 to 1.2 in.) wide, and single on a short peduncle. Almost the entire nut is enclosed by a warty, pubescent cup. Two trees in the SFA Gardens have experienced winter freeze events less than –12 °C (10 °F) with only minor foliage damage. While wet mountainous forests describe the native habitat, the species appears quite heat and drought tolerant once well established.

***Quercus glaucoides*, lacey oak.** Lacey oaks are especially popular in central Texas. Lacey oak is a Texas Superstar™ and is promoted for the central Texas Hill country. In more eastern landscapes, the tree benefits by being planted on a berm with good soil drainage. The tree is slow growing and somewhat irregular but leaves are blue-green and quite striking. Lacey oak is native to north east Mexico (Nuevo Leon, Tamaulipas, Coahuila, and San Luis Potosi), west Texas (Edwards Plateau), and is generally found at 800 to 2,500 m (2,625 to 8,202 ft). The tree should reach 3 to 10 m (9.8 to 32.8 ft) tall. Leaves are leathery, blue-green above, paler beneath, and 3.7 to 15 cm (1.5 to 5.9 in.) long and 2 to 6 cm (0.8 to 2.4 in.) wide. Trees at SFA have been deciduous but leaves persist into the winter. Acorns are 0.8 to 1.3 cm (0.3 to 0.5 in.), ovoid, singly or in pairs to three on a 2 to 6 cm long peduncle, and the nut is enclosed $^1/_3$ to $^1/_2$.

***Quercus hypoleucoides*, whiteleaf oak or silverleaf oak.** This is perhaps the most beautiful of all oaks. This species can be found also found in North Mexico; south west Arizona; New Mexico ("Copper Mines"), and in the Davis mountains of Texas, generally encountered at 1,100 to 2,700 m (3,609 to 8,858 ft). The tree can exceed 10 m (32.8 ft) tall, but is often shrubby, 2 to 5 m (6.6 to 16.4 ft), with slender, ascending branches. Leaves are evergreen, 5 to 10 cm (2.0 to 3.9 in.) long and 1.2 to 2.5 cm (0.5–1.0 in.) wide. Leathery leaves are usually lanceolate to narrowly oval, shiny green and hairless above, densely whitish or yellowish tomentose beneath. Acorns are 1.2 to 1.5 cm (0.5 to 0.6 in.) long, narrow, singly or paired on a short peduncle and the cup encloses about $^1/_3$ of the nut. In its natural range it appears to prefer wet mixed forests and canyons and is tolerant of a range of soil types.

PERFORMANCE OF MEXICO OAKS IN THE U.S.A.

While literature related to the performance of Mexico oaks in southern U.S.A. landscapes is rare, there is some reason for optimism. In 1995, J.C. Raulston of the North Carolina State University Arboretum (now JCR Arboretum), wrote, "*Quercus* sp. (Mexican oaks) — an enormous group of widely variable plants with over half of all North American oak species occurring in Mexico. Plants range from de-

ciduous to evergreen, and from tiny groundcovers to majestic trees. All tried at this point have done surprisingly well in our nursery of heavy clay soils subject to flooding. *Quercos canbyi* is fine textured with red oak type scalloped foliage, very rapidly growing with up to 1.8 m (6 ft) per year. *Q. polymorpha* is quite variable (as the name indicates) with large, thick leathery semi-evergreen foliage, more moderate in growth with 30 to 91 cm (1 to 3 ft) per year. *Q. risophylla* is perhaps the most beautiful with heavily textured and scalloped foliage which emerges with pink-bronze color on new shoots — evergreen to deciduous depending upon winter temperatures encountered. Hardy to at least –15 °C (5 °F). Commercial potential of oaks often depends on availability of acorns for seed propagation. Early trials indicate some of the Mexican oaks have potential for cutting production."

For the purpose of this article, I queried a number of colleagues and friends — in Texas and outside — with firsthand experience growing Mexico oaks. Paul Cox, past Director of the San Antonio Botanical Garden (SABG), San Antonio, Texas, commented: "When I showed my wife Michelle her first silverleaf oak, *Q. hypoleucoides*, her comment was "It is such an elegant tree." That it is — as well as very durable. The term "regal" would have to go to *Q. germana*, the Mexican royal oak. While San Antonio is far from the cloud forests of Mexico, *Q. germana* has performed admirably here and produced several nice specimens. Loquat leaf oak, *Q. rysophylla*, does better with a little extra water but does not show signs of stress without it. Mexican white oak, *Q. polymorpha*, is the Mexican oak most commonly used in our area. Dr. Elray Nixon, retired botanist, Stephen F. Austin State University, maintained that oaks had not finished speciating out because when species from different areas were exposed to each other they crossed readily. *Quercus polymorpha* certainly bears this out. Acorns planted from the first *Q. polymorpha* in San Antonio showed signs of crossing with *Q. virginiana*, *Q. buckleyi*, *Q. laceyi*, and *Q. muehlenbergii*. While the species is as rugged as any in the land, this tendency to hybridize with our native species must surely cause the native plant purists considerable consternation. *Quercus canbyi* does very well here, and there used to be a nice representative at the SABG, but the tree has never really caught on like the others."

Mark Weathington, assistant director of the JC Raulston Arboretum at North Carolina State University, Raleigh, North Carolina. Mark wrote, "The JC Raulston Arboretum has been evaluating Mexican oaks (we're up to 18 species!) for quite a while now and they just continue to impress us. The droughts and extreme high temperatures we have experienced over the past several years have shown us that fresh water is a limited resource even on the east coast. The southwestern and Mexican oaks take this adversity without missing a beat. The evergreen *Q. crassifolia* is among our favorites with thick, heavily textured, deep green leaves providing an ideal background for the bright red new growth and yellow catkins in spring. In over a decade, we have not had a bit of winter damage to our plant. Others which have been top performers for years include *Q. polymorpha*, *Q. rugosa*, and *Q. germana*. We feel there would be a huge potential for Mexican oaks, especially the evergreen to semi-evergreen, medium-sized species, to become major players in the southeastern U.S.A. nursery industry, if a reliable seed source was available. To date, our efforts at rooting most of them have met with limited success, but we are still trying to crack that nut (acorn?)."

Bob McCartney of Woodlanders (<http://www.woodlanders.net/>), in Aiken, South Carolina (SC), wrote, "At the citywide Arboretum, Aiken, SC, we are botanically very diverse. The varied habitats, which range from swamp forests to desert-like sandhills, support many native oak species. Oaks are prominent features in Aiken's broad tree-filled parkways, in a 809-ha (2,000-acre) urban forest known as Hitchcock Woods, and on many private properties. We have been impressed with the performance of a good number of Mexican and U.S. Southwestern oaks. The mild Zone 8 climate and well-drained sandy soils in the City of Aiken provide good growing conditions for not only the native oaks but a very wide range of oaks that are native elsewhere. For over 30 years Woodlanders, Inc., a rare plant specialty nursery located in Aiken, has planted a great variety of rare trees throughout the city. One notable group is the genus *Quercus* with oaks from throughout the Northern hemisphere. Aiken has been credited by the International Oak Society with having the most comprehensive collection of oaks in the U.S.A. Almost all U.S.A. species plus many of the species native to Mexico, Europe, the Middle East, and Asia are represented in this growing collection. Specimens range from large venerable trees to recently planted rare species."

Eric Hammond of Heritage Seedlings (<www.heritageseedlings.com/>) in Salem, Oregon commented that they are constantly looking for new plants for the landscape and Mexico oaks are making their mark. He remarked that, "Some of our favorites include *Q. hypoleucoides* because of its great form and the clean foliage, and *Q. crassipes*, which is totally unavailable, is very hardy here in western Oregon and is breathtakingly beautiful. Its evergreen foliage is glossy while the undersides are covered with brown fuzz and the bark is even beautiful; it just does not get better. *Quercus greggii* and *Q. mexicana* both do well too. We think that there are a great number of Mexican oaks that will perform well here in the U.S.A. Northwest and the only limiting factor is the availability of seed. Also we are producing *Q. canbyi*, *Q. polymorpha*, *Q. mexicana* (grows very well in western Oregon), and *Q. rysophylla*. And undoubtedly there are others we should produce but are not. There are many oaks native in the west and few are used to their full potential. Mexico is just an extension of that, with an international border and a few banditos tossed in."

Sean Hogan of Cistus Nursery, (<http://cistus.com/>) in Portland, Oregon adds, "Both personally and at the nursery, Mexican and Southwest oaks have been of great interest. As street trees in Portland, along with the western summer-dry oaks, we have been using several drought-resistant Mexican species (including those from the southeast Arizona to Big Bend, Texas). As Portland receives about 508 to 914 mm (20 to 36 in.) of rainfall yearly, and that nearly entirely between November and March, weaning the city off high water, cold-requiring mostly eastern deciduous species is a major goal. As well in an area of winter growth, more use of broadleaf evergreen decreases the dreary look of a nearly all deciduous canopy. Favorites have been *Q, hypoleucioides* (now an official street tree), *Q. fusiformis* (syn. *Q. virginiana* var. *fusiformis*), *Q. polymorpha*, *Q. canbyi*, *Q. rysophylla*, Q. *mexicana* (with its beautiful horizontal branch pattern), *Q. arizonica*, *Q. laceyi*, *Q. rugosa*, and the related *Q. greggii* as a very nice 7.6-m (25-ft) avenue tree. *Quercus crassifolia* with its elephant-skin-like bark, furry indumentums, and shocking pink new growth, and Lynn Lowrey's lost oak with an almost miniature red oak look but for bronze red color on evergreen leaves in winter, and with spring flushes. These are the best so far!"

Gary Foss, Oaks of the Wild West (<www.oaksofthewildwest.com/>) in southeastern Arizona recently wrote: "Dave, you asked about my favorite oaks. I'm at 1,341 m (4,400 ft) here in southeast Arizona and we have hard freezes. My best performers are specimens of *Q. hypoleucoides*, *Q. emoryi*, *Q. fusiformis*, *Q. buckleyi*, *Q. shumardii*, *Q. canbyi*, *Q. robur*, *Q. muhlenbergii*, *Q. petraea* (Europe), *Q. rysophylla,* and *Q. polymorpha*. I have small *Q. vaseyana* and *Q. wislizeni*, so I'm not sure about them yet."

PROPAGATION

In our region, Mexico oak acorns are harvested on the tree or shortly after they fall as fallen acorns are soon quickly infested with weevils. We have also observed Mexico oak acorns germinating while still attached to the tree (vivipary), particularly when wet, humid conditions accompany acorn fall. Our general strategy is to harvest acorns in late November and sow in tubeling flats that are kept cool and moist in the shade house — or are placed in a heated greenhouse for the winter. We have learned through experience that care must be taken not to overwater. Germination and emergence has been erratic for most species of Mexico oaks, some germinating immediately while others take months to emerge. We have made a few modest attempts at cutting propagation of the evergreen Mexico oaks and have yet to achieve any success. While hybridization is certainly a problem, we have been surprised at the uniformity of most of the seedling plants derived from Mexico acorns collected in the gardens. A major impediment to expanded use of many of the Mexican oaks is — and will continue to be — the availability of acorns.

CONCLUSIONS

The oaks of Mexico are relatively unexploited in the nursery and landscape trade and there is scant literature on their performance in the southern USA. Yet, there is a gathering body of mostly anecdotal evidence, which suggests optimism for expanded use in Zones 7 to 9. With hotter summers and extended droughts predicted, Mexico oaks may find increased popularity as landscape trees as their performance under those conditions becomes more widely known.

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Tea Oil Camellia: A New Edible Oil Crop for the United States©

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INTRODUCTION

Camellia oleifera has been cultivated in China as a source of edible oil, but there is no documentation that the crop has ever been grown for edible purposes in the United States. This species has been used as a parent of hardy ornamental camellia hybrids in the USA since at least the late 1970s; the U.S. National Arboretum having released more than a dozen such cultivars (Ackerman, 2007). However, these cultivars are grown and used only as ornamental landscape plants. Traditional row crop agriculture is in need of new crops for the southeastern U.S.A. In 1999, I initiated a research program to evaluate *C. oleifera* as a commercial oil seed crop for the southeast (Ruter, 2002).

Considerable research is being conducted to develop agricultural crops with high levels of oleic acid due to oleic acid's ability to help reduce low density lipoproteins (LDL, or "bad cholesterol"). The percentage of oleic acid in *C. oleifera* oil typically ranges from 75 to 85% (Shanan and Ying, 1982; Xia et al., 1993). In China, tea oil is known as "eastern olive oil" (Zhang et al., 2008). Olive oil, which also contains a large percentage of oleic acid, has been reported to reduce the risk of cancer (Anonymous, 2005a) and the U.S. Food and Drug Administration have approved the health claim for olive oil to fight heart disease (Anonymous, 2005b). One study reported that the oleic acid content of olive oil was 81.6%, while that of tea oil was 85.3% (Weng, 2003). Gao (1993) reported that tea oil can reduce serum triglycerides and increase high-density lipoproteins (good cholesterol) in humans. Recent research at Clemson University (Chen, 2007) has shown that camellia oil and camellia oil meal had different levels of antiproliferative activities against three lines of cancer cells (human uterus, human breast cancer, and human colon cancer). Antiproliferative and antioxidative bioactivities of the meal have been attributed to kaemperol, kaemperol glycosidic flavinoids, saponins, and five-ring tripterpenes. Squalene, a triterpenic hydrocarbon, is found in olive oil and camellia oil (Li et al., 2006) and is known to have antitumor and anticarcinoma activities. Camellia oil and its meal are known to have antioxidant, antimicrobial, and other bioactivities.

In addition to oleic acid, tea oil contains several other fatty acids, including stearic, palmitic, linoleic and linolenic acids (Xia et al., 1993; Zhang et al., 2008). Tea oil also contains several trace elements as well as Vitamin E and selenium. Camellia oil was found to have better stability against oxidation compared to olive and corn oils, while having suitable nutritional values (Chen, 2007). In addition, the smoke point for tea oil [252 °C (485 °F)], is reported to be higher than that of extra-virgin olive oil [161 °C (322 °F)], which makes it better for cooking over high heat (Anonymous, 2007).

Tea oil is a good raw material for industrial uses and is used to manufacture soap, margarine, hair oil, lubricants, paint, synthesis of other high-molecular weight

compounds, and rust-proof oil. Camellia oil has been proven to have its place in all emulsions used in the cosmetology and dermopharmacy fields (Sabetay, 1972). Uses include day or night creams, anti-wrinkle compounds, lipstick, hair creams, make-up, anti-sun preparations, rouge, and make-up remover products. Extraction of the fruit hulls also yields useful compounds such as saponins, tannin, and pentosan. Saponin is used as an emulsifying agent in pesticides, for foam-forming fire extinguishers, and in detergents (Shanan and Ying, 1982). Extracts from the residue of tea oil processing have also been used to feed livestock and are used to formulate pesticides, feeds, and fertilizers. The triterpenoid saponin from camellia has been shown to improve immune function, enhance antibacterial and antiviral activities, and to have antimutation and antioxidation properties in humans and animals (Zhan, 1999).

Tea oil residues have been used for effective control of the following pests: rice blast, sheath and culm blight of rice, wheat rust, rice hopper, cutworms, cotton aphids, scale insects, long-horned beetles, and leeches (Shanan and Ying, 1982). Extracts of the seed cake left over after processing are known to deter larval development in insects (Duke and Ayensu, 1985). The possibility of developing new biologically based pesticides exists for this product. Tea oil camellia appears to have few pests and may be suitable for organic production as well.

In China, tea oil camellia occurs from 18° to 34° North latitude and grows on acidic soils where mean January temperatures do not drop below 2 °C (Shanan and Ying, 1982). Extensive provenance trials were conducted in China in the 1960s and 1970s (Fang, 1994). Elite plants were selected numerous local cultivar trials were installed. Families were selected for superior fruit production and selections were made for different parts of China. Superior clones in regional tests increased oil production 3 to 5 times compared to local seedling stands (Zhuang et al., 1992). Tea oil camellia should be well adapted to the lower Piedmont and Coastal Plain regions of the southeastern United States.

PROPAGATION BY SEED

Little information exists regarding the requirements for germination of tea-oil seed. One study suggests that seed should be stored at a low temperature (0.0 to 2.0 °C) for 15 to 30 days (Han, 1984). Germination was accelerated by keeping the seeds between 20 to 25 °C. Plants were suitable for transplanting 25 to 35 days after sowing. Bill Ackerman suggests that tea-oil camellias need a minimum of 5-weeks cold, moist stratification to ensure decent germination (pers. commun.). For camellias in general, Tourje (1958) suggests that germination occurs within 10 to 30 days with an ideal temperature of 18.3 to 21.1 °C. Nonstratified seed of *C. oleifera* germinates slowly over a longer period compared to stratified seed (J. Ruter, pers. observation).

Seed from open-pollinated *Camellia oleifera* 'Lu Shan Snow' were collected, sorted, and placed in zip-lock plastic bags with moist pine bark for cold stratification periods of 15, 30, 45, and 60 days at 4.4 °C. Only seeds that sank during a float test were used. After the stratification period was complete, seed were planted in 60 cell trays (cell size of 4.5 cm wide by 10.0 cm deep) with a substrate of pine bark and sand (8 : 1, v/v). Seeds were covered to a depth of ~1.0 cm. Trays were randomly placed in a growth chamber with set temperatures (12 h) of 24 °C day and 18 °C night. Light intensity measured at the top of the germination trays was ~900 $\mu mol \cdot m^{-2} \cdot s^{-1}$ during the 12-h-day period. Germination was recorded daily

for 60 days as the visual emergence of the shoot from the substrate (Capon, 1990). Treatments consisted of four stratification periods with six replications consisting of 10 seeds per replication, for a total of 60 seeds per treatment. Replications were randomly assigned within germination trays. Data was analyzed using the nonlinear regression function of SigmaPlot.

Days to germination decreased curvilinearly as cold stratification period increased from 15 to 60 days [(days to germination = 60.1 – 0.89 (days of cold stratification) + 0.0084 (days of cold stratification)^2), $r^2 = 0.99$]. Seed stratified for 15 days germinated in 49 days compared to 31 days for seed receiving 45 and 60 days of cold stratification. Seed germination exceeded 96% for all four treatments.

Seed from *C. oleifera* 'Lu Shan Snow' germinated in high percentages in this study. Cold stratification for 45 to 60 days appears ideal for this species. Differences in days to germination compared with other studies may have been due to different methods (Han, 1984; Tourje, 1958) or determining that germination had occurred when radicle extension was visible versus visible shoot growth. For general production of seedlings, we have found that Beaver Styroblocks (Model 45/340, Stuewe & Sons, Tangent, Oregon) which have 45 cells each with a depth of 15.2 cm work very well, especially when treated with SpinOut®.

PROPAGATION BY CUTTINGS

One- to two-node cuttings from 28 elite selections were stuck by a commercial propagator (Innova Farms, Boston, Georgia) in July of 2010. A minimum of 38 cuttings per selection were used and each cutting was treated with a 3500 mg • L^{-1} quick-dip of Dip'N Grow® rooting hormone. The propagation substrate consisted of aged pine bark, perlite, and peat moss (7 : 2 : 1, by vol) amended with 3.6 kg • m^{-3} of Osmocote Plus 15-9-12 propagation blend. Plants were misted as needed and mist frequency was reduced when good callus formation was noted. When plants were shifted up in March of 2011, percentage rooting per selection ranged from 74% to 100% for an overall average of 93%. Shading (30% to 55%) and a low rate of controlled-release fertilizer appear to be the best treatments for growing off rooted cuttings in #1 containers in south Georgia. In a recent study using low plastic tunnels without mist, the highest rooting rate was 55% for a single clone (Zhang et al., 2009). In China, commercial rooting rates of 90% have been achieved using hormones at 3,000 mg • L^{-1}. Hypocotyl grafting is becoming an increasingly popular method of clonal reproduction in China with success rates often reaching 95% (Zhang et al., 2008).

CONTAINER PRODUCTION

In south Georgia, seedlings shifted to #1 containers (3.8 L) grew best when grown under 30% shade cloth, but good survival was possible with plants grown in full sun or under 55% shade. Chlorophyll fluorescence data indicated that plants grown in full sun during the summer were not physiologically damaged by high light conditions (Ruter, 2002). For plants grown in full sun, growth rate increased as fertilizer rate increased from 0.9 kg N/m^3 to 1.5 kg N/m^3. Plants treated with 8 month Osmocote grew better than plants treated with Multicote (Ruter, unpublished data). In another study using 12 month Polyon 17–5–11 controlled release fertilizer, 90% of maximal growth was achieved with 19 g of fertilizer per pot, while maximum growth occurred between 24 g to 30 g per #1 (3.8 L) container (Ruter, unpublished

data). Further studies in Georgia have shown that the addition of lime and micronutrients have little influence on plant growth if a controlled-release fertilizer with micronutrients is used.

FIELD PLOTS IN GEORGIA

Field trials were initiated in 2003–2005 at The University of Georgia Tifton Campus and at Jackson Farms Greenery in Wrightsville, Georgia. Approximately 1,200 seedlings from five different species were planted from #1 (2.8 L) containers using a field spacing of 1.8 m within the row and 3.7 m between rows. Plants in Tifton are irrigated as needed using drip irrigation. After 4 years of harvest in Tifton and 3 in Wrightsville, results indicate that selections are possible which annually produce >3.0 kg fresh weight of fruit per plant. Future plans include clonal selection and evaluation, economic and market analysis, harvesting and processing research, and studies on oil quality, biodiesel production, pharmaceutical, medical, and nutritional uses for this crop.

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Great Plants for Southern Gardens That Missed the Marketing Push©

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INTRODUCTION

The JC Raulston Arboretum (JCRA) has a 35-year history of collecting and evaluating new plants for introduction to the nursery industry. New plants drive the industry especially those that have a marketing push behind them. Many great landscape plants get passed over in the rush for the latest and greatest but deserve a second look.

The JC Raulston Arboretum (JCRA) has grown from the first plant the JCRA planted in the mid-1970s. Conifers which were not supposed to survive in the south have grown into mature specimens. Gardens and collections have been planted, grown up, torn out, and re-established. Students have been the mainstay of the arboretum development and have done a great job when given adequate direction.

The JCRA's collection holds many great landscape plants that may never make it to the mainstream due to propagation difficulties. Other plants have shown they have great potential for the south.

DECIDUOUS SHRUBS

Rhododendron 'Yoshino' has proven its worth in the arboretum with leathery, semi-evergreen foliage and trusses of bright flowers in March. The growth habit is much different than many other evergreen azaleas and is used extensively as a hedging plant in Japan. *Hydrangea hirta* is an underused member of the genus that suffers from not having the sterile florets of other landscape hydrangeas. The glossy, pale green foliage, powder-puff flower clusters, and great habit make it worth its place in the garden. *Corylopsis* is well known to plant enthusiasts but the dwarf *C. gotoana* 'March Jewel' from Camellia Forest could be a big hit with the general public. Growing 6 m × 1.5 m (2 ft × 5 ft) with primrose yellow flowers, pest-free blue-green foliage, and butter yellow fall color 'March Jewel' is sure to be a hit. *Lindera triloba* is a little known Japanese shrub with reddish new growth and brilliant fall color. Even less well known is the die-back fig, *Ficus gasparriniana* var. *laceratifolia*. Small figs turn bright red in fall and complement the roughly serrated foliage.

TREES

Maples are well established as landscape specimens but there are relatively few species that are smaller than *Acer rubrum* but larger than *A. palmatum* which are commonly grown. *Acer mono* deserves to be grown more widely. Its great form, fall color, urban tolerance, and size make it perfect for many applications. *Cornus wilsoniana* is another overlooked tree that shows promise with flat clusters of white flowers, blue fruit, spectacular bark and semi-evergreen foliage. For a more familiar species, *C. florida* 'Suwanee Squat' has been a great grower for us, and is 0.6 to 0.9 m (2 to 3 ft) tall and 1.5 to 1.8 m (5 to 6 ft) wide. It covers itself with broad

bracted flowers. It has good mildew resistance, good fruiting, and good fall color. Some have had trouble with it in the garden, but ours and propagules from it have been strong growers. It fills a 1-gal container in 1–2 seasons from cuttings. Less well-known, but very impressive, is *Meliosma parviflora*. It has white, panicles of scented flowers like astilbe give rise to masses of candy, apple red fruit. As attractive as the fruit is, the bark is even better. It can be propagated by seed or softwood cuttings taken from late May to July. *Styrax* has made its mark in the trade, but its relatives are mostly absent. *Sinojackia xylocarpa* 'La Grima' (Styracaceae family) is an upright form from Highland Creek Nursery. Masses of white flowers are as showy as almost any other spring-flowering tree with good yellow fall color. It is propagated by softwood cuttings in late May to early June, or by semi-hardwood cuttings in late June to July. Cuttings taken later in the season must be kept above –4 °C the first winter to ensure survival.

EVERGREENS

Space is a premium in many landscapes both residential and commercial. Upright plants like *Juniperus formosana* deserve wider use where the narrow form but relaxed branching is especially nice. It can be difficult to root, but semi-hardwood to hardwood cuttings with bottom heat and 8,000 ppm K-IBA seem to root well. Another upright plant with potential is the holly, *Ilex buergeri,* with reddish new growth, narrow habit, and red fruits on female forms. It is propagated by hardwood or softwood cuttings during most of the year. Another holly with potential for southern gardens is the entire-leafed *I. rotunda* with glossy, thick textured foliage and large fruits. *Cephalotaxus harringtonia* 'Mary Fleming' is perhaps the most prostrate of any plum yew growing low with a distinct layered form. It is propagated by hardwood cuttings. *Mahonia gracilis* is a non-spiny species from Mexico with glossy foliage and a rounded habit. Bright gold flowers are held on red peduncles and followed by blue fruit. It can be propagated by seed or hardwood cuttings. Another rounded evergreen shrub, but with much finer texture, is *Pittosporum parvilimbum* with yellow, somewhat fragrant flowers. It can be grown as a small tree or cut back to keep small. It is perhaps one of the hardiest of the pittosporum and easily propagated by softwood to hardwood cuttings. *Metapanax davidii* is a much confused and mis-identified plant in gardens and literature, this fatsia relative sports simple to 3-lobed leaves on a mounding evergreen shrub or small tree. There is considerable variation in plant size, shape, and leaf morphology over the plant's native Chinese and Vietnamese range.

VINES

Vines can be a tough sell, especially those that don't have big flowers but a pair of vines that have potential are the evergreen *Kadsura longipedunculata* and the deciduous *Heteropterys glabra.* The former grows densely making it perfect for covering an arbor or screen. Creamy white flowers are held on long stalks below the foliage followed by rounded clusters of red flowers. The latter, a scandent plant from Uruguay, starts flowering early with yellow flowers which continue until frost. The flowers are followed by red samaras that are almost identical to maple fruits but held in 3s, instead of pairs. The flowers and fruits combine for an interesting display. Young plants may die back to the ground. Both can be propagated by cuttings, the *Heteropterys* is also quick and easy from seed.

HERBACEOUS PLANTS

While the JCRA concentrates on woody plant material, some herbaceous plants catch our eye. *Gloxinia nematanthodes* 'Evita' (syn. *Seemania* (*Sinningia*) *nemanthoides* 'Evita'), a gesneriad, is a bright red-flowered perennial for shade which spreads rapidly and has attractive velvet foliage. It is propagated by dividing the scaly rhizomes. Recent JCRA trips to Taiwan have led to new plant selections which are showing potential. The deep green strappy foliage of one collection of *Dianella ensifolia* is attractive, has so far proven to be hardy, and has garnered much attention from visitors. Another Taiwan introduction, *Sedum nokoense,* makes an attractive, tight mound with gold flowers and burgundy tinted leaves. It should be grown on lean soils to avoid flowering itself to death.

While new plants always bring excitement to the garden and the nursery, lesser known but exceptional plants that missed the market — still hold out promise.

Nothing Very New: The Perpetuation of Successful Plants for the South©

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INTRODUCTION

The horticulture industry and gardening are a lot like the fashion industry. Both always have to come up with a new trend, present something different, or make an imaginative statement to excite and keep the public's interest. However, when it comes down to it, landscapers and the average gardener want plants that can stand up to a certain degree of neglect, can survive inexperienced and unknowledgeable maintenance crews, and still have the ability to provide a "WOW factor" with an expected and understood degree of longevity and dependability.

In fashion, when a lady requires a perfect look for an important event, she will pull out a classic black dress and her best string of cultured pearls. A gentleman will don a well-tailored suit, a perfectly starched shirt, a silk tie — and stylishly arrive in a Lincoln Town Car or silver Mercedes.

For success in horticulture, you are always going to depend on and select from your palette of plants that are "tried-and-true" and have stood the test of time, using the new introduction as an occasional accessory to the total look.

BEFORE PERENNIALS WERE COOL

There was a time when perennials were not in the mainstream of horticultural marketing and production. There was a time when everything that was a perennial was new, unfamiliar, and virtually unavailable. I know. I was there!

In 1977, when my late partner Marc Richardson and I started Goodness Grows, there were very few reliable sources for perennial plants or seed throughout the country and even less information on propagation, cultivation, and their performance in the South. Many of our earliest offerings were obtained from other gardeners who eagerly shared their plants, and thankfully their knowledge of how to grow and propagate them.

I remember calling the American Peony Society in those early years to get their recommendations on which peony cultivars would be best for the South. The woman on the phone said in her stately tone, "Peonies do not do well in the South…." I thanked her for her time and expertise and told her she was probably right and that it must have been "pee-OH-neez" in grandmother's backyard and not peonies.

Marc and I decided to plant trial gardens in order to observe, learn, and educate ourselves and others about what to expect of a plant's performance after so many years in the landscape. It was also imperative for us to maintain stock plants for divisions, cuttings, and seed in order to ensure our ability to perpetuate our offerings.

CHANGES IN THE PERENNIAL MARKET

What a difference 30-plus years have made in the horticulture industry! The availability of plant material and the knowledge of the average consumer, grow-

ers, garden center operators, educators, and industry leaders are greater now than ever before. Thirty-something years ago, every aspect of the perennial market was wide open, and it was exciting to be a pioneer and experience the wonder and fascination of a newly emerging trend offering a variety of plants to a virginal marketplace and to an industry yearning for something different and interesting. The search for new plants continues to this day. New cultivars are continually being introduced, the result of careful breeding and selecting and the astute observations of growers, horticulturists, and gardeners.

We were always thrilled when somebody was interested in buying an unfamiliar plant and happy to share our plants and our knowledge so the market would grow, a sentiment also expressed by Don Shadow on one of his early visits to our nursery. Now, it seems almost every new plant introduction is patented or branded in some way making it more expensive to grow, more expensive for the public to buy, and not necessarily any more garden-worthy than an older cultivar — just different. Many times the new introductions that shine and stand out in mass production fall short when it comes to dependability and longevity in the landscape. Can any of you think of a good example of what I am talking about? I'm sure you can!

SERVING THE WHOLESALE AND RETAIL TRADE

As a grower who serves both the wholesale and retail trade, I find customers may be interested in a few of the new patented introductions and willing to pay the higher price associated with that marketed brand; but, more often than not, they are going to opt for the less expensive cultivar which has been around for a long time. Not only do I sell fewer of the patented, trademarked, branded cultivars because of the cost, it is much more cost-effective to grow the ones that are not. For me, it has always been more prudent to maintain stock on the plants we propagate and produce our own cuttings, seed, and divisions instead of relying on outside sources. Typically, what a supplier offered a few years back has been replaced by a new, patented cultivar, or is no longer available at all.

Once, at a trade show, I was accused by an attendee of always growing "the same old stuff." I chose not to take that as criticism, but as a compliment. I explained that I felt it was a much greater challenge to be consistent with our offerings than it was to only have the newest thing on the market. To a landscape architect or landscape designer, there are few things more frustrating than to request a classic palette of plants for an important project only to find they are no longer available from the grower because the fashion has changed — and not always for the better.

At Goodness Grows, we produce a least 85% of the perennials we offer from stock we maintain at the nursery. The other 15% is material which is brought in as seed, bare-root material, or plugs. About 20% of our production is done from seed and the rest from stem or root cuttings, or divisions. Propagation at Goodness Grows is done year-round by talented staff members who have been with me for over 2 decades.

INTRODUCTION OF NEW CULTIVARS

Over the years we have introduced 25 different cultivars of herbaceous and woody plants. Many have become mainstays and even common namesakes in the industry. Many of you are familiar with our *Achillea millefolium* 'Oertel's Rose',

Dianthus 'Bath's Pink', *Veronica* 'Goodness Grows', *Vitex agnus-castus* 'Shoal Creek', and *Lantana* 'Miss Huff', to name just a few. Some of our earlier introductions have even been "re-introduced" by others under different cultivar names.

Marc and I discovered *L.* 'Miss Huff' after two of the coldest winters on record in 1983 and 1984. Ms. Ruby Huff had planted the original in the late 1950s. The plant is still growing at her home in Crawford, Georgia, about 50 years after it was originally put in the ground. That is truly a long-lived perennial!

Introduced in the spring of 1984, *L.* 'Miss Huff' is the most cold-hardy *Lantana* on the market and is the standard by which winter hardiness is measured in all other lantanas and has stood the test of time in landscapes across the southern United States. Selected for a research program by the University of North Carolina to discover what makes this *Lantana* unique, they determined it had an extra chromosome in its DNA other Lantanas did not have. They also discovered it was male-sterile and female-fertile, which has allowed it to be used for breeding its hardiness into newer cultivars.

Veronica 'Goodness Grows' and *V.* 'Shoal Creek' were both selections made from crops we grew from seed. Each was chosen from the rest because of its individual distinct attributes which stood out from all the others.

Dianthus 'Bath's Pink' and *A.* 'Oertel's Rose' were both pass-along plants shared with us by fellow gardeners who had cultivated them for years and recognized in them the beauty, sturdiness, and steadfastness that made them worthy of being in the marketplace.

PROPAGATION OF PERRENIALS

Many of the plants we grow from seed and from which we harvest our own seed include: *Baptisia australis*; *B. alba* (syn. *pendula*); species coneflowers like *Echinacea pallida*, *E. paradoxa,* and *E. purpurea*; *Hibiscus coccineus* and *H. coccineus* 'Albus'; *Hosta plantaginea*; mixed seedlings of the Japanese iris, *Iris ensata*; and other iris species such as *I. pseudacorus*; lilies like *Lilium philippinense*; *Lobelia cardinalis*, and *L. siphilitica*; and *Rudbeckia fulgida var. sullivantii* 'Goldsturm'.

Some plants that are done from stem or root cuttings include: *A. millefolium* 'Oertel's Rose' and *Leucanthemum ×superbum* 'Becky' (syn. *Chrysanthemum ×superbum* 'Ryan's Daisy') — and generally acknowledged to be the best "Shasta Daisy." This Shasta daisy was given to us in 1982 by the renowned garden designer, Ryan Gainey, who also shared *C.* 'Ryan's Pink' and 'Ryan's Yellow'. Other vegetatively produced plants include *Dianthus* 'Bath's Pink', *Phlox* 'Common Purple', and *Helianthus* 'Marc's Apollo'. 'Marc's Apollo' is a seedling selection made from a cross between *H. angustifolius* and *H. giganteus* 'Sheila's Sunshine' and named for my late partner Marcus Amos Richardson who died of lung cancer in February, 2008.

Some of those which are divided with crowns and roots include plants like the ginger lilies, *Hedychium coronarium* — which, by the way, is from the same stock Marc and I originally obtained 33 years ago from his grandmother's garden in Donalsonville, Georgia, Marc's hometown located in the southwestern corner of the state. Also propagated this way are *H.* 'Elizabeth' and *H.* 'Pink V', all the daylily cultivars we grow such as *Hemerocallis* 'Big Bird', irises like *I. cristata* and the named cultivars of *I. ensata*, *R. laciniata* 'Herbstsonne', and *Stokesia laevis* 'Mary Gregory' and selections of blue and white *Stokesia* seedlings. Currently, I am working on

introducing a new dwarf, weeping *Metasequoia glyptostroboides* 'Little Lace' — perfect for urban landscapes and always keeping a keen eye out for improved seedling selections while having a never-ending debate about the pervasive patenting and branding which has now become so fashionable in our horticultural industry. I am always thankful for my attentive and watchful staff for all their help and support.

It has been my pleasure today to share a sampling of the plants we produce at Goodness Grows, most of which we have been growing for well over 30 years. For many of you, they are probably nothing really very new.

Ornamental Blueberry Breeding at The University of Georgia: Surround Yourself With Flavorful Beauty©

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For nearly 70 years The University of Georgia (UGA) has been involved in commercial blueberry cultivar development. There has been great success with the effort, and a strong viable industry exists due largely, in part, to the research. With the growth of the commercial blueberry industry has come an increased interest from homeowners and consumers in having blueberry selections for their use as well. In fact, a rapidly growing movement across much of the U.S.A. is to have edible garden and landscape plants. Coupling edibility with attractive ornamental traits adds even more value to the plant material. The expectation is that consumers can "surround themselves with flavorful beauty."

In 2005, we initiated a pilot effort for selecting blueberries for the edible ornamental/home garden consumer. The effort quickly gained momentum from the ornamental industry, and is thus being expanded and becoming a second major effort of our UGA Blueberry Breeding Program. We are seeking a diversity of plant types for this industry that are specifically ornamental in nature. Traits being sought include compact plant habits, colorful berries, novel plant characteristics, and attractive foliage. Blueberry cultivars for these markets do not need typical commercial production attributes such as concentrated ripening and fruit quality traits for long-distance shipping. Therefore, this entire effort is substantially different than the commercial production evaluations we have done for years. To this end, we have begun to partner with some leading ornamental nurseries to provide us input and test our edible ornamental selections for their potential growing and marketing conditions. We now have more than 100 ornamental blueberry selections we are evaluating. This summary contains comments and photos from some of the more interesting ornamental blueberries as of 2011.

We currently have two released cultivars that have been, or are being, patented and licensed to ornamental nurseries. The first of these cultivars, *Vaccinium corymbosum* 'TH-682', Blue Suede™ southern highbush blueberry (USPP 21,222) should be available in Spring 2012. This new homeowner blueberry cultivar offers striking sky blue fruit and beautiful fall foliage color development for added attraction (Fig. 1). It flowers in late March to early April in south and middle Georgia, and ripens in late May to mid June. The cultivar is exclusively licensed to McCorkle's Nursery, Inc, and has become part of their Gardener's Confidence Collection. More information can be found at: Gardeners Confidence Collection — Blue Suede® southern highbush blueberry (<http://gardenersconfidence.com/Blue_Suede/Variety.aspx>).

Our second ornamental release is *V.* Summer Sunset™ (T-885, USPPAF), a blueberry hybrid (*Vaccinium* sp.) containing mostly rabbiteye (*V. ashei*) germplasm. This new blueberry cultivar has great appeal based on its multicolored berries. An accent of sunset orange fruit, draped against a backdrop of nonglaucous, deep green foliage is present on the plant through much of the spring (Fig. 2A). As the fruit

Figure 1. Blue Suede™ southern highbush blueberry sky blue fruit and colorful fall foliage.

Figure 2. Summer Sunset™ ornamental blueberry plant (A) and fruit (B) growing in South Georgia.

begins to ripen, berries develop a richer orange hue, followed by a deep red, until eventually the ripe berry turns midnight blue (Fig. 2B). The presence of the array of berry colors makes for good curbside appeal, and the mature fruit are very edible, with a full flavored blueberry taste. This plant continues to grow well at test sites in both south and middle Georgia. It tends to flower around the middle of March, with fruit beginning to ripen in early to mid June. Fruit ripening is protracted, so consumers can have a steady supply of fruit and color for several weeks during the early to mid-summer months. We expect this new cultivar to move quickly in the ornamental trade, hopefully, opening doors for a whole new product line of attractive ornamental blueberries. Summer Sunset blueberry has been exclusively licensed to James Greenhouse and Agri-Starts, Inc., in the U.S.A. Look for promotions concerning this new ornamental cultivar to begin in 2012.

In addition to the two new ornamental blueberry releases mentioned above, we have a number of exciting new selections under evaluation. We have several additional selections with various patterns of berry colors. A standout for 2010 and 2011 has been TO-1098 (Fig. 3). The berries have a brick red contrast with the medium green foliage for much of the late spring and early summer (Figs. 3A and 3B). As the berries begin to ripen, they too turn various shades of yellow, orange, and red before becoming midnight blue at full maturity. The plant structure for TO-1098 is

somewhat more upright than Summer Sunset blueberry. Also, berries mature 2 or more weeks after Summer Sunset blueberry, offering a later season multi-colored berry. Overall growth of the plant was very good in 2010 and 2011 at both the Griffin and Alapaha test sites. However, the selection is relatively new, and we will continue to evaluate for a few more years.

Compact or dwarf plants often have considerable appeal to consumers due to less space being required, and overall look for certain landscape settings. We are currently developing new dwarf edible blueberries. The selection TO-1088, which continues to perform well, is shown in a series of photos depicting a 1-year cycle in Figure 4. Note Figure 4A shows plants in late summer 2009 with a nice compact, full growth habit. Following in January 2010, Figure 4B shows that TO-1088 has great winter color in South Georgia, maintaining foliage cover throughout the winter in that location. By early spring, the compact plant is in full flower (Fig. 4C), and by early summer, very tasty fruit are present on the compact hedge. We are excited about this selection, and look to accelerate testing. In a limited trial TO-1088 was grown in a nursery setting from October 2009 through October 2010. The selection filled in nicely over the course of the year. Thus it appears the selection would make an attractive plant in containers as well. We have propagated this selection for further testing. Besides the selection TO-1088, we have several new selections and seedlings coming along with a range of looks that also have the compact plant growth habit.

In addition to the selections described above, we also have various new blueberry selections with a range of home garden appeal. A couple of large-fruited southern highbush selections are being looked at for the home garden market (TH-681 and TH-770). These both tend to be intermediate compact plants with beautiful displays of fruit. Berries are highly flavored, and plants should make an overall attractive shrub. We also have interesting small-fruited blueberry selections such as TO-1202 that may make a great home gardener type for those desiring a flavorful, but small berry. We continue to explore numerous selections similar to these for overall growth habit and adaptation to varied environments.

Finally, we are looking for various blueberry selections that have a good plant type, nice fruit during harvest, and attractive foliage for extended appeal. In 2011, several selections showed good foliage color development. The selection TH-663 is a southern highbush with flavor ratings among the highest for our blueberries, and it has good fall color development. The selection TH-889 is a nice southern highbush selection with early ripening fruit, large berry size, and sky blue color at berry maturity, and it too develops good fall leaf color. Two rabbiteye selections, T-1223 and T-1226, have notable silver-blue foliage.

In summary, we have a number of new ornamental blueberry selections under development at UGA. We continue to look for unique plant types and combinations of traits that appeal to consumers from both an edible and ornamental perspective. Our goal with this entire effort is to have consumers surround themselves with flavorful beauty. The effort will continue in the years ahead, with new selections yet to come.

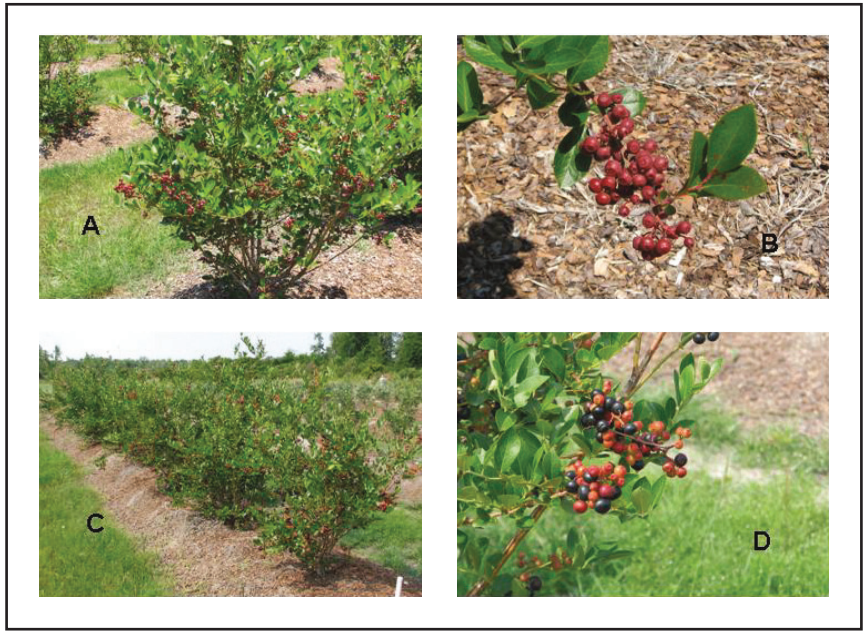

Figure 3. Colorful ornamental blueberry TO-1098 at different stages in Alapaha, Georgia during 2011. Sequence is (A) and (B) Mid-May; (C) and (D) Mid-June.

Figure 4. Dwarf ornamental blueberry TO-1088 development sequence at Alapaha, Georgia during 2009 and 2010. Sequence is (A) August, (B) January, (C) March, and (D) May.

Grafting *Ilex* for Increased Vigor and Durability©

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INTRODUCTION

Numerous forms of *Ilex* have been assembled over the years at Hefner's Nursery for evaluation. Variegated leaf forms, slower growing forms, and forms with unique habits such as fastigiate or pendulous growth have been entered into trial for evaluation. Although all of the *Ilex* in trial can be easily rooted at the proper time of year, many have not grown off well in container or field production. This is primarily due to the lack of vigor in the root system. Factors such as heat in container production and compact clay soils in field production have lead to the lack of durability in these unique and marketable plants. In the year 2000, grafting of some of these hollies was tried on a small basis to evaluate potential for increased vigor and eventually durability in the landscape.

UNDERSTOCKS

Ilex 'Nellie R. Stevens' was initially chosen as an understock due to its vigor and durability in the southeast of the United States. It was also chosen because of its similar genetic make-up to the unique *Ilex* forms in trial, namely *I. aquifolium* and *I. cornuta* cultivars. Other forms that have been evaluated as understocks include *I.* × *koehneana* 'Wirt L. Winn', *I.* 'Emily Brunner', *I.* 'Ed Stevens', and *I.* 'Mary Nell'. Currently 'Nellie R. Stevens' is being used for base grafting as well as top grafting of *Ilex* at Hefner's Nursery. Three-inch (7.6 cm) liners that are 15 to 20 cm (6 to 8 in.) tall, trade 1-gal liners that are 61 to 76 cm (24 to 30 in.) tall, and trade 3-gal liners that are 91 to 122 cm (36 to 48 in.) tall are utilized for grafting. All liners are from terminal cuttings and trained to have a straight trunk. Understocks are brought from the growing area and stored in a greenhouse prior to the first freeze of the fall season to prevent bark split of the vigorous growing understocks. They are held at 1.7 °C (35 °F) with minimal moisture needed until later in the winter. Any side branches on the understocks that remain are removed upon storing, but all leaves are left in place along the stem to aid in food production. Understocks are warmed with 18 to 21 °C (65 to 70 °F) bottom heat for about 3 weeks to initiate root activity prior to grafting. Most of the grafting is completed in late January and February but can be accomplished successfully until the understock starts growing actively. Success in grafting *Ilex* starts with proper growing and preparation of the understock.

GRAFTING

The side wedge graft is primarily utilized for lower grafts on 3-in. liners. Dormant, 7.6 to 10.2 cm (3 to 4 inch) scions of current season wood is collected from desired *Ilex* forms. Two sloping cuts are made on each side of the scion and then a thin flap is cut into the understock so the scion can match on both sides. The scion is held in place by 12.7 × 0.3 cm (5 × 1/8 in.) budding rubber. To protect the scion and graft union from drying out, the graft is covered with a pleated sandwich bag that is stapled in place. The humidity in the heated house is also supplemented with

intermittent mist. The apical wedge graft is utilized for top working the trade 1- and 3-gal liners. A similar scion is prepared as with the side wedge graft however the understock is trimmed horizontally across the stem and then a vertical cut is made to a depth that will accommodate the scion. The scion will form the graft union faster if the cambium on the scion matches on both sides of the understock. It is important to graft and match as close as possible to form a compatible union. Wrapping and covering is the same as above with the side wedge graft.

AFTERCARE

The potted grafts are checked on a regular basis to make sure they do not dry out and that the humidity is adequate. The grafts will usually show signs of activity about 3 weeks after grafting. The pleated sandwich bags are removed when new growth is about ½ inch long to not retard growth. The understock above the graft union on the side wedge grafts is trimmed flush when the bag is removed. The parafilm and budding rubbers will usually fall off but should be removed if any girdling is noticed. The grafts stay in the greenhouse until mid April and then are potted up in larger sizes for growing on or planting out.

CONCLUSION

Unique forms of *Ilex* grafted on 'Nellie R. Stevens' have shown remarkable growth in container and field production. Although the unit production cost of each plant is higher because of grafting the production time is far less. The grafts are also far more durable because of the coarser more vigorous root system of 'Nellie R. Stevens' compared to plants on their own roots.

List of *Ilex* Cultivars Grafted on *Ilex* 'Nellie R. Stevens'.

- *Ilex aquifolium* 'Argentea Marginata Pendula'
- *Ilex aquifolium* 'Argentea Marginata'
- *Ilex aquifolium* 'Ferox Argentea'
- *Ilex aquifolium* 'Pendula'
- *Ilex aquifolium* 'Phantom Gold'
- *Ilex aquifolium* 'Fastigiata Sartori'
- *Ilex aquifolium* Unnamed media picta weeping form
- *Ilex cornuta* 'Emerald n Cream'
- *Ilex leucoclada* 'Superberry'
- *Ilex* x *altaclerensis* 'Belgica Aurea'
- *Ilex* 'Hefcup' pp#8537
- *Ilex* × *koehneana* Unnamed variegated form
- *Ilex* × *koehneana* Unnamed media picta form
- *Ilex* 'Nellie R. Stevens' Unnamed cream variegated form
- *Ilex* 'Rock Garden'
- *Ilex* 'September Gem'

The ABCs of Plant Propagation at GreenForest Nursery©

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INTRODUCTION

Successful propagation requires the same amount of planning as does finishing the plant for sale. A careful analysis of the plant material to be propagated is an important initial decision. Just as critical is a clear understanding of who makes that decision. At GreenForest Nursery, a team approach is used and involves the sales manager, the production manager, the propagation manager, and the owner. A team approach often helps identify potential strengths and problems. These decisions are based on how a plant is selling, how it is projected to sell, ease of production, and production time.

Deciding when to propagate is also a critical part of the planning process. This again requires input from the previously mentioned team. Liners need to be ready when the production manager needs them. Non-available liners when needed waste valuable production time. Liners ready before production is ready for transplanting may be pot-bound and past optimum quality. These decisions are based on availability of cutting material, readiness of cutting material, economics, and optimal cutting time. For economics, considerations might be rooting hollies in the summer versus winter when hollies root similarly in the summer and winter heating costs are eliminated. It might also involve propagating during a time of the year when labor is not being utilized in other nursery areas. If the increased labor to stick additional cuttings costs less than sticking fewer cutting that require heat, you might be better served to stick more cuttings during a time that reduces other inputs.

Deciding how to propagate the needed liners should also be a part of the planning process. These decisions are based on experience, experimentation, and research. I maintain a notebook that includes everything done to a group of cuttings each year. I can look back and make sure we are being consistent with what worked previously. Conversely, notes are also a helpful tool to go back and discover what small thing you changed that had a tremendous unexpected result. Experimentation usually involves a small block of cuttings taken at a different time, using different hormone types or levels, different moisture levels, or different shade levels. We experiment a little each year to increase our successes. Research involves listening to other propagators at meetings like this, reading research papers on propagation, reading propagation books, and calling fellow propagators between meetings.

Deciding how many liners to propagate depends on the number needed for production, number targeted for direct sales, rooting percentages, and cull rate. You should also consider the number needed for production if additional liners are needed for multi-trunk containers.

The best cuttings available should be utilized for propagation. Stock blocks can be maintained for this purpose and are the ideal source of cuttings. However, due to many factors, production material is often used as a source of cuttings. In this case, coordination with the production manager is critical to make sure anticipated cuttings are not removed by routine pruning prior to the need for cuttings. You can-

not grow a great plant from a poor cutting, but you can produce a cull liner from a good cutting.

BASICS OF PROPAGATION AT GREENFOREST NURSERY

Timing is very important in propagation success. Again, success requires cooperation between propagation and production. Routine pruning operations can be synced with cutting needs. In some cases, the propagation crew can perform the routine pruning thus making sure cutting quality is maintained at the same time parent plant quality in enhanced. Timing is also critical for finished liners to be ready when production is ready to transplant. If liners are not ready when production is, labor is wasted during the delay. Similarly, if production is not ready for transplanting when the liners are, plant quality can be reduced and transplant shock increased.

Space is also critical to propagation success. A successful propagator should plan ahead and know which liners will be placed in which houses. Propagators should take and stick cuttings based on filling houses with plants with similar needs. Magnolias prefer high humidity and temperatures approaching 38 °C (100 °F). Leyland cypress prefers a drier environment. You cannot successfully root these two crops in the same house at GreenForest Nursery. If you choose settings in between, both crops will suffer. If you favor one crop, the other will suffer. It is much easier to maintain optimal conditions for magnolias when the house is completely full. Empty space is a negative for maintaining humidity. Finally, various cultivars of magnolias have slightly different preferences and can be best maintained in a mono-cultivar house.

Selection of the appropriate hormone (or hormones) is another key consideration. Using the correct hormone can decrease your rooting time, increase your rooting percentages, and promote a more vigorous root system. GreenForest Nursery uses various levels of K-NAA, IBA, NAA depending on the plant. Use of K-IBA has all but ceased because of source issues. All formulations are liquid. In some cases, we are experimenting with cuttings taken at times that require no additional hormone treatment.

Moisture management is the most critical element of cutting propagation. Each house is managed individually, and each cultivar is managed individually. Moisture can be in the form of fog in the magnolias houses to make sure humidity stays high. It can be in the form of traditional misters in each house, and it can be in the form of spot watering callused cuttings. Each facet of moisture must be tailored to the crop and the stage of the crop. Houses are on clocks, but the clocks are changed manually throughout the day to make sure cuttings have optimal conditions based on temperature, humidity, cloud cover, and stage of rooting.

Finishing the liner for use at GreenForest Nursery or direct sale involves moving the plant from a misting regime to a watering regime. Fertilizer is also added to the containers as a top dress at the appropriate stage and rate.

Stepping up of liners for use by GreenForest involves their movement to outside holding areas prior to transplant into larger containers. We prefer that the liners be held no longer than 1 year. Liners stuck in summer and spring will be typically be planted out during fall or the following spring. Liners for direct sale may come from outside or greenhouse holding areas. Sold liners are typically current year's crop.

Liners for direct sales can be prebooked based on customer need or bought on an as-needed and as-available basis. We currently use a quart pot for our propagation of magnolias. Other crops are propagated in 1801s or 3601s. We can also custom propagate in other sizes as requested. However, the majority of our propagation is for GreenForest use. Very little of our transplant material is from other sources at this time. We will be adding some seed propagation for the future.

SUMMARY

GreenForest Nursery uses a team-based approach to determine liner numbers and species, timing, and space requirements. The propagation manager handles the sticking and rooting of the cuttings. This approach has given us success in the propagation and production of difficult species such as magnolias.

CONCLUSIONS

Propagation is a complex process that begins long before a cutting is made. Attention to the ABCs we use should provide a propagator good starting point for someone wishing to become involved in propagation. Hopefully, existing propagators will gain some insight from what we have shared as we seek and learn from them.

Aronia: Cultural and Production Considerations as an Alternative Crop©

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INTRODUCTION

Black chokeberry [*Aronia melanocarpa*, (Michx.) Elliot] or aronia, as it is known commercially, is a small fruit-bearing shrub in the rose family (*Rosaceae*) and apple sub family (*Amygdaloides*). Its range is from Newfoundland, west to Ontario, south into Alabama, and east to Georgia, and is hardy to Zone 3 (USDA NRCS, 2011).

Aronia is a landscape quality plant with few pests and diseases. Because of this, it is an ideal candidate for organic fruit production. The fruit is typically between 1 and 1.5 cm in diameter, very similar in size to commercial blueberries. Often misnamed as a berry, the fruit is actually a pome (apple) and grows in clusters of between 5 and 20 in cyme-like inflorescences. The aronia fruit has nutraceutical qualities, heightening its marketability and sales potential as a value added product. There is currently great interest in fruits and vegetables that contain high concentrations of flavonoids, considered potent antioxidants (Gu et al., 2004; Pietta, 2000). In a recent study (Wu et al., 2004), aronia was shown to contain high levels of flavonoids including anthocyanins and proanthocyanidins, and has a total oxygen radical absorbance capacity (T-ORAC) of 16,062 µmoles Trolox Equivalents (TE) per 100 g of fresh fruit (USDA ARS, 2010). In comparison, blueberries have 4,669 µmoles TE per 100 g of fresh fruit (USDA ARS, 2010). Trolox is a water-soluble derivative of vitamin E and a standard for antioxidant activity. A review by Kulling and Rawel (2008) of in vitro medical studies have suggested that aronia has many medicinal properties that may benefit coronary/pulmonary systems, urinary tract systems, gastrointestinal systems and possibly, persons with type II diabetes. A number of research institutions and government agencies have promoted the production of aronia as an alternative crop (Finn, C., 1999; King, 2007; Ristvey and Mathew, 2011). In Eastern Europe where the aronia has been cultivated for many years, fruit products include juices, extracts, coloring agents, and wine (Scott and Skirvin, 2007).

The *Aronia* genus has often been renamed, and as recently as 1991, Robertson et al. (1991) changed this genus to *Photinia* based on floral morphology. However, Campbell et al. (2007) found that sequenced genealogical data did not clearly support this phylogenetic relationship and determined that *Aronia* should be a standalone genus (Leonard, 2011). Furthermore, an attempt to distinguish the cultivated variety of *Aronia* from its progenitor *A. melanocarpa* was made by Skvortsov and

Maitulina (1982), naming *A. mitschurinii* as the newly developed species (Leonard, 2011). Skvortsov et al. (1983), deciphers the historical records of the breeding of this plant by the Russian plant breeder Ivan Michurin (Leonard, 2011). According to Skvortsov et al. (1983), Michurin used the European Mountain Ash (*Sorbus aucuparia*) and a plant retrieved from Germany that he called *S. melancocarpa*, "black-fruited mountain ash" or "American *Sorbus*" (Leonard, 2011). Through DNA analysis, Leonard (2011) determined that the present cultivars of *Aronia* including 'Viking' and 'Nero', utilized mainly for fruit production in Europe and the United States, are a cross between a black-fruited *Aronia* and the European Mountain Ash (*Sorbus aucuparia*).

The research performed at the University of Maryland was initiated to be the basis for a University of Maryland Extension program designed to inform the public about aronia as a potentially valuable alternative crop for farms and land owners. In the past, marketing the crop has been difficult because of the fruit's flavor, at first sweet, but astringent if masticated. However, proper processing, like freezing and squeezing the thawed fruit can yield a rich colored juice, which has little of the astringent flavor and can be sweetened with sugar to taste.

CULTIVARS

Several cultivars of aronia plants are presently in the market. Two of the most popular which were developed in Europe are *P. melanocarpa* 'Viking' and 'Nero', both very similar in yield performance (McKay, 2004). A recent introduction, 'Galijcanka' from Poland, has been touted to have more even ripening of fruit over time than 'Viking' or 'Nero'. However, neither 'Viking' nor 'Nero' showed problems with uneven fruit ripeness at harvest in Maryland. Other cultivars have been developed in North America, but are not as good for fruit production. For instance, 'Autumn Magic' and 'Iroquois Beauty' seem to have better fall foliage color than fruit production.

PHENOLOGY

Before the growing season, an undetermined dormancy period with cold temperatures is needed before bloom initiation. An estimation of a minimum of 800 chill hours is required to break dormancy; however no studies have been initiated yet. Depending on temperatures, dormant buds swell in late March and begin opening in early April with vegetative growth (leaves) visible first and flower buds showing soon after. In Maryland (Zones 6b to 7b) aronia blooms between late April and mid-May. The flowers are apomictic, but are still pollinated by several species of hymenopterans (bees). The bloom cycle is approximately 10 days. By late May, fruit set begins and potential yield can be determined. Throughout June and July vegetative growth continues, doubling or tripling the size of the plant during the first few establishment years after planting. Throughout June, fruit turn from green to a burgundy color, starting at the calyx and moving towards the peduncle. By mid-July, all fruit are colored burgundy and by harvest time in mid to late August, fruit are a dark purple. Bud set for next season's yield occurs between late July and mid-August. Some vegetative growth will continue throughout August, but sharply declines as September begins. Harvest is in mid to late August when fruit clusters are fully ripened. Mature plants can yield up to 11 kg or more of fruit. Soluble sugar content or Brix (°Bx) of fruit varies between 15% and 22%.

PEST AND DISEASES

Aronia has few pests and disease problems, however, in Maryland, 5 years of observation have revealed specific threats that can be managed through basic integrated pest management practices, leaving opportunities for organic production possible.

Insects. Insect problems have been noted throughout the growing season from April through August. One of the first insect problems occasionally seen early in the growing season is blister beetle (*Lytta* sp.) which consumes flower buds. Aphids are a common problem throughout the summer starting in June. They are seen on the fresh vegetative growth and tend to disfigure leaves. Pesticides are not needed because they are often controlled by lady bird beetles and lace wings within a week of arrival and usually do not constitute a threat. By mid-June, however, Japanese beetles emerge and become a major threat to canopy growth. During years of heavy infestation, much of the growing canopy is removed. This may have a detrimental affect towards carbohydrate production. Additionally, grasshopper damage during the late growing season can also remove a large portion of the canopy. Another insect of concern, noted within the last 2 years of production in Maryland, has been the cherry fruitworm (*Grapholita packardi).* Finally, the brown marmorated stink bug (*Halyomorpha halys*) has been seen on aronia fruit and feeding damage has been noted. More research into practical control measures is necessary, especially for organic production.

Pathogens. Aronia has few problems with pathogenic organisms. One fungal pathogen, seemingly of minimal concern, is rust (*Gymnosporangium* sp). Initially, during the first few years of establishment in Maryland, infection was limited to fruit, and the aronia plants would abort the fruit before the fungal infection moved into the teleospore stage. In 2010, it was noted that fruit did not abort before the teleospore stage and stem tissue below fruit showed infection. Infection rates are not consistent annually, with low rates in 2011 and moderate rates seen in 2012.

PROPAGATION CONSIDERATIONS

Aronia can be easily propagated by cuttings and is the preferred method of keeping the integrity of the commercial cultivars. However, seeds have been used for propagation and seem to carry on the parental traits for hardiness and yield in both 'Nero' and 'Viking' (McKay, 2004). Both early and late season cuttings can be made, although if stock plants are also used for fruit production, early June cuttings are better as to avoid taking dormant flower buds which would reduce the following year's yield. Cuttings should be made to partially hardened stem tissue which has a purple color. Any commercial rooting hormone will be effective. A typical propagation misting system is advisable. One can expect 95% or more of cuttings to successfully root, so long as typical hardwood cutting procedures are followed.

RESEARCH SUMMARY

Post Propagation. A 2-year research program looking at fertility of rooted cuttings was undertaken to determine the optimal nitrogen (N) rate for optimal growth and nutrient uptake efficiency. Specific procedures for these studies are outlined in Ristvey and Tangren (2008). The first year, rooted aronia cuttings planted in 2-gal containers were supplied with either 150 mg N or 75 mg N, once per week in soluble form, for 34 weeks between March and October. Phosphorus was supplied

at 1/10 the N rate for both treatments. A total of 5.1 grams N and 2.6 grams N was supplied as a high and low treatment. At the end of 34 weeks, plants under the high N treatment had nearly 2.5 fold more dry mass as the low N treatment. Another study the following season was developed to indentify the effects of split applications of soluble N. Three treatments were used. A 150 mg N rate was applied as a single weekly dose or split into two applications per week. Likewise, a split 225 mg N per week rate was added as a treatment in a 29-week study from March to October. Results showed that aronia grew best with split applications of high N and had relatively high uptake efficiencies compared to other studies (Cabrera, 2003; Ristvey et al., 2004; Ristvey et al., 2007). This study's low and high rates actually corresponded to recommended low and medium rates for commercial slow-release fertilizer applications.

Fruit Production Research. Two European cultivars of aronia, 'Viking' and 'Nero', were planted in ground in May 2006 at Wye Research and Education Center in Queenstown, Maryland. The 'Viking' cultivar was planted as 24-month-old seedlings. The 'Nero' cultivar was planted as 12-month-old seedlings. Details outlining the first yield studies are given in Ristvey and Tangren (2009). In summary, plants were each given one of two N fertility rates amongst rows during the first yield studies. 'Viking' plants, being the most mature when planted, produced enough fruit during the third season (2008) to determine if fertility treatments affected yield. 'Viking' plants, each given a total of 24 g N during the period between planting and recorded yield (an initial 6 g at planting and 18 g throughout the next 2 years) produced an average of 2.2 kg (SE±0.16) per plant (4.8 lbs). This was significantly less than plants given 15 grams N (an initial 6 grams at planting and 9 g throughout the next 2 years), which averaged 2.8 kg (SE±0.25) per plant (6.2 lbs). The source of N was an Organic Materials Review Institute (OMRI) certified fertilizer consisting of 5% N. In spring of 2009, N treatments were expanded to include a total of four separate rates (0, 3, 7, and 14 g N) and where applied per plant within rows as a split plot study. A new OMRI certified N source was used with 11% N. Since beginning the new N rate study, three harvests have been recorded. Each year harvests have shown no differences in yield by N rate to either 'Nero' or 'Viking' cultivars. Brix was also measured. In each year, no difference in °Bx was found between N rates and cultivars. Jeppsson (2000) noted that high fertility, while increasing yield, negatively affected anthocyanin content in fruit. A recommendation from Jeppsson's study suggested that crops be fertilized with 50 kg N per hectare roughly translating to 45 lb of N per acre, however, in our studies, N rate did not affect yield. Based on our studies and anecdotal observations, new plants should be established in-ground with 7 g of N (0.25 oz) per plant and adjusted to plant needs in following years, never exceeding 14 g N per plant. Depending on plant density which may be between 1000 and 2000 plants per hectare, (roughly 400 to 800 plants per acre), this fertility would not exceed 30 kg N per hectare (27 lb per acre).

CONCLUSIONS

Aronia is an up-and-coming alternative crop in the U.S.A. While specific markets have yet to be completely defined, the marketing potential for this crop to be the next "superfood" is very likely. Because of its hardy character, the possibility for

organic production with the correct IPM measures and very little input makes this a worthwhile crop to investigate. The aronia research summarized in this paper serves as the basis for a University of Maryland Extension program. In Maryland, aronia has been shown to tolerate a range of soil types, can be grown with sustainable rates of fertilizer, and is tolerant to many of the pest species that make other fruit crops more difficult to manage. Presently, a move for consumers to "buy local" may bring a renaissance for small farms to sell aronia as value added product. Future research will include the determination of cultural methods that may increase the nutritional value of the fruit to maximize its market value and the determination of processing methods that do not negatively affect the fruit's nutritional value.

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Determining Trace Gas Flux From Container-Grown Woody Ornamentals©

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In recent years, anthropogenic climate change and its effects on the global environment has garnered significant attention from the scientific community. Increased trace gas emissions (CO_2, CH_4, and N_2O) are widely believed to be the driving force behind global warming. Agriculture is a large contributor to trace gas emissions. Much of the work on reducing greenhouse gas (GHG) emissions has focused on row crop, forestry, and pasture systems, with little work in specialty crop industries such as horticulture. Our objective was to determine efflux patterns of CO_2, CH_4, and N_2O associated with different nursery container sizes under common production practices. These data are needed to develop Best Management Practices for reducing trace gas emissions from container nursery production systems.

INTRODUCTION

There is widespread belief in the scientific community that anthropogenic climate change poses a serious global threat. While it is still uncertain that man-made emissions are causing an increase in global temperatures, it is known that concentrations of the three most important long-lived greenhouse gases (GHG) in the atmosphere have increased dramatically over the past 255 years (IPCC, 2007). Atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have increased by approximately 38%, 157%, and 19%, respectively, since 1750 (WMO, 2009).

The agriculture industry in the U.S.A. is a large contributor to GHG emissions, behind only energy production (Johnson et al., 2007). Emissions of CO_2, CH_4, and N_2O from agriculture collectively account for an estimated one-fifth of the annual increase in GHG emissions. When land use changes involving clearing of land, biomass burning and soil degradation are included, the overall radiative forcing from agriculture production is one third of the man-made greenhouse effect (Cole et al., 1997).

Mitigation of GHG by altering agriculture production practices has been heavily researched (Cole et al., 1997; Lal et al., 1998) with the majority of this work focusing on row crop and animal production systems. Virtually no research has centered on contributions from specialty crop industries such as horticulture.

The ornamental horticulture industry impacts the landscape of rural, suburban, and urban environments. The economic impact of the "green industry" (nursery, greenhouse, and sod) is $148 billion annually in the U.S.A. (Hall et al., 2005) and was $2.8 billion in Alabama alone in 2008 (AAES, 2009). There is a need for the horticulture industry, as well as other sectors of agriculture, to determine ways in which current production practices can be altered to reduce GHG emissions. Currently there is speculation that legislation limiting CO_2 and other GHG emissions could occur in the near future. There could also be opportunities for growers to profit financially by reducing GHG. Multiple organizations and federal agencies have proposed programs in which growers could be paid to reduce carbon emissions or to provide carbon credits to other industries to offset their carbon footprint (EPA, 2008; NFU, 2009). There is a need for all agricultural sectors to take preemptive action and examine alternative management practices that would comply with possible new legislation and reduce GHG emissions while balancing production goals and profitability.

GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement network) is a program initiated by the Agricultural Research Service of the USDA to identify and develop strategies that will enhance soil carbon sequestration, reduce GHG emissions, and provide a scientific basis for possible carbon credit and trading programs (Jawson et al., 2005). One of the goals of GRACEnet is to establish net GHG emissions of existing agricultural systems, which must be determined in order to begin exploring ways to reduce these emissions. GRACEnet's primary objectives focus on determining emissions from row crop and animal production systems; however, for horticulture producers to benefit from the same carbon trading or offset programs, net GHG emissions from horticulture production practices must also be established.

To determine methods of reducing GHG from nursery container production systems, baseline trace gas emissions (CO_2, N_2O, and CH_4) from common practices must be established. Determining gas flux from different container sizes will establish both a baseline for common nursery container production practices and the relative importance of container size on GHG fluxes. Estimates are now available on the number of container-grown plants in various pot sizes produced in Alabama (Marble et al., 2011). If a direct relationship between potting media volume and gas emissions can be established and other states develop estimates on numbers of container-grown plants in different pot sizes, then future measurements can be scaled to industry-wide levels. The objective of this research is to determine efflux patterns of CO_2, CH_4, and N_2O associated with different nursery container sizes under common production practices.

MATERIALS AND METHODS

This experiment was conducted at the Paterson Greenhouse Complex in Auburn, Alabama. On 1 April 2010, *Ilex vomitoria* 'Nana' (dwarf yaupon holly) liners [approximately 2.5 cm (1 in.)] were transplanted into four different nursery container sizes: 3 L (trade gal; TG), 3.8 L(#1; 1 gal), 7.6 L (#2; 2 gal), and 11.4 L (#3; 3 gal).

Containers were filled with a pinebark and sand (6 : 1, v/v) medium that had been previously amended with 8.3 kg • m^{-3} (14 lbs/yd^3) of 17–5–11 Polyon control-release fertilizer (10–12 month), 3.0 kg • m^{-3}(5 lb/yd^3) of lime, and 0.9 kg • m^{-3} (1.5 lb/yd^3) of Micromax. The study used seven replicates for each container size; there were no differences in plant size at study initiation. All containers were placed in full sun and received daily overhead irrigation [1.3 cm (0.5 in.)] via impact sprinklers.

Trace gases emitted from the containers were sampled in situ weekly for 1 year (1 April 2010 to 31 March 2011) using the static closed chamber method (Hutchinson and Livingston, 1993; Hutchinson and Mosier, 1981). Custom-made gas flux chambers were designed and constructed based upon criteria described in the GRACEnet protocol (Baker et al., 2003; Parkin and Kaspar, 2006) to accommodate nursery containers. A structural base consisting of polyvinyl chloride (PVC) cylinders [25.4 cm (10 in.) inside diameter by 38.4 cm (15.1 in.) tall] was sealed at the bottom. During gas measurement, the entire plant-pot system was placed inside the base cylinder and a vented flux chamber [25.4 cm (10 in.) diameter × 11.4 cm (4.5 in.) height] was placed on top of the base cylinder. The top flux chambers were constructed of PVC, covered with reflective tape, and contained a center sampling port. Gas samples for CO_2, CH_4, and N_2O were taken at 0, 15, 30, and 45 min intervals following chamber closure. At each time interval, gas samples (10 mL) were collected with polypropylene syringes and injected into evacuated glass vials (6 mL) fitted with butyl rubber stoppers as described by Parkin and Kaspar (2006). Gas samples were analyzed by a gas chromatograph (Shimadzu GC-2014, Columbia, Maryland) equipped with three detectors: thermal conductivity detector for CO_2, electrical conductivity detector for N_2O, and flame ionization detector for CH_4. Gas concentrations were determined by comparing to a standard curve using standards obtained from Air Liquide America Specialty Gases LLC (Plumsteadville, Pennsylvania). Gas fluxes were calculated from the rate of change of the concentration of trace gas (CO_2, N_2O, or CH_4) in the chamber headspace during the time intervals while chambers were closed (0, 15, 30, and 45 min) as described by Parkin and Venterea (2010). Calculations in this study were used to express data as mg (CO_2-C) and μg (CH_4 and N_2O) trace gas per pot (per day). Daily gas efflux from each sampling date, as well as yearly estimates of total trace gas efflux (made by extrapolating daily averages over the course of one year) from each pot size were subjected to Fisher's Least Significance Test ($p = 0.05$) using the Proc Mixed procedure in SAS (SAS® Institute version 9.1, Cary, North Carolina).

RESULTS AND DISCUSSION

Methane efflux was consistently around 0 in all containers for the entire duration of study (data not shown). It is likely these values were close to or below the detection limits of the gas chromatograph. It is not surprising, given the media was well drained, the anaerobic conditions needed for methane production did not occur in this system. Based on our results, methane efflux does not appear to have a significant effect on total trace gas emissions from container-grown nursery crops.

Weekly trace gas emissions indicate a significant relationship between container size and CO_2 efflux, with flux increasing as container size increased (Fig. 1). On 30 of the 50 sampling dates, #3 (3 gal) containers had higher efflux than any other container size. This trend continued when total CO_2 efflux was estimated over the course of one year (Table 1). On many sampling dates (13), #3 had the highest flux,

and #2 (2 gal) had higher flux than #1 (1 gal) or TG containers (Fig. 1). Obviously, decomposition (heterotrophic respiration) of larger quantities of growth media resulted in greater loss. Also, since plants grew larger in #2 and #3 containers (data not shown), higher losses (in #2 and #3 containers) were likely influenced by the larger plant sizes (autotrophic respiration), especially at later dates (Fig. 1). In addition to effects of container size, CO_2 efflux generally increased as temperature increased. Efflux was consistently highest during late spring and summer months with larger differences among container sizes (Fig. 1). Carbon dioxide efflux is known to be highly dependent upon temperature and water content (Fang and Moncrieff, 2001). While water content was not monitored in this study, container moisture levels were uniform due to daily controlled irrigation.

Average N_2O efflux ($\mu g \cdot d^{-1}$) was highest in #3 containers, followed by #2 containers, with no difference among the other two container sizes (Fig. 2). Yearly estimates of N_2O efflux (mg/yr) also show that most N_2O-N was lost in #3 containers (Table 1). Over the course of the study, #3 containers had higher N_2O efflux than all other containers on 32 of the 50 sampling dates. Because fertilizer was incorporated into the media prior to planting on a volume basis, larger containers had more fertilizer than smaller containers, likely causing a higher N_2O efflux. Further, all plants were similar in size at the beginning of the study and less fertilizer could be utilized by the plant in the larger containers, resulting in higher losses via N_2O efflux. Nitrous oxide emissions increased dramatically beginning in May, 2010 and increased again in June and July of the same year before leveling off in September (Fig. 2). This is likely because the release rate of the controlled-release fertilizer used in this study is highly dependent upon soil temperature, causing higher N_2O fluxes during warmer months. No increases in N_2O flux were observed as temperatures increased in 2011 as most of the fertilizer (10–12 month formulation) was likely utilized or depleted.

Our results show that loss of both CO_2 and N_2O were greatest in the largest containers. Trace gas emissions reported in this study show that container production may emit more trace gas per acre than has been reported in some row crops (Collins

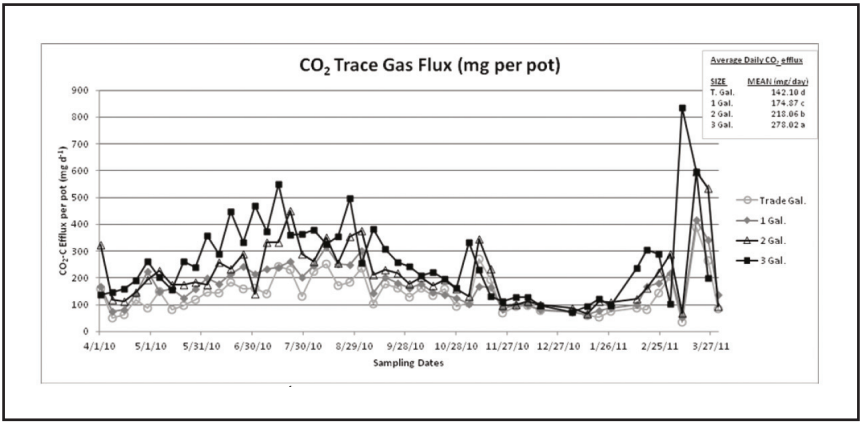

Figure 1. CO_2-C efflux (mg/d^{-1}) for dwarf yaupon holly grown in four container sizes over 1 year (1 April 2010 – 31 March 2011). The insert shows average daily efflux (means followed by the same letter are not significantly different from each other, $p = 0.05$).

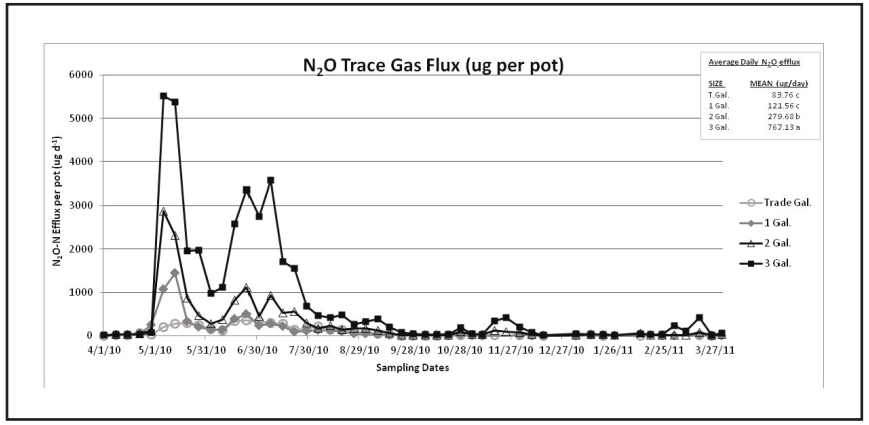

Figure 2. N_2O-N efflux ($\mu g \cdot d^{-1}$) for dwarf yaupon holly grown in four container sizes over one year (1 April 2010 – 31 March 2011). The insert shows average daily efflux (means followed by the same letter are not significantly different from each other, $p = 0.05$).

Table 1. Estimation of yearly CO_2 and N_2O efflux from container-grown nursery ornamentals.[Z]

		Yearly Efflux	
Container size	**Volume (L)[Y]**	**CO_2-C ($g \cdot yr^{-1}$)**	**N_2O-N ($mg \cdot yr^{-1}$)**
Trade gal.	2.05	51.89 d[X]	30.66 c
1 gal.	3.15	63.82 c	44.41 bc
2 gal.	5.15	79.59 b	102.08 b
3 gal.	10.10	01.48 a	280.00 a

[Z]Pots measured contained dwarf yaupon hollies (Ilex vomitoria 'Nana') in each pot size listed (n = 7).
Estimates were made by extrapolating daily averages over the course of one year.
[Y]Pot volumes show the amount of substrate [pinebark : sand (6 : 1 v:v)] contained in each pot size.
[X]Means were separated using Fishers Least Significance Difference Test in the Proc Mixed procedure ($p = 0.05$).

et al., 2008); however nursery production acreage is minuscule when compared to most agronomic crops. The National Agricultural Statistics Service (2009) reported that approximately 90 million acres of corn were harvested in the U.S.A. in 2007. When comparing acreage of nursery stock reported in the same study (455,000 acres), the nursery industry is likely producing only a fraction of total GHG emissions from agricultural production. It should be noted that the container flux data do not necessarily reflect net emissions as they do not account for carbon sequestered in growing biomass. Further, container nursery systems contribute to carbon sequestration by placing large amounts of carbon-rich growing media belowground when plants are transplanted into the landscape (Marble et al., 2010). Further in-

vestigation is needed to determine the impact of different production variables such as growing media, fertilization and irrigation practices, and plant species on trace gas emissions. While uncertainty still remains regarding the overall impact of the nursery industry on climate change, results from this study begin to provide baseline data of trace gas emissions from container-nursery production systems.

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Cotton Waste Stretches Pine Bark Supplies©

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The objective of this experiment was to look at growth of *Rhododendron obtusum* 'Sunglow' (azalea) and *Juniperus rigida* subsp. *conferta* 'Blue Pacific' (juniper) in different cotton waste amended substrates. Pine bark (PB) and whole pine tree (PT) were evaluated as substrate bases and were amended with composted cotton stalks without a nitrogen source added (CS), composted cotton stalks with a nitrogen source added (CSN), and aged cotton gin trash (CGT). Substrate bases were amended to achieve similar water holding capacities resulting in pine bark and composted cotton stalks (PB : CS; 4 : 1, v/v), pine bark and composted cotton stalks + nitrogen (PB : CSN; 4 : 1, v/v), pine bark and cotton gin trash (PB : CGT; 9 : 1, v/v), pine tree and composted cotton stalk (PT : CS; 1 : 1, v/v), pine tree and composted cotton stalk + nitrogen (PT : CSN; 1 : 1, v/v), and pine tree and cotton gin trash (PT : CGT; 4 : 1, v/v) along with a 100% pine bark control for comparisons. The plants were grown with two different irrigation/ground surface conditions: an overhead, sprinkler irrigation pad with black weed-fabric covering the ground (OH) or a low volume, spray-stake irrigation system with gravel covering the ground (LV).

Both juniper and azalea grew well in all substrates but there were significant differences in growth between substrates within each irrigation/ground surface covering. With LV, juniper shoot growth was highest in PB : CGT and 100% PB substrates and lowest in the remaining four substrates (PB : CS, PB : CSN, PT : CGT, PT : CS, and PT : CSN). Juniper shoot growth in PT : CS was not significantly different than any of the other substrates with LV. With OH, juniper shoot growth was greatest with PB : CGT and 100% PB and lowest with PT : CS. Juniper shoot growth was not different between PB : CS, PB : CSN, PT : CGT, and PT : CSN when irrigated with OH. Juniper root growth responded similarly to shoot growth with LV; while, juniper root growth was not significantly affected by substrate with OH (data not shown).

Azalea shoot growth was significantly higher in all of the PB-based substrates compared to the PT-based substrates with OH. With LV, azalea shoot growth was highest in the PB : CGT, PB : CSN, PT : CSN, and 100% PB substrates and lowest in substrates composed of PB : CS, PT : CGT, and PT : CS. The PT-based substrates maintained higher SS (1.5 to 0.3 mS) and pH (6.4 to 5.7) levels throughout all sample times (May–August); while, the 100% PB maintained the lowest (SS : 0.8 to 0.2 mS and pH : 6.6–5.7) (data not shown). The PB-based amended substrates were intermediate in SS and pH levels (SS : 0.9 to 0.2 mS and pH : 6.3 to 6.0). However, all substrates maintain pH and SS levels within recommended levels (Yeager et al., 2007).

The increase in growth with OH was most likely due to the cooling effect of the water applied to the canopies as evidenced by the azalea substrate temperature data. By utilizing local substrate amendments, the nursery industry can move back into a win-win situation, assist one industry in disposing of a waste while also moving away from the nursery industry's dependence on pine bark.

Assessing Phytotoxicity in Fresh and Aged Whole Pine Tree Substrates©

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Reduced plant growth in wood-based substrates has been attributed to a variety of factors, including phytotoxity. A detailed method for evaluating the phytotoxic potential of wood-based substrates has not been identified. Two biological assays (Phytotoxkit™ and seedling growth test) were conducted for identifying phytotoxicity in WPT, while examining the potential of such methods for testing other alternative substrates. Substrates evaluated in the Phytotoxkit included a reference soil (RS), aged (WPTA) and fresh (WPTF) whole pine tree, aged (PNA) and fresh (PNF) pine needles, pine bark (PB), peat moss (PM), and a saline pine bark (SPB) substrate. Substrates evaluated in the seedling growth test included WPTA, WPTF, PB, and a peat-lite (PL) substrate. The Phytotoxkit revealed some plant species may be sensitive to compounds present in PNF. The greatest germination/emergence rate and root length varied by species in regard to WPTA and WPTF; therefore, factors other than phytotoxicity affected seedling development in WPT. In the seedling growth test, total root length was greatest in the PL substrate for all three species, while substrate air space was lowest in the PL substrate.

INTRODUCTION

Many greenhouse and nursery crop producers have greater awareness and access to materials not traditionally used as container substrates. Materials such as composted plant debris and animal wastes, industrial by-products, and wood biomass have been successfully used for crop propagation and production. Never-

theless, many of these materials may not be ideal as the primary component of a substrate due to undesirable chemical or physical characteristics. Limited availability and lack of uniformity between sources or shipments is another concern producers must consider.

Processed whole pine tree (WPT), among other wood-based materials, are viable options as the primary component of a container substrate. Such materials can be uniformly produced over time due to consistent harvesting and processing methods. Concerns associated with wood-based substrates include availability and increased fertilizer rates required to overcome slow initial growth of some sensitive crops (Day, 2009; Gruda and Schnitzler, 1999). Questions also remain whether WPT substrates should be aged before use (Gaches, 2010). Additionally, substrate physical properties have contributed to disparity in root development of stem cuttings in WPT (Witcher et al., 2010). The most common factors associated with reduced plant growth and development in wood-based substrates include nitrogen immobilization, substrate physical properties, low buffering capacity, and phytotoxicity (Fain et al., 2008; Wright et al., 2008; Ortega et al., 1996). The detrimental effects of such factors can possibly be mitigated for crop production, but the effects may be more critical in crop propagation.

Laboratory analyses exist for determining chemical and physical properties of substrates, but the results do not account for interactions that may contribute to phytotoxicity. A method for testing the phytotoxic potential of alternative substrates would be beneficial to producers. Ideally, the method would be quick, inexpensive, and reflect the production environment. Seed germination tests are useful tools for evaluating phytotoxic effects associated with the chemical properties of a material, while seedling growth tests are used to gauge phytotoxicity due to the combined effects of substrate chemical and physical properties (Gong et al., 2001; Nassz et al., 2009). These tests have been widely adapted for evaluating compost maturity and contaminated soil, yet few protocols exist for similarly evaluating the suitability of alternative container substrate components. The objective of our research was to evaluate two biological assays for identifying phytotoxicity in WPT, while examining the potential of such methods for testing other alternative substrates.

MATERIALS AND METHODS

Two types of biological assays (Phytotoxkit™ and seedling growth test) were evaluated for determining possible phytotoxic effects of whole pine tree substrates compared with traditional substrates. The Phytotoxkit is a rapid, reproducible test designed for direct observation and root measurement of germinated seeds in contact with the substrate solution. Test plants included one monocot species (sorghum, *Sorghum saccharatum*) and two dicot species [*Lepidium sativum* (cress) and *Sinapis alba* (mustard)]. Substrates included a reference soil (RS), aged (WPTA) and fresh (WPTF) whole pine tree, aged (PNA) and fresh (PNF) pine needles, pine bark (PB), peatmoss (PM), and saline pine bark (SPB). Whole pine tree substrates were produced from 5 to 6.4 cm (2 to 2.5 in.) diameter loblolly pine (*Pinus taeda*) trees harvested in Pearl River County, MS. The main stems were chipped on 29 July 2010 (WPTA) or 14 March 2011 (WPTF) with a wood chipper (Liberty WC-6; Mesa, Arizona) and a combination of chipped stems and needles (9 : 1, w/w) was ground with a hammer mill (Model 30; C.S. Bell Co., Tiffin, Ohio) to pass a 0.63-cm (0.25-in.) screen. Pine needles were collected on 14 March 2011, directly from trees (PNF) or

from the ground (PNA) surrounding the same trees and hammer-milled to pass a 0.47 cm (0.18 in.) or 1.2 cm (0.49 in.) screen, for PNA and PNF, respectively. Saline pine bark, pine bark soaked in a sodium chloride (NaCl) solution (16 $mS \cdot cm^{-1}$ for cress or 30 $mS \cdot cm^{-1}$ for mustard and sorghum), was included to produce an inhibitory effect on seed germination and initial root growth and served as a negative control for the test procedure.

Substrates were passed through a 0.2 cm (0.08 in.) sieve to eliminate coarse particles. Three 95-ml (3.2-oz) samples (loosely filled) were collected in a coffee-filter-lined container (T.O. Plastics SVD-250) for each substrate. Samples were bottom-saturated to the upper substrate surface with deionized water for 1 h (SPB was saturated in NaCl for 10 h), drained, transferred to individual test plates, and covered with filter paper. Ten seeds of a test species were placed in a single row, a clear plastic cover was placed on each test plate, and test plates were incubated vertically in a dark growth chamber at 24 °C (75 °F) for 5 (cress and sorghum) or 6 (mustard) days. Plates were digitally scanned and analyzed using ImageTool software (ImageTool Version 3.0; UTHSA, San Antonio. Texas). Germination rate (%) and root length (mm) were collected at the conclusion of the experiment.

A seedling growth test was used to evaluate seed emergence and seedling root growth under a simulated production environment. Test plants included one monocot species (oat, *Avena sativa* 'Jerry') and two dicot species (lettuce, *Lactuca sativa* 'Green Ice' and tomato, *Solanum lycopersicum* 'Brandywine'). Substrates included WPTA, WPTF, a peat-lite (PL) substrate [peatmoss, perlite and vermiculite (3 : 1 : 1, by vol)], and pine bark (PB). Individual cells (cut from 72-cell propagation trays) were filled with substrate (36 replications), completely randomized into 72-cell propagation trays (36 cells per tray), and saturated. Two seeds of a single test species were sown on the substrate surface and covered with 2.5 ml (0.5 tsp) substrate. Trays were grouped by species and placed in separate growth chambers at 22 °C (72 °F) for oat and lettuce or 25 °C (77 °F) for tomato, each receiving a 14-h light and 10-h dark photoperiod. Seedlings were thinned to one per cell at 9 days after sowing. At 14 (oat), 25 (tomato), or 33 (lettuce) days after sowing, roots were washed and digitally scanned for analysis using WinRhizo software (WinRhizo Version 2007d; Regent Instruments Inc., Canada). Initial substrate pH and soluble salt concentration (data not shown), emergence rate (%), and total root length were collected. Germination/emergence rate and root length data were analyzed with analysis of variance using the GLIMMIX procedure of SAS (SAS Version 9.2; SAS Institute, Inc., Cary, North Carolina). Differences between treatment means were determined using the Shaffer-Simulated method.

RESULTS

Initial substrate pH ranged from 4.4 (PNA and WPTA) to 5.4 (PB). Substrate soluble salt levels ranged from 76.5 (PM) to 634.5 ppm (PNF). Using the Phytotoxkit, the lowest germination rates within a species occurred in PNF (cress) and SPB (mustard and sorghum) (Table 1). The greatest germination rate was 96.7% for mustard (RS, PB, and WPTA), 96.9% for sorghum (PNF and WPTA), and 97.0% for cress (RS). Significant differences in germination rates between PNA and PNF occurred only with cress, while germination rates were similar between WPTA and WPTF for all three species. Root length for cress was 3.8 times greater in PB compared with PNF, and 2.3 times greater in PNA compared with PNF. Although root

Table 1. Mean seed germination rate and root length of three plant species using a Phytotoxkit™.

	Germination rate (%)			Root length (mm)		
Substrate	Cress	Mustard	Sorghum		Mustard	Sorghum
Reference soil	97 a[Z]	97 a	88 a	56 a	53 bcd	87 a
Pine bark	94 a	97 a	88 a	66 a	89 a	65 ab
Peatmoss	91 a	87 a	94 a	42 a	46 cd	52 b
Saline pine bark[Y]	95 a	43 b	79 a	59 a	6e	15 c
Aged pine needles	86 a	93 a	94 a	40 a	62 cb	66 ab
Fresh pine needles	5 b	80 ab	97 a	18 a	41 d	59 ab
Aged whole pine tree[X]	93 a	97 a	97 a	51 a	52 bcd	52 b
Fresh whole pine tree	75 ab	93 a	88 a	40 a	67 b	73 ab

[Z]Means followed by different letters within columns indicate significant difference at $P < 0.05$ using the Shaffer-Simulated method.
[Y]Pine bark soaked in a saline solution.
[X]Processed whole pine tree.

length was statistically similar between PNA and PNF in cress, likely due to a high level of variability of measurements within a substrate, disparity between the two suggests otherwise. Mustard root length ranged from 5.8 mm (SPB) to 88.8 mm (PB), but was significantly greater in PNA compared with PNF. Sorghum root length was statistically lower in SPB compared with all other substrates and greatest overall in RS.

In the seedling growth test, emergence rate was similar among all substrates for lettuce and oat (Table 2), while tomato emergence rate was lowest for WPTF (73.6%) and greatest for WPTA (91.7%). Total root length was greatest for PL in each species, significantly different from all other substrates within species. Compared with WPTA and WPTF, total root length was approximately 11 times greater for PL with lettuce, 4.2 times greater with tomato, and 2 times greater with oat. Aging the whole pine tree material only affected tomato emergence and oat total root length. Substrate physical properties (specifically air space; data not shown) seemed to play a significant role in the greater total root length observed with PL, since the chemical analysis did not reveal any limiting factors.

DISCUSSION

We show that WPTA and WPTF can be used for seed propagation of six plant species sensitive to various phytotoxic effects. Additionally, the seed germination/emergence rate in WPTA/WPTF was similar to that obtained in traditional substrate components, specifically peatmoss and pine bark. The poor performance of cress in PNF was similar to results from a previous experiment with cress (Witcher

Table 2. Mean seed emergence rate and total root length of three plant species using a seedling growth test.

	Emergence rate (%)			Total root length (cm)		
Substrate	Lettuce	Oat	Tomato	Lettuce	Oat	Tomato
Peat-lite	86 a[Z]	88 a	81 ab	208 a	294 a	186 a
Pine bark	92 a	88 a	85 ab	35 b	258 b	67 b
Aged whole pine tree[Y]	86 a	89 a	92 a	19 c	135 d	45 c
Fresh whole pine tree	96 a	83 a	74 b	20 c	160 c	43 c

[Z]Means followed by different letters within columns indicate significant difference at $P < 0.05$ using the Shaffer-Simulated method.
[Y]Processed whole pine tree.

et al., 2011), and a separate experiment with lettuce exposed to a fresh pine needle leachate (Gaches et al., 2011). Gruda et al. (2009) treated tomato and lettuce seeds with leachate extracted from a pine tree substrate and found that washing the substrate reduced the phytotoxic effects indicated by germination rate and radical growth. Nassz et al. (2009) suggested that air space of bark substrates (various species) was a limiting factor in seedling development, more so than the inherent nutrient and chemical composition.

The Phytotoxkit and seedling growth test could be useful tools for testing substrates in a laboratory setting when reproducible tests are required, while the seedling growth test could be conducted by producers wanting to evaluate potential substrates. In both tests, root development was a more sensitive indicator of phytotoxicity compared with germination/emergence rate. Further investigation regarding the effects of substrate physical properties on seedling growth is warranted to fully understand which factors contribute to reduced root development.

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Milled *Paulownia tomentosa* as a Substrate Component in Greenhouse Annual Production©

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INTRODUCTION

The increase in demand for peat moss and the environmental concerns that are associated with the harvesting of peat bogs provide justification for seeking new alternatives to the industry standards. Two alternatives currently marketed for greenhouse crop substrate use are rice hulls and coconut coir. Recent research has indicated the potential of wood fiber products. WholeTree, a component made from loblolly pine (*Pinus taeda* L.) was evaluated along with starter fertilizer rate in the production of greenhouse-grown petunia (*Petunia* 'Dreams Purple') and marigold (*Tagetes patula* L. 'Hero' (Fain et al., 2008). Results of this study revealed that with the addition of an adequate starter nutrient charge, WholeTree is an acceptable substrate component replacing the majority of peat moss in production of petunia and marigold. Murphy et al. (2010) processed various hardwood trees as a peat alternative in annual production, and reported that annuals grown in up to 50% red cedar showed similar results compared to a greenhouse standard (GS) peat perlite mix, while annuals grown in sweetgum- and hickory-amended substrates had significantly less growth than the GS. A study by Wright et al. (2009) looked at the growth of mums and marigolds grown in white-pine-amended substrates. Results indicated both marigolds and mums had increased growth with addition of peat moss to the pine tree substrate at 25% or 50%. Plants were able to reach comparable growth to the control substrate with the addition of at least 50% peat moss.

Another possible wood fiber alternative to peat moss is *Paulownia tomentosa,* empress tree. *Paulownia*, a known light-weight tree could have a similar bulk density to peat moss, unlike other recently investigated wood alternative substrates which have higher bulk density. *Paulownia* is currently used in several industries including lumber for furniture and other household items. The *P. tomentosa* has very fast, vigorous growth that could prove to be beneficial to the growers. This study was conducted to determine the effects of *P. tomentosa*–amended substrates on production of greenhouse grown annuals.

MATERIALS AND METHODS

This study was conducted at the Paterson Greenhouse Complex, Auburn University, Auburn, Alabama. *Paulownia tomentosa* trees were cut, de-limbed and chipped through a Vermeer BC1400XL chipper and then milled through a 1/4-in. (0.64-cm) screen in a swinging hammer-mill (No.30; C.S. Bell, Tifton, Ohio) on 13 Aug. 2010.

Paulownia tomentosa (PT) substrate component was then combined with different rates of Canadian sphagnum peatmoss (P) to achieve six different treatments. Treatments were 100% PT, PT : P (2 : 8 v/v), PT : P (4 : 6 v/v), PT : P (6 : 4 v/v), PT : P (8 : 2 v/v), compared to a standard peat-lite (PL) mix P : perlite (8 : 2 v/v). Treatments were amended with 1.36 kg • m^{-3} of dolomitic lime, 0.68 kg • m^{-3} of Micromax (The Scotts Company, Marysville, Ohio) and 120 ml • m^{-3} of Aqua-gro L wetting agent (Aquatrols, Paulsboro, Ohio). Containers of 1.96 L (Dillen Products Middlefield, Ohio) were filled to capacity, tamped and filled on 14 Aug. 2010 and two plugs (200 cell flats) of either *Petunia* 'Celebrity Rose' or *Dianthus* Telstar Series Crimson were planted in each container. Containers were placed in a twin-wall polycarbonate greenhouse on elevated benches and hand watered as needed. Containers were arranged in a random complete block design with each plant species treated as separate experiment.

Substrate pH and EC (Accumet Excel XL50; Fisher Scientific, Pittsburgh, Pennsylvania) were determined at 0, 14, 21, 28, and 35 days after potting (DAP) on petunia using the pour-through method (Wright, 1986). Initial substrates were analyzed for particle size distribution (PSD). Substrate total porosity (TP), container capacity (CC), air space (AS), and bulk density (BD) were determined using the NCSU porometer method (Fonteno and Harden, 1995). At termination all crops were measured for growth index (GI) [(height + width + perpendicular width)/three (cm)] and bloom count (BC) (open flowers and unopened buds showing color). Roots were visually inspected and rated on a scale of 0 to 5 with 0 indicating no roots present and 5 indicating roots visible at all portions of the container substrate interface. At termination shoots were removed at the substrate surface and oven dried at 70 °C for 72 h and weighed to determine shoot dry weight (SDW). Data were subjected to analysis of variance using the general linear models procedure and a multiple comparison of means was conducted using Tukey's Studentized Range Test (Version 9.2; SAS).

RESULTS

Substrates containing higher amounts of PT had greater AS than substrates containing 40% or less of PT (Table 1). Substrate CC was found to be the highest in the low percentages of PT with no difference between 40% and 20% PT compared to the PL standard. All substrates containing PT had greater TP than the PL standard. Bulk densities of the PT substrates were found to be of equal value to the peat-lite standard. Substrate BD is usually found to be higher in wood fiber substrates when compared to peat-lite mixes (Fain et al., 2006; Fain et al., 2008; Wright et al., 2008). Substrate PSD indicated substrates with 60% or better PT had higher amount of coarse and medium particles than all other substrates. The larger particle size of those substrates explains in part the greater AS and TP.

At 0 DAP substrate pH was similar for PL, and all treatments containing at least 40% P. Substrate pH at 14, 21, and 28 DAP was highest for treatments containing from 60 to 100% PT. By 35 DAP PL, and treatments containing at least 40% P were similar and lower than those containing less than 40%. Initial substrate EC was greatest for PL and 20 : 80 PT:P with the PL treatment having the greatest EC at 14, 21, and 28 DAP. However by 35 DAP substrate EC was similar among all treatments (Table 2).

Petunia GI was 63% to 400% greater for plants grown in PL compared to other treatments (Table 3). Dianthus tended to respond better to PT as a substrate component than petunia although GI followed a similar trend with GI 26% to 135% greater in the PL treatment than all others. With one exception all other growth parameters followed similar trends on both species with plants grown in PL having the greatest BC, RR, and SDW of all treatments. The exception was with dianthus in substrates containing up to 60% PT had similar RR to PL.

DISCUSSION

The data presented here indicate that PT-amended substrates would result in significant reductions in crop growth compared to the PL standard, casting doubt that PT could be a viable substrate component. In conclusion, the data presented here indicate that although PT-amended substrates showed significant difference in growth when compared to the PL standard, casting doubt that PT could be viable alternative substrate component. However, a possible explanation for reduced growth of plants in the PT-amended substrates is N-immobilization from fresh PT fibers. Similar results were seen by Fain et al. (2006) where less growth of petunia and marigold were seen with increasing rates of WholeTree as a substrate component. Fain et al. (2006) suggests one explanation was nutrient immobilization, especially nitrogen, caused by the WholeTree component. This was confirmed in a follow up study (Fain et al., 2008) where results showed that with the addition of an adequate starter nutrient charge, WholeTree is an acceptable substrate component replacing the majority of peat moss in production of petunia and marigold. Future research with *P. tomentosa* as a substrate component should address the potential problem of nutrient immobilization.

Table 1. Physical properties of *Paulownia*-amended substrates.[Z]

Substrates	Air[Y] Space	Container[X] capacity	Total[W] porosity	Bulk[V] density
	---------- (% vol) ----------			($g \cdot cm^{-3}$)
80 : 20 Peat-Perlite	12.6 c[U]	72.2 ab	84.7 b	1.33 b
100 Paulownia	45.7 a	43.8 d	89.5 a	1.33 b
80 : 20 Paulowina:Peat	43.0 a	48.2 c	91.2 a	1.38 a
60 : 40 Paulownia:Peat	23.6 b	68.6 b	92.1 a	1.33 b
40 : 60 Paulownia:Peat	17.5 bc	72.5 ab	90.6 a	1.39 a
20 : 80 Paulownia:Peat	14.1 c	75.3 a	89.4 a	1.33 b

[Z]Analysis performed using the NCSU porometer.

[Y]Air space is volume of water drained fromt the sample ÷ volume of sample × 100.

[X]Container Capacity is (wet weight – oven dry weight) ÷ volume of the sample × 100.

[W]Total porsity is container capacity + air space.

[V]Bulk density after forced air drying at 105 °C (221.0 °F) for 48 h ($g \cdot cm^{-3} = 62.4274/ft^3$).

[U]Tukeys Studentized Range Test ($P \leq 0.05$, n = 3).

Table 2. Effects of Paulownia amended substrates on pH and electrical conductivity of greenhouse-grown Petunia 'Celebrity Rose'.

	0 DAP[z]		14 DAP		21 DAP		28 DAP		35 DAP	
	pH	EC[y]	pH	EC	pH	EC	pH	EC	pH	EC
80 : 20 Peat : Perlite	3.75 c[x]	4.11 a	4.59 d	5.07 a	4.52 c	4.56 a	4.33 d	4.03 a	5.21 b	1.56 ab
100 Paulownia	6.04 a	1.44 d	6.69 a	1.28 d	6.50 a	1.30 d	6.93 ab	1.50 b	6.82 a	0.62 b
80 : 20 Paulowina : Peat	5.16 ab	1.92 cd	6.35 ab	1.92 cd	6.40 a	1.84 cd	7.14 a	1.46 b	6.70 a	1.22 ab
60 : 40 Paulownia : Peat	4.68 bc	2.33 c	5.97 b	2.50 c	6.12 a	2.30 bc	7.09 a	1.86 b	6.24 b	1.74 a
40 : 60 Paulownia : Peat	3.88 c	3.05 b	5.19 c	2.48 c	5.18 b	3.14 b	6.66 b	1.54 b	5.43 b	1.79 a
20 : 80 Paulownia : Peat	4.07 bc	3.82 a	4.59 d	3.82 b	5.03 b	3.22 b	5.91 c	2.45 b	5.45 b	1.72 ab

[z]Days after planting.
[y]Electrical conductivity (dS/cm) of substrate solution using the pourthrough method.
[x]Tukeys Studentized Range Test ($P \leq 0.05$, $n = 4$).

Table 3. Effects of substrate on growth of greenhouse-grown *Petunia* 'Celebrity Rose,' *Dianthus* Telestar Series Crimson.

	GI[Z]	BC[Y]	RR[W]	SDW[X]
Substrates		*Petunia* 'Celebrity Rose'		
80 : 20 Peat : Perlite	32.1 a	25.6 a	5.0 a	11.1 a
20 : 80 Paulownia : Peat	19.4 b	5.8 b	3.3 b	2.6 b
40 : 60 Paulownia : Peat	10.5 c	1.1 c	2.5 c	1.0 c
60 : 40 Paulownia : Peat	7.0 d	0.0 c	2.0 cd	0.4 d
80 : 20 Paulowina : Peat	7.0 d	0.1 c	2.3 c	0.4 d
100 Paulownia	6.5 d	0.0 c	1.5 d	0.2 d
		Dianthus Telestar Series Crimson		
80 : 20 Peat : Perlite	20.7 a	17.6 a	5.0 a	7.9 a
20 : 80 Paulownia : Peat	16.4 b	4.8 b	4.5 ab	4.3 b
40 : 60 Paulownia : Peat	13.5 c	0.9 c	3.9 ab	1.5 c
60 : 40 Paulownia : Peat	11.7 cd	0.6 c	4.3 ab	2.3 c
80 : 20 Paulowina : Peat	10.3 dc	0.9 c	3.9 b	0.8 c
100 Paulownia	9.3 d	0.0 c	2.6 c	0.8 c

[Z]Growth index = [(height + width1 + width2)/3].($P \leq 0.05$, n = 12).

[Y]Bloom count = number of blooms or buds showing color at 35 days after potting.($P \leq 0.05$, n = 12).

[X]Shoot dry weight measured in grams.($P \leq 0.05$, n = 8).

[W]Root ratings 0–5 scale (0 = no visible roots and 5 = roots visible on the entire container substrate interface). ($P \leq 0.05$, n = 8)

[U]Tukeys Studentized Range Test ($P \leq 0.05$, n = 8).

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Managing Growth of *Hibiscus acetosella* by Controlling Substrate Moisture With Sensor-Controlled Irrigation©

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INTRODUCTION

Understanding how available water in the substrate affects plant growth and how much water plants use is important for effective irrigation management. A better understanding of plant water use will allow growers to irrigate more efficiently, increasing sustainability, reducing leaching and runoff, and decreasing disease incidence and severity. Precise control of irrigation can also provide growers the possibility to manipulate plant growth rate(s) by controlling substrate water content. The use of soil moisture sensors to successfully monitor substrate water content has been demonstrated in both greenhouse and nursery settings (Lea-Cox et al., 2008; van Iersel et al., 2009; van Iersel et al., 2010). Used in tandem with an automated irrigation system, soil moisture sensors can be used to monitor and control substrate water content (Nemali and van Iersel, 2006).

The ability to manage plant growth via control of substrate water content can be a valuable tool for growers, providing the possibility to increase or decrease the length of production cycles, foster or impede plant growth, or potentially help plants adapt to water-stressed environments. The objectives of this research were to understand how growth of *Hibiscus acetosella* 'Panama Red' (PP20121) was affected by maintaining various substrate water contents via soil moisture sensor-controlled automated irrigation and to quantify differences in growth due to variation in substrate water content.

MATERIALS AND METHODS

Experiments were conducted in Watkinsville, Georgia (USDA Zone 7b) and Tifton, Georgia (USDA Zone 8a) in order to address differences due to environmental factors. Rooted *H. acetosella* 'Panama Red' cuttings were planted in 3.8-L black plastic pots in summer 2010 in either a bark-and-peat-based substrate (Watkinsville) (Fafard nursery mix, Fafard, Agawam, Massachusetts) or a mix pine bark and sand (8 : 1, v/v) potting substrate (Tifton). At the beginning of the experiment, plants were pruned to 13 cm, top dressed with 18 g of controlled-release fertilizer (Harrell's 16N-6P-11K Professional Fertilizer, Harrell's, Lakeland, Florida), and irrigated thoroughly.

Throughout the experiment, plants were irrigated using a soil moisture controlled irrigation system as described by Nemali and van Iersel (2006). Two soil moisture sensors (10HS, Decagon Devices, Pullman, Washington) were used to monitor each plot. Sensors were inserted into the root zone of the plant at a 45° angle. Sensors were connected to a multiplexer (AM416; Campbell Scientific,

Logan, Utah) that was connected to a datalogger (CR10; Campbell Scientific). The datalogger recorded and stored voltage measurements from sensors every 20 min. Voltage readings were converted to substrate water contents (θ) using our own calibration [$\theta = -0.401 + 1.0124 \times$ output (V)]. The datalogger compared two sensor readings for each plot to a programmed set point (0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, or 0.45 $m^3 \cdot m^{-3}$) and initiated irrigation when both sensor readings were below the programmed set point.

When irrigation was needed the datalogger signaled a relay driver (SDM16AC/DC controller; Campbell Scientific) to open a solenoid valve (sprinkler valve; Orbit, Bountiful, Utah). Each irrigation event applied 60 ml of water over a period of 2 min using dribble rings connected to pressure-compensated drip emitters (Netafim USA, Fresno, California). Every 2 h, substrate moisture readings for each sensor were averaged and recorded. The number of daily irrigation events was also recorded allowing for calculation of daily irrigation volume. Environmental conditions were measured using a temperature and relative humidity sensor (HMP50, Vaisala), a quantum sensor (QSO-Sun, Apogee Instruments, Logan, Utah, and a rain gauge (ECRN-50; Decagon Devices) connected to the datalogger. Vapor pressure deficit was calculated by the datalogger using this information.

At the conclusion of the experiment, 10 plants from each plot were randomly selected for data collection. Plant heights were recorded. Shoots were cut off at the substrate surface and stem fresh weight was measured; stems were dried at 80 °C and stem dry weight was determined. Substrate water content was measured using a soil moisture sensor (ThetaProbe; Delta-T Devices, Cambridge, U.K).

The experiment was designed as a randomized complete block with eight treatments (substrate VWC set points) and two replications for a total of sixteen plots with 25 plants each. Data were analyzed using linear and nonlinear regression, with $P = 0.05$ considered to be statistically significant. Curve fitting was done using SigmaPlot (Systat, San Jose, California).

RESULTS AND DISCUSSION

Drying of substrates to programmed set points took longer than in our previous greenhouse experiment (Bayer et al., 2011) due to the influence of environmental factors. Frequent rain events occurred in both locations near the beginning of the experiments with setpoints not being reached until around Day 40 for the Tifton experiment and Day 34 for the Watkinsville experiment. After establishment of substrate water-content (θ) thresholds, restoration of setpoints was generally observed after subsequent rain events. The exception was in the Watkinsville experiment in which the 0.10 $m^3 \cdot m^{-3}$ threshold was unable to be reestablished after a 76-mm (3-in.) rain event near the end of the experiment (Fig. 1). This was most likely due to the volume of rain along with small size and low water use of the plants in the 0.10 $m^3 \cdot m^{-3}$ treatment.

Plant height generally increased with increasing θ thresholds (Fig. 2). In the Tifton experiment height increased from an average of 27 cm for the 0.10 $m^3 \cdot m^{-3}$ treatment to 90 cm for the 0.45 $m^3 \cdot m^{-3}$ treatment (Fig. 3). In the Watkinsville experiment, height increased from an average of 28 cm in the 0.10 $m^3 \cdot m^{-3}$ treatment to 69 cm in the 0.45 $m^3 \cdot m^{-3}$ treatment (Fig. 4). Shoot dry mass also increased (data not shown). The linear relationship between plant height and θ threshold (Tifton: $r = 0.88$, $p<0.001$; Watkinsville: $r = 0.90$, $p<0.001$) demonstrate that controlling

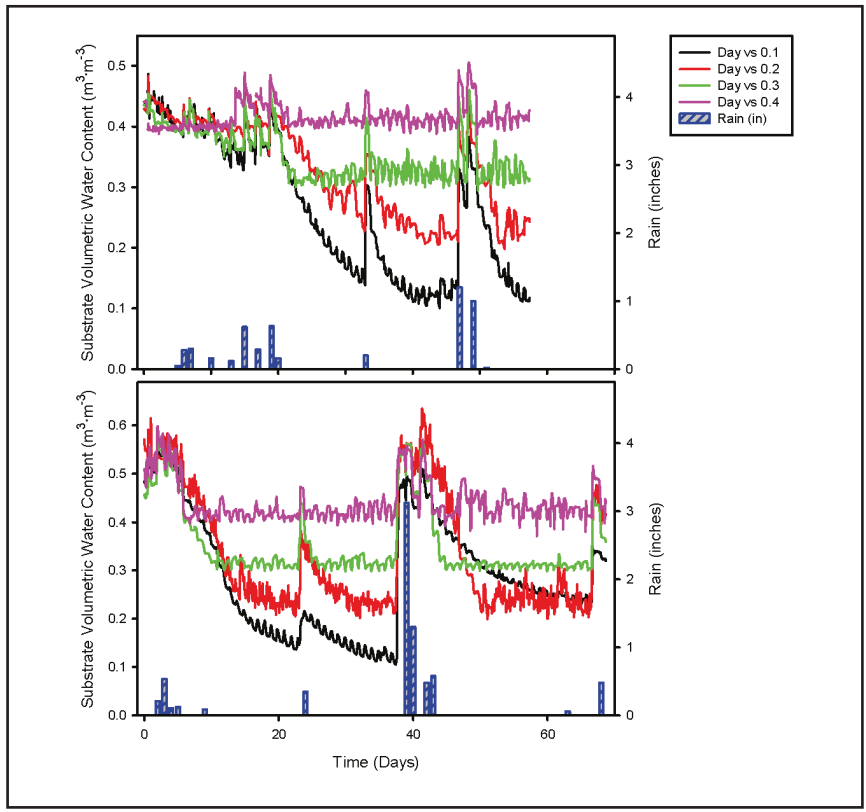

Figure 1. Substrate volumetric water contents over the course of the experiment. The θ thresholds were 0.10,0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45 $m^3 \cdot m^{-3}$, but only the 0.10, 0.20, 0.30, and 0.40 $m^3 \cdot m^{-3}$ treatments are represented for clarity (line graphs). Rain events are shown as blue bars. Nine rain events occurred during the first 20 days of the Tifton experiment (top) causing thresholds to not be reached until around Day 40 of the experiment. Five rain events occurred during the first 10 days of the Watkinsville experiment (bottom) causing thresholds to not be reached until around Day 34 of the experiment. A 76-mm (3-in.) rain event on Day 39 of the Watkinsville experiment prevented the reestablishment of the 0.10 $m^3 \cdot m^{-3}$ by the conclusion of the experiment.

substrate water content can be used to regulate plant growth. As has been observed in previous experiments (Burnett and van Iersel, 2008; Kim and van Iersel, 2009; van Iersel et al., 2010), total irrigation volume increased with increasing θ thresholds. Irrigation volumes over the entire production cycle increased from 0.24 L per plant for the 0.10 $m^3 \cdot m^{-3}$ treatment to 33.6 L per plant for the 0.45 $m^3 \cdot m^{-3}$ treatment in Tifton, and from 0.06 L per plant for the 0.10 $m^3 \cdot m^{-3}$ treatment to 23.0 L per plant for the 0.45 $m^3 \cdot m^{-3}$ treatment in Watkinsville. Similar plant heights can be achieved with a range of θ thresholds. For example in Watkinsville, the 0.35 $m^3 \cdot m^{-3}$, 0.40 $m^3 \cdot m^{-3}$, 0.45 $m^3 \cdot m^{-3}$ treatments all produced plants with similar heights, while height was reduced at lower θ thresholds. There was a

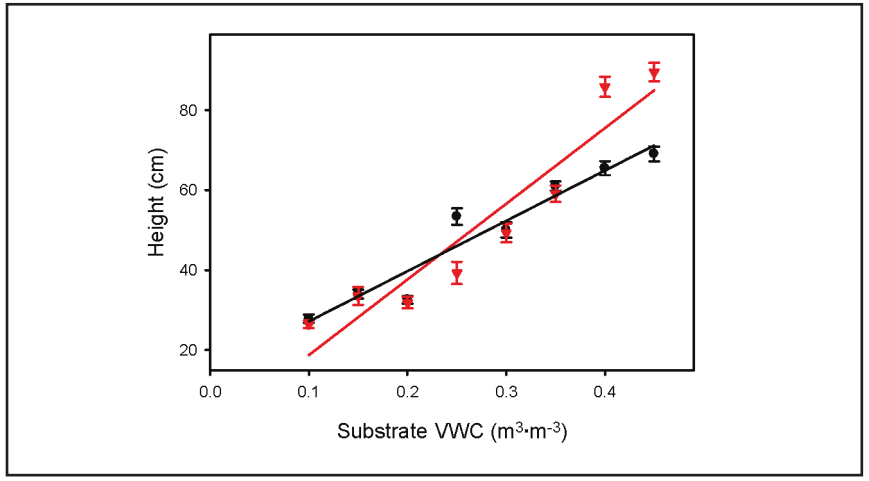

Figure 2. Plant height vs. substrate volumetric water content (θ threshold) for both the Tifton and Watkinsville experiments. Height and θ threshold had a linear relationship (Tifton: r = 0.88, $p < 0.001$; Watkinsville: $r = 0.90$, $p < 0.001$). Watkinsville data is represented by the black circles, Tifton data is represented by the red triangles.

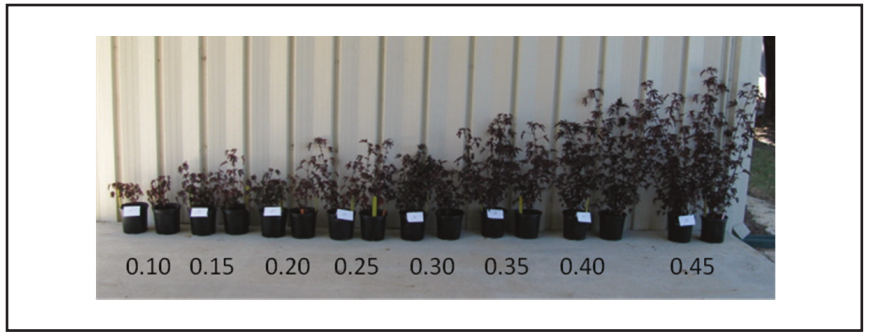

Figure 3. *Hibiscus acetosella* 'Panama Red' grown with increasing substrate volumetric water content (moving from 0.10 $m^3 \cdot m^{-3}$ on the left to from 0.45 $m^3 \cdot m^{-3}$ on the right). Tifton experiment.

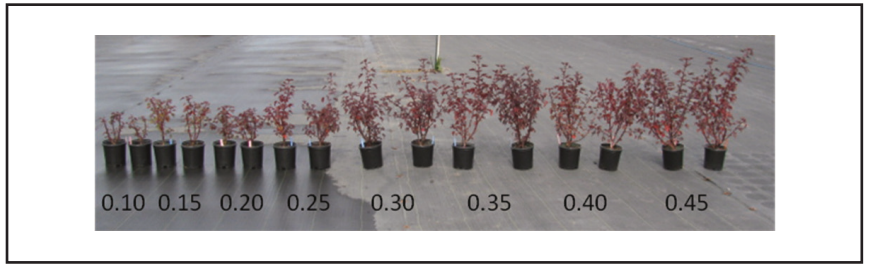

Figure 4. *Hibiscus acetosella* 'Panama Red' grown with increasing substrate volumetric water content (moving from 0.10 $m^3 \cdot m^{-3}$ on the left to from 0.45 $m^3 \cdot m^{-3}$ on the right). Watkinsville experiment.

7.65 L/plant saving in the 0.35 $m^3 \cdot m^{-3}$ compared to the 0.45 $m^3 \cdot m^{-3}$ treatments with only an 8 cm difference in plant height. This 33% savings in irrigation volume with minimal loss in plant height demonstrates that substantial water savings are possible.

Effects of θ thresholds on plant height and shoot dry weight suggest that growth can be controlled via control of substrate volumetric water content. This can provide growers the opportunity to alter production cycles by altering water availability and thereby controlling growth rate. Along with controlling growth, control of substrate volumetric water content can allow for substantial savings in irrigation and fertilizer. Reduced leaching through control of substrate volumetric water content can allow for a reduction in fertilizer application. An experiment in 2012 will look to quantify fertilizer savings.

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Evaluating Potential Plant Health Strengtheners©

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Plant strengtheners are increasing in popularity in the agronomic industry, and recently some chemical companies have expressed interest in exploring use of these products with ornamental crops. In our study, two fungicides were evaluated as potential drought tolerance enhancers using Impatiens walleriana Super Elfin Series XP White. Pageant (pyraclostrobin + boscalid), a conventional fungicide, and Regalia® (extract of Reynoutria sachalinensis), an organic fungicide, were applied weekly as a foliar spray to plants grown in soilless substrate maintained at selected moisture contents (85%, 70%, 55%, 40%, and 25% volumetric water content (VWC) in Expt. 1; and 85%, 55%, and 25% VWC in Expts. 2 to 4. Daily VWC was determined by creating a soil moisture curve based on the relationship between the soil moisture reading and actual VWC. In all four experiments, daily VWC, final growth indices, shoot dry weight, and root dry weight were measured. Use of Pageant applied at a 1.0X rate to well-watered impatiens (85% VWC) had greater shoot growth compared to all other rates and substrate VWCs, Expt. 2. In Expt. 3 the use of Regalia as a foliar spray did result in greater root dry weights compared to the nontreated, however there was no rate 5 moisture interaction.

INTRODUCTION

In recent years there has been increasing interest in the use of plant strengtheners to increase or induce plant tolerance to environmental stresses. By definition, a plant strengthener protects the plant by stimulating resistance or defense mechanisms or by outcompeting the attacking organism for space and food (European Commission, 2001). Ideally plant strengtheners need to be low risk and provide an adequate benefit such as a yield increase or reduced irrigation use. Typical plant strengtheners on the market include, but are not limited to, herbicides, fungicides, insecticides, and antitranspirants. Traditionally, these are referred to as crop health protectants, and aid plant growth by preventing or attacking unwanted

organisms. Fungicides, particularly the strobilurins, have recently been evaluated as potential plant strengtheners.

In 2009, BASF added "plant health" to their Headline fungicide (pyraclostrobin) after approval by the EPA (BASF, 2009). Additionally, in 2010 they launched Intrinsic™ brand fungicides into the turf and ornamental market not only for protection against fungi but also added plant health benefits. This brand of fungicide includes two separate brands; Honor® SC Intrinsic™ brand (pyraclostrobin + boscalid) and Insignia® SC Intrinsic™ brand (pyraclostrobin). Honor SC Intrinsic brand includes two fungicides with two target sites: complex III of fungal respiration (pyraclostrobin) and complex II in fungal respiration (boscalid). BASF reported improved turf health after application of Honor Intrinsic by alleviating drought/moisture and temperature extremes (BASF, 2010).

There has also been research with polyamines as potential stress enhancers. Polyamines are low-weight polycations found in all living organisms (Kaur-Sawhney et al., 2003) and have been shown to increase chilling tolerance in cucumber (Zhang et al., 2009). Additionally, foliar-applied abscisic acid (ABA) has been shown to reduce water loss and extend shelf life in impatiens, seed geranium, petunia, marigold, salvia, and pansy (Waterland et al., 2010).

Although it is known that some fungicides stimulate growth and may improve plant health in agronomic crops (Balba, 2007), little research has evaluated these fungicides for similar effects with ornamentals. Therefore, our objectives with this study were to evaluate the effects of two potential plant strengtheners for increasing plant tolerance to drought using *Impatiens walleriana* Super Elfin Series XP White (impatiens): a strobilurin (Pageant) and an organic fungicide (Regalia®).

MATERIALS AND METHODS

Plant Material and Culture. On 5 May 2010, a crop of *I. walleriana* 'Super Elfin XP White' were potted from 285-plug tray into 6-in. azalea containers for Expts. 1 and 2. All containers were filled to the rim with Sunshine Mix #1 and lightly tapped twice on a hard surface to reduce air pockets. After potting, impatiens were watered thoroughly and placed in a controlled-environment greenhouse [70 °C/65 °C (day/night) temperatures] located on Mississippi State University's North Farm research station. A second crop was potted in similar manner on 24 June 2010 for Expts. 3 and 4.

Substrate Properties. Physical properties of the Sunshine Mix #1 were determined according to the method of Hidalgo et al. (2001), with the substrate providing 90.9% total porosity, 28.3% air space, 62.6% water holding capacity, and 0.11 g/cc bulk density. Volumetric water content was determined according to the WATERSCOUT SM100 Soil Moisture Sensor instructions by Spectrum Technologies, Inc. and fit to a regression model, yielding the equation VWC = 0.00076503*MW – 0.79736 (MW represents target mass wetness defined as a percentage).

Experimental Treatments and Design. Experiment 1 was initiated on 14 June 2010 by recording VWC and watering each container to its designated VWC: 85% (control), 70%, 55%, 40%, and 25%. Four rates of Pageant (boscalid + pyraclostrobin), based on 3.04 oz per 100 gal, were used: 0, 0.5X (0.43 g/gal), 1.0X (0.86 g/gal), and 1.5X (1.29 g/gal). Foliar applications of Pageant were made once

a week 3 h after watering containers to their designated VWC. Experiment 1 was conducted using a randomized complete block design with a 5 × 4 factorial treatment design with 6 single-pot replications per treatment combination. Experiment 2 was initiated on 27 July 2010 and conducted in similar manner to Expt. 1, except that, based on results from Expt. 1, five moisture levels were reduced to three moisture levels: 85%, 55%, and 25%. Expt. 2 was conducted using a randomized complete block design with a 3 × 4 factorial with 6 single pot replications. Experiment 3 was initiated on 27 July 2010 by recording VWC and watering each container to one of three designated moisture levels: 85% (control), 55%, and 25% VWC. Four rates of Regalia (extract of *Reynoutria sachalinensis*) were used, based on the recommended label rate of 64 oz per 50 gal: 0, 0.5X (18.927 mL/1 gal), 1.0X (37.854 mL/gal), and 1.5X (56.781 mL/gal). Regalia was applied as a foliar spray once a week 1.5 h after watering containers to the designated VWC. Experiment 4 was initiated on 7 Sept 2010, and conducted in similar manner to Expt. 3.

Harvesting, Data Collection, and Data Analysis. Initial VWC, daily VWC, final growth index (FGI) [(height + width at widest point + width perpendicular)/3], shoot dry weight (SDW), and root dry weight (RDW) data were collected. Shoots were harvested by cutting the entire plant at the soil line to remove the entire upper portion of each plant. Roots were harvested by first soaking the container with substrate and roots in a 17.7-L container filled with tap water. After soaking for a minimum of 8 h, substrate was washed from the roots over a screen to catch all fallen roots. Further washing removed all remaining small pieces of substrate from the roots. Shoots and roots were oven-dried in a forced air drier at 65 °C for 72 h. Data were analyzed with the GLIMMIX procedure of SAS (version 9.2), with mean separation according to the Holm-Simulation method (alpha = 0.05).

RESULTS

Experiment 1. Differing rates of Pageant had no affect on FGI or SDW. However, the use of Pageant at the 1.0X rate resulted in greater RDW compared to the 0.5X and 1.5X rates. Additionally, VWC effects were seen with FGI, SDW, and RDW, indicating that grown with lower VWC levels averaged less growth than plants grown with higher VWC levels (Table 1). For example, substrate held at 25% VWC resulted in significantly less growth compared to all other treatments, which was similar to previous findings by Blaunusa et al. (2009). There was no significant rate × moisture interaction.

Experiment 2. Weekly application of Pageant did not have a significant effect on FGI, SDW, or RDW (Table 1). Conversely, VWC did have a significant effect on FGI, SDW, and RDW, with greater growth associated with higher VWC. In Expt. 2, there was a rate × moisture interaction with SDW (Fig. 1). After four 1.0x applications of Pageant, plants in containers maintained at 85% VWC had a greater SDW compared to nontreated and fungicide-treated plants. However, Pageant applied at the 1.0X rate to water-stressed plants (55% and 25% VWC) produced no differences in shoot dry weight compared to nontreated plants. These results were similar to previous reports with wheat, which showed increased water-use efficiency after application of pyraclostrobin to well-watered plants, but not water-stressed plants (Nason et al., 2007).

Experiment 3. Differing rates of Regalia had no effect on FGI and SDW (Table 2). However, the use of Regalia at the 0.5X rate resulted in greater RDW compared to the 0.0X rate (nontreated). There was a significance difference with containers maintained at 85% VWC compared to 55% and 25% VWC; however, there was no rate × moisture interaction.

Experiment 4. There was a rate effect seen with FGI when Regalia was applied at 0.5X (16.7 cm) and 1.0X (16.0 cm) rates, compared to the 1.5X (13.1 cm) rate (Table 2). Additionally, there was a rate effect seen with SDW, indicating that plants treated with Regalia at the 1.5X rate had significantly less growth over the 28 days compared to all other rates. Similar to Expt. 3, VWC was a significant factor in impatiens growth, having more growth associated with higher VWC.

DISCUSSION

Based on results from Expt. 2, Pageant applied at a rate of 1.0X to well watered (85%) impatiens enhanced shoot growth. However, Pageant applied to containers maintained at 55% and 25% VWC did not appear to enhance growth of impatiens. Furthermore, since results from only one of two of our experiments indicated an added benefit after applying a strobilurin fungicide, further research should be conducted with ornamental crops, especially since there are multiple reports indicating yield increases in agronomic crops (Zhang et al., 2010).

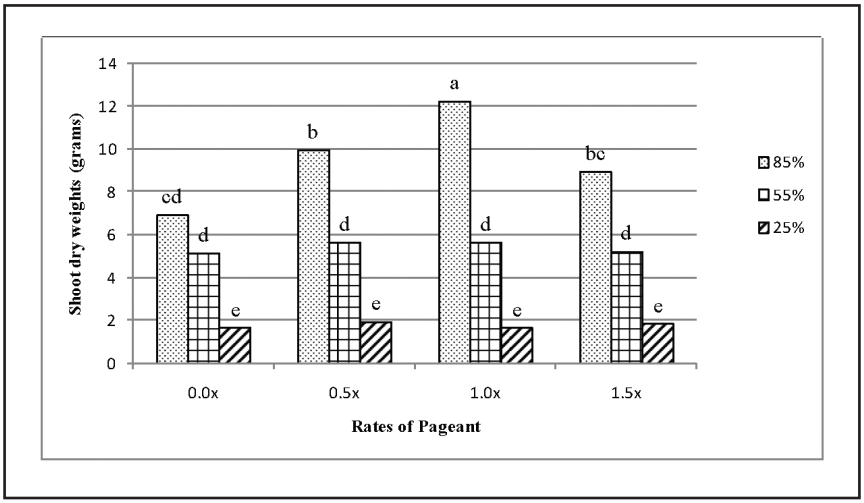

Figure 1. Effect of different rates of Pageant applied as a foliar spray on shoot dry weight of *Impatiens* grown in soilless substrate maintained at different volumetric water contents. Means with the same letters are not statistically different according to the Holm-Simulation method for mean comparisons, alpha = 0.05.

Table 1. Growth of *Impatiens walleriana* 'Super Elfin XP White' after weekly foliar applications of four rates of Pageant to plants grown in soilless substrate maintained at different volumetric water contents.

	Experiment 1, June 2010			Experiment 2, July 2010		
Rates[Z]	FGI[Y] (cm)	SDW[X] (g)	RDW[W] (g)	FGI (cm)	SDW (g)	RDW (g)
0.0X	20.4 A[V]	5.5 a	0.43 ab	22.0 a	4.5 b	0.24 b
0.5X	19.6 a	4.7 ab	0.35 c	22.4 a	5.8 ab	0.36 ab
1.0X	20.5 a	5.4 ab	0.47 a	23.3 a	6.5 a	0.65 a
1.5X	19.2 a	4.5 b	0.40 bc	22.7 a	5.3 ab	0.42 ab
Moisture level[T]						
85%	25.6 a	9.2 a	0.70 a	29.6 a	9.5 a	0.62 a
70%	22.4 b	6.9 b	0.50 b	23.9 b	5.4 b	0.44 b
55%	20.1 c	4.9 c	0.42 b	14.4 c	1.7 c	0.19 c
40%	17.5 d	2.9 d	0.30 c	-	-	-
25%	14.1 e	1.2 e	0.15 d	-	-	-
Effects						
rate	0.3852[S]	0.1116	0.0158	0.8882	0.1723	0.082
moisture	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
rate*moist	0.8045	0.2937	0.5375	0.1068	0.0081	0.165

[Z]Rates of fungicide applied weekly, based on recommended label rate: Pageant 0.0X, 0.5X (0.43 g/gal), 1.0X (0.86 g/gal) and 1.5X (1.29 g/gal).

[Y]FGI – final growth indices [(height + width + perpendicular width)/3].

[X]SDW – shoot dry weight, oven dried for 72 hours @ 65 °C.

[W]RDW – root dry weight, oven dried for 72 hours @ 65 °C.

[V]Means (within a column) with the same letters, within moisture level or rate are not statistically different according to Holm-Simulation method for mean comparison, alpha = 0.05.

[T]Percent moisture level containers were maintained based on volumetric water content.

[S]*p* value.

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Table 2. Growth of *Impatiens walleriana* 'Super Elfin XP White' after weekly foliar applications of four rates of Regalia to plants grown in soilless substrate maintained at different volumetric water contents.

	Experiment 3, July 2010			Experiment 4, September 2010		
Rates[Z]	FGI[Y] (cm)	SDW[X] (g)	RDW[W] (g)	FGI (cm)	SDW (g)	RDW (g)
0.0X	21.9 A[V]	5.6 a	0.49 b	15 a	2.6 a	0.30 ab
0.5X	23 a	6.4 a	0.74 a	16.7 b	2.6 a	0.45 a
1.0X	23.8 a	6.3 a	0.67 ab	16 aa	2.7 a	0.47 a
1.5X	21.3 a	5.7 a	0.57 ab	13.1 b	1.5 b	0.16 b
Moisture level[T]						
85%	29.8 a	10.4 a	0.86 a	18.5 a	4.1 a	0.47 a
55%	24.1 b	5.9 b	0.60 b	15.8 b	2.4 b	0.36 b
25%	13.6 c	1.7 c	0.41 c	11.3 c	0.5 c	0.20 c
Effects						
rate	0.6117[S]	0.925	0.0128	0.0028	0.0165	0.0991
moisture	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
rate*moist	0.6563	0.4524	0.7961	0.7022	0.4169	0.8878

[Z]Rate of fungicide applied weekly, based on recommended label rate: Regalia 0.0X, 0.5X (18.927 mL/gal), 1.0X (37.854 mL/gal and 1.5X (56.781 mL/gal).

[Y]FGI – final growth indices [(height + width + perpendicular width)/3].

[X]SDW – shoot dry weight, oven dried for 72 h @ 65 °C.

[W]RDW – root dry weight, oven dried for 72 h @ 65 °C.

[V]means (within a column) with the same letters, within moisture level or rate are not statistically different according to the Holm-Simulation method for mean comparisons, alpha = 0.05.

[T]Percent moisture level containers were maintained based on volumetric water content.

[S]*p* value.

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Optimization of Select Native Seed Propagation©

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Ecological restoration has become a grave concern due to long-term, anthropogenic impacts. The Coastal Roots program, a U.S. Gulf States project, provides educational opportunities working with local schools to inform and instruct students and teachers regarding successful propagation of various native species for ecological restoration. Two plant species native to Crosby Arboretum, Picayune, Mississippi, and surrounding natural areas have been chosen due to the lack of commercial availability, propagation knowledge, wildlife significance, and threatened or endangered status. *Vernonia angustifolia* Michx. (tall ironweed) and *Coreopsis nudata* Nutt. (pink coreopsis) seed were collected and acquired. Seed were placed in coin envelopes and stored under refrigeration at 5 ºC until germination tests were conducted. Seed were germinated on Whatman® filter paper (#1, Whatman International Ltd., Maidstone, England) hydrated with 5 mL Captan® Fungicide 50WP (2.37 g a.i./L H_2O) (Southern Agricultural Insecticides, Boone, North Carolina) solution in Petri dishes to determine optimal temperature regime. Seed were exposed to five alternating temperature regimes set at 5 °C increments to simulate day and night temperatures: 10/5, 15/10, 20/15, 25/20, and 30/25 °C. To check for seed viability after germination, the remaining ungerminated seed were pricked and soaked overnight in 0.1% tetrazolium chloride (TZ). Germination tests from 2010 and 2011 indicated pink coreopsis germinated best under warmer temperature regimes (30 day / 25 °C night to 25 day / 20 °C night) resulting in 41.45 and 7.65% overall germination, respectively. Tall ironweed germinated best under the mid- to upper-temperature range (20 day / 15 °C night to 25 day / 20 °C night) resulting in 36.15% and 9.35% germination, respectively.

INTRODUCTION

There is an ever increasing need for ecological restoration due to many natural and man-made disasters such as hurricanes, toxic oil spills, and mining. At least 83% of the Earth's land surface has been altered with estimations around 60 percent of our ecosystems being classified as degraded from such practices as overgrazing and logging (Groom et al., 2006). Many definitions have been given to define ecological restoration, but for the purposes of this research the working definition chosen is

"*the returning of a system that has been altered, degraded, or destroyed to a state that closely mimics pre-disturbance conditions*" (Anderson, 2007).

As land use intensifies from a more natural to a more artificial landscape, there is a great reduction in the populations from all species of flora and fauna. This reduction is directly associated with the presence of humans and their impacts to ecosystems from practices such as unsustainable agriculture, leaching of toxic chemicals, urbanization, logging, and mining (Groom et al., 2006). As a result of anthropogenic impacts and natural disasters, several programs have been developed to help with restoration efforts. One such program is the Coastal Roots School Seedling Nursery Program developed by Louisiana State University (LSU) in 2000 (Coleman and Bush, 2002). This program has now been adopted by the Coastal Research and Extension Center (CREC) of Mississippi State University (MSU). The Coastal Roots program works with schools that range from elementary to high schools. By constructing a small nursery on the schools' premises, science students are able to propagate, grow, and care for native plants to later be used in restoration plantings within a predesignated restoration site. In the classroom, the students learn about the issues and importance of ecological restoration, nursery maintenance, plant growth, wetlands, as well as other restoration and conservation issues. Within Mississippi, Woolmarket Elementary School in Biloxi was chosen to be the first school for the nursery program with their associated restoration site located within the Crosby Arboretum, Picayune, Mississippi (Coker et al., 2008). From this, there is a great need for information on how to propagate many of our native species. Popular species are well known in the nursery industry and easily propagated; however, they represent a very small portion of the plant species which historically contribute to a given ecosystem's biodiversity. Many other species important to biodiversity have very little known about their propagation and need more research to be conducted. Reintroducing composites greatly enhances plant diversity within a degraded ecosystem (Coffey and Kirkman, 2006). Promoting biodiversity in ecological restoration is crucial to creating a true healthy and functional system. To address these issues the project objectives are as follows: (1) to identify two native plants of significance for ecological restoration from various habitats located in southern Mississippi; specifically, plants with potential for production in a small, school-based nursery system; (2) determine the viability of seed propagation of these two native plants applicable in a small, school-based nursery system; and (3) determine the optimal temperature regime producing the greatest germination percentage for each species.

MATERIALS AND METHODS

Working in association with Crosby Arboretum, two plants native to their properties were chosen for seed germination research due to their threatened or endangered status, lack of commercial availability, ornamental value, and significance to wildlife populations.

Seed germination studies with *Vernonia angustifolia* Michx. (tall ironweed) and *Coreopsis nudata* Nutt. (pink coreopsis) seed were conducted separately for two consecutive years. Due to the lack of seed source on-site, tall ironweed and pink coreopsis were acquired elsewhere. Tall ironweed, Florida ecotype, was purchased from Ernst Conservation Seeds, Meadville, Pennsylvania, in January 2010, and from the Florida Wildflowers Growers Cooperative, Crescent City, Florida, in Janu-

ary 2011 because Ernst Conservation Seeds had none available. Pink coreopsis was collected from Apalachicola National Forest, Liberty County, Florida, in May 2010 and May 2011. Once collected, the seed were cleaned and prepped accordingly. Tall ironweed was debearded and then aspirated. Pink coreopsis was sieved to remove as much trash and debris as possible. Seed were counted by an electronic seed counter and placed in coin envelopes. Each year, individual coin envelopes contained 50 seed and were stored under refrigeration (5 °C) until May 2010, and January 2011.

Petri dishes (100 × 15 mm) were lined with Whatman® filter paper (#1, Whatman International Ltd., Maidstone, England) and hydrated with a 5 mL Captan® Fungicide 50WP (2.37 g a.i./L H_2O) (Southern Agricultural Insecticides, Boone, North Carolina) solution. Seed from each plant species were placed within the Petri dishes and then placed inside five germination incubators. The incubators were set at varying temperature regimes under a long-day photoperiod (16 h). Temperatures were alternated to simulate environmental conditions set at 5 °C increments to distinguish day and night ranges: 10/5, 15/10, 20/15, 25/20, and 30/25 °C. Eight replications of 50 seed per species per temperature regime were used for both species. Lighting was correlated to day temperatures.

Seed were placed under alternating temperature regimes for 28 days with germination counts conducted every 2 days. Determination of the optimal germination temperature was then made for each species based from the regime with the highest germination percentage within the 28-day period. Any remaining ungerminated seed from each species were placed within the determined optimal temperature for an additional 10 days with germination counts conducted every 2 days to determine quiescence. After the completion of the 10-day germination period, viability tests were conducted on the remaining ungerminated seed. Seed were pricked by a hypodermic needle within close proximity to their embryos and then soaked in a 0.1% 2,3,5-triphenyl-2H-tetrazolium chloride (TZ) solution for 12 h. The remaining viable seed were determined from the presence of a pink to red stained embryo which classified them as being dormant (Baskin and Baskin, 2001; Peters, 2000). Total viability was calculated by combining the germinated and remaining viable or dormant seed. The data collected include: germination counts conducted every 2 days, overall percentage of germination, and an overall percentage of seed viability. The data were analyzed as a randomized complete design, using generalized linear model of SAS version 9.2 (SAS Institute Inc., Cary, North Carolina) with mean separation according to the least significant difference test, $\alpha = 0.05$.

RESULTS

In 2010, pink coreopsis and tall ironweed resulted with overall germination percentages of 41.45% and 36.15%, respectively. Significant differences were found with pink coreopsis seed in relation to germination under separate temperature regimes for the 28-day period. The 28-day germination period indicated pink coreopsis germinated best under warmer temperature regimes (30/25 °C); whereas, tall ironweed showed the highest germination percentages at moderate temperatures (20/15 °C). At the completion of the study, viability percentages for pink coreopsis and tall ironweed were 60.2% and 65.95%; respectively.

Germination percentages varied between consecutive years among species. In 2011, pink coreopsis and tall ironweed resulted in 7.65% and 9.35%, respectively, which was substantially lower than the year prior. Pink coreopsis and tall ironweed

had higher germination percentages under 25/20 °C. Viability percentages in 2011 for pink coreopsis and tall ironweed were 32% and 9.60%; respectively.

An indication of a cold, moist stratification (10/5 °C) was found to enhance the germination percentage of tall ironweed. This was especially observed from the results of 2010; whereas, it was not as evident the following year (Figs. 1 and 2). The seed source differed in 2011 and initial observations upon arrival lead to the belief that much of the seed had desiccated and were not viable before undergoing experimentation.

In 2010, germination counts across the temperature regimes indicated warmer temperatures (30/25 °C) increased the germination of pink coreopsis; however, in 2011, pink coreopsis resulted in higher germination only after seed were exposed

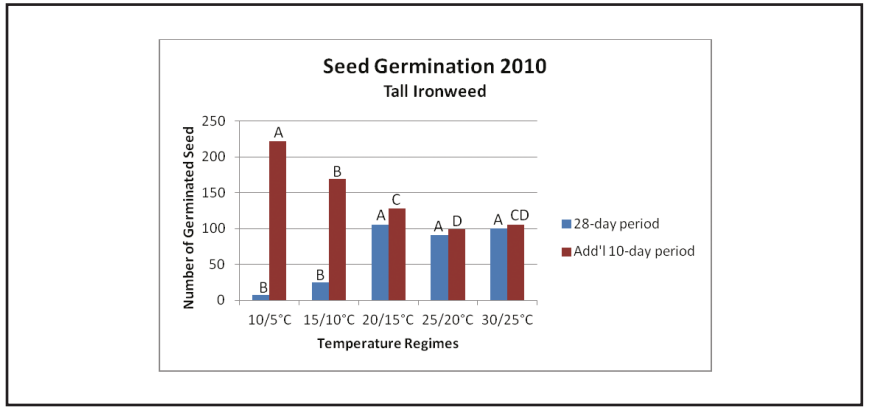

Figure 1. Germination counts across temperature regimes to determine optimal temperature (20 day / 15 °C night) combined with the additional 10-day period to determine quiescence under the optimal regime for tall ironweed (*Vernonia angustifolia* Michx.) in 2010.

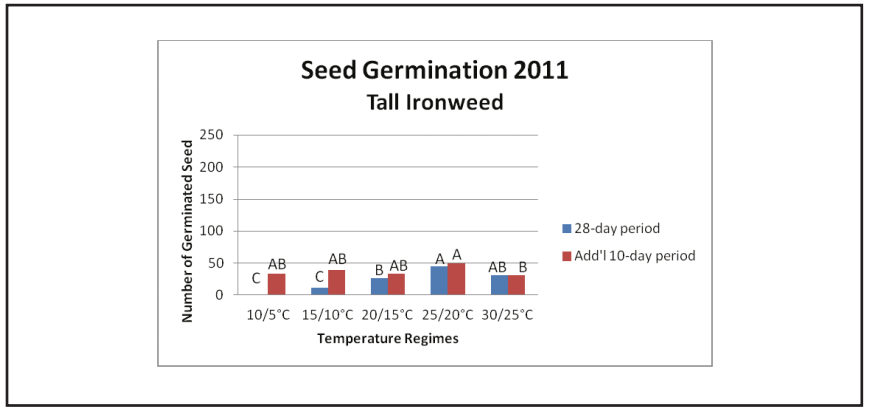

Figure 2. Germination counts across temperature regimes to determine optimal temperature (25 day / 20 °C night) combined with the additional 10-day period to determine quiescence under the optimal regime for tall ironweed (*Vernonia angustifolia* Michx.) in 2011.

to cooler temperatures of 10/5 °C and 15/10 °C and then placed under the optimal temperature that was determined to be 25/20 °C (Figs. 3 and 4). This suggests pink coreopsis may enter some form of dormancy and benefits from a cool, moist stratification process which is similar to the results of *Coreopsis floridana* and *C. leavenworthii* (Rukuni, 2008). However, indications have been reported that an after-ripening period is beneficial toward the germination of some *Coreopsis* species (Kabat, 2004; Norcini and Aldrich, 2007; Rukuni, 2008). Further research should be conducted to address after-ripening effects on pink coreopsis seed.

DISCUSSION

In conclusion, biodiversity needs to be promoted through research for ecological restoration to be most beneficial (Groom et al., 2006). With programs arising to

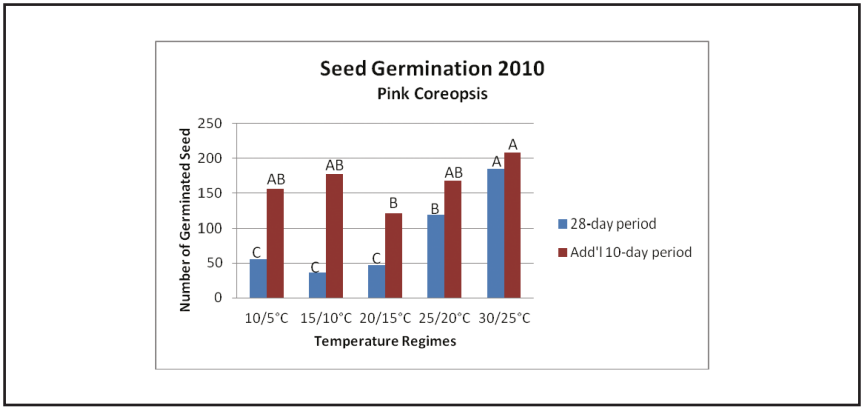

Figure 3. Germination counts across temperature regimes to determine optimal temperature (30 day / 25 °C night) combined with the additional 10-day period to determine quiescence under the optimal regime for pink coreopsis (*Coreopsis nudata* Nutt.) in 2010.

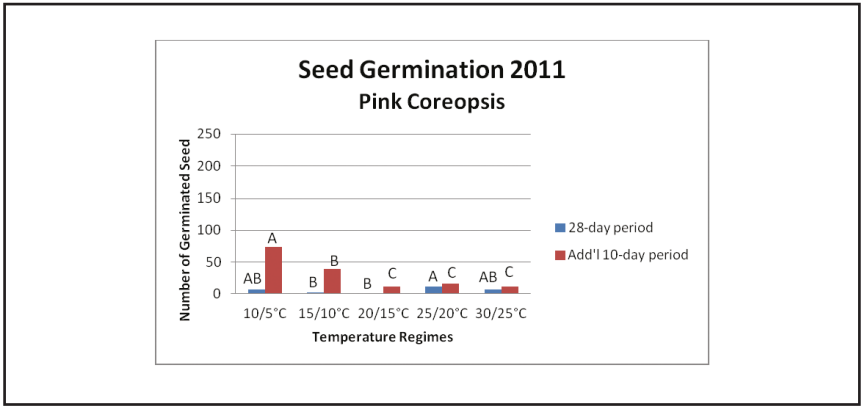

Figure 4. Germination counts across temperature regimes to determine optimal temperature (25 °C day / 20 °C night) combined with the additional 10-day period to determine quiescence under the optimal regime for pink coreopsis (*Coreopsis nudata* Nutt.) in 2011.

help aid against harmful impacts on the environment through restoration efforts, additional native plants continue to need research to be conducted. Germination of these selected native species from this research was influenced by temperature; therefore, optimal temperature regimes and germination percentages were able to be determined for both species. This determination greatly enhances the knowledge of seed propagation for these native plant species and gives some indication on the applicability of using these species within restoration efforts and the commercial native plant industry. Based on the results from 2010, additions to the Coastal Roots program's plant palette could include pink coreopsis and tall ironweed which would also benefit restoration efforts by promoting biodiversity. However, the source of the seed may prove to be difficult and limiting at times. The results from 2011 for both species vary in germination and viability percentages; thus, additional research within a nursery setting needs to be conducted for each of these two species before making a definite decision.

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Timing of Fungicide Sprays to Prevent Azalea Web Blight Symptoms©

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Rhizoctonia web blight affects azaleas, as well as other plant genera such as hollies, in nurseries in the southern and eastern U.S.A. Our research is demonstrating how little is known about some plant pathogens that infect ornamental plants in nurseries. Binucleate *Rhizoctonia* fungi grow and survive on azalea stems throughout the canopy and in the rooting media 12 months of the year, although plant damage only occurs in July to September. In a typical year, only about a quarter or fewer of the infected plants develop severe damage.

Several fungicides will control web blight, but guidelines about when to spray have not been clearly understood. Previous research has shown that maximum daily temperatures greater than 35 °C (95 °F) and minimum daily temperatures less than 20 °C (68 °F) slow web blight development. Unfortunately, weather conditions have not provided a precise prediction of when rapid blight will develop, despite the fact that moisture is critical for the development of all plant diseases. Apparently daily irrigation creates regular moisture conditions favorable for slow to moderate disease development and interferes with distinct patterns needed for predictions.

Disease starts building up weeks ahead of afternoon rains, which were not a consistently dependable weather pattern for predicting the rapid appearance of blight. Analysis is in progress that may still help identify temperature and moisture patterns that influence rapid web blight development.

Decision criteria are another approach sometimes used to select fungicide timing dates. With three years of research at two locations (Poplarville, Mississippi, and Mobile, Alabama), applying fungicides on scheduled calendar dates (around 10 July and 1 Aug.) was the most reliable criterion for suppressing blight development on 'Gumpo White' azalea. This is an easy approach to follow. Since azalea cultivars vary in susceptibility, only the more susceptible azaleas should be sprayed at the same time as 'Gumpo White'. The less susceptible cultivars could be sprayed 2 weeks later. A problem in timing still exists because web blight develops at different rates each year, at each nursery and in different blocks at the same nursery. Scouting provides a way to adjust to that variability. Scouting could allow fungicides to be applied a week or so earlier or later than the scheduled date and should take only 5 to 10 min per block of plants of the same cultivar and age. Scouting is done by spreading branches so you can take a quick count of the number of dead leaves present in the inner canopy (not ones on the surface of the bark medium). Count dead leaves

in at least six scattered plants. Small plants could have 5 to 30 dead leaves. Large plants could have 10 to 50 dead leaves. The important point is to spray when there is an increased count of 10 to double the number of dead leaves per plant from the previous week. Scouting should not be the main decision criterion, because rapid blight can develop later in the same week plants were scouted. It is primarily a way to adjust to the variability in when blight develops. By checking several blocks it will be obvious which blocks of plants have more advanced symptoms and when disease has advanced. Also decide risk of web blight based on your past experiences (cultivar, plant age, spacing, placement in nursery, and weather).

Fungicides are most effective when sprayed days to 1 week in advance of infection periods. Fungicides are a sophisticated technology and should be used wisely. Fungicides inhibit pathogen colonization of plant tissue and prevent (limit) symptom development, but do not eliminate the pathogen. Fungicides from different fungicide classes should alternatively be used and sometimes tank mixed to minimize the development of fungicide resistance.