Palletised nursery logistics©

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These proceedings represent an adaption of a pictorial power point presentation made at the South Africa conference of 2016.

The Natural Area Nursery specialises in growing Perth native species from seed for restoration, revegetation, and landscaping.

In 2013 the Natural Area Nursery in Perth, Australia established a distinct propagation area and nursery enclosure to facilitate a new approach to the sowing, germination, and handling logistics with the intention of improving efficiency, reducing staff work load, and handling strain.

The availability of low cost plastic pallets arising from the Western Australian mining boom combined with a large hardstand area gave rise to the concept. Central also to the plan was the expertise developed by the nursery in the germination treatments of many species and the availability of air seeding equipment.

Propagation mix is loaded from soil bin to a hopper and conveyor external to the processing shed.

The air seeding line is comprised of conveyor soil feed, automated composite tray dispenser, tray filler, compactor, and finishing surface brush. The seeder has dibbler, vermiculite top dress, and watering facility when required. The seeding line is coupled to a gravity roller conveyer with capacity for 24 trays. Two composite trays are used, 35 cell (50 ×50×120 cm) and 63 cell (40×40×90 cm). The two trays have essentially identical dimensions of length and width.

The operator sows 24 trays per run and then loads them to 1.1×1.1 m pallets, each pallet holding 12 trays. This process is repeated until six pallets are full. The loaded pallets sit on a powered roller conveyor which sits at right angles to the gravity tray conveyor. When all six pallets are loaded, they are powered one at a time to an extension of the powered conveyor which is external to the processing shed. A forklift or skid steer loader with forks moves the sown trays on pallets to one of two germination areas (Figure 1).

Figure 1. Auto seeder germination pallets.

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The two germination areas have different light, temperature, and moisture conditions. When germination is complete and plants strong enough, they are moved by fork to external growing area, some under shade cloth and others to direct light (Figure 2). Sizeable plant movements are done almost exclusively by forklift and mini loader with forks, either to shed for grading and cleaning or to loading area for transport.

Figure 2. Palletised outdoor external growing area.

This nursery facility produces, maintains, and despatches up to 450,000 plants annum^{-1} with total staff of 1.5 FTE.

Plant tray recycling is undertaken using cages elevated by forklift to chlorination baths for min 48 h as a first step and after to a commercial dishwasher at 90°C for 5 min.

Plant production system: testing and implementation©

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INTRODUCTION

Plant Production System (PPS) is a web-based database which helps to organise nursery tasks in specific weeks, from propagation to potting as well as create work lists and capture completed work daily in order to have control over stock in the nursery. This talk introduced and explained PPS.

BACKGROUND

Arnelia farms nursery produces close to 150 different taxa in various genera including *Protea*, *Leucospermum*, *Leucadendron*, *Erica*, *Telopea*, *Chamelaucium,* and *Bougainvillea*. Each taxon has its own nutritional and management requirements to achieve high quality outcomes. However, keeping track of these tasks as well as additional tasks of weeding, growth regulating, and spacing is a challenge in an ever expanding nursery. With most taxa pinching, pruning, or spacing must be completed by specific dates and if these are not met the planned outcome is not achieved. Historically, everything was managed with the use of Microsoft® Office Excel® (2010) spreadsheets and knowledge of personnel. But as the nursery grows the need develop for a more effective way to keep track of tasks including propagation, potting, plant maintenance, and stock. After unsuccessfully searching for appropriate industry software, we decided to approach DiPAR Systems (Bellville Park, Cape Town, 7530, South Africa) to help create a plant production management system. Most systems available are aimed at short term nursery crops where the cycle starts with propagation (vegetative or seed), transplanting of plugs or rooted cuttings after a specific number of weeks, and finally potting again to the final pot size. Plants are sales ready within a couple of weeks or months. This did not fit well with our nursery where plants are grown mostly from cuttings for 12 to 18 months. We have different ages of plants of the same taxon for different sales periods at the same time in the nursery and this should be managed.

PLANT PRODUCTION SYSTEM

The program consists of various master files in which the user is able to set up all the plants, containers, locations, tasks, and product lines for a nursery. For each production line which the nursery will produce a production plan is created (number of units to sell) as well as all the production steps necessary to produce the product and this is linked to specific weeks in which the tasks must be completed. A work schedule is then generated which can be modified either in the office or on a mobile device in the nursery. Once the schedule is saved work lists are generated via a module called Dynamic Reporting. After the work is completed, individual workers or team leaders can capture the daily work completed.

With the use of Dynamic Reporting various reports can be generated depending on the user's needs and management level. Reports could include work still to be done per week or weeks, completed work or status of stock in the nursery.

FURTHER PHASES

As soon as phase one of PPS is fully functional several other phases will be considered including:

- Dispatch of stock and management thereof.
- Management of consumable stock such as pots and potting media.
- Setting up and management of demand planners for following seasons.

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Climate change: risks and opportunities in nursery production©

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INTRODUCTION

The purpose of my presentation is to bring some of the latest information to you about the predicted impacts of climate change on South Africa, with a particular focus on how it may affect the nursery industry. Plant growth is driven by environmental factors, and so any change to the environment will impact on production and therefore our livelihood as growers of living products.

Everyone here has heard of climate change and you will all have your own opinions about the issue and possible solutions. After a while, hearing about climate change can become like background noise; too big a problem to be able to directly relate to your own life and business decisions. So while most people acknowledge that climate change is happening, it's difficult to prioritise time to plan how to handle these impacts.

There's no doubt that many of the predicted changes are worrying but I also want to talk about some of the opportunities that are unique to our involvement in nursery production. We all need to engage with climate issues and I believe there are many opportunities for growers to increase their production while also taking a leading role providing green solutions in their communities.

DISCUSSION

Understanding the atmosphere

Sunlight passes through the atmosphere and warms the earth's surface. That heat is then radiated back towards space but fortunately our lower atmosphere has a blanket of gases—we call these greenhouse gases—whose chemical structure reacts to absorb this heat. These gases then re-emit the heat in all directions, some of which radiates back to warm the surface of the earth and the surrounding lower atmosphere. This is a natural effect and thanks to its existence, our average global earth surface temperature is a comfortable 15°C, which enables us to grow crops and exist.

About 1% of the earth's lower atmosphere is composed of these greenhouse gases: mainly water vapour, carbon dioxide, methane, and nitrous oxide. Without them our world would be cold and uninhabitable but…the proportion of these gases in our atmosphere is changing.

The most significant of these gases is carbon dioxide because it lasts for a long time in the atmosphere, and it is therefore considered to have a greater long-term warming effect. A recent report by Stevens et al. (2015), notes that the concentration of atmospheric carbon dioxide is higher than it has been for the past 800,000 years. Scientists have been able to unravel some of the history of our earth's atmosphere by sampling the air trapped inside frozen bubbles of ice from Antarctica. In more modern times, our atmospheric CO_2 measurements are recorded at the Mauna Loa Observatory in Hawaii. At the time of writing, the level of atmospheric CO_2 for January 2016 was 402.52 ppm as displayed at http://co2now.org/Current-CO2/CO2-Now/. When the Mauna Loa Observatory first started recording in 1959, CO_2 levels were below 320 ppm.

Some people might pine for the good old days when things seemed more certain and we believed we had little effect on the environment. As levels of CO_2 from burning fossil fuels, methane from intensive farming, and nitrous oxide from nitrogen fertiliser use increases; so does global warming. The Intergovernmental Panel on Climate Change (known as IPCC)

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produces public reports on climate change every 5 to 7 years, drawing together research from scientists around the world. This group has concluded in their latest Fifth Assessment Report, that it is highly likely that humans are the dominant cause of warming since the mid-20th century (IPCC, 2015). Copies of this report, including summaries of climate change effects on all regions of the world, are publicly available from their website: (https://www.ipcc.ch/ report/ar5/).

Global effects of climate change

Intergovernmental Panel on Climate Change (2014) reports that we are already experiencing some of the global effects of climate change: increasing air temperatures; longer periods of drought in some areas; longer, more intense heat waves, and increasing frequency of wildfires.

By warming the atmosphere, climate change is predicted to increase the number, duration, and frequency of tropical storms. Warmer oceans are leading to a loss of sea ice, and increasing sea levels. The global sea level has risen 10-25 cm in the last century (Stevens et al., 2015).

Of course we share this planet, and other living organisms are also affected. Some are moving to different habitats or ranges, particularly cooler ones, to survive climate change effects. Migration patterns and seasonal behaviors such as flowering have changed. According to the IPCC "most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change in most landscapes" (IPCC, 2014). This global redistribution of species is recognised by scientists as an identifying sign or "fingerprint" that climate change is taking place (Pecl and Williams, 2015).

Effects of climate change on South Africa

The earth's climate will not change uniformly across the globe. What may happen in South Africa, will be different from what may happen in my corner of the world, New Zealand. It's important to get the most accurate technical information you can for your area, as you can't manage the risks, if you don't know the risks.

The following section describes information about climate change trends in South Africa from recently published sources such as the Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) and others (Ziervogel et al., 2014; DEA, 2013). A report titled "Change Is in the Air" by Stevens, Bond, Hoffman, and Midgley is particularly interesting (Stevens et al., 2015).

CLIMATE CHANGE TRENDS IN SOUTH AFRICA

Effects of climate change on temperatures

The first two bullet points below describe changes that have taken place, whereas the last two describe what is predicted to happen in the future.

- Over the last 5 decades, mean annual temperatures have increased in South Africa by more than 1.5 times the observed global average of 0.65°C.
- Maximum and minimum temperatures have been increasing annually across the country, with the exception of the central interior.
- Temperature increases of more than 4°C are projected under scenarios, where emissions remain high, for the central and northern interior regions over 2080-2100.
- The coastal regions are expected to experience the least amount of warming.

Effects of climate change on rainfall

The first two bullet points below describe changes that have taken place, whereas the last two describe what is predicted to happen in the future.

- There is less autumn rainfall and fewer days with rain in the central and north-eastern parts of the country; overall annual rainfall has not reduced significantly but fewer rainy days means a tendency towards an increase in the intensity of rainfall

events with longer dry spells in between.
- Spring and summer rainfall has increased in southern Drakensberg region.
- Unlike temperature, there is more uncertainty about future rainfall trends.
- Current models project rainfall to reduce over Limpopo and south-western Cape while it will increase in the central interior extending to the southeast coast in the far future. Increases are projected to occur in spring and summer.

Work by MacKellar et al. (2014), illustrates the trends in annual mean daily maximum temperatures and trends in annual mean rainfall across South Africa, over a 50-year period (1960-2010).

Effects of climate change on biodiversity

South Africa has nearly 10% of the world's plant species—what an amazing natural heritage. We experience climate change and these ecological systems also show the effects of such change.

To understand the distribution of this plant diversity, ecologists have broadly characterised it into eight different vegetation types or biomes, plus the mixed Indian Ocean Coastal belt. Biomes have distinct plant growth forms and are often linked with particular climates.

Changes in the vegetation patterns of these biomes have been mapped and it shows that the Savanna biome is becoming woodier and these plants are expanding into the grassland biome. In turn, the grasslands tend to be expanding into the eastern Karoo biome. While the increase in trees may have some positives, researchers are concerned that in some wetter areas they shade out the grasses, reducing biodiversity and ultimately reducing grazing and the economic benefits of tourism (Stevens et al., 2015). While different land use practices such as burning and grazing are established factors in vegetation change, these researchers believe that it is the increase of CO_2 itself, rather than warming that is promoting growth in plants that are sensitive to it. Climate change is also causing changes in rainfall seasonality, and it may be this factor that accounts for shifts of grasslands into the eastern Karoo.

Future projected changes, until 2050, in the distribution of biomes under low, medium and high-risk climate scenarios, have also been developed (DEA and SANBI, 2013a). The most threatened biome under all climate scenarios is the grassland—replaced with savanna and potentially forest; second most threatened is Nama-Karoo with savannah and desert; third most threatened Indian Ocean Coastal Belt, fynbos and forest. Desert will expand under all climate scenarios especially the high risk one.

EFFECTS OF CLIMATE CHANGE ON NURSERY PRODUCTION

In IPPS we share a love of plants—complex living organisms that are responsive to their environment. I thought it was worth reviewing the environmental factors that drive plant growth and consider how climate change will affect our plant-based livelihoods. To be specific, what will increased temperatures, reduced water resources, and increased carbon dioxide, mean for nursery production in the future. Remember, for South Africa, climate change projections up to 2050 and beyond point to warming as high as 5-8°C over the South African interior, if we aren't able to decrease global emissions (DEA and SANBI, 2013b).

Effects of increasing temperatures

- Heat stress damages, and in extreme cases, kills plants. It is a function of intensity, duration and rate of increase in temperature.
- High day temperatures have direct damaging effects linked to hot tissue temperatures or indirect effects linked to plant water deficits.
- High soil temperatures can reduce plant emergence and also damage the reproductive development of many crop species, i.e., no flowers, or if flowering, poor fruit set/seeding.
- Plants take up an enormous amount of water—much more than an animal of a similar size and water is essential for photosynthesis and cell processes.

- Almost 99% of the water taken in by the roots is released from leaves in a process called transpiration through stomata openings.
- Increasing temperatures increases transpiration; the rate of water evaporation doubles for every 10°C rise which increases the risk of cell death.

The role of stomata

- Plants have the ability to control both the amount of water in their bodies and gas exchange by opening and closing the stomata in their leaves—there are thousands of these pores per square cm of leaf.
- Stomata need to be open in day light hours for plants to take in carbon dioxide and this allows water vapour to move out. When the plant senses it is too dry, it will shut the stomata rather than die through lack of water. Temperatures higher than 30 to 35°C can also lead to stomata closing. The result of this will be that the plant cannot make the food needed for growth processes as there is no carbon dioxide entering the leaf.
- Root initiation in cuttings depends on the temperature but root growth after that is strongly dependent on available carbohydrates (Hartmann et al., 1997). Low food reserves equals poor root growth and ultimately a poor quality plant.
- Some researchers are investigating genetically altering plants to increase the density of stomata per area of leaf. The idea is that this will increase the amount of CO_2 drawn in, increasing the photosynthetic efficiency of the plant and removing more CO_2 from the air to the benefit of our atmosphere.

Effects of increasing carbon dioxide

When CO_2 increases, trees will grow faster. Research by Bond and Midgley (2012) illustrated roots of the common acacia karoo (sweet thorn) exposed to different levels of CO_2. A plant grown at CO_2 levels typical of the pre-industrial age (i.e. 180 ppm) had a much smaller root system than a plant grown at 375 ppm CO_2 (the concentration representing the level of CO_2 in the late 1990s). The difference between these plants was a three-fold increase in their biomass.

As there is more carbon dioxide in the atmosphere to take in, it is easier for plants to absorb it and manufacture food. Trees store the extra carbon in their roots or woody stems. This produces much larger root systems with increased starch concentrations. The consequence of enlarged root systems is that this enables plants to re-sprout quickly after fire and browsing, and also increases the growth rate of tree seedlings, and so many trees are gaining a competitive advantage due to high carbon dioxide conditions (Bond and Midgley, 2012).

How might increasing CO_2 levels affect my nursery?

- Increased carbon dioxide levels increase plant growth there will be less need for artificial CO_2 enrichment.
- Increased carbon dioxide levels mean plants will use less water when growing. This is because plants don't have to open their stomata as much to gain carbon dioxide, and so less water vapour is lost from the plant. This means that for the same amount of water, plants will grow more; a useful benefit for plants growing in drier areas.
- In urban areas demand for plants may increase due to urban greening and carbon credit schemes. In Australia, the Nursery and Garden Industry have set a target of 20% more urban green space by 2020 (Horticulture Innovation Australia Ltd.).
- As increasing CO_2 is partly driving changes in indigenous vegetation, those nurseries growing for ecological restoration work need to ensure their plant mix is "future proofed." If the balance between grasses and woody plants in your local biome is changing, that means the type of stock plants or seed stock you hold, needs to reflect that changing pattern.

Instead of maintaining genetic purity by only collecting from local seed sources (known as ecosourcing), new ideas are being developed known as "climate adjusted provenancing." Where landscapes remain largely fragmented, the idea is to collect genetically diverse material to use in revegetation to enhance a species' adaptive potential. For example if your local area is predicted to become drier in the future, by introducing a broader range of genetics to native plant populations, there is a greater chance that those plants will be able to adapt over time and survive into the future.

If you want to know more about climate change implications for those supplying the restoration sector, the Society for Ecological Restoration Australasia has a draft of national restoration standards out which you may find useful. I believe there will be increased demand for seed resources and restoration work as habitats to sustain biodiversity come under pressure.

How might increasing temperatures affect my nursery?

- Review the use of greenhouses—with temperatures already high, do you need to fully enclose plastic houses? This may allow cheaper structures to be built.
- Identify ways of cooling plants that are energy efficient. With the decrease in the price of solar cells and the abundant light in South Africa, this would seem to be a likely option for future energy efficiency.
- Increase shading by use of natural plantings/shade materials.
- Increase technical knowledge to deal with new pests and diseases that are likely to establish.
- Grow crops that fit your conditions.
- The shorter time to crop maturity may be an opportunity for increased crop rotations.

How might decreasing water availability affect my nursery?

- Have you thought about how you would deal with the possibility of reduced water resources?
- Now is the time to investigate ways of improving irrigation efficiency: increase water storage, water recycling, fittings and infrastructure.
- Grow more drought tolerant crops.
- Conserve soil moisture with mulches.
- The increased demand for drought tolerant garden plants is an opportunity.
- Give wise water advice to your customers; help them to adapt their gardening methods.

TOOLS AND INFORMATION RESOURCES

It is normal business practice to plan ahead to manage risk, and climate change will bring changes to markets, logistics, operational processes, finance, insurances, people, and premises. Although the exact impacts of climate change are uncertain, they can be managed like any other business risk. The point is to start the discussion now with your staff and identify a few key risks and develop an action plan to make your business more resilient to these risks. Use the issue as a catalyst to review and focus on what you can control, rather than worrying about all the things that you cannot.

I recommend having a look at the UK Climate Impacts Programme website (2010), now just called UKCIP, which is all about decision making for adaptation. They have a number of tools you can access for free such as Adaptation Wizard and Adapt Me toolkit. Their information is considered a model for other countries to use.

There are also numerous carbon footprint calculators available. Food & Trees for Africa developed the first South African calculator which can be found at: http://www.trees.co.za/carbon-offset/carbon-calculator.html The Australian nursery production industry has also developed one specifically for the nursery sector known as NurseryFootprint (NGIA).

There is also information on the Green Economy for Sustainable Development Project for businesses, including Green Economy resources and other climate change information on the DEA (Department of Environmental Affairs) website which can be found at https://www.environment.gov.za/

Another source of information is the SANBI website (South African National Biodiversity Institute) particularly the LTAS Factsheet Series which are located at http://www.sanbi.org/biodiversity-science/state-biodiversity/climate-change-and-bioadaptation-division/ltas (DEA, 2013). South Africa has some of the best vegetation, geology, and soils data in the region (Ziervogel et al., 2014).

CONCLUSION

We can feed the world

The world population has now reached 7 billion and is expected to reach 9 billion by 2050. It is estimated that 70% more food will be needed to feed the world population by 2050 (Ministry for the Environment, 2015). Opportunities for both domestic and international food production will increase the market for starter plants for the vegetable and fruit production sectors.

Think of the potential advantage South Africa has in heat and drought tolerant plant genetic material for future breeding.

Green yourself

Investigate industry standards and policies on climate change and sustainability. Take the time to educate yourself and plan how to sustain your business into the future. Along the way share your knowledge with your customers and your community—consumer awareness of the value of plants is your best advantage. Take a future focused approach—you are not only there to sell plants, you're there to sell a solution; to help the customer feel they have taken a small active step towards creating a better environment or becoming more self-sufficient.

Lead the green

Carbon dioxide removing, food creating, life enhancing—plants are a huge part of the solution to global warming. Horticulturalists fundamentally understand that plants are the corner stone that sustain all other life. If any group can position themselves as having an answer to saving the planet, it's plant propagators! This puts us at the forefront of leadership, both professionally and personally, on the most significant global issue of our age! Whether we decide to embrace the risks and opportunities of this situation is up to us.

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Container blueberries as an “ornamental edible”©

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INTRODUCTION

Blueberries are a great candidate for container production by nursery growers. They fit into the “ornamental edibles” market niche and combine consumer interest in edible gardening, sustainability, and low-care perennials. Blueberry cultivars selected for local conditions can be planted out into the environment as a perennial landscape plant, enjoyed as patio potted plants, and have multi-season interest with spring to summer blooming, fruiting, and foliage, and fall color.

FLOWERING AND FRUITING CYCLE

Flower initiation, dormancy and chilling processes in blueberry (*Vaccinium*) are similar to florists’ azalea (*Rhododendron*, also in the *Ericaceae*). Blueberries initiate flowering naturally in the autumn under short days and cool night temperatures (Figure 1). In most locations, this is followed by a “dormant” cycle with cool winter temperatures. During the dormant period in late autumn, active growth ceases, leaves turn red and may then fall off. After the plant becomes dormant, a cultivar-dependent chilling period (between 0 and 8°C) of roughly 200 h (southern USA cultivars) to 1000 h (northern USA cultivars) is required to break dormancy.

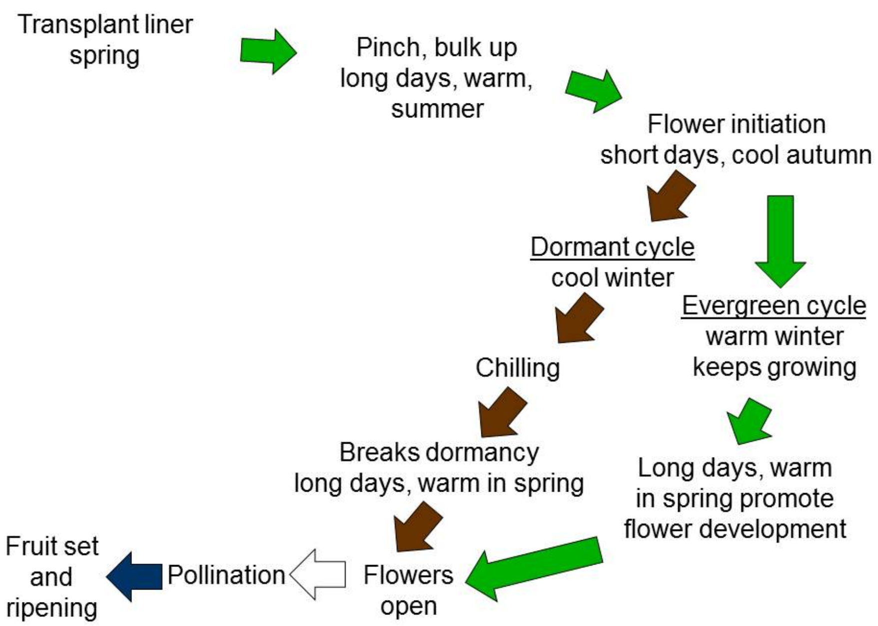

Figure 1. Production steps for blueberries in containers, showing the dormant and evergreen cycles.

After chilling and under the longer days and warming temperatures of spring, the plant begins to grow actively again, with a flush of leaves and vegetative shoots, and development of flowers. Fruit set occurs following pollination by insects such as honey bees.

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Green fruit typically appear 4 weeks after flowering, and ripe fruit 9 weeks after flowering, but this varies considerably with cultivar and temperature. Flowers contain both male and female organs, but growing a mix of cultivars for cross-pollination significantly increases fruit set. Flowering tends to be variable between plants, meaning that if marketing plants in bud or fruit, they need to be hand-selected from the bench.

Plants can also be grown under warm conditions without dormancy or chilling requirement (termed "evergreen" or "non-dormant" production, Figure 1). The flowering period for evergreen production tends to be more extended and less intense than for plants grown with a dormancy cycle. In Florida, this evergreen cycle naturally occurs during warm winters with southern USA highbush cultivars.

However, evergreen production is unlikely to be useful for growers in cool winter climates with heated greenhouses, because evergreen flowering on most northern USA cultivars tends to be weak, flowering occurs too early in the spring, and without pollinating insects the flowers will mostly senesce and fall off without fruiting unless gibberellic acid sprays are applied during flowering. An exception is 'Top Hat' (a hybrid of northern USA highbush (*V. corymbosum*) and lowbush (*V. angustifolium*)) which is the only northern USA cultivar where we have seen strong flowering in response to day length changes (short days to initiate flowering followed by long days to develop flowers) in the absence of chilling.

CULTIVAR SELECTION

Grow cultivars that are suitable for local conditions, so that your customer will have success in their landscape (and will return next year to buy more!). Young plant suppliers, breeders, farm advisers, and blueberry grower associations can suggest cultivars matched to your climate. Many excellent and free university extension bulletins are available online from the USA, although most of the information is oriented towards field or homeowner use. Search the internet for a "chill-hour map" for your location. The most common mistake is not matching chilling requirement to the local climate—plants with too low a chilling requirement may flower too early, resulting in low fruit set or cold damage. Plants that have too high a chilling requirement will not break dormancy for an extended period and may not fruit.

When trialing blueberries as a new crop, select cultivars that are recommended for your location and provide a range of flowering dates and plant vigor. Based on this experience, you can fine tune the planting and marketing schedule under your conditions, and narrow down to a few high-performing cultivars.

For container production, important features are strong and even branching, attractive foliage (typically small to medium leaves), resistance to disease, and profuse flowering. For landscape use and large containers, higher plant vigor is desirable. For warmer locations such as northern Florida, we use southern USA highbush (*V. corymbosum*) cultivars. Based on a multi-site trial and several years of trialing at UF in Gainesville Florida, recommendations for container-grown cultivars in Florida include:

- 'Emerald' (University of Florida patent) is a vigorous, full plant loaded with large fruit for landscape use and large containers
- 'Sunshine Blue' is a well-branched, non-patented compact plant with attractive foliage, and very high number of flowers which develop from deep pink to white, especially in smaller containers

For colder locations, 'Top Hat' has excellent characteristics, with compact growth, profuse branching, small leaves, abundant flowers and small fruit, and good fall color. The downside of 'Top Hat' is that it can be late to set fruit under natural chilling conditions. Northern USA lowbush cultivars can work well in small containers. Other highbush/lowbush hybrids such as 'Northcountry' and 'Northblue' provide more vigorous growth than 'Top Hat' for larger containers.

MARKET SPECIFICATIONS AND FOOD SAFETY

Plants are more likely to have consumer interest in flower or fruit. The peak marketing window therefore occurs from mid-spring to early summer. The season can be extended if a mix of cultivars is grown, and research at UF is also focusing on plant culture (light, temperature, pinching) to program flowering. Consider large photo tags or printed pots for off-season sales. Aim to produce finished plants with many branches and a full canopy, with a well-established root system throughout the growing medium, free of leaf spots and other disease and pest problems, and at a similar height to other potted flowering crops (for example, 35 to 40 cm including the pot for a 3 L container).

For food safety reasons (with potential liability ramifications, and also challenges in shipping), use caution if marketing with ripe fruit at retail. It is essential to follow regulations on food safety, for example avoiding contamination with *Escherichia coli* or *Salmonella* in irrigation water, which you might not consider when growing purely ornamental crops. For more information, refer to UF IFAS Extension guidelines at edis.ifas.ufl.edu, and other food safety guidelines available through your local regulatory agencies or farm advisory service.

PEST MANAGEMENT

Only apply pesticides registered for use on greenhouse/nursery blueberry plants intended for food consumption. Blueberry is susceptible to a number of leaf spot, stem and crown rot diseases, plus the usual root diseases for ornamental crops, including *Pythium* and *Phytophthora*. Typical insect issues such as fungus gnats, mites, and whitefly, along with blueberry bud mite, and gall midge. Carefully check the permitted use of pesticides recommended for field production of blueberries, or for ornamental production in greenhouses. Table 1 includes some insect control strategies that are acceptable in greenhouse blueberry production in Florida. Insecticides should not impact pollinators, and biological control is both effective and desirable. For more info, refer to UF IFAS Extension document HS1156 “Florida Blueberry Integrated Pest Management Guide” by J.G. Williamson, P.F. Harmon, and O.E. Liburd, available at: edis.ifas.ufl.edu.

PRODUCTION SCHEDULE

Blueberries are propagated from tissue culture, stem, or tip cuttings. Most growers producing container blueberries in significant numbers purchase rooted liners from an experienced, specialist propagator. Many cultivars are patented, for which propagation is restricted to licensed propagators. Non-patented options such as ‘Sunshine Blue’, ‘Gulf Coast’, and ‘Top Hat’ are available if planning to propagate your own cuttings. If propagating from tip cuttings, at least 10 weeks is needed to produce a well-rooted, pinched liner. Ensure that the tip cutting is vegetative by taking cuttings from stock grown under long days (which typically means the previous summer). Tissue culture plants branch more readily than stem or tip cuttings, resulting in a more attractive plant and reducing production time in the finished container. If using non-tissue cultured cuttings, multiple cuttings per pot may be required to have a well-branched appearance. We have not observed juvenility (resulting in delayed flowering) to be an issue for tissue culture or tip cuttings propagated in the spring and initiating flowering in the fall for fruiting the following spring-summer.

Plant from a 72-count or larger liner in early summer to finish in a 3 L pot the following spring. For larger pot sizes, plant in late spring with a vigorous cultivar. One plant per pot is sufficient if adequate time is allowed for pinching and establishment during the summer, but multiple plants per pot can provide a fuller canopy. Large containers may require a second year of production to develop a large, well-branched plant if planting is late or with a low-vigor cultivar. Grow at 30 cm on center between 3 L pots during bulking up in the summer and blooming in the spring.

Alternatively, if purchasing a “fast crop” large liner in the spring to finish in early summer, it should have a strong root system, and be pre-chilled, well-branched, and near the final market height. I have seen “pre-chilled” liners sold in the spring to northern growers as a fast spring crop, where the problem was that liners had been pruned to about 10 to 15 cm. Flower buds form on wood in the fall, so pruning liners during the winter also removes flower buds, and another year of growth would be needed for acceptable flowering.

Table 1. Suggested arthropod pest management strategies for greenhouse ornamental blueberries. Paul Fisher and Lance Osborne, UF IFAS. Be sure to follow label directions, and test applications on a small number of plants before applying to the entire crop. No endorsement or criticism of any product is implied, and check pesticide regulations in your area before application.

Pest	Product	Application notes
White fly	Neonicitinoid systemic insecticide labeled for edibles and greenhouses	One soil drench application per crop after roots are well established—avoid leaching and apply to moist soil. Do not apply pre-bloom, during bloom, or when bees are actively foraging. Neonicitinoid use is increasingly restricted in many locations and markets
	Parasitic fungus *Beauvaria bassiana* biological control	Spray as needed. Most effective against whitefly nymphs
	Azadirachtin (neem plant extract) spray	Spray as needed. Insect growth regulator
	Amblyseius swirskii biological control (predatory mite)	Whitefly eggs and larvae. Monthly releases
	Other biocontrols available (e.g. predatory wasps)	
Caterpillars	*Bacillus thuringiensis* (Bt) biological control spray	Repeat spray applications usually necessary after 3 to 14 days
Aphids	Neonicitinoid systemic insecticide	See above for whitefly
	Other biocontrols available (parasitic wasps, predatory midges and beetles, lacewings)	
	Insecticidal soap spray	Spray as needed, but not on blooms. Be careful to avoid phytotoxicity
Fungus gnats	Azadirachtin (neem plant extract) drench	Somewhat effective against immature gnats
	Steinernema feltiae entomopathogenic nematodes for biological control	Soil drenches, at least two per crop, 2-4 weeks apart. Most effective when soil temperatures below 30°C
	Other biocontrols available (e.g. *Hypoaspis miles* and *Atheta coriara*)	
Thrips	*Amblyseius swirskii* biological control (predatory mite)	Thrips larvae. Monthly releases
	Other biocontrols available (e.g. other mites, pirate bugs)	
Spider mites	*Phytoseiulus persimilis* predatory mite biological control	Performs best under humid conditions and moderate temperatures. Needs prey presence to survive. Corrective
	Neoseiulus californicus predatory mite biological control	Slower acting, survives longer in absence of prey than *Phytoseiulus*. Preventative
	Other biocontrols available (predatory mites, predatory midge)	

During the bulk up phase in the summer, pinch for height control and branching approximately every 6 weeks as new leaves flush out, starting 10 cm above the media in a 3 L container (15 cm for large pot sizes) and with each pinch 2.5 to 5 cm above the previous pinch. When pinching, use clean clippers including a dip in sanitizing agent between each bench or cultivar. Pinching cuts serve as an entry point for many stem (and leaf) pathogens and a broad-spectrum fungicide may be needed at the end of each day that pruning occurs. Do not overwater after pruning, and keep foliage dry over the following week. Maintain air circulation with fans, especially before and after pruning. Ensure foliage is dry when pruning, and avoid bruising leaves. Avoid pinching shoots after flower initiation (short days) in the late autumn. One final pinch can be made as plants enter dormancy to shape the plants for the spring flush, but beware of removing shoots that will potentially form flower buds.

A typical soilless substrate with moderate to high porosity (for example, peat and/or bark with 30 to 40% coarse perlite) is important to avoid *Phytophthora* and other root rot diseases. Blueberries are susceptible to iron deficiency and should be grown at pH 3.5 to 5.5 (i.e., with minimal or no limestone), typically in a substrate with little or no lime added. Do not use your regular limed mix—if pH is 6 or above, plant vigor will be greatly reduced and you are likely to struggle with iron deficiency and pale color throughout the crop. Avoid overwatering while plant is getting established and during the winter dormancy and slow-growth periods. Allow media to dry between watering, but do not allow plants to severely wilt or leaf damage will occur, increasing labor needed to clean up the crop. Keep plants well hydrated under high air temperature and light. Nutrients can be supplied either in water-soluble form, with 100 to 150 ppm nitrogen with each irrigation from an acid-reaction (high ammonium) peat-lite fertilizer including chelated micronutrients during the active growing period, **or** a moderate rate of controlled release fertilizer incorporated or surface applied to the growing medium.

Growing under cover from the rain helps to reduce leaf foliar diseases. During the winter, provide protection from rodents and deer—in one of our trials we discovered blueberry plants provide tasty winter food for rabbits! Air movement with fans or natural ventilation are needed to avoid powdery mildew in a greenhouse. Shade is not desirable except to avoid high temperature stress, because blueberries are full-sun plants with increased flower count at high light level.

Greenhouse temperature during the establishment period (spring to summer) should be 21°C or higher average temperature. This bulking up can occur in available greenhouse space after spring crops are sold, or outdoors with careful attention to diseases. Blueberries accumulate chilling hours between 0 to 8°C, and plants can be moved to a high tunnel or outdoors in the autumn. Plants overwinter with sub-freezing temperatures so long as plant root systems are well established and the cultivar is suited to your area. Following chilling, plants can be grown under ambient temperatures for a slower, natural flowering time, or brought into a heated greenhouse (18 to 21°F) under long days for more rapid flowering.

FRUIT SET

With artificially early flowering, remember that naturally strong fruit set only occurs in the presence of insect pollinators (such as bees), and young developing buds are susceptible to freezing damage.

We have found that two applications of gibberellic acid can greatly increase fruit set inside greenhouses where pollinator numbers are low. In our trials, we have used ProGibb™ (4% GA_3) at 250 ppm at full bloom and 2 weeks later (which is an acceptable label use in the USA). The resulting "parthenocarpic" fruit is seedless, so texture is slightly different, but our initial tests indicate plants have fruit similar in size and flavor as naturally pollinated fruit.

CONCLUSION

Blueberries provide a niche crop that fits with market trends. Retail prices is likely to be highest with well-branched, blooming plants in 3 L or similar containers. Consider adding container blueberries to your line of ornamental edible crops.

ACKNOWLEDGEMENTS

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An introduction to pot-in-pot nursery production©

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INTRODUCTION

The nursery industry is highly dependent on container plant production. Utilizing sustainable inputs and adopting sustainable practices have become a significant trend for horticultural production world-wide. This has led to a significant increase in pot-in-pot nursery production in the USA, especially for large caliper trees traditionally produced as field-produced balled and burlapped crops (McNiel et al., 1996). Pot-in-pot production is a combination of traditional container and field production where the production container is placed within an in-ground socket pot (Figure 1).

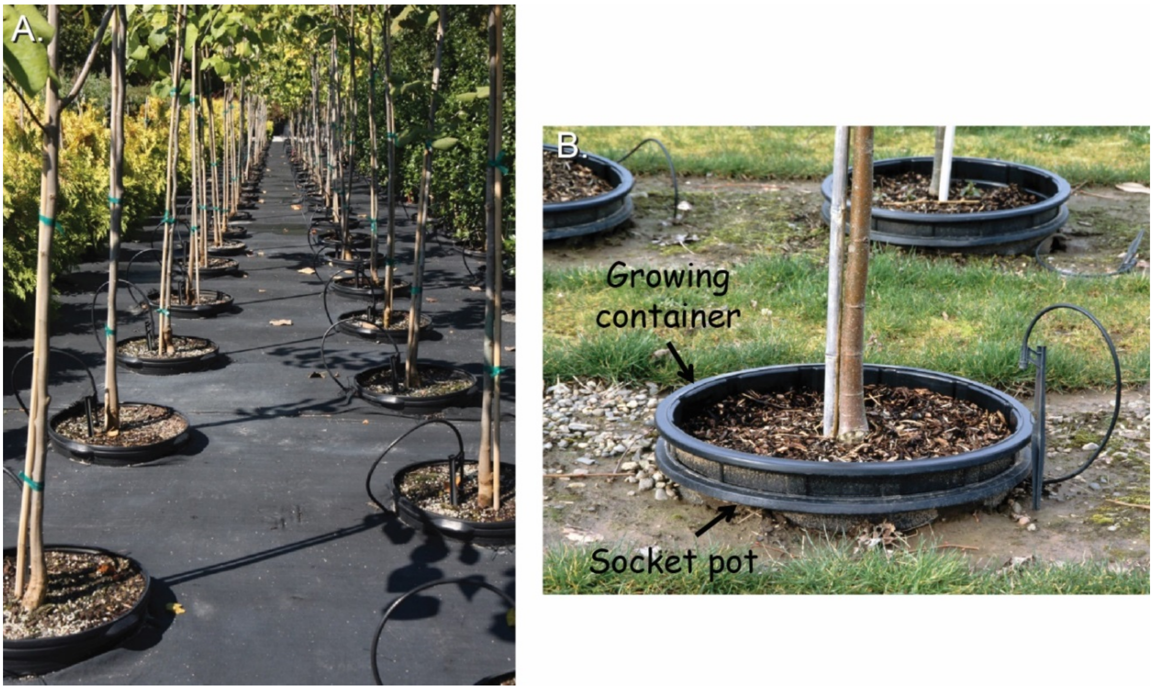

Figure 1. Typical components in a pot-in-pot production system. Left: Containers on a high density planting using an in-row fabric floor management. Each tree is staked and has an irrigation spray stake from main lines covered by the fabric. Right: Floor management with an in-between row grass cover. Side view shows the relationship between the socket pot and the growing container.

Pot-in-pot production was originally developed as the "Minnesota System" in the 1980s as an alternative to field and above-ground container production for tap-rooted shade trees (Pellet et al., 1980; Pellet, 1983). The system proved to be equally useful for general shade and flowering tree production (Parkerson, 1990). The major advantages of pot-in-pot production compared to standard above-ground container production include a reduction in container blow-over tipping, root insulation protection from summer heat and winter cold extremes, and therefore, no need for winter protection. Pot-in-pot also uses water more efficiently because it utilizes microirrigation rather than overhead watering systems (Nambuthiri et al., 2015).

Pot-in-pot is arguably the most sustainable production system for nursery trees.

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Compared to field produced trees, pot-in-pot uses water and fertilizer more efficiently and eliminates “soil mining” because it uses a renewable bark-based growing substrate rather than digging trees from the nursery field. Compared to above-ground container production, pot-in-pot results in a reduced use of plastic where Quonset structures are required for overwintering.

The major disadvantage of a pot-in-pot production system is its high initial installation cost, but these costs can be spread over several years of production. The initial costs can also be off-set by the higher planting density compared to field production (McNiel et al., 1996). Another problem encountered during pot-in-pot production can be roots escaping the growing container making harvest difficult.

Since pot-in-pot is a semi-permanent production system, care needs to be taken during its initial installation. Most sites suitable for pot-in-pot should be relatively level (<3% grade) with easy access to clean water for microirrigation. The most important consideration is soil drainage where the socket pots will be located. Without proper drainage, water will pool in the production holes during periods of sustained rain. For many locations, this requires providing supplemental drainage such as a 4 inch drain tile beneath the planting row of socket pots.

Socket placement and spacing must also be pre-determined. This becomes a fixed spacing of a single size production container for the next five years or more. As with field production, roadways and container spacing must consider access for equipment for spraying, cultivating and harvest as well as anticipated plant size. In general, growers plan for more trees per block for pot-in-pot compared to standard field production. There are several options for digging the socket pot hole involving either trenching, augering or a combination of the two. There is an excellent University of Kentucky on-line video prepared by Dr. Amy Fulcher that describes each type of installation procedure (Fulcher, 2011; http://www.youtube.com/watch?v=wNeBurkznIk). Regardless of the digging method, the socket pot should be placed level with the grade with only the top of the rim above ground.

There are several strategies for nursery floor management around the containers. These include maintaining a bare weed-free area, grass/sod middles between container rows, or a geotextile nursery fabric covering each block. The fabric should be installed after the socket pots are set by fitting the size of the fabric to the tree block and cutting an “X” over each socket pot prior to setting the production container into the in-ground socket pot. There is an initial cost with using the fabric, but it can be easier to maintain during the production cycle and because cultivation equipment will not be required within the block, containers can be staggered between rows leading to more efficient spacing.

Another consideration prior to setting the production container in place is whether a root barrier material will be used to prevent “rooting out”. For several nursery species, rooting out of the production container into the socket pot and surrounding field soil can be a problem. It makes harvest difficult and inefficient. Several chemical deterrents are available to reduce this rooting out problem. One product is a root barrier consisting of a copper-treated fabric that is placed between the production container and socket pot. A second option is using a volatile herbicide impregnated root barrier placed at the bottom of the socket pot. A tight fit between the socket and production container is necessary for optimal control of rooting out.

Water management is most often through a microirrigation system. This is an efficient way to deliver irrigation to each container using a microsprinkler (spray stake or trickle). Like other microirrigation systems, initial water quality, filtering systems, fertigation and water pressure are all considerations that should be addressed prior to planting. It is usually more efficient if plants are grouped by their relative water use requirements. Inspect irrigations lines on a routine basis for leaks or malfunctioning lines to avoid extended periods where containers are not being irrigated. Use of a microirrigation system also allows growers to consider several advanced irrigation practices that can minimize water use and fertilizer run-off and in some cases improve tree growth. These include adopting an on-demand system for scheduling irrigation based on plant water use that could also employ a cyclic irrigation strategy (Geneve, 2014; Nambuthiri et al., 2015).

Another advantage of pot-in-pot production is that harvest is not tied to the traditional digging seasons for field-produced plants. Mid-season harvesting can offer a competitive advantage if a market is available to use these trees. Harvesting involves lifting the production container out of the socket pot. Because of the size and weight of larger caliper trees, mechanical assistance is usually necessary. Both physical and mechanical lifting machinery is available in the trade. These machines basically attach clamps to the growing container rim and use physical leverage or hydraulics to lift the container from the socket pot.

This has been a quick overview of typical pot-in-pot production issues. There are several more in-depth discussions of this system from University Extension publications available on-line. Both the University of Kentucky (Dunwell et al., 2009) and University of Tennessee (Holcomb and Fare, 2009) have excellent publications that are currently available. Each includes an extensive publication lists concerned with the economics and production of pot-in-pot plants.

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Novel genetic marker technologies revolutionize apple breeding©

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INTRODUCTION

For the past 24 years, my vision and research focus have been to lead the development of modern tools for fruit breeding at Plant & Food Research (PFR). My initial focus was very specific, on apple, however this has expanded, so that our "Mapping & Markers" team of genetic mapping researchers now works on a range of crops, including apple, pear, kiwifruit, peach, apricot, raspberry, blueberry, blackcurrant, hops, and most recently, manuka, applying the same DNA-based technologies to all. We work closely with industry and breeders for each crop, as well as many other PFR and international scientists, including genomics scientists focussing on DNA, those who work on pests and diseases, or fruit characters, such as flavour and texture, using our genetics and genomics expertize to develop tools to "breed better cultivars faster" (van Nocker and Gardiner, 2014) for international consumers and New Zealand growers. I will discuss some of the novel features of the modern apple breeding programme at PFR, which has led the world in applying new fruit breeding technologies. This programme employs marker assisted selection for critical "must have" characters in large seedling populations, which can include thousands of seedlings, in order to increase the efficiency of developing new apple cultivars with the features sought by consumers. I will discuss in some detail a specific example of how marker assisted selection is being applied by our breeders to speed up the development of rootstock varieties with the very specific characters needed in the rootstocks of tomorrow.

THE PFR BREEDING PIPELINE TODAY

The pipeline currently used by our apple breeders is illustrated in Figure 1. As has always been the case, the primary raw material for breeders is the treasure house of existing cultivars and other germplasm in the research orchard. Another, more recently developed resource comprises DNA-based information about apple. In 2010, the sequence of the apple genome was published (Velasco et al., 2010) and this includes around 57,000 sequences of genes, that together determine what goes to make up the apple tree and fruit, and control their development. From the point of view of the scientists in my "Mapping & Markers" team, these genes are all potential candidates for developing "genetic markers" that are associated with the control of a specific trait and we use to select elite seedlings that carry a particular combination of traits from large breeding populations. Our task is to work with genomics scientists to narrow down the candidates to one for each trait of value to breeders and then develop a marker that maps to the trait, at a defined position on one of the 17 apple chromosomes (Gardiner et al., 2007). The choice of the specific traits we work on depends on industry needs and priorities. In general, these are traits that characterize a crisp, juicy, flavoursome, and attractive apple at the point of sale to the consumer. New cultivars will require a minimal input of sprays by the grower to control pests and diseases, as natural genetic resistances against common pests such as apple scab (*Venturia inaequalis*), powdery mildew (*Podosphaera leucotricha*), woolly apple aphid (*Eriosoma lanigerum*), and fire blight (*Erwinia amylovora*), will be bred into both scion and rootstock cultivars. The trees of new scion cultivars will be dwarfed, fruiting earlier after planting, with a high yield per hectare because they are grafted onto rootstock cultivars that confer these grower-friendly traits to the scion.

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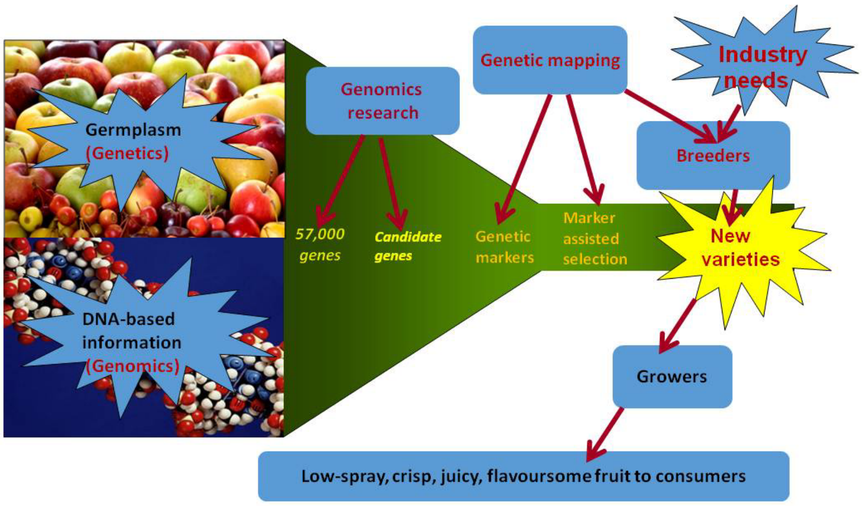

Figure 1. Apple breeding pipeline. The pipeline is driven from top right (industry needs). The process is depicted from left (resources of germplasm and DNA-based information) through far right (new varieties) and to bottom (fruit to consumers). Inputs from genomics research, genetic mapping and breeders occur sequentially, following definition of industry needs.

The role of the apple breeder is to combine these desired attributes by making new crosses and to select the best seedlings to proceed to new cultivars, or as parents for further crosses. To select parents to make crosses, he or she needs to use knowledge of the germplasm available, both existing old and new cultivars, as well as previous selections that carry the traits of interest. My team's role is to assist the breeder in selecting the parents for new crosses and subsequently the genetically elite seedlings that carry the "best" combination of traits in the resulting progeny populations. To achieve this, we work in partnership with the breeders and use genomics information to develop genetic markers that are associated with a particular trait and can hence be used to select plants that have the genetic potential to express the associated character. These genetic markers can be compared with DNA fingerprints and are derived in the best case from a candidate gene that controls the expression of the trait, e.g., for resistance to apple scab, fire blight or powdery mildew, and/or red fleshed-fruit; or are located on one of the 17 apple chromosomes, so close to the controlling gene that they are generally inherited together. Examples here could be resistance to woolly apple aphid, or the dwarfing of a grafted scion by a rootstock.

MARKER ASSISTED SELECTION

Marker assisted selection is the process of using these genetic markers as diagnostic tools, to identify plants that carry the desired traits, by screening DNA extracted from each plant for the presence or absence of the form of the marker associated with the trait. These plants may be potential parents, or seedlings derived from crosses made by the breeders. Newly germinated seedlings can be screened as soon as they have a few leaves, because the amount of tissue required for DNA extraction is only the size of a small fingernail. The most effective use of marker assisted selection in seedling populations is to screen for a combination of "must have" traits. In scion cultivar breeding, these include resistance to apple scab, powdery mildew and woolly apple aphid (Gardiner et al., 2007), red skin (Chagné et al., 2016) and flesh colour (Chagné et al., 2013), while some breeders also use markers for genes that contribute to complex fruit traits, such as texture (Longhi et al., 2013). In rootstock breeding, "must have" traits are also pest and disease resistance, as well as the absolutely critical trait of the capability to dwarf a scion grafted onto the rootstock.

In the case where a parent that is heterozygous for any specific trait (carries one copy of the gene) is crossed with a susceptible parent and the trait is controlled by a single gene, only half the seedlings in the population from the cross will carry that trait, according to

Mendelian inheritance. Seedlings that do not carry the marker for this trait can be discarded, as these are not of further interest to the breeder. Only the seedlings carrying the "must have" trait need be screened for the next trait, after which the number of the seedlings of interest can again be potentially halved. The relatively few genetically elite seedlings that remain after the screening of seedlings for all "must have" traits that the breeder has included in a specific cross are planted in the research orchard. Here, the breeders examine them closely for the level of expression of these traits, as well as for other traits that have not been screened for using markers.

Because the size of the population has been reduced following the marker screen, breeders can afford to accelerate the development of the smaller number of elite seedlings, using environmental treatments that promote flowering and so reduce the time between generations. Culling of unwanted seedlings before planting in the field reduces orchard costs for each population, as well as expensive and laborious screening of very large numbers of seedlings for some traits, for example ability of fruit to store well, or the dwarfing trait in rootstocks. An important feature of marker assisted selection is that the seedlings need not be mature enough to express the trait of interest. This is most significant for the selection of traits expressed in the mature tree only, i.e., any fruit trait, such as flesh colour and crisp texture. A novel application of marker assisted selection is to identify plants that carry more than one resistance to a particular pest or disease. Such plants are termed to carry "pyramided resistances" and have the advantage of reducing the possibility of the pest or disease overcoming the resistance, as it is simpler for a pathogen to overcome a resistance controlled by a single gene, than by two different genes. To develop such plants, the breeder crosses parents carrying resistances from different sources, then uses genetic markers specific for the different resistances to select only the seedlings carrying both (Bus et al., 2009). These will be 25% of the initial population for resistances each controlled by an independently segregating single gene and inherited in a Mendelian fashion.

Marker assisted selection of genetically elite seedlings has been employed in the PFR apple breeding programme as a tool to breed better cultivars faster for more than 10 years, with more than a combined 25,000 seedlings now screened annually in the scion and rootstock cultivar breeding programmes.

EXAMPLE OF MARKER ASSISTED SELECTION IN THE APPLE ROOTSTOCK BREEDING PROGRAMME

Commercial apple production depends on the grafting of scion cultivars onto rootstocks as the method of propagation. The choice of rootstock is important, as not only is the stature of the scion markedly reduced by grafting onto a dwarfing rootstock compared with a vigorous rootstock (Figure 2), hence making management and harvesting of the trees much easier, but there is a positive effect of using dwarfing rootstocks on orchard production traits, including a reduction in time to fruiting following grafting and a yield increase per hectare.

Four years ago, our rootstock breeder Vincent Bus came to us with two populations that had been developed to incorporate new traits into future dwarfing rootstock cultivars. Crosses had been carefully designed, whereby both populations would carry the dwarfing trait controlled by *Dw1*, inherited from both parents (Figure 3), so that the seedlings would include some that carried two copies of *Dw1*. In addition, each population carried the *FB_R5* resistance to fire blight, mapped to chromosome 3 of *Malus* × *robusta* 5 (Peil et al., 2009; Gardiner et al., 2012) as well as resistance to woolly apple aphid conferred by the genetic locus *Er2* on apple chromosome 17 (Bus et al., 2008) of *Malus* × *robusta* 5. The latter was inherited from one parent in population one and both parents in population two. Population one additionally carried the different *Er3* woolly apple aphid resistance from chromosome 8, originally from *M. sieboldii* 'Aotea 1' (Bus et al., 2008), inherited from one of its parents. Leaves had already been harvested from the seedlings for DNA extraction and were stored freeze-dried in our laboratory. Vincent wished to identify the dwarfing seedlings that also carried fire blight and woolly apple aphid resistance from one or both sources. Both the DNA extraction from the stored leaves and marker screens were performed efficiently in less than

2 weeks by Slipstream Automation Ltd (http://www.slipstream-automation.co.nz). This service company was established by a former team member and specializes in performing automated DNA extraction and subsequent genetic marker screens, including cherry-picking out marker positive DNA samples to carry forward to the next screen, hence reducing screening costs per plant.

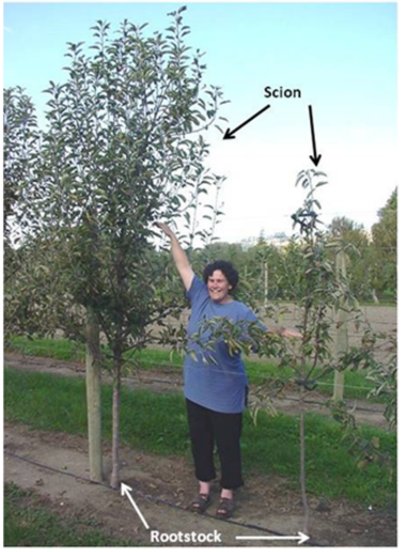

Figure 2. Comparison of relative size of scions grafted on vigorous (left) and dwarfing (right) rootstocks, two years after grafting of scion to rootstock.

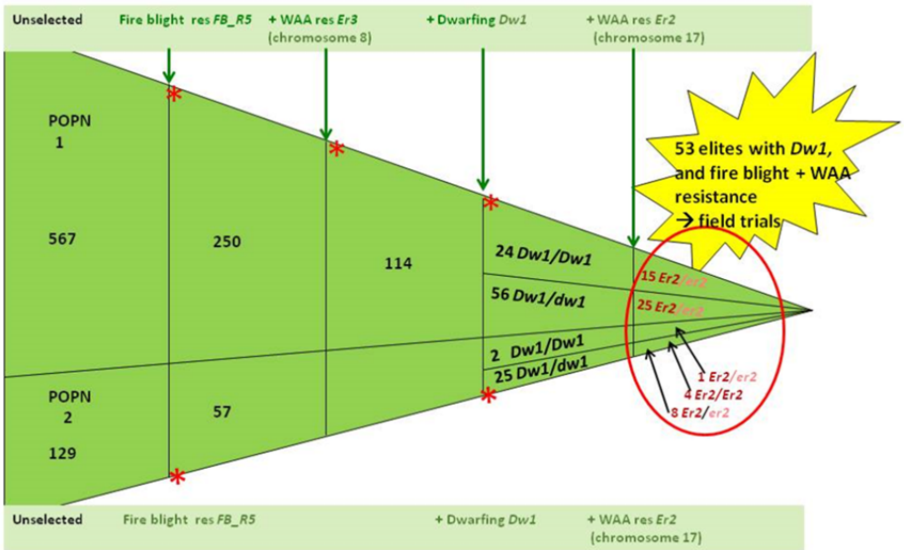

Figure 3. Protocol for efficient rootstock marker assisted selection. Two breeding populations of 567 and 129 seedlings respectively were screened sequentially with markers for *Fb_R5* (fire blight resistance), *Er3* (woolly apple aphid resistance on chromosome 8) screened over population 1 only, *Dw1* (dwarfing of grafted scion) and *Er2* (woolly apple aphid resistance on chromosome 17). Green arrows indicate timing of each marker screen. Red asterisks * indicate timing of selection of marker positive seedling DNA for the subsequent screen. Numbers of seedlings at each of the 5 stages (unselected through to fully selected population) are indicated.

Figure 3 shows the protocol for the genetic marker screening over the total of 696 individual DNA samples. Marker screens were performed in a specific order, with the cheapest marker first (*Fb_R5*), followed by the next cheapest (*Er3*) and finally the most costly marker screens, which were for the genetic loci *Dw1* and *Er2*, with no sample picking employed between these. The first screen with *Fb_R5* approximately halved the number of seedlings to be screened with the next marker from 696 to 307, as predicted by Mendelian inheritance. Population one was more than halved again following screening with the *Er3* marker. Next came the very important screen over both populations for the genetic locus *Dw1*, where the specialized marker employed was able to identify not only the 107 seedlings that carried the locus, but also the number of copies (alleles) carried by each seedling, as it can distinguish between the heterozygous and homozygous states. The final screen for *Er2* revealed 53 genetically elite seedlings that carried the dwarfing trait, as well as resistance to fire blight and woolly apple aphid. Vincent chose all of these seedlings to advance to orchard trialling to validate the expression of the traits selected for, as well as other traits for which markers were not yet available. Forty of these seedlings exhibited the *Er2* resistance pyramided with *Er3*, thus enhancing the potential durability of resistance to woolly apple aphid. Seedlings that were identified as homozygous for either *Dw1* or *Er2* would theoretically make ideal breeding parents, as all progeny would carry the genetic locus. The effect of the homozygosity on the expression of these traits will be investigated during the course of the orchard trial.

The 53 elites selected for the field trial represented 7.6% of the initial seedling population. Such a large reduction in population size has enabled a restructuring of the orchard trial protocol, as shown in Figure 4. The starting material for both the conventional protocol in the absence of marker assisted selection and the new protocol is seedlings that have been pre-selected for lack of obvious adverse traits after growing in the nursery for 1 year. These unwanted characters include spines and burr knots. The conventional protocol involves initial grafting of each seedling with a scion cultivar, then evaluating each plant over 3-4 years for orchard production traits exhibited in the scion, such as extent of dwarfing, time to first flowering and fruit yield. About 10% of the rootstocks are selected at this stage to go forward to evaluation for stool-bed production traits. Plants that root easily and demonstrate good stool-bed production traits, e.g., many stools of the right size, are selected after 5 years of monitoring in the stool-bed, to proceed in replicate to orchard production trials following grafting with scions. This process takes another 5 years before selections are made of the best performing rootstocks for potential advance to new cultivar status. The complete protocol takes about 14-15 years starting from seed. In the new protocol where marker assisted selection is employed, the number of seedlings entering the orchard trial is reduced by over 90%. The initial orchard production trial performed on single trees in the conventional protocol is bypassed and rootstocks proceed immediately to the stool-bed production trait trial. The plants are closely monitored, so that ones that root most easily are speedily identified, grafted with scions and advanced to the replicated orchard production trait trials after 3-4 years. The important production trait trials last 5 years, as in the conventional protocol; however, the new protocol incorporating marker assisted selection reduces the time from seed to potential cultivar by 5 years, compared with the previous protocol. In addition, because fewer seedlings are assessed in the orchard trial, costs for both land and for labour involved in trait assessment are reduced. This is a revolution!

The protocols for marker assisted selection and field trials in the apple rootstock breeding programme are constantly developing as new traits are introduced into the crosses that Vincent makes annually and as our team develops genetic markers for these traits. We can now screen for a second genetic locus influencing dwarfing (*Dw2*) that enhances the effect of *Dw1*. This will be important in the development of rootstocks with a greater or lesser dwarfing effect on grafted scions. In the past year, the seedlings carried a genetic locus which has been shown to control root formation and we were able to use a published genetic marker (Moriya et al., 2015) to identify seedlings carrying this trait, which still will need to be validated. Screening for a third genetic locus for woolly apple aphid resistance (*Er1*), mapped to chromosome 8 (Bus et al., 2008), was introduced to increase the options for resistance pyramiding.

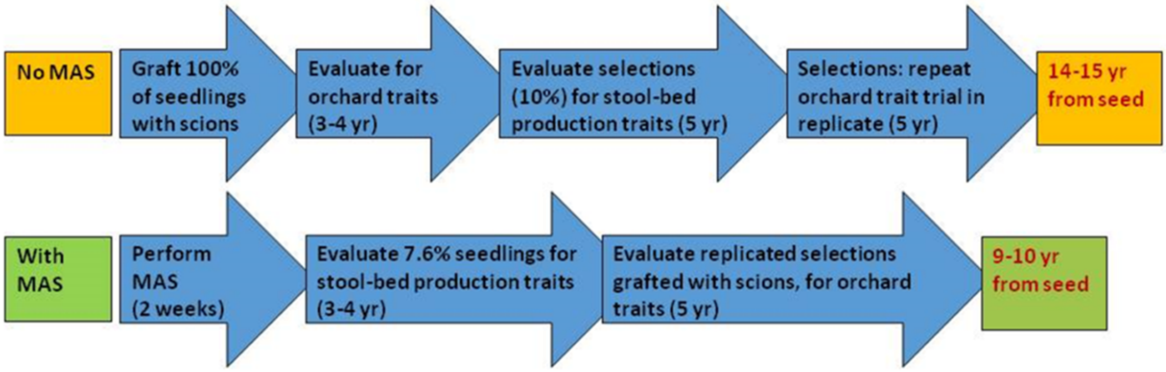

Figure 4. Comparison of orchard trial protocols for examining performance of apple rootstocks, with and without the application of marker assisted selection.

FUTURE TRENDS

Our team is steadily developing new genetic markers for traits that are important to consumers and consequently our apple breeders. These include resistances to additional pests and diseases, such as apple canker, as well as traits associated with fruit quality, particularly texture. We are working to transform existing genetic markers into improved forms that are highly reproducible across different seedling populations from different genetic origins, as well as being easier to use and more amenable to automated screening. We are working with other PFR scientists to introduce the new technology of genome wide selection into our apple breeding (Kumar et al., 2012). This process considers thousands of genetic markers across the 17 chromosomes of apple at the same time and enables the selection for or against complex characters controlled by a number of genetic loci, each with small effects, but which when taken together are significant.

In summary, new genetic marker technology has indeed revolutionized apple breeding. The revolution is not yet over and the future will be exciting.

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The advantages of sprinklers over mist nozzles©

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INTRODUCTION

Elliott's Wholesale Nursery is 45 km north of Christchurch. We're primarily growing ornamental trees and shrubs and we're on nearly 10 ha. We grow and sell plants from 7 cm to 45 L. We have 16 full-time staff and propagate 90% of our own product. Our nursery grows plants totally on spec so our sales method is primarily peddling. I think all those things are quite significant when you're in the trade.

EVENTS THAT CHANGED MY THOUGHT PROCESS ON DOING THINGS

I've been in business 36 years or something now, and since the earthquake in Christchurch in 2011 we've had seven other events including two more earthquakes, a tornado, and three snow storms—and they've been the best things that have ever happened to us. Because if it wasn't for them we wouldn't have changed the way we think, and we wouldn't have moved ahead. We would just be doing the same old things we were doing 10 years ago.

One of the first things that happened with the earthquake of 2011 was that overnight, our sales to the landscape market stopped. Nobody did any landscaping. They all wanted to fix their properties. Landscaping was a third of our business. We had a third of our production area in it and we had to basically throw all of that out.

So what do you do? You look for new margins. So we set up a "factory shop", a little retail shop in Amberley where we could increase our margin. Now that shop does about 10% of our overall turnover and we're able to sell 50% of our nursery leftovers at a higher price to the public than we would get for it as first grade plants selling at wholesale. And we don't have to freight it or do anything else. And what that's done to our business is made it balanced all of a sudden because we've got rid of some of our shrinkage and it has made us a lot more profitable.

The earthquake sure made life tough and if we hadn't had a $60,000 wage subsidy straight after the earthquake, I don't know how we would have survived.

In 2014 Caroline and I went for a trip to India and when we came back, we had a look around the nursery and it looked fantastic. And because I'd been away, we hadn't spent any money so there was $60,000 less spend than I would have done and somehow also we'd sold $60,000 more product than normal so the business was $120,000 better off without me being there!

Anyway we'd just got home that evening and all of a sudden I could see these bits of plastic whirling around in the sky and next door to us a hailstorm had just gone through so I thought, I'd better go down and see what the nursery was like just in case, you know, something might have happened. Well anyway, I got down to the nursery and it sort of looked ok but as I got further and looked to the right it started to look a bit funny. I went on a bit and I could see there had been a tornado come through and taken out the shelter belts—and our propagation houses as well. Instead of having nine propagation houses we had only one functional one. All the others had their foundations ripped out and I don't know how they were just sitting there. One of the houses had been completely sucked up, the floor and everything had gone. I'm sure that was the one that ended up 2 km away and up a 15 m high gum tree (Figure 1).

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Figure 1. What remained of one of the propagation houses.

So you can see, we were in a real, real dilemma. We had no insurance or not much, having only insured our irrigation. What do you do? Well, you have to really, really think and, as I said, having so many things happen to us in such a short time, changed my thought process on things.

We had to start going again. We had to get some structures up, we had to do it simply because we didn't have lots of money and we had to do it fast. And one of the first things we were thinking of also, when re-building, was what we were going to put in the houses, mist, or sprinklers?

In our propagation houses we have always had a sort of dual system where, if we felt the house had rooted, we could turn off the mist nozzles and turn on the sprinklers. Well, one Christmas holiday one of my staff, Judith, had turned some of the houses inadvertently from mist to the overhead sprinklers. I would go down to check the houses as necessary and of course I'd do that early in the morning when the mist never goes on anyway so I didn't notice that there was anything wrong. But as the break went on eventually I did figure out what she had done—and then I realized that the houses that were on the sprinklers were so much better than the houses on mist so I immediately turned all the houses over to sprinklers. Our results improved markedly as soon as I turned off the mist. Our dry spots went away; our hand watering became none—we don't have to do any hand watering in our propagation. We put our cuttings in, we water them in, and we leave the house alone. Sure, we have some issues sometimes if we put in cuttings that are too big and the leaves shed the water across and the cuttings don't get any water so they go backwards, but you know stuff happens.

Most of our propagation is done at ground level and one of the advantages of this is that it is the coolest place in the house. As soon as you pull your propagation up onto benches, sure, it's nice to work at and we do have one house with benches and it's lovely to work in, but the coolest place for the cuttings themselves is down at ground level because obviously heat rises.

We have a normal irrigation controller and it operates for 3 mins three times a day. It goes off at 10 A.M., at midday and at 3 P.M. and puts 3 mm of water on the propagation crop. And that basically is what eliminated all our hand watering. We were spending 2 h a day in the morning in our propagation houses, somebody wandering through with a hose and my feeling is that hand watering is such a complicated subject and to do effectively it would take me a lifetime to learn.

Having a sprinkler which gives 91% uniformity—which is what Naan claim for their sprinklers—is better than I'm ever going to do anyway.

The big thing we're trying to do with our houses is trying to keep them cool. I think in J.G. Wells book, one of the first propagation books I'd ever read, it was cool tops misty middles and hot bottoms and sometimes a lot of people who are in propagation are just propagating in environments that are way too hot.

I liken the whole thing as if you have a bucket of water and you throw it at somebody they're cool down pretty fast and if you have a sprinkler and you sprinkle them they're going to cool down pretty fast and if you have mist nozzles they're not really going to cool down that fast and if you have a fogger and you fog them they're not going to cool down fast at all.

So this is some Jeff logic. It comes without much research. The average day summer maximum temperature in New Zealand actually is 22-23°C so I'm assuming that the average plant has evolved to reach the maximum growing at probably 22-23°C. But most plants reach their maximum growing potential at a lot lower temperature than that. They probably reach their maximum photosynthesis at 10°C if they're going to reach maximum at 22°C for example, which I would imagine New Zealand plants are. In other words, if you can keep your plants at 10°C in a plastic house with good light levels they're going to produce as much photosynthesis as at 25°C. But the transpiration is also going to change at those levels. As the temperature goes up, the transpiration goes up and obviously peaks at a certain level which I'd imagine for New Zealand plants is probably around 27-30°C. And at that 27-30°C, they're just doing it tough. So what do you do? You've got to get the temperature down and the easiest and quickest way to do that is to spray them with water. And it doesn't matter whether you spray a leaf with a fine mist or a sprinkler—after 20 s. it will look the same because the water just spreads. So you can have in your greenhouse a whole lot of mist nozzles—we would need 15×6 plus a whole lot more around the edge to stop the drift—or you can have just nine nozzles running down the middle as we've got and you've got the same uniformity; much less capital cost and at the end of the day, the same results.

I have a fogging unit in my museum of bits and pieces. In 1983 after being in business a mighty 3 whole years I was actually making money in horticulture. Wow. I went to the United States doing my nursery 101 and I visited some of the big northwest nurseries. I met a couple of blokes that were really amazing. One was John Iseli. He was an absolute inspiration to me in the time I spent with him. He has now died, and so has Bruce Briggs who was another inspiration. One of the things Bruce had at his nursery was a Mee fog system and I thought, wow, this is amazing. He was doing all this tissue culture on this Mee fogger and I thought right, and I came back to New Zealand and the first thing I did was go and buy an Aussie fog system and for about 5 years I swore black and blue that it was the best thing since sliced bread. Anyway the reality was I had these overly hot, slimy glasshouses that were a death trap. I've still got those but they're slightly cooler. I gave up on the fog system. It was just too hot and I was getting nowhere. The temperatures in my fogger house were ending up at 40°C. The evaporative cooling just wasn't working so I gave up on this and went back to the mist system. Well anyway a few years later I went back to Briggs Nursery and he'd ripped out all his fogger systems as well. Long and the short of it, I hated fog, it was an absolute disaster for me. As soon as I got rid of the fog my results went up. And as soon as I got rid of mist my results went up even more.

GROWING MEDIA

Years ago I experimented with all sorts of propagation media, I tried polystyrene, crusher dust, plaster, sand, all sorts of stuff and the best results I got from all media was without doubt, sawdust, plain simple sawdust. It rooted the cuttings far faster than anything else.

There's no real scientific method in this but that was the thing. The one thing I realised pretty quickly is that most plants rooted or initiated roots in the first 3 weeks. But sawdust wasn't the best medium after 12 weeks. So eventually I went to using pine bark which also gave me some quite good results, it was less variable and there was no big nitrogen draw down. And so we had one medium and it's been great and has so simplified the nursery.

I'm also now wondering whether we can actually get rid of the propagation mix altogether and have the general mix used as our propagation medium as well. I think we can just about achieve that because we use a long-term starting potting mix that's got an 8 to 9 month fertiliser in it.

LEARNING FROM THE UNEXPECTED

You know, some of the things you do in the nursery you forget until one day you have to remember them. I think the Judith incident was one of those times. And there was another involving one of my daughters. We were doing olive cuttings one day, shortening the leaf back in half, leaving two leaves and doing a cutting that was about 100 mm long. Emma who is my oldest daughter and is now 31, came along and said "here daddy I've found a cutting." And she gave me this big hockey stick cutting and I thought it's so sweet because she had never really been down to help us, so I put it in a 14-cm pot and stuck it in a corner of the glasshouse—and sold it 6 months later!

And you know after the tornado I recalled Emma's 50-leaf cutting and because we'd now got the houses cooler and better insulated, we've started doing a lot bigger cuttings.

I haven't finished this talk because what you do in the nursery is always ongoing always an experiment. But the best thing that happened in the whole thing was probably the tornado, I honestly think.

The tornado cost me about quarter of a million but I reckon we're already $250,000 ahead because of it in 2 years. That's just enormous.

Sometimes the gains you can make through disasters, some of the memories you can bring back to mind, some of the silly things that happen to you, like the Emma cutting or Judith turning off the mist, can actually really, weigh in your favour really make you go ahead.

Lean production and your plant factory©

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We all deal with doing more with less. There was a time in my career when I thought that the entire "more with less" situation was unique to my generation and time. I'm now convinced that sooner or later everyone will be faced with trying to match production goals and expectations with limited and/or declining resources. Over the years, new techniques and thrusts have risen to the forefront in the areas of production efficiency and cost reduction. Each new method has had its own merits and some seemed to last longer than others. Lean production has its roots in many of the techniques developed in the early 20th century on the first production assembly lines in the USA. It is perhaps because of the history and pedigree of "Lean" that it works so well for so many diverse industries. Lean is, in many ways, more common sense and intuitive techniques than hard core science. Perhaps this explains its draw and staying power. Toyota is credited with refining what we call lean production through the development of the Toyota Production System. After little interest in the USA was expressed in the ideas of pioneers including Juran and Deming, Japan opened its doors and minds to adopting the techniques that made them one of the top manufacturing dynamos in the world.

Historically, Lean has had most if its success in support of pure manufacturing processes. Over the years, other industries have joined the ranks of success stories associated with lean implementation. Upon examination of the characteristics of a typical manufacturing process, concepts such as customer driven order processes, inventory management, concerns over cycle time and quality, and time sensitive delivery come to mind. At its most elemental level, a nursery/greenhouse operation is really no different. If you can see past the argument that growing a plant is inherently different than building a "widget", Lean techniques can easily be adapted for use in your "plant factory".

Most process owners interested in diving into Lean, can do so without going any farther than the 5 S's. These 5 concepts, conveniently all starting with the letter "S", are the bread and butter of any Lean implementation and are described below.

1) Sort: Sorting items necessary for each process stage from those items deemed unnecessary, is the first step. These decisions can be difficult to make; sometimes made easier by using "outside" eyes. Over time, it is common for supplies to be left behind long after processes change, causing a build-up of items not required for the current process needs.
2) Set in order: Once you've ensured that only the process driven items are located at each work station/area, arrange these items in an order based on process needs, i.e., items used more often should be positioned closer to the point of use.
3) Shine: One of the best ways to maintain order is to keep work areas clean. Given that you will expect employees to maintain a clean work area, make sure to provide ample time during the day to support this expectation.
4) Standardize: Having standardized processes helps to ensure that employees are providing consistent results. Remember that undocumented (verbal) processes are not different than non-standardized processes; so be sure to establish more formal, written process definitions.
5) Sustain: If the prior 4 "S's" are handled correctly; it's not too difficult to maintain the system. Typically, breakdowns occur with the movement of new employees and/or managers into an operation. An effective new employee training process can help to mitigate any problems.

The customer is the focus (as well as making a profit!) within the lean system.

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Customer focus can be summed up by looking at three areas: quality, cost, and delivery. Quality is an absolute as much as it is a customer perception. As a process owner, we establish the minimum quality levels we are willing to accept as outputs from our system. By the same token, the customer will establish their own perception of the level of quality of the product they are purchasing. This perception may or may not be in alignment with the actual quality (when compared to specifications) of the product. Nevertheless, in the end, it is this perception that carries much more weight than how well you are able to meet customer requirements. A lean manager understands this and finds ways to obtain customer feedback on quality perception. We also look at cost in two ways; what the customer is willing to pay, based on the perceived value of the product, and also internal cost within your nursery. Similar to Quality, a lean manager must not only work to drive internal cost down, but find ways to increase the customers' perception of product value. Delivery can be defined as transfer of a quality, right priced product at the right time, but also as internal delivery between process steps in your operation. Meeting external customer schedules starts with meeting your own internal process cycle time expectations.

Waste reduction may be the single largest lean component that can provide the most improvement for an organization. Typically, we think of nursery waste as either product not sold due to reductions in demand, unsaleable product due to quality shortcomings, or plants which may become damaged during processing. Waste in a lean system carries a much larger meaning. Waste, or "muda" in the Japanese language, relates to any general waste; scrap product, employee wait time, or wasted movement of people or products. Waiting is a very obvious killer of efficient production. Nobody is really keen on paying employees to wait. We pay employees to work! Identify the root cause that is driving this wait time, and fix it. Look for ways to improve the efficient movement of your most valuable resource; your employees. Try to address the placement or proximity of needed supplies to your workers. Other obvious concerns would be excessive movement, twisting and/or bending, transfer of items between hands and inherently unsafe movements. Generally speaking, any movement that an employee considers difficult or unsafe will be performed in a much slower fashion.

Another effective instrument in the lean toolset is "mistake-proofing", or "poka yoke" (loosely translated: avoid mistakes). Understanding that inspecting to catch defects before they leave your nursery will never be 100% effective. To this end, it makes sense to avoid making mistakes in the first place. The idea behind poka yoke is to use methods to, ideally, prevent an employee from making a mistake in the first place or from accepting a mistake or allowing a mistake to leave the operation. In a manufacturing operation, this may include use of non-symmetrical parts. For the green industry, realistically, this technique can be used to reduce the number of human errors by developing a system of visual cues of expected results, training materials and/or stops to prevent defects from moving on to the next process or leaving the nursery. Basically, find ways to visually show your employees what is acceptable and what is not.

The number one reason that Lean projects fail or never live up to expectations is leadership. Managers must learn that in a lean system, the focus is rarely on short term goals, putting out fires or meeting today's production objectives. Effective leaders in a lean system focus on long term goals, finding root causes to issues and fixing them for good and changing the way employees view their role in the organization. People mistakenly assume that a lean implementation will change the culture at an operation or company. You must remember that the culture at your nursery is the result of employee experiences under the current management style. Change the style and you can create a new culture over time.

SUMMARY

I will share what I consider the five most important lean principles.

1) Eliminate non-value added activities: Be sure to question all activities that you perform. Don't take anything off the table. Everything is fair game for three questions… Why do we do this? Does it add value? Is it something that our customer is willing to pay for?
2) Order will drive efficiency: Studies in human behavior have shown that the human

eye is drawn to chaos. As an example, when we drive past an automobile wreck, we have to slow down and look; we can't help it. If your nursery operation is cluttered with items not needed, your workers cannot get to the items/supplies they need without "slowing down to look" at the chaos.

3) Improvements = Profit: There are two ways of looking at your nursery operation in terms of Business 101. Typically, business owners look to set the selling price asked for their product as their costs + profit margin. However there are many other variables that drive selling price (customer perception, economic climate, …) and, in many cases we have less control over the selling price than we may think we do. In a lean world, instead of looking at cost + profit = selling price, you should consider selling price a virtual constant and define profit as selling price – cost. In this scenario, decreases in your costs have more of a direct relationship to profit.
4) Movement ≠ work: Never confuse movement of your employees with work. Busy looking employees always shuffling around may indicate inefficiency and wasted time. Remember that work should be defined as something that adds value to your product. Movement without added value is potential waste.
5) Management style drives culture: Many organizations implement a lean system in hopes of changing the culture. The fact is, if you want to change the culture within your operation, you must change your management style and expectations. Remember that the best you should hope to get out of your employees is your minimum expectations. So set the bar high, give reasonable expectations and hold employees accountable.

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An evaluation of yellow-flowering magnolias and magnolia rootstocks

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Abstract

Yellow-flowering magnolias were evaluated for flower color, bloom duration and growth rate in USDA Hardiness Zone 6b. Of the 30 selections evaluated, all were reported to have yellow blooms; however, tepal color ranged from light pink with some yellow coloration, creamy yellow to dark yellow. 'Daphne', 'Judy Zuk', and 'Yellow Bird' have the darkest yellow tepals and would often be the last to bloom. 'Gold Star', 'Golden Gala', 'Stellar Acclaim', 'Sun Spire', and 'Sundance' had the lightest yellow tepal color. 'Goldfinch', 'Butterflies', and 'Elizabeth' were the earliest to bloom and 'Elizabeth' had one of the longest flowering periods. 'Carlos' and 'Gold Star' are the tallest selections at 7 m each after 10 years in the evaluation. 'Golden Gala', 'Gold Star', 'Carlos', 'Lois', and 'Yellow Lantern' had the largest trunk diameters and averaged over 2.5 cm growth per year. 'Sun Spire' has one of the smallest trunk diameters and shows an annual increase of about 1.5 cm per year. Powdery mildew incidence, *Phyllactinia corylea* and *Microsphaera alni*, was observed on all selections; however, 'Golden Sun', 'Solar Flair', 'Stellar Acclaim', 'Sunburst', 'Sunsation', and 'Yellow Bird' had greater than 40% of the leaf area affected with mildew with over 60% of the canopy affected by late summer. Powdery mildew was significantly less on 'Banana Split', 'Carlos', 'Elizabeth', and 'Sun Spire'. An evaluation of rootstocks revealed 'Leonard Messel' had more height growth occur with scions than selections budded onto other rootstocks in comparison to scions budded on to 'Wada's Memory' rootstock which produced the smallest height growth. Rootstocks 'Wada's Memory' and 'Ballerina' produced the smallest scion trunk diameter growth. After 5 years, bud incompatibility was observed on rootstocks 'Ballerina' and 'Leonard Messel' as indicated in the difference of growth between the rootstock and the scion.

INTRODUCTION

Deciduous magnolias are well adapted to many landscape situations and are highly desirable due to their floriferous nature. About 800,000 flowering magnolias are sold each year in the USA and about 10% of the nurseries that grow magnolias are located in Tennessee (USDA, 2014). There has been interest in breeding for deciduous yellow-flowering magnolias since the 1950s. Most of the yellow-flowering magnolias have been breed from a USA native magnolia, *Magnolia acuminata* or *M. acuminata* var. *subcordata,* a smaller stature than *M. acuminata*. This species provides cold hardiness and can be grown in a wide array of soil types. Hybridization with *M. denudata* or *M. liliflora*, native to China, can offer yellow flower color and a range of tree sizes and shapes. Most American magnolias bloom with the foliage, which means a late spring-summer bloom whereas the *M. denudata* bloom before the leaves emerge in the spring. Many selections of yellow magnolias bloom in late March-early April, but often spring frosts and freeze affects flowering as well as leaf out (Fare, 2011). Cultivars like 'Elizabeth', 'Yellow Bird', and 'Butterflies' were a few of the first commercially available. A second generation of yellow-flowering magnolias with cultivars like 'Golden Sun', 'Golden Gift', 'Gold Star', 'Yellow Lantern', and a well-known cultivar 'Butterflies' were developed by breeders Dr. David Leach and Philip Savage. Dr. August Kehr released 'Gold Cup', 'Solar Flair', 'Stellar Acclaim', 'Sundance' and 'Sun Ray' and in later years,

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he released ‘Sunburst’, ‘Sunsation’, and ‘Sun Spire’. A notable cultivar, ‘Lois’, was developed by Lola Koerting (Knox, 2001). Yellow-flowering deciduous magnolias are becoming popular landscape plants because they offer an unusual color palette and there are very few yellow-flowering small trees in the landscape plant inventory (Knox, 2002).

This evaluation was conducted at the Tennessee State University Nursery Research Center located in middle Tennessee on the border of USDA Hardiness Zones 6 and 7. The area is known as a climatic and geographic transition zone. Plants produced in this area can be used in landscapes as far north as Zone 5 and as far south as Zone 8. Plant evaluations made in transition zones are ideal because results can be utilized over a wide geographic and climatic area.

The primary objective of this research project was to compare yellow-flowering magnolias for flower color intensity, flower size, and duration as well as growth rate and canopy form. It was noticed during the evaluation that bud incompatibility was occurring on some of the selections. Often, there was not a knowledgeable source as to the rootstock used during propagation. Thus, a second project was initiated in 2011 to evaluate known rootstocks with three selections, ‘Elizabeth’, a large canopy selection, ‘Golden Pond’, a moderate sized selection and ‘Sun Spire’, a slow upright growing selection.

MATERIALS AND METHODS

Plant evaluation

Many selections of yellow-flowering magnolias are only available in low numbers and small sizes so plants for this evaluation were purchased, grown in #3 or #5 containers for a year, and planted in the evaluation plot the following spring. The first plantings were in March 2006 in a field plot with well drained silt loam soil (Waynesboro) using a 4.6 m (15 ft) in-row spacing and 3.7 m (12 ft) between row spacing. Each magnolia selection was planted in a randomized block design with three single plant replications. Plants were maintained with traditional management including fertilization, mulching, and weed control. Pruning was limited to removing branches from the trunk about 61 cm (24 in.) above the soil line. In March 2007, a few weeks of unseasonably warm temperatures occurred followed by a hard freeze that lasted several days. Many plants had broken dormancy and as a result of the freeze were killed or suffered severe dieback. Plantings were reestablished and up to 37 selections of yellow-flowering magnolias have been under evaluation; however, several selections have died from subsequent spring freezes with damage to the trunks and or canopy (Magnolia Society, 2010). Flowering duration was determined from the first observation of flowers until flower tepals no longer had a visual impact. Data presented is an average time period that flowering occurred from 2008 through 2016. To determine flower color, three flowers per tree were removed on the day the flowers opened and color was measured on the inside and outside of the tepal using the Royal Horticultural Society Colour Chart (RHS, London, England) and a portable spectrophotometer (Minolta 2600d). Leaf-out was recorded from the time the foliage was at least 50% unfurled until full leaf.

Each fall, height, two canopy widths (perpendicular measurements) and trunk diameter [measured 15 cm (6 in.) above the substrate surface] were recorded. During June 2014, five leaves were removed from each tree to determine leaf size (CI-203, CID, Camas, Washington). Powdery mildew was rated during August, September, and October each year for the percentage of foliage affected and the percent of disease severity on the entire canopy (only data shown from October 2015). All data was statistically analyzed using the general linear model in SAS 9.1. Mean separation was performed with Fisher’s protected LSD with alpha =0.05.

Bud incompatibility

Rooted cuttings of *M.* ‘Ann’ and ‘Jane’; *M.* × *loebneri* ‘Ballerina’, ‘Leonard Messel’, and ‘Merrill’; and *M.* × *kewensis* ‘Wada’s Memory’ were potted into #3 nursery containers (Classic 2000, Nursery Supplies, Chambersburg, Pennsylvania) in April 2011 with a bark substrate amended with 9 lbs 19-5-9 Osmocote Pro, 1 lb Micromax and 1 lb AquaGro per yd. Plants were grown in full sun until August 2011 when 'Sun Spire', 'Elizabeth', and 'Golden Pond' were budded onto the rootstocks. Plants were maintained in a shade house until late fall then placed in a plastic covered overwintering house. In late March 2012, rootstocks were transitionally pruned to the scion bud. Stakes were placed on the growing scion bud to ensure upright growth. Plants were grown under shade until spring 2013. Three plants of each budded selection on each rootstock were planted in a field with 10 ft between rows and 15 ft in-row spacing. The field soil had been tested prior to planting and treated with lime and phosphorus to bring the Waynesboro silt loam soil up to good growing conditions. Plants were maintained with traditional field management practices for fertilization, mulching, and weed control. Each fall, trunk diameter measurements were made 2.54 cm (1 in.) above and below the bud union. Magnolias were planted in a randomized block design with three single plant replications. All data was statistically analyzed using the general linear model in SAS 9.1. Mean separation was performed with Fisher's protected LSD with alpha = 0.05.

RESULTS

Plant evaluation

Figure 1 shows the average time that flowering and leaf-out occurred from 2008 until 2015. Due to temperature fluctuations that occur during spring, in some years, unseasonably warm periods cause the flowers to mature quickly, thus the flowering period was shorter and in other years, late spring frosts resulted in poor flowering and delayed leaf-out. 'Goldfinch' is the earliest selection to bloom in mid-to-late March, followed by 'Butterflies' and 'Golden Pond'. 'Golden Pond', 'Sunsation' and 'Elizabeth' have flowering periods that often last up to 3 weeks; however, the best floral display is often during the mid-point and less showy in the beginning and end of the flowering period. 'Yellow Lantern' and 'Gold Star' have the shortest flowering periods which lasts about 1 week, then a distinct period of time before leaf-out occurs. The latest flowering magnolias are 'Sunsation', 'Yellow Bird' and 'Judy Zuk'. In most years, 'Sunsation' flowered about a week before 'Judy Zuk and 'Yellow Bird'. 'Yellow Bird' is the most floriferous selection in the evaluation and may have more than twice the number of flowers than other selections.

With many selections, there was a distinct period between flowering and leaf-out, i.e. 'Butterflies', 'Carlos', 'Gold Star', 'Goldfinch', 'Sun Ray', and 'Sundance'. These selections started blooming in late March and leaf-out did not occur until early-mid April. Selections, 'Solar Flair', 'Sun Spire' and 'Sunburst', had overlapping periods of flowering and leaf-out, but leaf-out did not affect the floral display. However 'Judy Zuk' and 'Yellow Bird', two of the latest selections to flower, often had the floral display concealed by the foliage which unfurled during the peak flowering period.

One of the challenges with yellow-flowering magnolias is the tendency for the yellow flower color to vary from year to year or in certain climates not to develop fully. With many cultivars, the intensity of the yellow quickly fades into a soft creamy color. Color varies markedly from the inner side to the outer side of the tepal and from the basal end to the tip. Some selections, i.e., 'Sunsation' have flowers with an incursion of pink. With warmer spring temperature, color intensity is less than in the springs where the temperature has been cooler.

The Royal Horticulture Colour Chart was used to determine tepal color and the author found differences in this test compared to colors reported in the Magnolia Cultivar Checklist and other notable sources (Robinson, 2006; Fare, 2011). This is to be expected due to the maturity of the flower, location of the plant, and expected differences from year to year (Knox, 2001). The portable spectrophotometer used to measure color intensity also showed differences in color from tepal to tepal, plant to plant, and year to year; even though a more precise color was measured than what was dependent on the human eye with the color chart. 'Daphne', 'Judy Zuk', and 'Yellow Bird' have the highest yellow color reading on the spectrophotometer from year to year, even though the color intensity changes from year to year. 'Gold Star', 'Golden Gala', 'Stellar Acclaim', 'Sun Spire' and 'Sundance' have routinely had the lightest yellow tepal color.

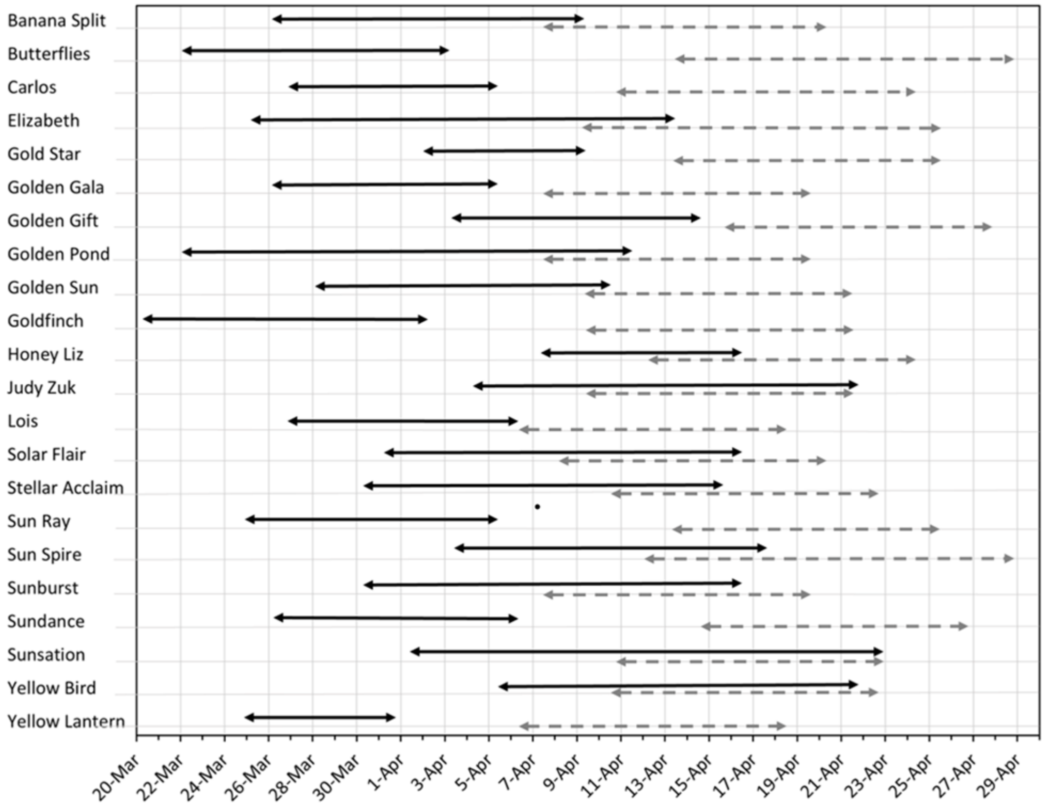

Figure 1. Flowering and leaf-out duration of selected yellow-flowering magnolias averaged from 2008 to spring 2015. Solid lines represent the flowering period and dashed lines represent the leaf-out period.

Since the initial planting, there are some distinct differences in canopy growth and development (Table 1). 'Carlos' and 'Gold Star' are the tallest selections at 708 and 699 cm, respectively. 'Golden Gala', 'Judy Zuk', 'Yellow Lantern', and 'Yellow Bird' have averaged about 85-95 cm of height growth annually. Several of the magnolias, such as 'Solar Flair', 'Sun Spire', 'Sunsation', and 'Sunburst' are slow growing and average about 60-65 cm a year in height. 'Golden Rain' and 'Green Bee' are currently the smallest magnolias in the test. Slow growth appears to be typical for many of the yellow-flowering magnolia selections during the first year or two after transplanting, but yearly height growth has increased after the third year in the test with many selections.

Canopy growth was calculated from an average of two canopy widths measured from one canopy drip line perpendicular to another (Table 1). Distinct canopy shapes were prominent with several cultivars. 'Gold Star', 'Sundance', 'Lois', and 'Sun Ray' have the widest canopies among the selections and could be labeled as broadly ovate. 'Judy Zuk' and 'Sun Spire' have a distinct upright growth habit and will probably become more distinct with age. On an annual basis, 'Judy Zuk' and 'Sun Spire' have about half the canopy width increase (~25 cm year^{-1}) compared to 'Gold Star' at 55 cm year^{-1}.

Trunk diameters were measured 30 cm (12 in.) above the soil surface in late fall. Trunk growth averaged from 1 cm to 2.6 cm per year during the evaluation (Table 1). 'Golden Gala', 'Gold Star', 'Carlos', 'Lois', and 'Yellow Lantern' had the largest trunk diameters and averaged over 2.5 cm (1 in.) growth per year compared to other selections. 'Sun Spire', planted in 2007, has one of the smallest trunk diameters and shows an annual increase of about 1.5 cm per year.

Table 1. Growth increase of height, canopy width and trunk diameter from March 2009 to December 2015 and average leaf area in 2015 of yellow flowering magnolias in Tennessee.

Selection	Height (cm)		Canopy width (cm)		Trunk diameter (cm)		Average leaf area (cm)	
Anilou	557	a-h[1]	175	g-k	11.6	d-j	177	cde
Banana Split	555	a-h	193	f-k	12.1	c-j	184	bcde
Butterflies	444	e-i	180	g-k	9.6	hij	98	ghij
Carlos	708	a	278	b-g	18.2	ab	213	abc
Daphne	491	c-i	209	f-k	10.5	f-j	99	ghij
Elizabeth	560	a-h	243	d-i	15.8	a-g	141	efgh
Gold Cup	482	c-i	135	k	10.0	g-j	123	fghij
Gold Star	699	a	401	a	18.3	a	96	hij
Golden Gala	675	ab	346	a-d	18.4	a	236	a
Golden Gift	466	d-i	248	c-i	11.3	d-j	90	ij
Golden Pond	447	e-i	174	g-k	9.0	hij	154	defg
Golden Rain	345	i	172	g-k	8.0	ij	120	fghij
Golden Sun	491	b-i	240	e-k	11.1	e-i	148	defg
Goldfinch	560	a-h	193	f-k	11.5	d-j	105	ghij
Green Bee	355	i	139	jk	7.4	j	95	hij
Honey Liz	422	f-i	150	ijk	8.3	hij	178	cde
Judy Zuk	596	a-f	193	f-i	13.5	a-i	192	abcd
Koban Dori	419	ghi	169	h-k	7.5	ij	87	ij
Lois	579	a-f	372	ab	18.0	ab	167	cdef
Petit Chicon	515	b-i	167	h-k	9.7	hij	125	fghij
Skyland's Best	401	hi	199	f-k	9.6	hij	98	hij
Solar Flair	542	a-h	284	b-f	13.8	a-i	109	ghij
Stellar Acclaim	561	a-h	317	a-e	13.6	a-i	93	hij
Sun Ray	633	a-d	354	abc	17.0	abc	164	cdef
Sun Spire	541	a-h	150	ijk	12.4	b-j	126	fghij
Sunburst	558	a-h	287	b-f	16.0	a-e	85	j
Sundance	620	a-e	377	ab	17.5	abc	181	cde
Sunsation	481	c-i	187	f-k	16.7	a-d	233	ab
Yellow Bird	644	abc	258	c-h	14.1	a-h	147	defg
Yellow Lantern	667	ab	327	a-e	17.6	ab	213	abc
LSD	174		106		5.8		49	

[1]Means followed by the same letter within a column are not significantly different at $P \leq 0.05$, using Fisher's least significant difference test.

Leaves on the yellow-flowering magnolias vary in size (Table 1). 'Carlos', 'Golden Gala', 'Sunsation', and 'Yellow Lantern' are among the selections with the largest leaves. The foliage presents a very coarse textured canopy and may result in concerns with fall leaf litter. In contrast, 'Butterflies', 'Gold Star', 'Golden Gift', 'Stellar Acclaim', and 'Sunburst' have some of the smallest leaves among the selections in the evaluation. An identifying characteristic of 'Sun Spire' is the dark green foliage that is prevalent throughout the summer months. Flowering and leaf out are both affected by spring temperatures and late frosts, but in most years 'Judy Zuk', 'Solar Flair', 'Sunburst', 'Sunsation', and 'Yellow Bird' leaves mature while flowering is in the peak period. Leaf maturity often masks the flowers and thus flowering is not visible from short distances away.

Powdery mildew, *Phyllactinia corylea* and *Microsphaera alni*, has developed into a serious problem in the evaluation (Table 2). The foliar mildew appeared naturally and disease pressure has continued to be high in most years. No attempts have been made to apply preventative fungicides in the evaluation. There were significant differences among cultivars in severity of powdery mildew. In October 2015, all selections had some incidence of powdery mildew on the foliage; however, the severity varies with plant selection. By mid to late summer, 'Golden Sun', 'Solar Flair', 'Stellar Acclaim', 'Sun Burst', 'Sunsation', and 'Yellow Bird' had greater than 40% of the leaf area affected with mildew with over 60% of the canopy was affected. Another selection, 'Gold Star' had 15% of individual leaf surface affected with powdery mildew but over 66% of the canopy was affected. Powdery mildew severity was significantly less on 'Banana Split', 'Carlos', 'Elizabeth', and 'Sun Spire' than on other selections.

Table 2. Severity of powdery mildew, *Phyllactinia corylea* and *Microsphaera alni*, on foliage of select yellow flowering magnolias, October 2015.

	Powdery mildew on individual leaves (%)		Powdery mildew on plant canopy (%)	
Anilou	24.8	cde[1]	50.0	c-f
Banana Split	20.0	cde	20.0	h
Carlos	13.0	de	20.0	h
Elizabeth	10.0	de	16.7	h
Gold Cup	30.0	bcd	46.7	c-g
Gold Star	15.0	de	66.7	abc
Golden Pond	43.0	abc	30.0	e-h
Golden Rain	20.0	cde	58.3	bcd
Golden Sun	60.0	a	35.0	d-h
Goldfinch	30.0	bcd	25.0	fgh
Green Bee	47.0	ab	83.3	ab
Honey Liz	43.0	abc	80.0	ab
Judy Zuk	17.0	de	23.3	gh
Koban Dori	41.0	abc	70.0	abc
Lois	20.0	cde	28.3	e-h
Petit Chicon	30.0	bcd	21.7	gh
Solar Flair	60.0	a	35.0	d-h
Stellar Acclaim	47.0	ab	85.0	a
Sun Ray	13.0	de	21.7	gh
Sun Spire	3.0	e	13.3	h
Sunburst	50.0	ab	61.7	abc
Sundance	10.0	de	35.0	d-h
Sunsation	43.0	abc	51.7	cde
Yellow Bird	63.0	a	71.7	abc
Yellow Lantern	30.0	bcd	26.7	e-h
LSD	29.0		21.0	

[1]Values are the means of three replicate plots; means followed by the same letter within a column are not significantly different at P≤0.05, using Fisher's least significant difference test.

Bud incompatibility

In the plant evaluation test, it was obvious after a few years that the rootstock and scion growth was occurring at different rates with several of the cultivars which resulted in bud incompatibility and poor growth. Inquiries were made to the source of the original purchases of magnolias but a lack of records made it impossible to confirm the root stock of many of the plants. While it is possible for the scion to overgrow the rootstock and vice versa, a strong bond must be present in the callus bridge or incompatibility will occur. Overgrowth or undergrowth of the scion may be more related to genetic tendency for growth than to incompatibility (Hartmann et al., 2002).

Five years after budding (3 years in the field plot), height growth was greater with ‘Elizabeth’ and ‘Golden Pond’ than ‘Sun Spire’ regardless of rootstock (Table 3). This was similar to results observed in the evaluation test; however, rootstocks had an effect on height growth. Selections chip budded on to ‘Leonard Messel’ had more height growth occur with scions than selections budded onto other rootstocks. The least amount of height growth occurred with scions budded on to ‘Wada’s Memory’ rootstock compared to other rootstocks.

Table 3. Effects on growth of yellow flowering magnolias budded onto select magnolia rootstocks.

	Height (cm)	Trunk diameter (cm)	Difference in diameter of rootstock and scion bud (cm)[1]
Scions			
M. ‘Sun Spire’	316.5 b[2]	6.2 b	1.2 a
M. ‘Elizabeth’	400 a	7.3 a	0.5 b
M. ‘Golden Pond’	400.7 a	7.7 a	0.4 b
LSD		0.5	2.9
Rootstocks			
M. × *loebneri* ‘Leonard Messel’	418.3 a	7.6 a	1.4 a
M. × *loebneri* ‘Ballerina’	363.9 b	6.4 c	1.7 a
M. × *kewensis* ‘Wada’s Memory’	337.4 c	6.4 c	0.9 bc
M. × *loebneri* ‘Merrill’	368.7 b	6.8 bc	1.1 bc
M. ‘Ann’	382 b	7.4 ab	0.5 cd
M. ‘Jane’	375.3 b	7.4 ab	0.2 d
LSD	19.9	0.7	0.5

[1]Difference in rootstock and scion diameter was determined by measuring the trunk one inch above and below the bud union.

[2]Means followed by the same letter within a column are not significantly different at P≤0.05, using Fisher’s least significant difference test.

Trunk diameters of scion growth (measured at 2.5 cm above the bud union) were largest with ‘Elizabeth’ and ‘Golden Pond’, 7.3 and 7.7 cm, respectively, compared to ‘Sun Spire’, 6.2 cm, which reconfirms that ‘Sun Spire’ is a slower growing selection of magnolia (Table 3). Trunk growth averaged 6.4 to 7.6 cm among scions, with significantly larger trunks on rootstocks of ‘Ann’, ‘Jane’, and ‘Leonard Messell’. ‘Wada’s Memory’ and ‘Ballerina’ rootstocks produced the smallest trunk diameter of scion growth among the selections.

The difference in trunk diameter above and below the bud union showed that ‘Ballerina’ and ‘Leonard Messel’ had the greatest difference in growth between the rootstock and the scion. ‘Ballerina’, for example, averaged a difference of 1.7 cm among all the scions; however, specifically with ‘Sun Spire’, ‘Elizabeth’, and ‘Golden Pond’ there was a difference of 2.2, 1.7 and 1.2 cm, respectively. In contrast, ‘Ann’ and ‘Jane’ rootstocks averaged less than 0.5 and 0.2 cm, respectively, with trunk diameter difference above and below the bud union. There were instances, especially with ‘Golden Pond’ where the scion diameter grew more than the diameter of the rootstock. In the future, selections matching growth of the rootstocks to the scion may be chosen from genetic information that will eliminate time in choosing parents and or rootstocks (Ranney and Gillooly, 2015).

CONCLUSION

A comprehensive replicated evaluation of new and familiar yellow-flowering magnolias in one location will benefit magnolia connoisseurs, the nursery industry, and prospective plant breeders. In time, more valuable information will be collected as the plants grow in the evaluation and as the evaluation on rootstock with bud incompatibility matures. As yellow-flowering magnolias become more widely known, many selections in this evaluation may be less popular and will serve only as a breeding line for developing improved selections. Time of flowering is critical for plants in USDA Hardiness Zones 6 and 7 due to early spring frosts (and freezes) and will be the deciding factor to the success of many yellow-flowered selections (Tubesing, 1998). The palette of yellow color is well represented with the *Magnolia* selections from border-line creamy yellow to distinctly yellow in color (Cover, 2009). However, in this evaluation, the selections that flowered after the threat of spring frosts also leafed-out during the flowering period which caused a lesser flowering impact than earlier blooming selections.

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The edible landscape: an interesting market niche©

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INTRODUCTION

With the growing trend to eat local, in-season foods it is no wonder customers are looking to incorporate more edible plants into their landscape design. The trend has sparked the return of edible landscaping—which is all about incorporating edible herbs and flowers as well as plants, trees and shrubs that produce vegetables and fruits—in residential gardens. While the concept is gaining popularity now, edible landscaping is really just as old as gardening. In fact, ancient Persian gardens consisted of a variety of edible and ornamental plants. And medieval gardens took the concept to a whole other level with most gardens housing an array of fruit and vegetable plants, edible flowers and medicinal herbs. Today, with a newfound focus on health, sustainability and environmental protection, edible landscaping is a trend that's here to stay.

An interesting way to expand your market may be to incorporate value-added service to your business plan. If your business includes edibles or "edimentals" as they are sometimes called, you may consider offering edible landscape consultation to your clients. Your service may include design, as well as installation and maintenance with a focus on offering edible annuals, perennials, trees, shrubs, and even ornamental arrangements.

Educate your clients on the benefits of edible landscaping. Edible landscaping can offer benefits to personal health, environmental sustainability, as well as family finances. Eating more fruits and vegetables is the key to better health and growing them in a home landscape is the best—and tastiest—way to get more vitamins and nutrients without preservatives. Additionally, home gardeners can take control of their own chemical use, and may choose to adopt organic practices. Gardeners can access the freshest, most flavorful food without the cost of shipping great distances and the loss of flavor that results from premature harvest for supermarket shelves. Planting edible gardens also gives consumers the opportunity to plant and grow foods that aren't always available in your local supermarket.

It's important to present your client with plenty of ideas for incorporating edibles into their existing landscape. For every type of plant commonly found in a "traditional" landscape, there is an edible alternative.

TREES

Citrus

Since citrus trees are particularly sensitive to cold temperatures, they are not well-suited for most home landscapes. The kumquat (*C. japonica*), calamondin (*C. japonica*), and satsuma (*C. reticulata*) have the greatest degree of cold hardiness. However, most gardeners can successfully enjoy citrus trees in patio containers. Any type of citrus tree can be grown in a container, but navel oranges, grapefruit (*Citrus* × *paradisi*), and most other oranges are very vigorous and outgrow all but very large containers.

Naturally small citrus cultivars such as 'Improved' lemon (*C.* × *meyeri* 'Improved'), satsumas, kumquats, and calamodins are easy to grow in containers. If you can purchase citrus that is grafted onto *C. trifoliata* 'Flying Dragon' rootstock, it will be significantly dwarfed, which will extend its life in a container. Following are some recommended taxa (Porter, 2013):

- 'Owari' satsuma (*C. reticulata* 'Owari') was introduced from Japan and is the most widely available satsuma. The fruit is seedless and matures from October to mid-November. 'Owari' trees tend to be more vigorous than other satsumas.
- 'Nagami' kumquats (*C. japonica* 'Nagami') produce oblong fruit with a smooth rind,

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deep orange color, and acid juice. They ripen from mid-October through February. The fruit is one and a half to two inches long and one to two inches in diameter and contains seeds. The 'Nagami' tree is vigorous, with a round, bushy top. It is very cold hardy.

- *Citrus* × *meyeri* or *C.* × *meyeri* 'Improved' are the only lemons recommended for container culture due to their small degree of cold hardiness. It is not a true lemon, but a cross between a lemon and an orange. It ripens in mid-October and holds on the tree until December or longer. *Citrus* × *meyeri* is better when grown from a rooted cutting than when grafted. It has a strong tendency to bloom and set fruit throughout the year.

Fig

Ficus carica is a native of Asia and was imported into the United States in the 16th century. The fruit is tasty and can be eaten fresh, made into preserves and jams, or used in baking. Figs have the potential to produce an early crop, called the breba crop, on last year's wood in the spring, a main crop on the current-season wood during the summer, and a third crop in the fall. These different crop productions vary from one cultivar to another. Popular fig varieties include 'Celeste', 'LSU Purple', 'LSU Gold', and 'Brown Turkey' (Gill et al., 2011).

- 'Celeste' produces small- to medium-size fruit that is resistant to splitting and souring. The fruit is violet to brown with a light strawberry-colored pulp.
- 'LSU Purple' has medium-size, dark purple fruit and good resistance to foliage diseases. Its tendency to produce three distinct crops—a light crop in early spring, a heavy main crop in early July and a later crop sometimes lasting into December—makes it popular.
- 'LSU Gold' is a relatively new yellow-fruited variety that may still be hard to find, but it is well worth growing. The 'LSU Purple' and 'LSU Gold' cultivars were developed from crosses made by Ed O'Rourke in the 1950s.

Fig trees need room. They can reach heights of 10-15 ft with an equal spread. Plant them in a sunny location away from large trees with overhanging branches. Figs will not produce well unless they receive at least 6 h of direct sun daily.

SHRUBS

Blueberries

Blueberries are increasingly popular fruits with well-documented health benefits. Blueberry plants are also exceptionally handsome bushes worthy of planting in the home landscape. The fruit can be eaten fresh, or frozen for out-of-season use. Plants have a profusion of white blossoms in late spring, and the leaves are glossy green in summer and have outstanding red foliage in autumn. Blueberry production may present a challenge for some gardeners because the plants need special growing conditions. They require acidic, well-drained soils (Hoover et al., 2009).

There are three main types of cultivated blueberries that can be grown in the Southeast: rabbiteye, northern highbush, and Southern highbush. This section focuses on the rabbiteye and southern highbush types (Polomski and Reighard, 1999).

In general, rabbiteyes (*Vaccinium ashei*) are the most adaptable, productive, and pest-tolerant of the three types of blueberries. In general, rabbiteye blueberries have some degree of self-incompatibility; therefore, a minimum of two cultivars are required for cross-pollination to ensure maximum fruit. Some recommended rabbiteye cultivars include:

- Early season: 'Beckyblue', 'Bonita', 'Brightwell', 'Climax', 'Premier', 'Woodard'
- Midseason: 'Bluebelle', 'Briteblue', 'Chaucer', 'Powderblue', 'Tifblue'
- Late season: 'Baldwin', 'Centurion', 'Choice', 'Delite'

'Woodard' is a good berry for fresh-eating but develops a tough skin when frozen. 'Tifblue', 'Powderblue', 'Brightwell', 'Briteblue' and 'Centurion' are most resistant to spring freezes.

Southern highbush blueberries are hybrids derived from crosses between northern highbush blueberries and native southern species, mainly Darrow's evergreen blueberry (*V. darrowi*). Southern highbush cultivars, in addition to lower chilling requirements, also have greater tolerance to high summer temperatures, somewhat greater drought tolerance and develop superior fruit quality under southern growing conditions. As a rule, southern highbush blueberries are self-fertile. However, larger and earlier-ripening berries result if several cultivars are interplanted for cross-pollination. The following Southern highbush blueberries are recommended for the garden and landscape:

- Very early season: 'O'Neal'
- Early/midseason: 'Cape Fear'
- Midseason: 'Blue Ridge' and 'Georgia Gem'
- Mid/late season: 'Legacy' and 'Summit'
- Late season: 'Ozarkblue'

Pineapple guava

Acca sellowiana (feijoa) is an attractive evergreen shrub bearing delicious fruits with an unusual, refreshing pineapple-mint flavor. The leaves are soft green on top, silvery underneath. One inch wide white petal flowers have showy red centers reminiscent of fuchsia flowers. These plants are low maintenance with few insects or diseases. Ideal for containers, feijoa also looks excellent in the landscape and makes a beautiful hedge. Two different plants (not the same clone) are required to insure pollination and fruit set.

Aronia arbutifolia

Aronia is commonly known as chokeberry. 'Brilliantissima' is commonly grown by the nursery industry, probably more so than the species. It possesses enhancements to all the desirable features of the species. It blooms and fruits heavily; has larger fruit than the species; produces very glossy, dark-green foliage; and dependable, intense red fall color. Most experts roundly praise this cultivar, and it may serve as a fine native substitute for the invasive, exotic *Euonymus alata* (burning bush).

FLOWERS

Violets and violas

Violets (*Viola*) are adapted to woods and pasture. The purple flowers are edible and the plant is medicinal. Make sure your spring salads include violets. Grows exceedingly well in hard bark mulch as a companion with bush fruits such as blueberries.

Roses

Rose hips are the large seed pods that form on rose canes after blossom. Some roses, especially *Rosa rugosa*, form rose hips that are as big as crab apples—about the size of a quarter! And, in the fall they turn brilliant colors of red and orange, and sometimes even purple.

And, being a true member of the apple family, rose hips are edible. Rose hips are also very high in vitamin C, and you'll often see them listed as the main source for vitamin C in many commercially available vitamins. You can also eat rose petals. Sprinkle them on salads, use them as garnish, or make them into wonderful rose-petal jelly.

GROUNDCOVERS

Mint

Corsican mint (*Mentha requienii*) is a dynamic ground cover and ornamental mint if you can give it lots of moisture. It takes some abuse from being trod on and comes back just fine. If you have a low spot in the garden with a few neglected looking pavers surrounded by bare dirt, Corsican mint may be the solution to your problem. Corsican mint prefers sandy soil and dappled light. It should never be allowed to dry out.

Rosemary

Rosmarinus officinalis (syn. *R. prostrates*) is a creeping rosemary type that has made a name for itself as a container rosemary. It is an evergreen ground cover, but also looks natural in containers, hanging baskets and easily wraps around circular wire frames to create topiaries. Creeping rosemary is a tender evergreen perennial with fragrant evergreen foliage and pale blue summer flowers.

FOLIAGE

Basil

Basil (*Ocimum basilicum*) is an easy to grow and easy to use herb. It grows well in pots and in beds. There are many types to choose from:

- Thai basil (*O. basilicum* var. *thyrsiflora*). Characterized by its strong licorice fragrance and flavor, this annual is also referred to as anise or licorice basil. It reaches heights up to 24 in. and with a nearly 2-ft expanse. Thai basil is more easily found in specialty grocery stores that carry exotic or high-end fresh herbs, but is easy to propagate.
- Genovese basil (*O. basilicum* ‘Genovese Gigante’). A well-regarded favorite among foodies, Genovese basil is considered the best basil for use in Italian recipes (pesto, tomato-basil sauce, Caprese salad, etc.) Like sweet basil, this annual has a strong clove fragrance and ranges from 12 to 24 in. in height, but is easily distinguished by it’s more crinkly and in-turned leaves.
- Lemon basil (*O.* × *citriodorum*). Similar to the other basils, this annual grows to a height of about 2 ft, but exudes a savory lemon flavor and fragrance. This basil is a bit spindlier than its other basil relatives and is characterized by a flatter, narrower leaf.
- Cinnamon basil (*O. basilicum* ‘Cinnamon’). The name describes it all—basil with a cinnamon flavor. Its strong cinnamon scent easily distinguishes it from other basils. It also has a somewhat harrier leaf. This medium-sized annual grows up to 2½ ft tall and produces pale pink to purple flowers.
- ‘Siam Queen’. *Ocimum basilicum* var. *thyrsiflorum* ‘Siam Queen’ is a type of Thai basil that produces mint green leaves with very large flower heads—up to 6 in. across—that give off a spicy anise scent. It reaches heights up to 2½ ft, but it can be pinched back to restrict growth.
- ‘Purple Ruffles’ (*O. basilicum* ‘Purpurescens’). This is a great plant to spice up the kitchen and the landscape! It is perhaps the most colorful basil for landscapes. Similar in color to ‘Dark Opal’, this plant is slightly smaller in stature (reaches up to 1½ ft) and its leaves are very frilly and ruffled. While it can handle a shadier spot in the garden, it still needs at least three hours of sunlight to mature properly. ‘Purple Ruffles’ gives off a combination of licorice and cinnamon scents and produces lavender and pink flowers that can also be eaten. Somewhat difficult to start from seeds, this plant works best from transplants.

Lemongrass

Lemongrass (*Cymbopogon citratus*), is an instant tea plant; just a few leaves in a cup of hot water yield a lemony drink. A tropical ornamental grass, it will take over an outdoor bed and will even grow well indoors. It is also known as a source for citral, the essential oil responsible for citronella's lemony scent. Lemongrass comes in two main varieties: East Indian and West Indian. They have subtle differences but are grown under the same conditions. Lemongrass is a perennial in growing Zones 10 and warmer but can be grown as an annual in cooler climates, though it may be difficult to grow outside in Zones 8 and colder. In general, plant lemongrass after the danger of frost has passed, in late spring for a late summer harvest. Lemongrass takes at least 100 days and sometimes up to 4-8 months to be ready for harvest.

CONCLUSIONS

Ensure the success of your customer's landscape by following up. By becoming a resource for your clients, they will return to your business for advice and additional plant material. Word of mouth referrals are invaluable!

Edible landscaping enhances the environment, is beneficial to our health and our wallets. It is a sustainable practice and by growing our own food we enhance our access to local food and decrease our carbon footprint.

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If I knew then what I know now©

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INTRODUCTION

Well what do I know now that I didn't know before? A LOT!! And I am still learning and know there is more to yet come. I guess that's a good thing, we should never stop learning.

I find it intriguing that anyone would be interested to hear what I know, for what I know now is probably what most of you have known a long time, which is—Don't get into plant importation if you want to make money (or at least not spend money) and stay sane!

I am Jan Barnett, the Managing Director of Bambina Rose NZ Ltd, which imports rose cultivars into New Zealand (NZ). We concentrate on the "tween"s sized roses. Shorter plants with largish blooms that make a stunning impact in the smaller sized gardens of today, some are highly perfumed. They have great looking and disease proof foliage.

I am lucky to be married to Paul (or PB), a man who makes a living as a building consultant and building project manager, which has been rather useful to me. Thank goodness he is very supportive of me and my dreams, plus he works hard in a practical way to help me build MY "empire." I have been his office manager for a long time and we have raised four children.

I am new to the plant nursery world, but not horticulture. My mother has always been interested in plants and as I grew up she taught me the names of plants in her garden. I had my very first rose pruning lessons from Mum who wanted help to prune hers when I was still at school. It should have been enough to put me off roses.

When I was a teenager Mum and Dad built a new house and had it professionally landscaped. Mum and I spent many happy hours poring over the catalogues choosing plants we could grow with an "empty" garden to establish. She worked in the Morrinsville Nursery for quite a few years.

I have always enjoyed reading the gardening magazines, like *New Zealand Gardener* and *Kiwi Gardener* so I am familiar with the columnists, the plants, the plant breeders and personalities. And I have met some of them along the way.

My grandparents had a rambling, romantic country garden with high hedges, a fish pond, and every type of flower and vegetable imaginable, but the roses were my favourite. Every Sunday afternoon we would visit my grandparents. Mum and Poppa would wander round the garden and I would follow listening to the discussions on the various plants and flowers. I was allowed to pick a bunch of flowers to take home and the car was loaded down with seasonal fruit and/or vegetables. I must have soaked up some knowledge because I find it strange that people can look at plants and not know what they are looking at. To me the gardens are populated with "friends", most of who are on a first name basis.

This particular grandfather is Allan G. Scott, MBE. Known to many people because he wrote the Rose Notes in the *New Zealand Gardener* magazine for 30 years, just stopping to write his memoirs 1 month before he died at age 97. He was a very intelligent and charismatic man who owned and farmed a 400 acre sheep and beef farm just out of Morrinsville. He won prizes for his animals and meat. He also became widely known and respected in the world of roses both in New Zealand and overseas winning many awards for his service to the rose.

For myself, once married and with my own garden, naturally I planted a few roses. I started off with a small rose garden, until the passion took hold and eventually I ended up with around 200 plants.

Now I grow and love roses, and grow them quite well with more than one champion rose to my credit. The First in 1992—I was still a novice exhibitor and actually had two champions at that show. The most recent was Champion of Champions at the National

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Spring Rose Show in 2014 hosted by Waikato Rose Society. This was probably my "swan song" as I am a bit preoccupied with other activities now.

I particularly love my miniature roses. After a large number of cultivars were introduced in the 1980s, the numbers of new miniatures declined and dwindled, then tailed right off, but I felt there was still a demand for roses of this size with the smaller gardens of today.

The first International Rose Convention I ever attended was the Inaugural World Rose Convention convened by my grandfather in 1971 when I was still young.

Held at the Claudelands Show Grounds in Hamilton, the wonders of that show are legendary with flowing streams full of live Trout and exquisite Floral Art Displays. The centrepiece of the show was a large white pergola that is now the centrepiece at the Hamilton Lake Rose Garden. But the roses—world class!

The second international rose convention I attended was in Christchurch in 1994, my Grandfather was alive and attended as well. Since then my husband and I have attended many International Rose Conventions and Tours as a chance to combine our love of international travel, sightseeing and meeting people, with roses. Attending these Conventions was integral to what we are up to now!

Since then

My interest in things to do with roses has evolved. After visiting other countries and seeing the roses available there I wanted some of them in New Zealand; as I previously described, shorter growing plants with larger blooms, in an array of colours which carried a better visual impact, some scented. All bred to be more disease resistant because of the ban on chemicals in Europe especially. Despite my interest in miniature roses I was convinced this type of rose was a much better garden subject.

WHY ARE THEY NOT IN NEW ZEALAND?

As Paul chatting sociably with breeders at rose conferences (not knowing, or caring, who they were) they griped that they couldn't get their roses into New Zealand.

This seemed to be why the New Zealand rose buying public were offered only a smattering of internationally bred roses, the rest are New Zealand bred roses by talented breeders like Rob Somerfield, BUT, even Rob knows that to create really novel and disease resistant roses there is needed new rose blood in NZ.

Much work has been done overseas by breeders looking to species roses with high disease resistance and thornlessness. Of course this gets technical with "ploidy" and remontancy, but breakthroughs have been made to overcome these problems. With this work done some New Zealand rose breeders are keen to access these genes and add them to their own breeding lines.

PB would ask the Rose Breeders "Why do you want to get them into NZ? It is such a small market in the scale of things". "Because I want to and I am told I can't".

We thought—"Is that true? How hard can it be"? Hmmm.

Back in New Zealand, we flew to Wellington for an appointment with the Ministry of Primary Industries (MPI). We met with Brian Rose, who gave us the rundown on what was required. Brian was great; he spoke frankly and probably gave us more direction than he could have done in emails.

For me—having ready and willing breeders happy to send their creations to NZ—what next? "Bambina Rose NZ Ltd" was born. Next was the beginning of my steep learning curve.

We had business partners with a nursery willing to take care of that side of things, all we had to do was bring in the new roses and quarantine them. So we set about building quarantine units.

WHAT I KNOW NOW

How to build quarantine units

We started with a house in town on a ¼ acre gully section. We had to reconfigure our section to have some flat space to build the units.

Knowing nothing about it there was quite a bit of collaboration with MPI. I had to study the MPI Standards and do the research:

- Greenhouse plans, what type? Glass, twin-skin, polycarbonate? What was available to quarantine standard?
- A building consent to apply for.
- Ventilation, cooling, heating, benches, shade, protection. How many taps and where to put them? How many power points and where to put them?
- How to feed the plants—a hydroponic system. Capillary, matting, drippers, flood and drain?
- Misting system.
- Erection of the units—our prototype was one house with three units.

The list seemed endless.

Once built, we obtained MPI approval for use. Finally, we could start importing.

Applying for a permit

Firstly, approval from the Environmental Protection Authority (EPA) is required. This turned out to be an enormous task both for myself but also for them. For every rose cultivar I wanted to import I had to provide a "Parentage List" which involved hours of research to build up a family tree of the forbears and provide proof these forbears are or were in New Zealand. Then, once the EPA had been furnished with the parentages of the roses, then they had to check them all off by doing their own research.

Researching roses in New Zealand was difficult to do, for roses introduced just after the war, for example, according to diaries he left, back in the day my grandfather just sent away direct to growers in England and the roses would arrive wrapped in burlap stored in the bilges of the boat that brought them in. There were no official records to track these taxa into New Zealand, therefore I had to look for mentions of roses in New Zealand gardens and in any New Zealand rose publication I could find. The old New Zealand Rose Annuals were invaluable and thanks to a senior Waikato Rose Society Member, Trevor McIlroy, who had kept a collection of all his Rose Annuals since he joined and let me borrow them.

The result of all this research is the invaluable database I now have of names of roses that have been grown in New Zealand, referenced to the publication where it is mentioned, its chapter, page number, etc. plus the scans of historic New Zealand rose books, New Zealand rose catalogues, New Zealand rose annuals, New Zealand gardening magazines. It has taken a huge amount of time, researching, recording and scanning, and it is still ongoing to keep the database up to date.

Of course I needed the co-operation of the rose breeders to divulge the parentage in the first place. Some breeders keep this very close to their chests and "seedling × seedling" without the parents, or parents of parents meant a dead end for me, so no clearance from the EPA to import this cultivar.

The countries New Zealand can import roses from are very limited. This is important because many beautiful roses are created in the United States or Canada and other countries New Zealand cannot import directly from, so we needed a go-between nursery in Europe willing to receive the budwood from the breeder, grow the plants for anytime up to four seasons, then prepare the budwood, dip it in chemicals, organise the phytosanitary certificate, pack it and send it on to us.

Exactly how to bring in a consignment

- Give advice to the foreign exporter so there are no delays at the border
- The process to be followed when the consignment arrives at the border, appointment for MPI inspection. Treatment of consignment if MPI deems it necessary. Applying for a Biosecurity Authority Clearance Certificate (BACC) and then release to me for quarantine.
- Preparation of the greenhouse before consignment arrives
- Growing understocks, having them well rooted and ready to take buds when a

consignment arrives.

How to grow them in quarantine

- How to bud roses —thanks to Wynne Johns, ex Wintec Horticulture Tutor, who personally gave me latex glove on hand lessons on this surgical technique.
- Now working out little tricks that improve the success rate with buds taking.
- Tricks that coax stubborn buds into life that have taken, but refuse to shoot away—the quarantine time doesn't start until the last live bud or cutting is showing leaves, so the quicker I can encourage growth the better.
- Rooting cuttings—what to root them in, little tricks that improve the success rate.
- Keeping records, tracking each cultivar as they grow or fail. Setting up spreadsheets, record books and databases with little idea at first what exactly I wanted recorded; I just recorded everything which has turned out to be invaluable.
- Names that everyone can understand. I am not a numbers person. A rose cultivar that is sent to me with a designated code number very similar to another cultivar with a similar code number is just too hard for me to "bond" with. A book of baby names comes in handy, the cultivars are given nicknames to make it easier to recall, record, discuss, and follow its progress. Like tropical cyclones, the same names are never reused so there are no mix-ups.
- Talking of names I have many unnamed roses that need a good commercial name that hasn't been used in the past, so if you have any suggestions I would love to hear them. Or, if you have a hankering to have a rose named after you or someone else, naming rights are available.

Once the cuttings are rooted and the buds are growing:

- The best growing medium to pot into for growing on.
- Keeping the units clean and free of slime and mould—thanks to marijuana growing websites!
- Calibrating the hydroponic system.
- What to do with used soggy growing medium when cuttings or bud grafts fail in quarantine.
- Record keeping, MPI Inspections, samples for testing by MPI Laboratory.

I am reasonably knowledgeable when it comes to common rose diseases and can spot the difference between black spot (*Diplocarpon rosae*) and downy mildew (*Peronospora sparsa*) for instance. But I have had to become a virtual "scientist" researching rose viruses. One or two non-regulated viruses have been picked up on some of the roses that have arrived in my quarantine. Studying the symptoms and descriptions, e.g., "epinasty"—sounds nasty. "Reading" the roses and looking for likely viral symptoms as I go about tending them. I hope the day never comes that something "new" to New Zealand arrives and I lose a consignment.

After the quarantine conditions have been satisfied and a BACC for clearance is received.

- Hardening off the plants.
- Planting the plants.
- Bulking up numbers if needed.
- Treatment of the greenhouse after release of plants.

TRIAL GARDENS

Things were rolling along, slowly at first. Breeders took the plunge and sent me a few rose cuttings. I learned how to do things—the hard way. Got consignments in successfully grown, cleared, released. Then things sped up a notch, and a bit more, then it became an express train and a runaway train.

There are ups and downs with any enterprise—unfortunately the wheels fell off the partnership, we had successfully brought in all these new roses but then had no way of getting them onto the market. What to do next? The answer was obvious—set up our own nursery—we had come too far and invested too much to stop now, I was not about to give up the dream. These little roses growing in New Zealand conditions were proving to be fabulous and I really wanted to introduce them to the New Zealand consumer.

We quickly ran out of room trialling roses on ¼ acre. The gardens were filled with roses being trialled for New Zealand conditions, the lawns were dug up, there were roses in every available space, every nook and cranny of the section.

To pursue the dream we have had to sell the family home of 36 years and the holiday bach to purchase a small plot of land in Newstead just out of Hamilton. "Greenacres"—that old TV programme comes to mind, two townies learning how to be "farmers". We have had a lot of hard work, but some fun and some laughs along the way. We shifted all the imported roses and the miniature roses. I only took some of the personal roses with sentimental attachment that reminded me of special people in my life, not necessarily exhibiting roses.

Thus three new quarantine houses were erected and fitted out.

The three from town were moved out so now I have the ability to quarantine six house lots with the ability to lease out space if room is available.

Another propagation house has been erected and two shade/finishing houses will be added shortly.

One hundred raised rose trial garden beds have been erected and filled with the finest compost I could find and another hundred will be added soon. The roses are grown in a "no spray" trial to really test their disease resistance.

An unwanted triple garage was moved onto the property and this has been converted into an office. Another double garage that was already there is used as a storage and potting shed. There was already a barn we also use for storage and machinery.

I have had to learn how to use some pretty heavy duty tools: air compressors, leaf blowers, hedge trimmers. "Tim the Toolman" has nothing on me. Strip down and clean a complete hydroponic system. Buy and handle a tractor, with pallet lifter, post-hole borer, bucket, mower, grader blade.

To help increase my horticultural knowledge I have joined the Nursery and Garden Industry Association of New Zealand and attended conferences. I have also become a member of the IPPS New Zealand Region and have enjoyed studying the published papers to glean what information I can from them.

I attended a chemical spray course to get accredited to use some heavy duty sprays. Not that I have needed to use them, I am not allowed to spray without permission from MPI in quarantine and my imported roses are in a spray free trial, as such they are supposed to be disease resistant so no spraying necessary.

And a first aid course to get accredited.

For the business I have had to write a business plan, a business action plan and a strategic plan and write an Occupational Safety and Health (OSH) plan. Thanks to the new MPI Import Standards I am presently writing an operating manual for the quarantine houses.

I also have to get my head around:

- Contracts with breeders and agents.
- Royalty payments.
- Plant Variety Rights forms, trade marking.
- Rose trial entry forms.
- A website first and now Facebook® and Instagram®.

As you people well know, we have to be psychic, look into the future and try to be ready for it. I am always assessing in my trial fields and take copious notes and photographs of all the roses. This helps in February when I am looking at cultivars to have budded in the field trials. What may I want to send to the trial grounds next year? What might be released for sale? How many to have budded? What to take cuttings from and how many? What will the customers want and buy?

AT PRESENT

We haven't got to the market yet, the cogs are turning and we are getting closer. Still trialling rose plants and building up plant stock numbers.

- Still building infrastructure. Thanks to Peter Fraser (Growing Spectrum Nursery, Kihikihi, New Zealand) for his invaluable advice.
- Still learning what has to be done to create a workable nursery.
- Timing.
- Presentation of the product.
- Getting product to the people.
- You people will all know this, what works best for you.

I have to mention that all of this was not accomplished by me alone. Apart from Paul of course, I have had help from many quarters; family first, and friends, associates, and acquaintances. Some have also taken on board my vision and been so much help I doubt I would have got this far without them.

Our daughters, Melanie and Briony, are also Directors of Bambina Rose NZ Ltd. Our son Greg, the Pilot, enjoys being a farmer on his days off now and again.

At the moment I think I am very fortunate, living the dream, I think Paul just feels exhausted!

If we can, we like to travel—Europe is a must in June/July for their summer and escape our winter to visit our eldest son Tim, his wife, and two children who happen to live in Poland.

We have been attending International Rose Trial Judging Events which is a chance to meet and talk to rose breeders and talk business. Or we visit them en-route. We have been treated as VIPs "all the way from New Zealand" and introduced to the local Mayor or MPs and dignitaries and photographed with them.

We are hosted by rose friends worldwide, have made personal friends with many of the rose breeders whom we meet when we are travelling and they visit us when in New Zealand. Needless to say we have a fine old time for two "nobodys" from Hamilton

To create "shopping lists" of new roses we like to:

- Visit other trial grounds in Europe to take many photographs of roses with potential and the award winners.
- Visit rose nurseries and growers in Europe—I collect and study their new rose catalogues.
- Study rose trial awards results.
- We like to call in to the go-between nurseries in Europe to see how the roses are doing in the field.
- I like to visit rose shows as an International rose judge for exhibiting roses—I can judge anywhere in the world at rose shows, so now I like to when I can.

You may well ask WHY??? Why did we start this? Rank naivety? Maybe. Then maybe it was because we could and nobody else would.

If I knew then what I know now—would I still go ahead and do it? Maybe not—I could be fishing, PB would like that. But then maybe, Yes. It is hard work, but very satisfying and even exciting to see a new to New Zealand variety start to root, then grow, then flower for the first time. Then look at what we have accomplished so far. Life is an adventure.

I am personally gaining an education, knowledge, travel, best of all I am bringing into NZ beautiful new roses. I would like to add in future…and making money. Wouldn't that be nice? Sam McGredy says to Paul "Better keep your Day Job PB!"

IPPS Western Region exchange 2015©

K. Scott[a]

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In conjunction with IPPS Western Region and IPPS New Zealand I was selected to travel to sunny California for 3 weeks in September 2015 to visit nurseries and learn.

My Hosts, Jim and Andi Conner, picked me up from LAX and we drove to their seaside condo in Oceanside where vast number of nurseries reside. Jim and Andi were the most superb hosts, they had planned my visit to a tee. In the first week we visited around 10 to 12 nurseries in from Rainbow to Vista. I've never come across such big nurseries and was totally in awe of the space (but maybe I don't get out from the nursery much here!) Fields upon fields of growing spaces, prop houses. Nearly every container nursery I visited did their own propagation and vice versa.

The family operated nursery, Olive Hill Greenhouses, in Fallbrook was a nursery of note, and it was like being in a tropical rain forest with ferns above and bromeliads and palms below. All the houses were on rolling benches and above, in some places, growing spaces three tiers high.

Jim and Andi's 100 acre nursery, Alta Nursery, located in San Jacinto is a tidy well operated nursery with the most amazing back drop of Mt. San Jacinto towering above the nursery. I enjoyed working in the nursery for the day and I had a very valuable lesson learning how to sow seed with chicken grit, vermiculite, and to work on their production line.

First Step Greenhouse in Temecula was also a well set out nursery for its three quarters of an acre size with the entire nursery under cover and on rolling benches. I managed to squeeze in some work to my busy schedule at First Step and Village Nurseries. It was difficult to talk to any of the staff as I didn't know any Spanish and most of the ladies were on a piece rate, so I think that some of them were getting annoyed with me slowing down their production line.

I knew the USA was big but until you travel there and visit these nurseries, you don't get a good perspective of land mass. Hines and Altman were both of the two biggest sites I visited; Altman has seven sites and more than 3 million square feet of greenhouses. Hines had a number of nurseries; I visited one which was around 600 acres. They are also linked to Color Spot Nurseries.

We drove up from San Jacinto to Modesto through the biggest growing plains I've ever seen. I fell asleep for two hours and when I woke I felt like we hadn't moved, it was incredible to see the vast amount of fruit and nut orchards on flood plains. My outstanding hosts took me to some very fancy restaurants and wineries along the way to break up the driving.

We arrived in Modesto for the 56th annual meeting of the IPPS Western Region on September 23rd and started our tours at 7 A.M. It was a long day, but very fulfilling as we visited a diverse range of nurseries, seed companies, and tissues labs. It was exhausting but intriguing at the same time as I learnt so much.

I had arrived to California with no knowledge of growing under difficult conditions like water shortages, high salt content, and competitive markets. I'm glad we don't have that here in New Zealand, but I'm thinking that maybe time will tell with how the climate is shifting.

A very big thank you to all involved with organising this trip and to Jim and Andi who put a huge amount of time and effort looking after me. I hope to go back and visit again.

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IPPS Japan exchange 2015©

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Getting from my hometown of Kihikihi to the city of Toyohashi in Japan was a whirlwind experience. Never having travelled overseas, the contrast in the landscape and culture was overwhelming. Everything was completely alien and utterly amazing.

Mrs Mizutani was my lovely host in Toyohashi. Our first destination was her company's tissue culture laboratory. What made the greatest impression on me was the dedication and efficiency of the staff; they were very knowledgeable and passionate. They processed around a thousand plants an hour, their dexterity in manipulating the tissue was fascinating to watch. In the company's greenhouse I was able to see how staff maintained *Mandevilla* propagated from cuttings. The dead leaves and material were removed by tweezers that were disinfected continuously. While time consuming this is obviously a good practice as the plants were of an exceptionally high quality.

We then visited a 'Home Store', where I could have happily spent a whole day. The range and quality of the plants available was fantastic. They also had an amazing range of landscaping supplies, seeds, bulbs, tools, fertilisers and composts. While in Toyohashi we had the opportunity to visit the botanical gardens and zoo. I really enjoyed seeing the large number of conifers and deciduous trees, many of which I was unfamiliar with. Akemi and I had some interesting discussions about issues in the Japanese horticulture industry. Japan faces many of the same issues that we have in New Zealand; environmental concerns, not enough young people entering the industry and large chain stores outcompeting with smaller businesses and growers.

From Toyohashi I went to a small village called Mitsu to stay with the Ohuchi family who grow table grapes (*Vitis*), dragon fruit (*Hylocereus undatus*), and orchids. Johnny-san, Okaasan, and Neil-san became like my second family for a few days. When I arrived they were preparing for the locally famous table grape festival. That night we had a concert in the café. The local men were very enthusiastic karaoke stars, their favourite being the Beetles (in Japanese). Although that may have been due to the large quantities of beer and sake consumed! The following morning we were up early and straight to work at the local shrine where the festival was being held. At 10 A.M. the queuing hordes were set loose upon the stalls. It was madness! I have never seen people so enthusiastic about fruit. I really admired the community spirit of the townspeople- even though they all grow the same varieties and are essentially competitors, they came together and supported each other, even helping to sell their neighbours fruit. I was also lucky enough to have the chance to visit Johnny's orchid nursery, which was a two hour drive from Mitsu. The natural beauty of the area was amazing; the mountains and forest dominate the landscape, with rivers and waterfalls alongside the road. I had such a fantastic time with the people of Mitsu, they reminded me so much of New Zealand because of their community spirit, connection to the land and can-do attitude.

Saying goodbye to the Ohuchi family, I travelled on to the small city of Suzuka to stay with the Uchida family. Uchida-san is a very inspiring man. I admire his ability to operate both a strawberry farm, café, and landscaping business, this flexibility and knowledge in multiple disciplines of horticulture was very impressive. On my first day in Suzuka Uchida-san took me to visit a tree auction, large tree nursery and two properties that he is landscaping. The tree auction was amazing. Trucks and people were swarming everywhere like bees. The trees that had been sold were flying through the air on cranes, being loaded into trucks. The large tree nursery we visited was great. I had never seen trees with such healthy and well-developed root systems. I had the opportunity to learn about some of the methods used to grow these trees, which I found fascinating as they are very different to our

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own methods. As saplings the trees are uprooted from the forests and brought into the open ground nursery. They are meticulously cared for, manicured a single leaf at a time. Traditional pruning and training methods, centuries old, are still common practice. Every winter the trees are wrenched by hand and expertly wrapped in burlap and twine and then replanted elsewhere. This regular transplanting encourages the formation of a dense root ball with many fine roots.

Uchida-san's landscaping projects were very interesting. I own a landscape design business so I was excited to learn what ideas motivated Japanese garden design. Uchida-san explained that a connection with the land, the property owner and nature are important concepts to incorporate into the garden. This way of thinking is similar to the concepts of 'Genius loci' and 'Tangata Whenua'. Even though our garden styles are completely different, the desire to connect people with nature is international. Uchida-san also took me to some famous historical sites in Kyoto. I thought all of the places were extremely beautiful but my favourite was Ryōan-ji. I have coveted the chance to see this garden since learning about it as student. The experience was amazing, a dream come true.

From Suzuka we went to the conference in Maebashi. I really enjoyed visiting a rose growing nursery, plant breeder and seed producer and a ridiculously huge home store. After the conference I travelled with Mrs Mizutani, Kiko-san and Peter to Tokyo. We had a great time visiting the castle, shops and restaurants. Leaving Japan and my new friends was almost like a bereavement. The two weeks I spent travelling through this amazing country felt like a very short time. I didn't realise that travel would expose me to feelings of awe, discomfort, inspiration, fear, love and excitement. I hope I will be able to visit Japan again as there is so much more to learn and to see.

Thank you to both the IPPS New Zealand and IPPS Japan Regions for this life changing experience.

Capers: from wild harvest to gourmet food©

B. Noone[a]

Caperplants, Adelaide, South Australia, Australia.

INTRODUCTION

In this presentation I would like to introduce the caper plant, known generally as *Capparis spinosa*. This botanical name is complicated and a source of debate amongst botanists. Suffice it to say that the capers you buy in the shops around the world will come from 6 different species of *Capparis*.

I will talk about how I became involved with capers, and this will lead to a discussion of the propagation of this plant, its difficulties and solutions. Finally I will talk about the future of this plant both locally and overseas.

DISCUSSION

The caper plant

The caper plant is a small shrub (Figure 1), which is harvested for its flower bud (the caper) and its fruit (the caperberry), which develops from the flower. To a lesser extent, young leaves and stems are harvested in early spring.

Figure 1. Caper plant.

The caper plant, *C. spinosa*, is described as a perennial deciduous plant and it will live for 30-50 years. The caper plant is a low shrub, with many branches growing from a basal root. If they have not been pruned, the branches will continue to grow longer and develop more side shoots or branchlets. As the weather warms up in the spring and summer, many branches start to emerge from the basal root if the plant has been pruned in the late autumn or winter.

When the branches are about 30 cm long they start to produce flower buds (Figure 2),

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which are the capers. Each branch continues to grow longer and produce more flowers, especially if the capers are picked regularly. The branches, normally not woody enough to stay upright, will bend over and lie on the ground, but continue to grow longer. The prostrate growth produces a carpet effect, which acts like a mulch to conserve water. The bushes can grow to about 1 m in height. In a cultivated situation, the bush will grow to a width of 3.5 to 4 m over the summer season.

Figure 2. Caper flower and flower buds.

Most species and taxa of caper plants produce thorns or curved spines at the leaf axil under the leaf branch or pedicel, which become woody and sharp. This is a serious problem for pickers. The variety without spines, known previously as *C. spinosa* var. *rupestris*, and now as *C. orientalis*, grows around the Mediterranean, in places like the islands of Pantelleria, Salina, and Lipari. This is probably the parent plant of the thornless caper plants that have been developed in Australia, Argentina, and Uruguay.

The young leaves of caper plants are structurally and physiologically different from the mature.

Caper plants live in conditions of high irradiation and high temperature. The leaf structure is unique to absorb the intense sunlight and to photosynthesize and grow. They are able to keep thriving in very hot and dry conditions, while most plants lose their leaves and die.

Climatically, the caper plant grows best in well drained soils and in hot dry conditions. They can withstand temperatures higher than 40°C. They respond well to good winter rains. They do not like waterlogged conditions as mature plants. Caper plants develop extensive and deep woody root systems. Some researchers have discovered roots 6-10 m long.

The caper bush is normally deciduous in the winter; it is salt tolerant and they can survive on poor soils and in areas with only 200-mm annual rain. They are well described as “drought tolerant” and are used in many countries and United Nation programs for reforestation and for fighting soil erosion.

Propagation

The story of capers started for me in the early 1990s with a seed catalogue, and the thought that we grew all the other so-called “Mediterranean diet” plants, such as tomatoes, olives, basil, parsley, grapes, almonds, and pistachios. So why didn't we grow capers in the warm Mediterranean-like parts of the world, as a domesticated home garden plant? It wasn't long before I realized that one of the reasons why we didn't grow real capers was that it was very hard to propagate caper plants, either from seed or from cuttings. Secondly, capers prefer a hot dry climate.

In 1995 I purchased some caper seeds from a herb seed catalogue, and I successfully germinated a few plants. I thought that I needed to learn how to grow these interesting plants, and naturally I planted them in our large herb display garden. At the time my partner, Julia, and I owned and operated a wholesale herb nursery. This garden was overhead watered, and eventually I realized that caper plants did not like this. So I moved them in the winter to the back of our nursery and put them in a row with lavenders in the full sun with no automatic watering. They thrived.

I quickly realized that there was great variation in each individual plant. Some grew upright, and others prostrate. Some had reddish stems, some pale green stems; the leaves of some turned purple earlier in the autumn, and most importantly, some produced more capers (flower buds) than others.

Living in Australia, there was no local information about capers, and no local knowledge on how to propagate and grow them. In 2002, I successfully applied for a Churchill Scholarship to study caper growing in the Mediterranean region. So Julia and I headed off to Morocco, Italy, and Spain, to witness how capers were grown, harvested and processed. We are indebted to the Churchill Trust for providing this important service. My report on this trip can be found on the Churchill www.churchilltrust.com.au/fellows/reports/ agriculture/horticulture/.

Back in South Australia, just north of Adelaide, we applied new knowledge to our endeavour to grow and provide good caper plants and enjoy capers in our cooking. Growing caper plants from seeds was no guarantee of good plants. Valuable years can be lost to produce a plant of poor quality. Nobody really grows grapes or oranges from seed. As with growing peaches, grapes, lemons, and many other fruits, we needed a proven taxon. We needed thornless caper plants that had a longer season of flowering, which would produce more capers. We needed a bush that produced more capers on each branch and more capers every 10-12 days. Another important requirement was the capacity of the bush to produce a caper with good flavor and taste.

We experimented over many years. We grew over a 100 caper plants, and over time measured each one for the needed qualities. Every time we picked, we weighed the amount of caper each bush produced and we counted the number of branches. We recorded when they started flowering and when they stopped, photographing everything.

The 'Eureka' caper plant stood out. It produces more with good flavour. It has a longer season of flowering, and more capers on each branch. This 'Eureka' cultivar, *C. spinosa* var. *rupestris* 'Eureka', was successfully registered with IP Australia2 under the Plant Breeder's Rights (PBR) legislation, in 2008.

The real hurdle was still to come…how to clone this special caper plant? Nobody had successfully done this anywhere in the world. There had been some success with tissue culture in Italy and in Queensland, Australia, but not commercially. Again there had been minor success in Israel with propagation from cuttings. The old Italian practice of taking about five cuttings from a plant at the end of winter offered no real solution.

I collected and prepared many cuttings, and twice arranged for commercial nurseries to "mind them" for me in commercial propagation hot houses while they rooted, but these efforts were not successful. The challenge was to clone the plant. The next step was to build a propagation house to cater for the particular requirements of capers.

Although the caper plant can endure long drought, the cuttings, with no roots, require an exact amount of water to keep them alive, without becoming too wet. Caper plants generally don't like water and humidity, and have little inclination to develop roots. These requirements present a challenge to the process of cloning. Some overseas research and experience has helped, and I believe that we have achieved a successful result.

Because the caper plants grown from seed are not true to form, the need to clone a good cultivar is essential. From my research, it is indicated that only 30-40% of seedlings are of any value. It will take up the 4 years for a plant to mature, and years are wasted if 60-70% will not produce a reasonable harvest. Some early releases of caper plants in Australia were from seedling and some nurseries, still today, are disappointedly selling seed-grown caper plants to home gardeners and commercial farmers.

In its natural environment, the caper plant has no inclination to propagate itself vegetatively. In fact, its sexual reproduction, with great variation, has evolved to successfully survive and adapt to new environments.

My first attempt at cloning was close to a perfect failure, but one plant grew roots proving it was technically possible.

Pantelleria caper farmers, who have a cooperative to process and market their produce, had traditionally kept five branches on the deciduous winter plant, and used these for cuttings in the early spring. They had a degree of success, but their farms are dotted with uneven size bushes and different productivity.

The success of cloning the caper plants comes from understanding the plant.

- Its leaf/root structure
- Its water holding ability
- Its turgidity
- Its environment.

I had to throw away many of the conventional parameters advocated by textbooks on propagation. The caper plants survive in a high level of light radiation and subsoil moisture for roots. They do not like to dry out and their water holding capacity needs to be highly controlled. They do not like cold or humid conditions.

I established my own propagation house and I have had to establish an environment:

- That allows for a higher level of light than usual (One year I thought that the plants were drying out from the sun, and introduced shade curtains—this was disastrous.)
- That very carefully keeps the leaves from being too wet or too dry (This of course is a traditional propagators problem). The experts talk of "leaf water relations" and the "water and solute potential.")
- The concept of temperature differential is doubtful in this situation.
- Both aerial parts and the root zone require a higher level of temperature, where other plants would not dare to go.
- Extra light radiation is provided at night for a limited period.
- An experiment in blue and red LED light was inconclusive, but I will try again in a tissue culture laboratory.
- With a need to remove any hint of humidity above average by air exchange or working in a hot dry climate like Adelaide. (The removal of humidity by using an air conditioner did not work, as it introduced a colder environment which caper plants do not like.)

Some useful tools.

- The UK publication by HDC "Hardy Nursery Stock Propagation Guide", which is a record of the UK nursery industry's practices, was very helpful.
- The UK mist controller called 'Evaposensor' totally brilliant, which responds to humidity, wetness, radiation at the leaf level.
- Japanese secateurs, which contains no spring, but gives the user double control with your hand, and thus full control over the cut.
- I was also helped by IPPS members, and their useful advice.

The caper plant is the latest addition to the so-called Mediterranean diet. It is a perfect home garden plant for a large part of Australia, but not the coastal parts of Queensland because of high water and humidity, and Tasmania because it is just too cold, although parts of Tasmania are dry.

COMMERCIALLY

Caper farming will struggle in Australia because of labour costs and cheap imports of caper products from countries with cheap labour, e.g., Morocco, Turkey, and others.

Many countries are trying to establish a caper industry because the market is there.

Nearly all the reports and governments' investigations into the potential caper industry in many countries, have concluded that the industry required cheap labour, and well-chosen selections, thornless at least, and the ability to clone good cultivars. So far nobody has really solved solved this problem, and we have an opportunity here.

CONCLUSION

What I have done is to apply horticultural principles and practices to a wild plant. It is an attractive bush with beautiful and fragrant flowers and edible flowers buds, fruits, and young leaf shoots.

I have written a book on capers and it will be release later this year. You can preorder at this conference or through my web page: www.caperplants.com

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Innovation through adversity: tricks of the horticultural trade©

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INTRODUCTION

Often underrated, the horticulture industry is one of diverse opportunities and one which accommodates some of the most innovative problem solvers of any industry in operation today. The purpose of this report is to both share some of my experiences with such opportunities and innovation but also spur discussion and creativity within the International Plant Propagators' Society's members. The intention is to achieve this by showcasing what can be accomplished in horticultural production in situations where little or no conventional resources are available and to then pose the question of what could be achieved when taking these ideas and innovations and combining them with the means and resources available in developed countries like Australia.

The visual content of this report has been collected over the last seven years during a period of international placements focused on production horticulture. A pursuit I would not have started if not for IPPS who in 2009 granted me the opportunity to participate in the Australian region of IPPS's South African Exchange Program. This exchange allows participants to see first-hand, the contrasts in the nursery industry in South Africa and sparked a continuing pursuit for travel and horticulture research internationally. In subsequent years leading to this presentation I have found opportunities from scholarships to volunteer work to study and work in horticulture in locations including: Tanzania, Nepal, Solomon Islands, South East Asia, Israel, Turkey, Jordan and Egypt. All of these opportunities and more can be accessed with relative ease and I strongly encourage any inclined horticulturalist to look into such opportunities as they are largely underutilised.

DISCUSSION

From value-adding potted plants with old ostrich egg shells from a nearby farm, to utilising toiled roll inserts for nursery tubes and using repurposed 44-gal oil drums as water boilers, in South Africa there is a definite thought of "If you can, use it". The relaxed regulation of industry has proved to be a great way to foster innovation. Ease of acces to coconut coir has aslo led to the industry often incorporating hydroponics into traditional growing operations. *Eucalyptus* stock plants are grown in raised hydroponic beds eliminating proximity to soil borne pathogens and at one site these cuttings were then struck airoponically using no media and potted up by hand after producing roots.

Heading north to Tanzania subsistence horticultural operations become more prevalent however it working in this scenario still provided ideas that could benefit operations elsewhere. Particularly successful in this project was the implementation of a school production and demonstration garden. For this project students were photographed during each stage of the growing process at completion an instructional book was produced in swahilli featuring the students themselves providing the steps to success. This was received with great enthusiasm and offers the potential for the knowledge to be transferred to other family members and not just the participants themselves. This idea could be utilised by retail nurseries and garden centers seeking to create an experiential environment. A short book template could be created and designated photo stations located in the nursery. The book could be printed on the spot providing a positive experience and lasting marketing memento for the nursery. These innovative ways to engage customers are emerging around the world and another good example was seen in Israel, were the garden centre sold plants and also various terracotta and ceramic pots. They provided a station and potting mix were

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customers could take the plant they had chosen and pot it into the pot they had chosen using free potting mix and an assortment of bows and ribbons suited to gifts.

Look to the South pacific and work in the Solomon Islands requires innovation on a daily basis. One such innovation was taking a serious pest problem in the giant African Snail and turning it into a positive by utilising the snails' shells in an unconventional medium mix. It was found that the shells contained98% calcium carbonate deposited in an organic matrix with the remaining 2% consisting of compounds of Fe, Mg, Mn, Al, Na, K; perfect for increasing air filled porosity and providing a slow release fertiliser.

Among diverse challenges, many villages are located on coral outcrops with no arable land so vertical hydroponics systems were constructed using coconut husks for media and giant bamboo for structures. Manure teas were then brewed for nutrient supply.

There are not many countries that could be considered more innovative than Isreal the home of Netafim drip irrigation, Home Biogas stations, the LivingGreen Rooftop Farm and GrowBox emergency relief aquaponics farms. However, perhaps the most impressive of Israel innovations are the farming operations of the Negev. This Rocky desert covering more than half of Israel receives as little 31 mL of annual rainfall in some areas, yet farmers are producing 45,000 tons of tomatoes including 8,000 tons of cherry tomatoes annually. They do this by growing in channels isolating plant roots from surrounding saline soils and using fossil water deposits that can be up to 3,500 ppm in total dissolved salutes. Fortunately these are predominately calcium carbonates and calcium sulphates, so less detrimental to plant health in high doses as other salts often present in such water supplies. Other nutrients are then nutrients supplied making the systems virtually hydroponic. An interesting result has been noted when growing with such saline water. Smaller sweeter fruit is produced which poses a problem for shelf life but the dry weight of biomass is near equivalent so the practice is ideal for dried produce.

I came across another innovative way that nurseries may engage their customers when visiting Indonesia's Bogor Botanic Gardens. Here Dr. Sofi Mursidawati was working with the giant and endangered flowers of the region including the world's biggest flower, *Rafflesia arnoldii* and one of the world's biggest inflorescences, *Amorphophallus titanum*. Dr. Mursidawati spoke of the plight of the *Rafflesia* which she is fostering at the gardens. Here she maintains a display plant by taking wild flower buds of the wholly parasitic plant and grafting them onto a host *Tetrastigma* vine. In a strange twist these flowers have all bloomed as females and as the viability of the plants pollen is only about 8 h, no pollination or seed production has ever been able to occur.

What may be of most value to nurseries though, is the public interest in these flowers. Dr. Mursisawati also spoke of using 2 tons of silica gel to transport both *A. titanium* and *Rafflesia* to Taiwan where they received over 400,000 visitors. In South Australia people queued for over an hour in 2016 to glimpse *A. titanium* in bloom. While the event only lasts about 48 h and takes around 7 years to occur imagine the reward for the nursery when opening its doors for public sales the days that plant does flower!

CONCLUSION

Back home in Australia there does not tend to be the adversity that spurs innovation in some of the aforementioned scenarios but non the less there are some great illustrations of modern innovation particularly in South Australia, host to this year's IPPS Australia annual conference. The Australian Plant Phenomics Facility and the Plant Scan System located at the University of Adelaide's Waite campus, provides state of the art growing facilities and root mapping services that do not disturb the rootzone or introduce unwanted radiation that may influence growth; a great asset for research into our industry.

South Australia has more land devoted to hydroponic farming than any other state and Sundrop Farms' Seawater Greenhouse at Pt Augusta leads innovation in this field. The greenhouse utilises solar energy to purify seawater that is then used for hydroponic growing. Carbon dioxide produced in heating processes is harvested and pumped back into growing operations to support growth and the list of innovation at this site goes on.

So the country is not lacking in innovators but imagine what could be achieved if everyone was doing this, not just the big end of horticulture and imagine if the practices of developing countries were not discounted but combined with additional means. The industry would certainly be better for it.

In closing, to get the best out of horticulture, growth in the industry needs to be fostered and supported. Make opportunities, take opportunities, innovate, seek and share.

Threatened plant species: *Amorphophallus titanum* propagation©

M. Coulter[a] and R. Baldock

Botanic Gardens of South Australia, Australia.

INTRODUCTION

One of the most exciting plant species is the titan arum, *Amorphophallus titanium*, which can truly be regarded as a flagship species for botanic gardens. Wild populations suffer from increasing pressure on their natural habitat and botanic gardens can play an important role in the ex-situ conservation of the species.

DISCUSSION

Amorphophallus titanum is one of the most prominent plants in the plant kingdom. It has the largest unbranched inflorescence known and what looks like a single flower is in fact a group of flowers making up the inflorescence. Like all arums, the inflorescence contains a spadix which extends in the middle and is usually a creamy yellow colour and a spathe which once unfurled is a dark maroon colour. The spadix can grow more than 3 m tall and the spathe can extend over a 1 m wide. The true flowers are extremely reduced with separate male and female flowers. There are approximately 400-500 of each located at the bottom of the spadix. Female flowers are active as the spathe starts to open (which happens in the afternoon of the day that it opens) and into the night. The next day the male flowers are active, however the female are no longer active so the flower can't self-pollinate so pollen from a different flower must be brought to it by a pollinator for successful pollination and fruit and seed set to occur. This is the reason that the flower mimics the smell of rotting flesh, to attract pollinators to the flower that are usually carrion beetles, blowflies, and sweat bees which bring the pollen with them.

It was discovered in Sumatra (where it is endemic), Indonesia in 1878 by the Italian Botanist Odoardo Beccari who sent seeds to the botanic gardens in Florence and Kew. It took 11 years before the first plant flowered in 1889 at the Royal Botanic Gardens Kew. For the next 100 years flowering events of titan arum in botanic gardens were extremely rare with only 21 flowerings recorded worldwide until 1989.

In 2006 the Botanic Gardens of South Australia received three seeds and all of these seeds were successfully germinated. Since 2006 these plants have been grown on in a glasshouse at the Botanic Gardens of South Australia Nursery located within the Mount Lofty Botanic Gardens (Figure 1). The likelihood of receiving subsequent wild collected material is remote as this species is listed as vulnerable in the wild on the Red List of Species and with CITES (Convention of International Trade in Endangered Species).

As an *Amorphophallus* plant grows the original corm grows and a side corm can form which when the plant is dormant and can be removed to make an extra plant. By this method we have made seven plants from the original three. Propagating plants from the original corm via division is a valid form of propagation but the number of plants that can be propagated is limited and this is a very slow form of propagation. Vegetative propagation of this species via leaf cuttings has been reported but very little information regarding the techniques and conditions used has been published. In early 2013 nursery staff at the Botanic Gardens of South Australia decided to undertake some trials to evaluate if this technique was achievable.

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Figure 1. *Amorphophallus titanum* pots growing at the Botanic Gardens of SA Nursery in its vegetative stages (image, Reg Baldock).

Figure 2. Cuttings prepared of *Amorphophallus titanum* before planting (image, Reg Baldock).

We successfully developed protocols to vegetatively propagate this species by two methods of leaf cuttings—horizontal and vertical. Leaves were harvested from motherstock pots held in the nursery and included material from each of the three original seeds. The cuttings were prepared by cutting leaves into 20-30-cm segments (Figure 2). The leaf material on the lower end of the cutting was removed and the leaf material on the top part retained with the leaflets shortened to reduce water loss from the cutting by transpiration. The bottom part of the cutting was dipped into rooting hormone solution—indole butyric acid (IBA) 3,000 ppm. Each cutting was planted into propagation medium that consisted of 80% perlite and 20% coir peat. Once completed the cuttings were placed into fog chambers with 25°C bottom heat and a minimum of 70% humidity (Figure 3). Vertical cuttings were planted into a 150-mm pot. For horizontal cuttings the leaf was laid down horizontally in the propagation medium in a seedling tray.

Figure 3. A*morphophallus titanum* leaf cuttings placed in humidity fog chambers at The Botanic Gardens of SA Nursery (image, Matt Coulter).

After 8 weeks adventitious root formation started at the base where hormone application had occurred (Figure 4). The cuttings continued to grow and on the side of the stem where roots formed corms started to form with their own independent root system (Figure 5). Sometime later the original leaf died down and the corms went into dormancy. Following this new shoots formed and grew from these corms. The new plants went on to go through their normal cycle of growing, dying down then a period of dormancy (Figure 6). Each year the leaf and the corm continued to grow. The first plantlets we propagated by leaf cuttings are nearing 3 years old.

The interesting observation that we have found is you get quite different leaves/plants from vertical and horizontal leaf cuttings. Vertical leaf cuttings have the ability to make multiple corms and leaves from the one cutting and in many cases we achieved 6-7 leaves per leaf cutting which gave 6-7 individual plants. Horizontal leaf cuttings usually produced just the 1 leaf and corm per cutting however a much stronger vertical shoot was achieved as there is less competition, on the other hand if the maximum amount of cuttings was needed to be achieved then the vertical cutting is a useful technique.

Figure 4. Adventitious root formation of the *Amorphophallus titanum* leaf cutting (image, Matt Coulter).

Figure 5. The leaf of the *Amorphophallus titanum* cutting has died down and corms with independent root systems have developed on the cutting (image, Matt Coulter).

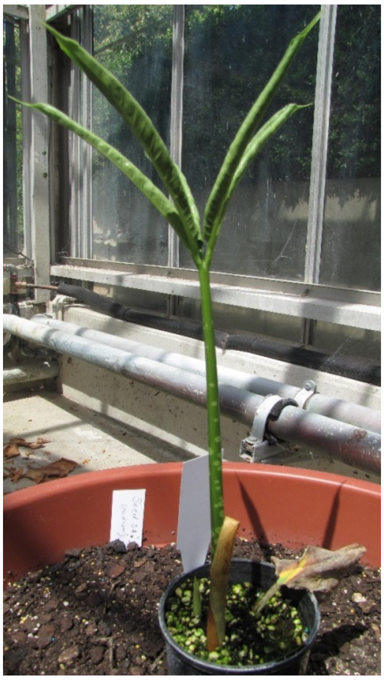

Figure 6. The corm has gone through its dormancy phase and the new leaf has emerged from the corm to start its growth (image, Matt Coulter).

CONCLUSION

In the coming years we hope to refine the technique for propagating and growing this unique species. Through this technique we have produced 100 new plants (Figure 7) from the 7-old specimens that we have. All this started with the three seeds that we had. This is an important process in ex situ conservation of the species and will give us a greater ability to display the characteristics of its exceptional growth habits and to display the flower to the public when we can flower the plants that we have.

Figure 7. The many new plants of *Amorphophallus titanum* growing in at The Botanic Gardens of SA Nursery 3 years after propagation trials, we have more than 100 new plants (image, Matt Coulter).

Growing African violets: learning from IPPS experiences©

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INTRODUCTION

A new system for growing and caring for African Violets has been developed that overcomes many of the issues encountered by consumers when grown indoors. The inspiration for much of this arose through IPPS conference participation and through its members.

BACKGROUND

African violets have long been a popular houseplant; but their popularity has declined somewhat in recent times. Some people see them as plants their mother or grandmother had and hence is not for them, but more often the reaction is that people have difficulty in growing them.

They are a plant that my mother had a passion for growing, and I have kept at least two varieties going through propagating them from leaves over the last 35 years. Most reference books for consumers date back to that era and there are few current.

They are probably not seen much these days however in Australia for a number of reasons, which include changing trends, poor consumer experience with plants failing to flower, or dying soon after purchase, and the difficulty that big box hardware and retail nurseries have in managing them. Some of these symptoms are due to poor media leading to dampening off, poor nutrition, and the difficulty consumers have in finding a place to grow them in their home.

Our nursery considered including them in the product mix after the closure of many of our retail nursery customers through stiff competition from “big box” hardware stores and the drought in the early 2000s on the east coast of Australia. We had a large part of our greenhouse benches underutilized and needed to find new markets.

The genus *Saintpaulia* was named after Baron Walter von Saint Paul-Illaire who discovered them in 1892 on the tropical floor of what is now Tanzania and reported his finding. Species grow in the leaf mulch of rocky crevices and forest floor. Now there are nine recognized species, eight sub-species and two varieties recognized. There are a huge number of hybrid cultivars commercially available around the world in a range of forms from miniatures through standard cultivars and trailing forms.

DISCUSSION

The main characteristics of the natural growing environment that we should try to replicate indoors are: filtered light, high humidity without drafts, warmth with temperatures around 18 to 27°C, moist open free draining soil. These plants have been successfully grown around the world indoors as many of us like to live in an environment similar to their growing requirements.

They are mainly propagated commercially by leaf cuttings and tissue culture. Leaf cuttings develop roots in 2 to 3 weeks, and plantlets within 6 to 8 weeks. These are divided to a single crown and transplanted with smaller sections placed back in propagation trays for planting later on. The first flush of plants is typically ready in 24 to 26 weeks, but flowering may take up to another 6 weeks.

Temperature and humidity

Temperatures above 15°C and a relative humidity of at least 50% is commonly found

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inside homes. We warm our homes in cooler months and mostly avoid drafts. The main growing conditions that we need to meet then are irrigation, light, and the medium.

Irrigation

In 2001 at the IPPS Canberra conference I was introduced to a new mechanical automated capillary irrigation system for greenhouse benches. It was there that I heard Ben Stocks (2001) talk about his capillary watering bench system and met Jim Fahr the inventor of the AutoPot™ hydroponics system Smart Valve® that incorporates a wet dry cycle. Discussion with Ben Stocks and a subsequent visit to Stocks Native Nursery at Harden convinced me that the system would be able to provide what I was after; a reliable capillary system that would operate automatically and reliably with little maintenance attention as long as a good water filtration system and 10 psi low pressure regulator were being used.

A number of benches were constructed with this capillary rise and fall bottom-up watering system. The system uses a geotextile as the capillary bench surface and wick; this is covered by weed-mat. Pots used on the benches must be suited to capillary irrigation. Occasional hand watering from above is necessary to flush dissolved salts depositing on the top of the pine bark media surface.

By about 2008 we had about 40 m^2 of such benches under-utilised, so we looked for alternative plants and markets that suited our greenhouse infrastructure. Fortunately this opportunity has enabled us to develop a more versatile easy care form of indoor flowering pot plant.

Light

Back in 2000 there appeared to be little effective advice to growers from shade cloth distributors or in technical literature as to which grade of their products were appropriate for a given mix of plants. Using advice at the time we installed 75% shade moveable composite screens to maximise growth and reduce transpiration losses of young plants. It was in 2008 that we found from trial that we could grow *Saintpaulia* on our capillary benches under this amount of shade. Our only light meter at the time measured lux with a limited maximum range (more suited to indoor lighting). At the time we did not know of any research or guide for the optimum intensity of light required by any particular species of plant.

Paul Fisher (2014) presented graphs for average daily light integral (DLI) for various months of the year in New Zealand at the 2014 Wellington IPPS conference. This concept attempts to define the average amount of light plants need over a day for optimum growth. He mentioned that the Australian Bureau of meteorology had data that could be used to generate similar graphs for Australia.

These were interpreted and first published by myself in the Australian Region's The Propagator Spring 2014 newsletter. The Bureau of Meteorology data available online is presented as average irradiance in units of MJ m^{-2} d^{-1} which can be readily converted to photosynthetically active radiation (PAR) units of moles m^{-2} d^{-1} by multiplying by 2.01. DLI light intensity values for optimum growth have been available for over 10 years for a range of ornamental plants. For African violets too much light stunts plants and bleaches the leaves, while too little light leads to leggy plants (Figure 1).

Quantum meters can be readily purchased that measure light over a period and integrate this to give DLI figures directly, or you can purchase a less expensive lux meter and apply a conversion factor, or even use measurements using light meter apps available for most commonly available smartphones and converting these to PAR units. This is accomplished by recording light readings where the plants are growing every 30 min. over a day. Convert the readings into the average quantity of PAR light in µmol m^{-2} s^{-1}. For each column (e.g., full sun, greenhouse bench) multiply the per second figure by the number of seconds between readings (1800 for 30 min. gap) and sum the result in the column and divide by 1,000,000 to get the DLI PAR daily moles m^{-2}. For example if our 30-min. daylight readings from 8 a.m. to 4 p.m. in Tasmania in winter in lux were: 0, 2,700, 5,400, 7,500, 7,500, 8,300, 9,700, 10,200, 10,700, 10,200, 9,300, 8,000, 6,400, 5,300, 4,200, 2,700, and 0.

Divide each by 10.76 and multiply by 0.2 to arrive at average PAR units. Multiply by the number of seconds in the time gap between each measurement (1,800 s for each of 30 min. in this example) and add all the resultant numbers and divide by 1,000,000 to get 3.6 mol per day (try this and see if you get this result). From J.E. Faust (2011) in the Ball Red Book, *Saintpaulia* require an average DLI of from 6 to 10 mol m^{-2} day^{-1}.

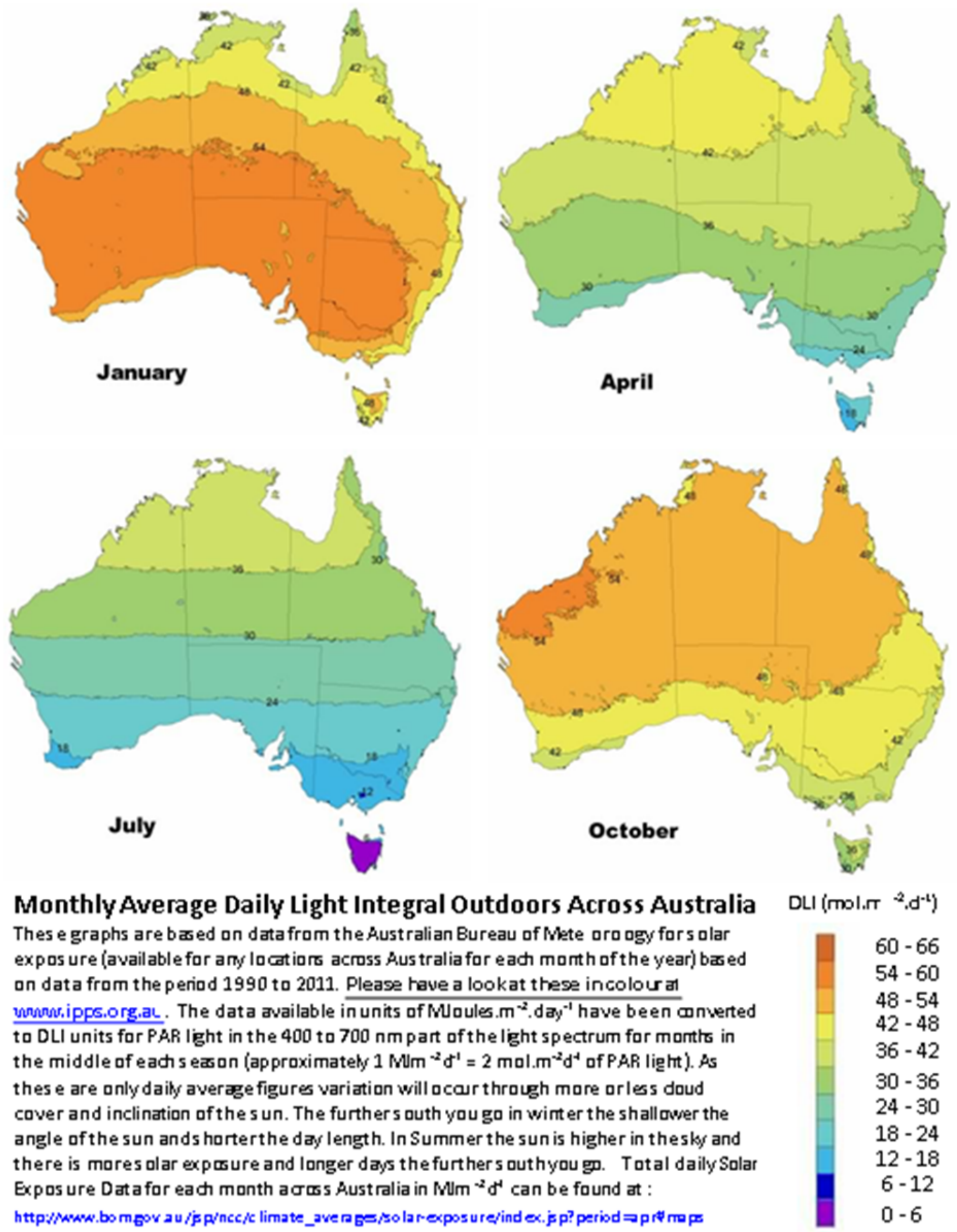

Figure 1. Monthly average daily light integral outdoors across Australia.

In order to assist consumers locate the best places to grow these plants we are suggesting that they try to measure the light intensity at the best lit times at locations with values from 5,000 to 30,000 lux as a guide.

The paper “Coloured LED lighting in propagation” delivered by Karen Brock at the 2013 Melbourne combined IPPS NGIV conference (Editor’s note: paper not published) has also inspired our exploration of LED lights for subsidiary lighting options for consumers. At present we do not have any results to report on.

Although more work is required to determine optimum DLI values for a number of Australian ornamental species, this approach not only allows you to select appropriate shade screening for the species grown, but also provides a means of determining how much supplemental lighting may be needed in winter months. It also assists site selection for low light or high light requirement species. Optimum DLI figures may also vary at different times of the year. The information may also be used to give consumers a guide for example in locating the best location for indoor plants.

Media

Historically African violets were grown in medium comprised of peat moss and perlite and a wick was used to limit the water capillary rise. This approach often necessitated the use of special pots with a water reservoir at the base into which the wick sat. More recently medium available and typically used is comprised of either relatively fine composted pine bark or coco peat or a mix of these which have a high water holding capacity and present a management issue of restricting the amount of water provided whilst not allowing the medium to completely dry. Fastidious consumers need to monitor their plants on almost a daily basis in order to minimize plant loss through fungal diseases such as dampening-off.

We decided that this was unacceptable and set out to match the results achieved with the wick system but without a wick and with medium based mainly on grades of readily available composted pine bark.

Initial medium trials comprised of varying amounts of perlite, peat moss, and different screened grades of composted pine bark were unsuccessful (plants did not survive more than 3 months on the capillary benches due to dampening-off or insufficient capillary rise). A range of commercial African violet mixes were also trialed as well as an open medium grade orchid mix and native potting mix. The medium orchid mix proved to give an acceptable result after slight modification to improve wettability after drying out. Mix was ordered in pallet lots unfortunately after several years supply the mix changed and we urgently looked for a replacement. A multi-factorial experimental design resulted in an open course mix with low fines and sufficient capillary rise. This mix has an AFP of 37% and typical pH of 6, and has proven itself now with over 2-years commercial growing experience. Using this system consumers are able to now reliably grow their plants in a range of commercially available “self watering” pots as well as ones with a saucer. The approach has also enabled mixed plantings in a single container with minimal care.

Nutrition

At the 2006 Brisbane IPPS Conference John Hall (our key note speaker) presented a case for providing nutrition matching the leaf tissue analysis of plants (Editor’s note: paper not published). This approach has been used for many years now for hydroponically grown fruits and vegetables. After some research we found that NPK and sometimes micronutrient data from leaf tissue elemental analysis results were available for many types of plants or could be derived from published results.

This was also certainly the case with *Saintpaulia* where Chen and Henny (2015) had determined values of nutrients for optimum growth and nitrogen requirement. Conversion of the values into what to look for in a controlled release fertilizer resulted in a typical percentage composition of 16N:1.3P:18K to 16N:4P:24K for which we chose to use a 9-month, slow-release native fertilizer.

The other critical factor in determining dosage is the nitrogen demand for the plant species according to a method outlined in the text “Growing Media for Ornamental Plants and Turf” by Handreck and Black (2002). We adopted this using controlled release fertilisers for a wide range of plants so we looked for data for *Saintpaulia*. It had however been found that a revised formula was needed to determine the quantity of fertilizer used.

- $F = N \times t / (FN \times 10)$ g plant^{-1} (pot)
    - o 1 g L^{-1} = 1 kg m^{-3} of mix
    - o For established (larger) garden plants use about 10 times this

- F is the quantity of fertiliser (g per plant-pot)
- N is the nitrogen requirement of a plant (mg week^{-1})
- t is the estimated duration of fertiliser in weeks—for CRF use 2/3 of claimed life and t = 1 for weekly liquid fertilizer, e.g., in this case commercial "African violet food"
- FN is the percent nitrogen in the fertiliser

African violets have a low nitrogen demand resulting in a dosage of 4 g (1/2 teaspoon per plant). Simulations using suppliers release rate data with typical indoors growing temperatures in the south eastern states of Australia indicated that such fertilizers could last up to 1 year in practice before refertilising plants. This has also contributed to the long flowering and easy care reputation of these plants.

CONCLUSION

A system has been developed allowing African violets to be grown with minimal care by consumers, and resulting in healthier indoor plants. Many of the advances were achieved through knowledge gained from IPPS conferences and members. Many of the concepts should be able to be adapted and applied to improve the growth of many other types of plants. This is important in an ever changing world where the marketplace is in constant change through the impact of internet sales and marketing.

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Connecting opportunities to a wider audience©

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INTRODUCTION

I am an Australian foundation member and still, many decades later, passionate about propagation. I have been at various times, on most relevant committees and Presidencies of both the Australian Region and the International governing body. I have not only an intimate knowledge of how our Society has and is operating, but a "feeling" of time and attitude changes, surrounding our common goals of "Seeking and Sharing" in our plant propagation world.

I gained a Churchill Fellowship in the first batch of recipients in 1965, and departed Australia for 5 months in 1966 with almost no contact with home as overseas phone call costs were prohibitive.

When we started the Australian Chapter of this Society in the 1970s, telephone and letter writing were still the principal means of communication. Then we were overwhelmed with the advent of the facsimile machine and a rapid conversion to electric typewriters, still with a carbon copy. The lightning and ongoing speed of communication technology from the 1990s has affected the very foundation of so many not for profit organizations and we as members of IPPS are not immune.

DISCUSSION

We are an international organization and we need to take stock of our world-wide role to preserve and propagate our plant life as the very foundation and continuum of our life on this, our only habitable planet. The original focus of our Society was, and still is, to share better ways to propagate plants, and for nurserymen and others to multiply these new findings.

The commercial necessity of survival, in an increasingly competitive environment, is pressurizing would-be innovative propagators to consider the bottom line as the prime reason for endeavour, and innovation can be the casualty. Difficulties with the now understood climate changes may well provide exciting opportunities. Despite the prevarication of Federal politicians trying to avoid global warming responsibilities, our need for agility to cope in Australia, one of the hardest hit continents, with heat extremes, massive storm events be they winds, floods, bushfires and increasing lightning strikes, may well demand we alter our concepts of the kind of plants that are much more resistant to these conditions, and play our vital role in reversing more frequent continental disasters.

Advances in the art of propagation, seldom come from big business. They make it clear—if it is not plainly going to be profitable now, it should be discarded. I have always believed "If life throws you lemons, make lemonade." We need to play our role as part of a global strategy to reverse the worsening climate trends and not wait until someone else leads the way. I am privileged to have been a subscriber for many years to *Australasian Science* (www.austscience.com for full online access as part of your subscription).

If you want authenticated facts on our fast changing world I would recommend it. The incredible diversity of plants that are continuing to adapt to micro-climate changes and opportunities, may not lend themselves to rapid evaluation and instant profit making.

I have no need to tell you how long it takes to "discover" a cultivar and develop it to a commercial stage where, perhaps, there may be a place to make a profit.

In today's world that decision may well be in the hands of a bean counter in an enclosed office of a major retailer, with little direct contact with the world we inhabit. A current option is to go to a tin shed, be told the plant is in aisle 10, costs $35, and pay on the way out! Despite all that's promoted, they are not the place to get sensible, accurate

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information tailored to the home gardener's need in their own micro-climate.

In the past 6 years, involvement in my chosen world of plant propagation has evolved to connect with aficionado home gardeners in communities who constantly inform me they want to be self-sufficient, by converting their limited garden spaces to productive plants that can feed their families. The proliferation of these determined plant people I have had contact with over the years, and continue to have, numbers the many thousands through Master Classes, Workshops, ABC TV, local ABC Radio sessions, direct phone, and email enquiries.

I am getting a relevant cross section of community endeavour pointing to a need for good, accurate KNOWLEDGE of how to produce a range of plants to improve: their home's internal and external aeration, to herbs, edible flowers, vegetables of all kinds and particularly fruit tree crops.

The basics they want to understand are based on our familiarity of the influence and effects of the BIG FIVE, namely aeration; heat; light; moisture and nutrition.

We need to connect more to this major sector of our communities. They are our greatest supporters. Sadly, I find some on both sides of this equation don't realize the need for this vital connection. If you feel you could do with a little inspiration and relevance, can I draw your attention to Jane Smith's 326-page book on Luther Burbank's life a hundred years ago, titled *The Garden Invention*. This marvelous epitome is encapsulated in George Bernard Shaw's "life wasn't meant to be easy my child, but take courage: it can be delightful." In fact, we should be enjoying those challenges and achievements.

It is one of the critical pressure points I have been under for the past decade having now completed the text last month, of a book titled *Common Sense Citrus*. It is much more than using citrus as a vehicle, but aimed to help nursery people and gardeners, understand interactions between the BIG FIVE—and what propagation means, to help them in sensible decision-making to establish the mix of plants they really need in their local environment and for Australia as a whole.

I hope those of you dyed in the wool nurserymen, practice your craft by sending a satisfied customer away, not only with plants that help them achieve self-sufficiency and beauty, but the KNOWLEDGE they need to grow them well. If you do that, they will keep coming back, and you will have made a positive contribution to understanding what plant life should, and must, mean to us all.

May I address those of you that passionately propagate plants, to assess your role in world plant preservation, to develop your own set of guidelines that contribute to the greater good, world-wide? I have been consulting with governments, United Nations, and private companies world-wide in many countries for well over 50 years. My lifetime in horticulture has involved a lot of direct contact with farmers producing food, and feeding an increasing population is a major challenge.

The incredible diversity of plants and our increasing scientific understanding of them through Plant Physiology and many other new sciences, are providing opportunities and challenges that humankind is yet to harness.

Consider the proverb: "from little acorns big trees grow." Utilize your valuable imagination

CONCLUSION

If you are passionate about growing plants, allow a little time to reflect on where it is leading you.

Are there some specific aspects of plant propagation that might be more worthwhile?

What legacy are you developing, to hand on to succeeding generations in your capacity as a skilled producer of plant material?

Are you recording what you do, the minute detail could hold a valuable key to those who follow?

How might you positively contribute in some related field, in the future?

Appreciate what other members have recorded before you, to add to your experience.

There is a rich background to our combined contributions in and to the plant world. The far sighted creators of our Society insisted we should record our individual contributions to this art.

As International President of IPPS in 1985, when I initiated the first changes to digital records, it led to a goldmine available to members instantly on disc, and was a start to a new era of availability of a treasure trove of information. It is your task to convert this information into KNOWLEDGE.

How and in what form will you make your contribution to our plant world?

Bridging the green gap©

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INTRODUCTION

The information I am about to present today is purely a result of speaking with people in various sectors of the horticultural industry. This is their feedback when asked what issues they have when trying to source plants or to complete their jobs as designers or installers of plants. This is in no way a criticism of anyone's business it is purely an effort to bridge the gap through communication.

- The horticultural industry consists of many sectors.
- Do you know what is happening in others sectors?
- How do you communicate with them?

As editor of Hort Journal Australia (HJA), I network constantly with many different sectors and attend many industry functions, shows, expos, and conferences. I talk to people and ask lots of questions about their businesses — in particular, I am keen to find out and share information that could help improve business for all — and in some way help to bridge the gap.

One of the most common responses is about communications or the lack of it between different sectors and what could be done to improve communications. Of course people are busy; everyone is busy, regardless of what sector you are in. Communication between them is just another job to be done.

We are bombarded with emails, social media, telephone calls, and flat out getting through our day's work. Some may say, why do I need to know what is happening in other sectors? Well, I guess that comes down to the fact that there are quite possibly business-to-business opportunities out there that could benefit all. After all, don't we all want to make a fair dollar for a fair day's work and if we do things right perhaps a bit extra?

There are already several current options that include: trade register, evergreen connect, websites, and social media. These are some of the options available for businesses to connect with suppliers, whether it is plants, pots, growing media, labels or anything associated with supplying plants or materials. What else? What do you use? How do you receiving information from suppliers via lists or images?

BRIDGING THE GAP THROUGH COMMUNICATION

Landscape architects/designers are an example of one sector. For them good communication is important for forward planning. Plant lists are wanted as are websites with good content, including mature sizes listed. Websites that crash are worse than no website. Skilled staffed are key to customer satisfaction and help with career progression.

Forward planning should take the stress from both the landscape designer/architect and also from the grower. The designer by knowing in advance what plants will be available can better design a landscape that can be installed as intended. The grower will have an idea of what they should be growing thereby reducing wastage and maximising sales.

For many commercial jobs, the project may not go ahead for anywhere between 6 months and 3 years. What plants selected now may not be available when the plants are required. Quite often the designer then has to go back to the drawing board and try to source plants that are available after that time. This is extra time for them that they do not get paid for. Many have told me they tend to reuse the same types of plants they know will be available. If you have a range of plants that you grow regularly — let designers know about them. Send them specs — growing and cultural.

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Plant availability lists

Looking at Table 1 below, what is missing from this list if you are a designer — what other information do you require?

Table 1. Example of a plant list with inadequate information.

Acanthus mollis	$5.95	$10.00		
Acer × freemanii 'Jeffersred', Autumn Blaze® Freeman maple				$88.00
Acer palmatum		$12.50	$35.00	
Acer palmatum 'Senkaki'			$35.00	$88.00
Acer palmatum var. *dissectum* 'Dissectum Palmatifidum'			$95.00	$140.00
Acer palmatum var. *dissectum* 'Dissectum Variegatum'			$95.00	$140.00
Acer palmatum var. *dissectum* Dissectum Atropurpureum Group			$95.00	$140.00
Acer palmatum var. *dissectum* Dissectum Viride Group			$95.00	$140.00
Acer rubrum 'October Glory'				$88.00
Agapanthus blue		$4.75	$8.20	
Agapanthus dwarf blue		$4.95	$8.20	
Agapanthus dwarf white		$4.95	$8.20	
Syzygium hemilamprum		$8.50	$32.00	$80.00
Syzygium smithii		$8.50	$32.00	$80.00
Syzygium smithii 'Allyn Magic'		$9.50	$35.00	
Syzygium smithii 'DOW30', Sublime™ acmena		$12.70	$35.00	$80.00
Syzygium smithii 'Hot Flush'		$10.00	$32.00	

This type of list is probably ok for some landscapers as they are usually more "hands on" and regularly go to trade marts etc. and some are horticulturists. However, many designers are in an office situation and they require more information such as how big the plant will eventually grow — its mature size and what it looks like?

No mature plant size and no image, which might sound like a lot of work but let's look at how simple it can be in a simple table with the key data needed by the designers (Table 2).

Table 2. Simple table with key information.

Symbol	Botanic name	Common name	Qty	Pot size	Mature height and width (m)
Courtyard					
Ar	*Ajuga reptans* 'Caitlins Giant'	Ajuga	3	150 mm	0.2×1.5
Cfn	*Cordyline fruticosa* 'Negra'	Negra cordyline	3	200 mm	1.5×1
Hg	*Helmholtzia glaberrima*	Stream lily	1	200 mm	1.5×1.5
Pj	*Pandorea jasminoides*	Bower of beauty vine	2	200 mm	5×5
Sa	*Scaevola aemula*	Fan flower	4	150 mm	0.3×0.5
Rear garden					
Az	*Alpinia zerumbet*	Shell ginger	2	200 mm	2×1.5
Azv	*Alpinia zerumbet* 'Varigata'	Variegated shell ginger	1	200 mm	2×1.5
An	*Asplenium nidus*	Birds nest fern	3	200 mm	0.5-1×1.5-2
Ba	*Balantium antarcticum*	Soft tree fern	1	1 m length	2×2
Cm	*Clivia minata*	Kaffir lily	16	Moved	0.5×0.3
Drv	*Dianella tasmanica* 'Variegata'	Variegated flax lily	6	150 mm	1×0.5
Gl	*Guzmania* 'Luna'	Bromeliad	2	200 mm	0.5×0.5

Websites

Good information about the plants can also be offered through websites (Figure 1).

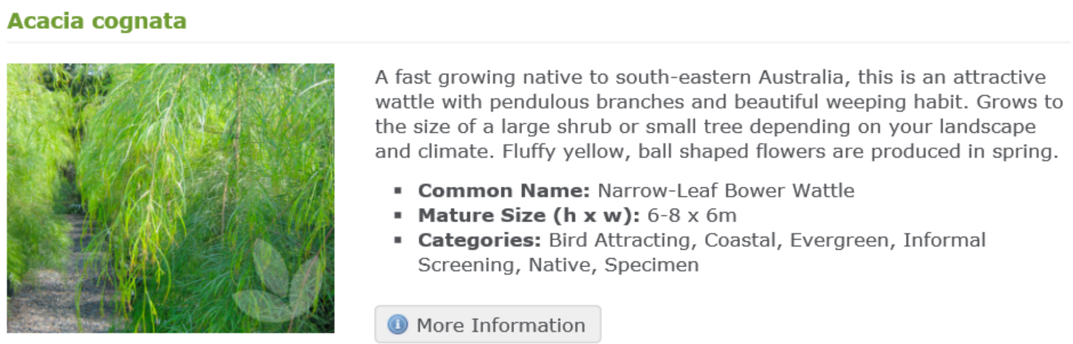

Figure 1. Website for *Acacia cognata* (Specialty Trees, Victoria, Australia with permission).

Figure 2 shows a snip taken from Specialty Trees, Victoria, Australia website (www.specialitytrees.com.au). You could browse a search engine put in your requirements and it came up with all this information. You land on the page shown in Figure 2 after pressing the 'More Information" button. This page tells you when the plant is available, uses, growing requirements, and includes another image of the plant.

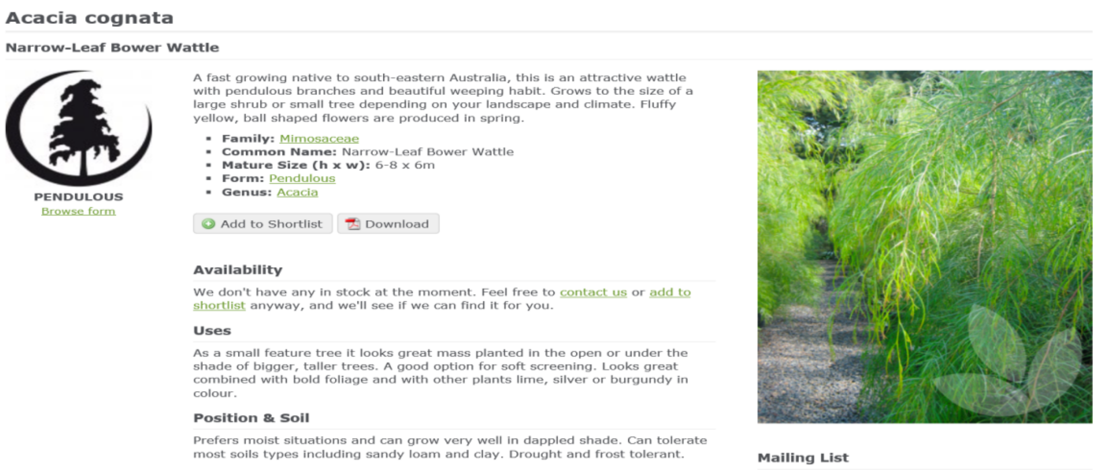

Figure 2. More information page for *Acacia cognata* (Specialty Trees, Victoria, Australia with permission).

Specialty Trees website was easy to navigate with plenty of relevant information. There are a few really good websites like this, e.g., Flemings and Ozbreed. Websites like this require someone dedicated to looking after them. This is fine for larger business. Of course not all businesses are in a position to allocate someone full time to the task.

So how do the designers know about these websites? Search engine optimisation is important but not the only way. How would you let people know?

Down websites (HTTP Error 503: service is unavailable) are just plain annoying. I heard many complaints from designers that many websites they have tried to use to research plants crash or they are outdated and haven't been touched for years. If you are going to have a website, keep it up-to-date or don't have one.

Knowledgeable staff is valuable to your brand. They need to be able to communicate with customers, otherwise you are likely to lose the sale — and maybe the customer, Training gives staff a career path and enable career progression. Many people I spoke with said they felt frustrated when phoning some companies to ask about particular plants and the person they spoke with was not able to help them because they didn't have enough knowledge.

One comment made to me was about career progression and perhaps providing staff with training and offering that person career progression with incentives or profit share on the sales they make could only benefit everyone. Poorly trained staff may lose customers and may also lose staff.

Other forms of communication

Other types of communication include: books, catalogues, e-blasts, newsletters, and fax outs. Some of the bigger companies have books such as Flemings and Ozbreed, to name a couple. E-blast is an "email blast", i.e., an email that you send to a mailing list or large group of people, who are usually known as your subscribers. They are often sent to hundreds or thousands of subscribers and are managed using email marketing software or web applications. When considering other forms of communication remember the following.

1. The KIS principle.

If your business is not at the stage where it can afford the big website or books then you can still market if you use the KIS principle: Keep it simple.

Do it from the office by sending out lists via e-mail (a fax machine can be annoying to business owners). However do it properly and be sure to send a full list with correct information and images. Availability is also important.

2. Regular lines — always available?

List the regular lines that you always have and send the list complete with specs and also mature size. Show off what you do best. Promote those plants you grow well — PLUS use an image if you have one! Use images from your nursery, from the field, or as last resort from other sources with permission. Images from your suppliers of seeds and plugs show how the plant will fit into the landscape. A picture tells a thousand words (Figure 3). Images tell and sell the story of plants. They can demonstrate and inspire their use. For example, does it grow in a pot or does it look good in a hanging basket?

Figure 3. A quick and simple image that tells all.

3. Subscribe to publications and attend plant shows.

Subscribe to publications for inspiration and ideas and speak directly to growers and colleagues to source materials. They attend landscape and garden shows. They would like to connect with more businesses who supply plants and materials. They want to have two way communications with growers and follow the trends. They find they see more products displayed at landscape and garden shows. They are still keen to discover more websites and collect journals and trade lists and connect with growers. Trade associations such as IPA (Interior Plantscape Association) want to connect with growers to develop a list of suppliers for their members. It is all about two way communication:

- Good quality plants are always required by IPA.
- Keeping up with trends and even predicting the next big trend!
- By connecting with suppliers they can work on new trends or create the next big trend. That would be inspiring.

A two-way communication would ensure they know what is available and growers would also know what they are seeking.

IPA is always looking for good suppliers of various plants and materials. They would like to hear from growers when new plants are available or when you have a plant that is suitable for indoor plantscaping. i.e., *Zamioculcas zamiifolia* (Zanzibar gem). This can be sent directly to the association who will then send out to their members via e-blast, newsletters, etc.

The same applies with container suppliers. According to IPA there are a lot of great looking containers but they are not all terribly practical, for example: really small containers or containers that are not made for standard sized grow pots. IPA wants to/needs to work with container suppliers to come up with the right goods.

Vertical/green walls are becoming the norm in both interior and exterior design. With vertical gardens becoming increasingly popular and they are likely to be around for some time. They require many plants as well as requiring replacement plants. A good plant supplier is valuable to designers. One that has a good range and know what will grow on such sites.

4. Magazine writings.

Articles and advertorials in magazines/publications are a fast and efficient way of getting your name out there, especially good for new plants. Hort Journal will be running a dedicated section annually for new plant introductions.

Growing opportunities

What other opportunities could there be through collaboration with other sectors of the industry?

1. Big events – G20 Brisbane.

Plants on display at garden shows provide inspiration. Not all the displayed plants are indoor plants such as the native *Anigozanthos* in the about display (Figure 4). This business searched Australia wide to supply plants for the G20. They were shipped across the country as the designer had enormous issues trying to source plants. Some plants dead on arrival and he should have spoken with Teena Stanford from Darwin Plant Wholesalers! She is an expert on transport and logistics. Many plants were required for the G20 event. Two way communications helps when large quantities are required.

Figure 4. G20 Brisbane Australia 2014 showing *Anigozanthos*.

2. Medicinal plants and horticultural therapy.

Austin Health's, Royal Talbot Rehabilitation Centre, has well established healing gardens.

The Lancet, made reference to these early examples adding that "historical forces are now refiguring the role of gardens in modern medicine at a time when countries face the growing burden of chronic diseases."

3. Greening cities.

Becoming a preferred supplier with government contracts requires a good business manager that can build relationships via networking.

4. Film sets.

Jeremy Critchley from The Green Gallery in Sydney supplied plants for the film set for The Great Gatsby.

5. Wedding and bridal fairs.

Many weddings today use potted plants as decorations, table settings and gifts, particularly with the trend of farm style weddings. Having a stand at a bridal expo to show off your beautiful plants and obtain future business with displays from flowers to rustic pots for table settings and decorations. Plants can be a take home gift (bomboniere) as well as a decoration at weddings.

CONCLUSION

Hort Journal Australia connects with many sector based organistaions. Such groups include:

- Horticultural Therapists
- Botanic Gardens
- Landscape industry
- Interior Plantscape Association
- Nursery & Garden Industry
- Government – Councils/Educational Institutions
- International Plant Propagators' Society growers
- Retail garden centres

It has worked hard at bridging the gap to introduce people from various sectors of the industry. Botanic gardens, interior plantscaping and horticultural therapy are all now sectors of the industry represented in the magazine on a regular basis. We endeavour to make it easy for industry people when they think of plants HJA is the magazine to go to.

How can HJA help? It connects you with all sectors of the industry and is here to help you in your business. We would like your feedback regarding how to do this.

We are looking to build a website link that will enable designers or businesses that require plants in the future to be able to upload their desired list to the site and growers in return can look at the list to see if it is a line they are able to supply.

- What do you think about that?
- Can you offer other suggestions?

Hardwood and softwood cutting propagation of MKR1, persimmon dwarfing rootstock©

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INTRODUCTION

'MKR1' is a newly released rootstock for persimmon (*Diospyros kaki* Thunb.). In spite of dwarfism, some cultivars grafted onto it showed early fruit bearing and less physiological fruit drop (Ishimura et al., 2013). Cuttings of the persimmon were speculated to be difficult-to-root (Tao and Sugiura, 1992). However, recent studies indicated their high rooting percentages, particularly with cuttings from root-suckers (Tetsumura et al., 2000, 2001a, b, 2003). In the present studies, we showed some effective rooting treatments for the 'MKR1' adventitious root formation.

MATERIALS AND METHODS

Experiment 1: hardwood cutting

In late March 2015, 'MKR1' less than 10 years-old trees raised by micropropagation and seedlings, planted in the field science center of University of Miyazaki (32.0167°N, 131.3500°E, 100 m a.s.l., 3100 mm average annual rainfall) were cut back to the ground level. A shallow pit about 10 cm in depth and 30 cm^2 around the stump was dug. The roots were bared to stimulate sucker differentiation in the presence of sunlight (Figure 1A).

In mid-June 2015, some suckers were mounded (etiolated) (Figure 1C) with rice husks and the rest remained unmounded (exposed) (Figure 1B). Rice husks can be easily eroded with heavy wind or rain, hence, they were covered by green plastic netting around the root-suckers. It is woven very open, allowed free penetration of sun, air, and rain drops to the mounded substrate. During all this period, no irrigation was conducted in order to wet the mounded medium, because adequate rainfall was taking place throughout all the growing season (Figure 1).

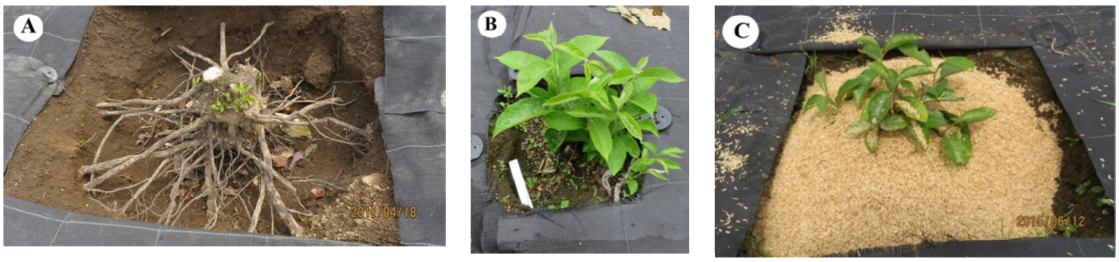

Figure 1. Experiment 1: Sucker stimulation from 'MKR1' roots: (A) A shallow pit around the stump; (B) unmounded suckers; (C) mounded suckers.

In late January 2016, rice husk was gently removed from the dormant root-suckers. None of the mounded and unmounded root-suckers had developed roots before separating from the mother plants. The suckers were de-attached, labeled, and then measured for diameter and length. The cuttings varied in terms of thickness and length, where longer shoots were clipped at 30 cm. Before being set into the rooting medium, the cuttings were re-cut straight at the proximal end to a length of 2-4 mm and angled to the distal end. The 'MKR1' cuttings were collected from mounded and unmounded (control), and 'Jiro' from mounded and hedges (control). Half of the mounded 'MKR1' suckers were wounded with pruning shears on two opposite sides of the stem by longitudinal incisions about 1-2 cm in

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length and 3-5 mm in width. The basal wound along with intact bark of each cutting was treated with 0.5% IBA in talc after once briefly immersed in the tap water. The prepared cuttings were planted vertically to a depth of 5 cm into bottom heated plastic net baskets (inside = 12.8 cm wide × 41 cm long × 7 cm deep), filled either with a moist mixture of peat and bora-tsuchi (1:1, v:v) or peat alone. The inserted cuttings spaced uniformly in rows ≈5 cm from the sides of the basket and being apart from each other. The basal heating mat was set to warm the substrates to 28°C. The cuttings were placed under netting, coated with vaporized aluminum in a propagating frame covered with plastic film. The propagation house was ventilated with fans when the ambient temperature rose above 20°C. The mean temperature in the substrate was 22±2°C. The mean air temperature in the propagation house was 25°C during daylight hours. Air temperature was recorded every 20 min for the duration of the experiment using a data logger (TR-72i, T&D Corporation, Japan). The substrate was watered when needed.

The experiment layout was 2×5 factorial, with 12 cuttings per each treatment. Data on percentage rooting, root number, leaf area, leaf number, callus, root and shoot lengths, fresh weights, and dry weights were recorded after 4 months from planting (late May). Cutting scored as “rooted” when an adventitious root had emerged from the stem. The roots were cut off from the stem, washed and then fresh weights were measured. Root and shoot dry weights were determined by weighing the dry mass after oven drying at 60°C for 48 h. Leaf area was calculated with the help of ImageJ application software (Rasband, 1997-2012) after scanning with a photocopier machine (Satera MF8570Cdw, Canon Inc. Japan).

Data were subjected to analysis of variance (ANOVA) using the general linear models procedure using SPSS (16.0). Mean separation was performed using Tukey’s honestly significant difference (HSD) method at $p \leq 0.05$ or 0.01.

Experiment 2: softwood cutting

In late June, late July and late August of 2015, single-node stem cuttings with one leaf and one bud (Tetsumura et al., 2000) were collected from ‘MKR1’ actively growing root-suckers. After excising, the basal part of the each cutting was immediately dipped for 5 s in the prepared 3000 ppm indole-3-butyric acid (IBA) 50% ethanol aqueous solution. The cuttings were planted singly in the plastic pots (EG-90, 300 ml, MINAMIDE Inc., Japan), filled with pre-soaked perlite, vermiculite, peat, or Metro-Mix®360 (Sun Gro, Horticulture Distribution Inc., Washington DC). Twelve replications of each medium pot were placed under intermittent mist, operated 30 s every 15 min during daytime and ventilated with thermostatically controlled fans when the ambient air reached 38°C. The other replications were put in the flood-tray polyethylene tent (FTP), which was fully covered with transparent plastic film but opened for 30 min ventilation once a week. The lowest part of the pots in FTP was always in the tray water, as substrate absorbed water by capillary action. Both systems were placed under netting, coated with vaporized aluminum in the propagating frames covered with plastic film. The data loggers measured the temperature and relative humidity in the systems.

Rooted cuttings were carefully washed in a bucket having tap water to remove substrate as much as possible. Data of root number, root length, survival, and callus for each experiment were assessed 60 days after planting. Cuttings were scored rooted, having length ≥1 cm with or without leaf retention. Those that were severely rotted or blackened were defined as “dead.”

The layout for the experiment was a 3 (planting time) × 2 (irrigation systems) × 4 (rooting medium) factorial. The method of data analysis was the same as Experiment 1.

After root assessment, rooted cuttings of the each propagation substrate were re-potted (EG-105, 400 ml, MINAMIDE Inc. Japan) into the same substrate as they were for root formation, and placed under direct misting for 2 days. Thereafter, cuttings were weaned from the mist bench, (10N-10P-10K) controlled-release fertilizer (Hi-control all 10, JCAM AGRI. Co., Ltd., Japan) was added at 1 g pot^{-1}, and remained in the ambient greenhouse for 11 more days. After passing these days, rooted cuttings then were transferred to the adjacent minimally shaded (50%) greenhouse which was misted once in the midday. Unless otherwise mentioned, mist was conducting more in accordance with prevailing irradiance and temperature conditions in a given day.

The experiments lasted in the minimally shaded greenhouse until winter passed and acclimatization survival was checked in April of the following year. The hardening process for the rest of two other months was conducted in the same manner, however, in order to encourage natural dormancy, amount of the fertilizer gradually reduced to 0.5 and 0.25 g to the late July and August planting.

Experiment 3: different IBA concentrations affecting adventitious roots of the 'MKR1' softwood cuttings

In late June of 2016, single-node stem cuttings with one leaf and one bud were collected from 'MKR1' root-suckers. Five IBA concentrations (1000, 2000, 3000, 4000, and 5000 ppm) and a solvent control were utilized. For each concentration, IBA was dissolved into a 100% ethanol solution and then diluted with the same volume of distilled water. The IBA was applied for 5 s to the basal portions of the each cutting. Unless otherwise mentioned, cuttings for the control treatment were dipped only into a 50% ethanol-distilled water solution. The cuttings were inserted singly into the plastic pots (EG-90), filled with a presoaked peat, and then placed under vaporized aluminum netting in a propagation frame covered with plastic film. The propagation frame was intermittently misted (30 s mist every 15 min in the daytime) and was ventilated with fans when the ambient air reached 38°C.

A randomized completely block design (RCBD) with two replications and 10 cuttings per each replication were used. The rooting percentage, survival, callus, root number, root length, root fresh and dry weights were measured 2 months after planting. A cutting was considered rooted if a minimum of one root ≥1 cm in length was present.

The results were statistically analyzed using SPSS 16.0. Percentage data were arcsine transformed before conducting ANOVA. Means separations were carried out by Tukey's HSD. Regression for the selected variables was performed combining data for each parameter collected from two replications.

RESULTS

Experiment 1

Rooting and callus percentages of 'MKR1' mounded and control (Figure 2) were compared with 'Jiro' mounded and control (Table 1). Later, a one way ANOVA was conducted separately for 'MKR1' mounded, control and wounding preceded IBA treatments (Table 2). Although 'Jiro' and 'MKR1' received the same treatments in terms of cuttings source and substrates only wounding and IBA were applied to the 'MKR1' cuttings. The data for the shoot parameters along with leaf number and leaf area encompassed both rooted and un-rooted cuttings are shown in Table 2.

There were significant differences in the cultivar, cutting source and substrate, and the interactions with respect to rooting percentage. Callus was not affected by any of the factors with the exception of the interaction between the cultivar and cutting source (Table 1). The cuttings treated with mounding rooted significantly better than the controls in both cultivars. The highest rooting (92%) and callus (67%) percentages occurred in the mounded 'Jiro' planted in the mixture (Table 1). 'MKR1' also formed maximum callus (33%) in the mixture, but the rooting percentage was as high as that in peat induced in the mounded cuttings (17%). Despite that peat medium was less effective with respect to rooting and callus, it had very sticky particles which didn't allow deep roots to pull or separate easily during harvesting.

Figure 2. Experiment 1: Hardwood cuttings of the 'MKR1' root-suckers, inserted into mixture substrate and measured four months after planted in January 22, 2016: (A) Unmounded treatment; (B) Mounded treatment; (C) Mounded received wounding plus 0.5% IBA in talc. Ruler = 30 cm.

Table 1. Effects of cultivar, cutting source and substrate on rooting and callusing of persimmon hardwood cuttings. The data were collected four months after planting.

Cultivar	Cutting source	Substrate	Rooting (%)	Callus (%)
Jiro	Control	Peat	8	8
		Mixture	0	25
	Mounded	Peat	25	33
		Mixture	92	67
MKR1	Control	Peat	0	25
		Mixture	8	33
	Mounded	Peat	17	8
		Mixture	17	8
Significance				
Cultivar (Cv)			**[1]	ns
Cutting source (Cs)			**	ns
Substrate (S)			**	ns
Cv x Cs			**	**
Cs x S			**	ns
S x Cv			*	ns

[1]ns, **, *: nonsignificant or significant at $p \leq 0.01$ or 0.05, respectively.

The highest callus formation was observed in the highest percent rooting, but the callus developed well even when no roots or fewer roots formed (Table 1). Mounding dramatically enhanced 'Jiro' rooting and callusing, but 'MKR1' appeared to be still difficult-to-root.

The addition of wounding practice with IBA 0.5% in talc to the mounded root-suckers significantly increased 'MKR1' rooting percentage, callus percentage, leaf number, leaf area, shoot fresh and dry weights over the control and the mounding alone (Table 2). The root length, shoot length, root fresh and dry weights failed to increase with wounding, since those were not significantly affected by the treatments. Although there was no significant difference between the substrates, the mixture medium tended to promote root and shoot development (Table 2).

Table 2. Effects of cutting source and substrate on root and shoot parameters of 'MKR1' hardwood root-sucker cuttings.

Treatment	Rooting (%)	Callus (%)	Root no.	Root length (mm)	Root Fwt (g)	Root Dwt (g)	Shoot length (mm)	Shoot Fwt (g)	Shoot Dwt (g)	Leaf no.	Leaf area (cm^2)
Cutting source											
Control	4 b[1]	8 b	3 a	83 a	0.04 a	0.02 a	59.1 a	0.75 b	0.27ab	5.38 b	5.99 b
Mounded	17 ab	29 b	2 a	218 a	2.46 a	0.41 a	52.6 a	0.69 b	0.24 b	4.78 b	4.78 b
M + W + IBA[2]	42 a	79 a	3 a	303 a	3.34 a	0.52 a	78.4 a	1.57 a	0.49 a	10.57a	10.57a
Substrate											
Mixture[3]	28 a	36 a	3 a	299 a	3.63 a	0.58 a	70.7 a	1.17 a	0.39 a	7.05 a	7.14 a
Peat	14 a	36 a	3 a	199 a	1.62 a	0.25 a	56.0 a	0.83 a	0.27 a	7.02 a	7.29 a

[1]Mean value within each factors in the same column, followed by the same alphabet are not significantly different at $p \leq 0.05$ level (HSD).

[2]M = Mounding, W = Wounding, IBA = Indole-3-butyric acid.

[3]Mixture (Peat: Bora-tsuchi; 1:1).

Experiment 2

The cutting collection time had significant influence over on all parameters except of root number, which was affected by none of the factors (Table 3). The highest rooting percentage occurred in late June (70%), followed by late July (34%) and late August (17%). A significant increase regarding survival, callus and root length was also evident to the June planting. There was no significant difference between mist and FTP with the exception of callus and root length (Table 3). Similarly, substrate affected percentage rooting, callus, and root length at $p \leq 0.05$, however, it didn't show a significant difference for the survival and root number. The highest rooting percentage was obtained by peat (50%) and the lowest was observed in perlite (28%). Conversely, callus was significantly higher in perlite (51%), but it was significantly poor in the peat (25%). Perlite also returned significantly lower root length, whereas Metro-Mix® produced the maximum.

Table 3. Effect of planting time, irrigation system, and substrate on rooting of 'MKR1' softwood cutting. The data were collected 60 days after planting for each experiment.

Factor	Rooting (%)	Survival (%)	Callus (%)	Root no.	Root length (cm)
Planting time					
Late June	70 a[1]	93 a	65 a	3.9 a	466.3 a
Late July	34 b	61 b	42 b	3.1 a	265.5 b
Late August	17 c	63 b	9 c	4.0 a	230.2 b
Irrigation system					
Mist	39 a	71 a	48 a	3.7 a	297.4 b
FTP	42 a	74 a	29 b	3.7 a	450.6 a
Substrate					
Metro-Mix®	40 ab	75 a	32 bc	4.0 a	516.1 a
Peat	50 a	71 a	25 c	4.2 a	338.3 ab
Perlite	28 b	71 a	51 a	2.9 a	287.0 b
Vermiculite	43 ab	72 a	46 ab	3.4 a	348.5 ab

[1]Mean value within each factors in the same column, followed by the same alphabet are not significantly different at $p \leq 0.05$ level (HSD).

Irrigation systems and substrate had pronounced effects on June rooting at $p \leq 0.01$ (Table 4) (Figure 3). The mean percent rooting of the FTP was significantly greater than that of the mist. The highest rooting percentage was achieved in peat (100%) and the lowest was also yielded under mist in the perlite (17%). In spite of vermiculite which stimulated 92% rooting, other propagation substrates either displayed the maximum rooting (≥75%) under the FTP system.

Although none of the factors affected survival per original cutting (SurvP), there was a significant difference in survival per rooted cutting (SurvW) between the substrates (Table 4). One hundred percent acclimatization survivals of rooted cuttings was observed in perlite and Metro-Mix® substrates in both systems.

Average day/night temperatures in the mist house and FTP were 23/25, 27/28, and 29/31°C for June, July, and August, respectively. Likewise, average day/night relative humidity in the mist house and FTP were 97/99, 93/99, and 89/96% for June, July, and August, respectively.

Table 4. Effect of irrigation system and substrate on June rooting and survivals of 'MKR1' softwood cutting.

Irrigation system	Substrate	Rooting (%)	Survival[2] (%)	
			SurvP	SurvW
Mist	Perlite	17	75	100
	Vermiculite	42	83	60
	Peat	100	100	75
	Metro-Mix®	75	100	100
FTP	Perlite	75	100	100
	Vermiculite	92	100	82
	Peat	75	100	78
	Metro-Mix®	83	83	100
Significance				
Irrigation system		**[1]	ns	ns
Substrate		**	ns	*

[1]ns, **, *: nonsignificant or significant at $p \leq 0.01$ or 0.05, respectively.

[2]Survival (%) SurvP = the number of cuttings surviving the propagation phase as a proportion of the original number; Survival (%) SurvW = the number of survival as a proportion to the rooted cuttings. See Wilson and Struve (2003) and Tetsumura and Yamashita (2004).

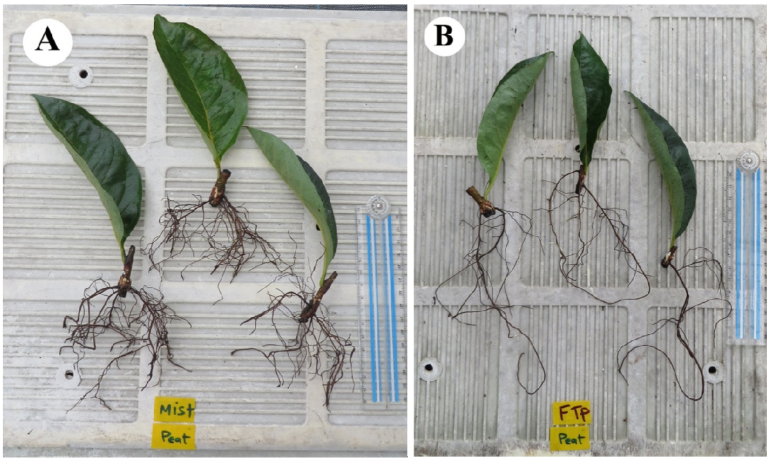

Figure 3. Experiment 2: Softwood single-node cuttings of the 'MKR1' root-suckers: (A) Roots formed under intermittent mist; (B) Roots under FTP condition. Ruler = 15 cm.

Experiment 3

The rooting percentage, root number, root length, root fresh and dry weights were significantly different at $p \leq 0.05$ (Table 5). Although callus and survival were not affected by any of the treatments, it tended to decrease gradually in high IBA concentrations. The greatest percentage rooting (90%) occurred in 2000 ppm and the lowest (30%) observed in 5000 ppm IBA. On the contrary, root number and root length continued to increase throughout the range of IBA concentration from the control to a remarkable increased in 5000 ppm (Table 5) (Figure 4). In addition, root fresh and dry weights were also significantly higher in 5000 ppm than did those in the control (Table 5).

There were significant quadratic relationships at $p \leq 0.05$, between rooting percentage (y) and IBA concentrations (x), root number (y) and IBA concentrations (x), and rooting percentage (y) and root number (x). Equations and R^2 values for the above correlations were [$y = -0.000006x^2 + 0.023x + 59.29$, $R^2 = 0.76$], [$y = 0.0000004x^2 - 0.0009x + 2.53$, $R^2 = 0.75$], and [$y = -0.803x^2 + 2.75x + 67.89$, $R^2 = 0.40$], respectively.

Table 5. Effect of different IBA concentrations on survival, callus and rooting traits of the 'MKR1' softwood cuttings. The data were collected 60 days after planting.

Treatments	Survival (%)	Callus (%)	Rooting (%)	Root no.	Root length (mm)	Root Fwt (g)	Root Dwt (g)
IBA (0 ppm)	100 a[1]	100 a	55 abc	2.3 b	144.6 b	0.10 b	0.033 b
IBA (1000 ppm)	100 a	100 a	80 ab	2.3 b	221.3 b	0.23 b	0.126 ab
IBA (2000 ppm)	100 a	100 a	90 a	2.4 b	224.2 b	0.45 ab	0.160 a
IBA (3000 ppm)	95 a	90 a	70 abc	3.6 ab	277.9 b	0.44 ab	0.154 a
IBA (4000 ppm)	95 a	75 a	45 bc	5.6 ab	412.2 ab	0.42 ab	0.137 ab
IBA (5000 ppm)	90 a	75 a	30 c	7.7 a	605.0 a	0.77 a	0.237 a

[1]Mean value within each factors in the same column, followed by the same alphabet are not significantly different at $p \leq 0.05$ level (HSD).

Figure 4. Experiment 3: Depicts treatment differences about number of roots per cutting: (A) Cuttings treated with 2000 ppm; (B) Cuttings with 5000 ppm. Ruler = 15 cm.

DISCUSSION

Experiment 1

Our main purpose of this study was to optimize 'MKR1' rooting. In general, the whole result of the 'Jiro' was a kind of control, used to know precisely about 'MKR1' rooting difficulties.

The rooting responses between 'Jiro' and 'MKR1' were statistically distinct, but both were considerably improved by mounding. Tetsumura et al. (2001a) demonstrated 52% rooting for the mounded suckers of 'Jiro' and 'Nishimurawase', which was significantly higher than that of control (27%). Likewise, the mounded micropropagated stock plant of 'Nishimurawase' rooted (47%), as high as the mounded root-suckers did, while the unmounded micropropagated stock plants and the unmounded root-suckers were respectively no and less responsive to the rooting (Tetsumura et al., 2002). As for the useful dwarfing rootstock for 'Fuyu' Japanese persimmon, *Diospyros rhombifolia* Hemsl., hardwood cuttings from basally etiolated root-suckers rooted better than those of the basal or middle suckers (Tetsumura, 2000). In a number of woody plant species, etiolation as a pretreatment has been beneficial to improve rooting. Anatomical changes associated with etiolation are delayed lignification of pericyclic cells (Amissah et al., 2008). Numerous studies have proposed a correlation between difficulty in rooting and the presence of a pericyclic sclerenchyma layer. A continuous sclerenchyma layer might act as a physiological barrier to the adventitious root initiation or as a mechanical barrier to root emergence (Amissah et al., 2008). Tetsumura et al. (2001a) showed that a moderately developed sclerenchyma of the unmounded 'Jiro' sucker was connected with low rooting, but a poor developed sclerenchyma of the mounded cutting was associated with significantly higher rooting. Thus, no or scarce rooting of the unmounded suckers or hedges in our study would be related to a wide range of lignification.

It is well known that the substrate has influence over adventitious root formation. In our study, cuttings in two-component mixture of peat moss and bora-tsuchi rooted and callused better than in pure peat. Generally, peat moss was noted for low callus and root rates in proportion to the mixture substrate. Hechmi et al. (2013) reported higher percentage rooting for the olive semi-hardwood cuttings in two component media of perlite and sand, whereas peat moss returned poor rooting. Similarly, Ercisli et al. (2002) investigated rooting characteristics of *Actinidia deliciosa* 'Hayward' hardwood cuttings in perlite, peat, sawdust, peat + sawdust (1:1), and peat + perlite (1:1). The highest rooting percentage was found in two component medium of peat + perlite and peat + sawdust. Hardwood cutting of figs (*Ficus carica* L. 'Roxo de Valinhos') also indicated best result in the soil/sand (v:v, 1:1) for the root and shoot parameters (Antunes et al., 2003). The author added that soil alone decreased root and shoot development. In order to improve aeration, nutrient uptake and water retention of the propagation medium, investigators give preferences to the mixture instead of using a single substrate (Aklibasinda et al., 2011; Al-Salem and Karam, 2001; Al-Saqri and Alderson, 1996).

The physical properties of the different propagation substrates (water content, aeration capacity and drainage) together or separately affected adventitious root and shoot development in several studies. Yingqiang et al. (2007) assessed sand, perlite and peat mediums and mixture of them to the grapevine seedless cultivars hardwood cuttings. He observed high percentage rooting, quantities and strong adventitious roots to the cuttings planted in peat: sand: perlite (volume as 1:1:1) mixture. Sand may be linked to excessive aeration and low capacity of water retention, however, peat serves vice versa. Hechmi et al. (2013) found peat moss unsuitable because it produced large swellings at the bases of the cutting and occasional apical necrosis. Though, we did not observe such a symptom for 'MKR1' or 'Jiro', but soft particles of the peat may allow medium to retain excessive water, which probably brought anaerobic condition and stressed adventitious root formation. The addition of Bora-tsuchi (coarse particles) to the peat moss possibly improved aeration and retained water in a balance other than to over saturate the substrate. This was also confirmed by Al-Salem and Karam (2001) who improved rooting of the Greek strawberry by increasing perlite to the peat moss medium.

Our result of wounding plus IBA treatment was similar to that of Howard et al. (1984), who found a significant rooting response of the winter cuttings of apple rootstock M.26 to wounding and IBA treatment. Hardwood cuttings of the bitter almond collected in November also exhibited significantly maximum rooting and number of roots when wounding preceded IBA 10,000 ppm solution (Kasim et al., 2009). Wounding by making two opposite longitudinal incisions at the base of the cuttings and using different IBA concentrations were significantly effective for *Arbutus andrachne* L. root growth (Al-Salem and Karam, 2001). This paper later concluded that the rooting percentage was three times greater in the wounded cuttings than in the non-wounded. A threaten plant species *Leucadendron discolor* E. Phillips & S. Hutch, though to be difficult to propagate by stem cuttings, showed the high rooting percentages in the both terminal (85%) and basal (52.5%) stem cuttings when wounding followed with 4000 ppm IBA solution (Rodríguez Pérez et al., 1997). IBA without wounding encouraged less than 30% rooting in all the concentrations (Rodríguez Pérez et al., 1997). Apart from in vivo, in vitro rooting of a promising pear rootstock (*Pyrus betulaefolia* L.) was also increased with wounding followed by the low concentration of IBA (Pasqual et al., 2002).

Based on the result we obtained from a preliminary trial in 2015, 0.5% IBA in talc, without wounding didn't have stimulatory effects on adventitious root formation of 'MKR1' unmounded cuttings. Tetsumura et al. (2001a) also reported no impact of IBA to both mounded and unmounded hardwood sucker cuttings, soaked in 25 ppm IBA for 24 h or dipped in 3000 ppm IBA for 5 s. They stated that a possible reason for the ineffectiveness of the IBA treatment might be degradation of the IBA before it could exert an effect. In contrast, our study showed significant improvement to the wounding plus IBA treatment. Wounding might expose more cambium to the IBA and talc might avoid the rapid degradation. MacKenzie et al. (1986) illustrated that the incision as wounding treatment induced new cambium differentiates within the callus from undamaged cambium on either side. The new cambium then was sensitive to the applied auxin. Thus, high callusing (79%) of the wounded treatment of 'MKR1' seemed to be the case for IBA effectiveness (Table 2). 'Jiro' achieved the best rooting without wounding and IBA treatment. On the other hand, the high callusing (33.3%) of 'MKR1' with poor rooting (8.3%) might be due to the lack of exogenous auxin application (Table 1). Rooting via callus formation may depend on genotypes. A significant yield of the shoot fresh, dry weights, leaf number and leaf area by wounding in our study could be related to increased water absorption. Lin et al. (1997) described increase in water uptake as wounding benefit which keeps cutting leaves turgid.

In the present study, improvement in adventitious root formation of 'MKR1' would be more due to callus sensitivity to the applied auxin. Hence, stimulating callus with different types of wounding with or without IBA is required to be tested in the future researches.

In conclusion, although our results indicated that mounding alone was effective for 'Jiro' rooting, the addition of wounding and IBA would be necessary to stimulate rooting in 'MKR1' hardwood cuttings. Instead of pure peat, two-component medium of the peat and bora-tsuchi might be suggested for the planting.

Experiment 2

Propagation from single node softwood cuttings is now a practical method for obtaining clones of several persimmons. Cuttings planted in late June were more suitable for this method of propagation and responded more favorably to the substrate than did cuttings in late July or August (Table 3). Our results agreed with several reports that showed time of collection had a great influence over rooting of cutting of some trees and shrubs (Jalil and Sharpe 1956; Ryan and Frolich, 1962; Tetsumura et al., 2000; Pijut and Moore, 2002).

Tetsumura et al. (2000) reported that single node stem cuttings of a dwarfing rootstock of the Japanese persimmon (*Diospyros kaki* L.) produced high percent rooting and survival either in late June and July, while significantly low rooting and survival was occurring from the cuttings planted in August. Similarly, cuttings prepared from the root-suckers of 'Nishimurawase' and 'Jiro' rooted better when set in June than in July or August (Tetsumura et al., 2000). The rooting response of basal cuttings of 'Bartlett' pear was as high in June (100%) as it did in March (Ryan and Frolich, 1962). However, cuttings taken in May 23 did not root (Ryan and Frolich, 1962). Rooting percentage and quality of the peach cuttings taken in June were best, but gradually became poorer in July and August (Jalil and Sharpe, 1956). Gur et al. (1974) tested leaf-bud cuttings (including a small branch piece) for the almond × peach hybrid under intermittent misting. Success only achieved in May or in June planting. In our study, less or few rooting of the late July and late August planting may be due to a reduction in the growth rate of the suckers. Tetsumura et al. (2000) also linked decreases in rooting ability with growth rate of the root-suckers. The cuttings of deciduous shrub (*Amelanchier alnifolia* Nutt), with edible berry-like fruit, taken in late June returned better rooting than those taken 2 weeks earlier (Bishop and Nelson, 1980). The authors added that time and stage of growth were the most important considerations in regard to Saskatoon (*A. alnifolia* Nutt) propagation. Compared to August, June was the best season for clonal multiplication of *Alnus maritima* (Marsh.) Muhl. ex Nutt. landscape woody-plant species (Schrader and Graves, 2000). When means of the cuttings sources and IBA treatments were combined, more cuttings rooted (41%), survived (72%), and callused (67%) in June than did cuttings collected in August (8% rooted, 31% survived, 29% developed callus). In a correlation with our study where June yielded a significantly high root length, *A. maritima* also developed longer roots in June than did cuttings taken in August (Schrader and Graves, 2000). Pijut and Moore (2002) suggested June with 62 mM K-IBA or 74 mM IBA for the greatest rooting success (76.9 and 87.5%) of the butternut softwood cuttings. Japanese chestnut (*Castanea crenata* Sieb. et Zucc.) like Japanese persimmon is not easy to root (Tetsumura et al., 2008). However, the optimum rooting was evident for June (90%) and July (98%) than cuttings inserted in August (71%). Based on visual inspections, weather was rainy during late June planting, however, it was hot and sunny during late July and August. Hence, leaves desiccation which caused low rooting and survival in the latter months might be related to maximum ambient heating.

There was no significant difference between FTP and mist for rooting and survival (Table 3). Goh et al. (1995) also observed no significant difference between open and closed propagation chamber regarding survival and rooting percentages of *Gymnostoma sumatranum* [syn. *Casuarina sumatrana* (de Vriese) L.] softwood cuttings. He explained open chamber as a perforated plastic trough with cuttings put in a greenhouse, covered with a transparent polyethylene film and supported by a metal frame. Likewise, cuttings in a close chamber were tightly covered by Neoflon film, maintained high humidity around stem cuttings without any gas or temperature built up. Çet al. (1994) revealed that cutting of *Olea europaea* 'Gemlik' planted in the end June rooted better under shaded polyethylene tunnel (SPT) than in mist. SPT which was covered by a transparent polyethylene sheet and shaded with coarse white calico obtained overall 30-100% rooting, while mist did 0-40%. An economic tree of Shea (*Vitellaria paradoxa* Gaertn) acting as source of the income for semi-arid west Africa, multiplied successfully through a propagation bin (63.3%) and polyethylene propagators (57.5%) (Yeboah et al., 2011).

It is well known that nutrient leaching takes place from cuttings and often leaves become chlorotic under mist (Preece, 2003). Despite leaching problems, we observed deep humidity fluctuations to the mist during day-night period. Hence, significant difference for the FTP in terms of June rooting could be associated to consistence humidity and retention of the essential soluble plant substances. Contact tent polyethylene enclosures were also more favorable in relation to better rooting of three ornamentals than either of open propagation or mist (Mudge et al., 1995). Goh et al. (1995) concluded that a closed chamber without mist seemed to be an efficient plant propagation system, which required little attention and induced high yield. Mudge et al. (1995) revealed that earlier stomatal closure may have occurred in response to the higher temperature, which in turn reduced further water loss from contact polyethylene-enclosed cuttings. This phenomenon probably would be the case for the effectiveness of the FTP in our study.

The result displayed significantly lower callus for the FTP than was in the mist (Table 3). Tetsumura et al. (2008) also obtained high callus of the Japanese chestnut to the mist and fewer with the micro mist. They noted that formation of the callus might be affected by a propagation environment as well as a genotype of the cutting. Although, the cuttings were prepared from a single genotype, high callus of the mist in our study could be relatrd to the environment. In addition, we speculate that significantly high mean root length of the FPT would be due to water status. We have noticed that roots were growing well out of the drainage holes; however, they were not evident in the mist as pots were placed on a raised bench.

Rooting percentage, root length, and callus were affected by propagation substrates (Table 3). Peat produced the highest percent rooting, but it was significantly lower in perlite. The softwood cuttings of the red raspberry also rooted well and had more fibrous roots in peat than that of perlite, which didn't induce roots at all (Kobayashi et al., 1999). Under mist propagator, Jalil and Sharpe (1956) found inferior rooting of the peach cuttings in the grade 8 (2-3 mm) perlite. He asserted that perlite was the coarsest substrate and may hold less water than any of the other substrates. Mixing coarse perlite with peat and either used fine perlite alone returned significantly higher rooting (Jalil and Sharpe, 1956). Tetsumura et al. (2009) also observed cuttings of the Japanese chestnut in Bora-tsuchi easily wilted and died earlier in the mist than those in Metro-Mix®. They thought it might be associated with high porosity of Bora-tsuchi, where cuttings without roots couldn't uptake enough water from the cut surface. However, in a parallel experiment, Bora-tsuchi showed improved rooting to the micro mist, because of maintaining more than 60% relative humidity at midday even in the dry hot summer (Tetsumura et al., 2009). In a similar manner, perlite returned less rooting in the mist, but, it remarkably enhanced rooting with the use of FTP (Table 4). The fact that FTP contained always plenty of water at the bottom of the tray, which may replace transpired water rapidly and kept the ambient humidity optimum even in hot mid-days. Besides, good water holding capacity of the Metro-Mix® probably reflected the longest root length for this treatment.

Although, perlite was less responsive in some studies, it was more positive to the rooting of softwood cuttings of some woody species (Aiello and Graves, 1998; Fatemeh and Zaynab, 2014; Graves and Zhang, 1996; Jalil and Sharpe, 1956; Prat et al., 1998). Prat et al. (1998) reported that perlite alone was as good as its mixtures for the rooting of jojoba clones. It also exhibited better percent rooting, number of roots, root length, fresh and dry weights of the *Schefflera* cuttings than a couple of other substrates (Fatemeh and Zaynab, 2014). Kobayashi et al. (1999) insisted that a well-drained medium is important to select, because red raspberry cuttings were sensitive to overwinter. Thus, significantly high callus and 100% acclimatization survival in perlite might be attributed to a well drain status of the medium. Conversely, poor rooting of the perlite could be referred to the rapid loss of the water (Tables 3 and 4).

Researchers mostly focus to reduce dead cuttings and increase root formation, while few of them considered acclimatization. A special care should be taken for the hardening, because most of the plants are dying in this stage, particularly after transplanting into another or fresh medium. During hardening of our experiments, few cuttings were yellowed shortly after being weaned from the mist bench. Although there was no correlation between root number and cutting survival, desiccation often has been evident to the cutting which had one and short root. Perhaps, cuttings with only one root may easily die even from slight damages because an alternative root doesn't exist. Tetsumura et al. (2000) also considered abundant roots important for successful transplanting.

Although, perlite and Metro-Mix® maintained 100% percent acclimation survivals, they have shown deficiencies-like symptoms to the cutting foliage in late growth. These symptoms were also displayed by vermiculite with the exception of peat, which was the only intact treatment. Gur et al. (1974) found vermiculite suitable for a short time; however, for a long time growing of the rooted cuttings, he suggested mixture of the perlite and peat.

As a conclusion, FPT can utilize a number of substrates with maximum rooting than that of intermittent misting. It would be a safe substitute for the mist; however, additional research is needed to evaluate the use of FPT in large-based production. This may lower costs of the saplings and reduce the energy expenses.

Experiment 3

IBA concentrations significantly affected most of the rooting traits (Table 5). Percent rooting increased with increases in IBA concentration up to an optimum, before decreasing steadily. The number of roots per cutting and root lengths sharply increased at high concentrations. Root fresh and dry weights significantly increased from lower to high concentrations (Table 5). A similar trend was evident for the pomegranate semi-hardwood cuttings, where 9000 ppm was significantly an optimum for all the rooting characteristics, before falling at 12,000 ppm IBA (Owais, 2010). Olive stem cuttings also showed significantly maximum rooting (60%) at the first IBA treatment (3000 ppm) than it did either the control or high concentration (Kurd et al., 2010). Aminah et al. (1995) reported that IBA application improved number of roots on each cutting, but, higher doses were less responsive to the rooting of the *Shorea leprosula* single node leafy cuttings.

As a conclusion, although most of the rooting parameters except percent rooting gradually increased with increases of IBA, high concentration in particular 4000 ppm and 5000 ppm were appeared detrimental to tender bases of the 'MKR1' softwood cuttings.

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Comparison of growth between own-rooted and grafted 'Aikou' mango trees, and the effects of soil volume on the growth, yield, and fruit quality of potted own-rooted trees©

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Abstract

This study investigated the characteristics of own-rooted 'Aikou' mango trees (*Mangifera indica* L.) propagated by air layering. The own-rooted, 4-year-old trees were compared with grafted trees (Scion: 'Aikou', rootstock: 'Aikou' seedling). Growth of the own-rooted trees was significantly lower than that of grafted trees. Except for the shoots, thick branches, and fine roots, the flesh and dry weights of each own-rooted tree organ were lower than those of grafted trees. Total fresh and dry weights of the own-rooted trees were about 56% and 51% of the grafted trees, respectively. The effects of soil volume (15-, 30-, and 45-L pots) on own-rooted trees were also examined over 9 years. The differences in tree growth were not significant among soil volumes. In addition, the differences in yield, fruit number per tree, and average fruit weight among soil volumes were not significant. Fresh weights of the leaves and fine roots, as well as total fresh weights of the under-ground plant parts, increased with soil volume. There were no differences in the fresh weights of shoots, trunks, or thick roots among the soil volumes. Fresh weights of the above-ground plant parts and total tree fresh weights for the 30- and 45-L treatments were significantly greater than those of the 15-L treatment. Differences in dry weights of each organ were approximately the same as the fresh weight differences. There was no observed effect of soil volume on fruit quality.

INTRODUCTION

Mango (*Mangifera indica* L.) is a fruit tree that is difficult to propagate from cuttings. Although cuttings have been successful in rootstocks (Yamashita at al., 2006) and seedlings of cultivars (Reuveni and Castoriano, 1993; Reuveni et al., 1991), there are few reports of rooting by cuttings of cultivar (Nunez-Elisea et al., 1992). Therefore, mango propagation is usually performed by grafting using a Taiwan native strain as the rootstock source, as it is readily obtained in Japan.

Mango trees are generally tall. In Japan, however, mango trees are cultivated in greenhouses because they require warm conditions during cold weather and precautions are needed to prevent anthracnose infection. Greenhouses restrict tree height to ≤2 m by applying under-ground root restriction sheets or potting plants.

The vigor of tree grafted on a Taiwan native strain tends to become strong. Flower bud formation tends to be unstable, depending on the soil conditions. Temperatures during the autumn–winter period have increased due to global warming, which has resulted in new shoot growth during autumn. The instability of flower bud formation is becoming a serious problem in warmer regions.

Since grafting is performed relatively high above the ground (about 30 cm) to increase the survival ratio. This is particularly the case in pot culture, as pot height adds to total plant height. Fruit set position is higher and inconvenient where low tree height is preferred.

Grafted trees require 3 years to become productive. Therefore, a nursery price for mango trees is roughly 4-5 times greater than that for other fruit trees. If farmers grow

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recently planted mango, the initial cost of cultivation is higher than the price of other fruit trees, which has become an obstacle to increasing mango cultivation.

Cultivation using grafted nursery plants presents several problems for mango trees. In addition to the increased cost, the height of fruit set is increased in pot culture and flower bud formation is destabilized in response to increased tree vigor. One way to solve these problems is growing own-rooted trees. However, the cutting technique of mango trees is undeveloped, and there is very little information about own-rooted tree characteristics.

This study was performed to evaluate own-rooted nursery trees propagated using the air-layer technique (Fumuro, 2011). Own-rooted and grafted trees were compared, and the effects of container soil volume on tree growth, yield, and fruit quality in own-rooted 'Aikou' trees were investigated.

MATERIALS AND METHODS

These experiments were performed in the greenhouse (width: 7.5 m, length: 22 m; 165 m^2) at the experimental farm of Kinki University (Yuasa, Wakayama Prefecture, Japan).

Experiment 1. Comparison of tree growth between own-rooted and grafted trees

In the own-rooted nursery, the air-layer technique was performed using 'Aikou' trees planted in a greenhouse on 8 Sept. 2007. A 1-naphthaleneacetic acid (NAA) solution (2,000 ppm, 50% ethanol) was sprayed on the girdles (width: 2-3 cm) of air-layered branches and covered with polythene bottomless bags. The ends of the branches were then tied with a string. The bags were filled with moist vermiculite, and the tops of the branches were tied with a string. Subsequently, the outside was covered with aluminum foil to prevent high-temperature damage. On 11 Nov., the rooted branches (Figure 1) were removed and planted in a small pot (diameter: 13.5 cm, height: 11 cm). On 21 Aug. of the following year, the own-rooted nursery was planted in pots made of non-woven fabric (25-L pot; diameter: 30 cm, height: 30 cm) and filled with a mixture of mountain soil, perlite, compost, and vermiculite (1:1:1:1, by vol.).

Figure 1. Rooting of air-layered 'Aikou' mango.

On 15 Jun. 2008, in the grafted nursery, the 'Aikou' scion was grafted onto 2-year-old rootstock ('Aikou' seedling) planted in polythene pots (diameter: 24 cm, height: 24 cm; 9 L). On 5 Oct. they were planted in a pot made of non-woven fabric as described above. In this experiment, all inflorescences were removed during flowering. Root age of the trees used was 4 years for both the own-rooted and grafted trees.

A dissecting survey was performed 19-20 Feb. 2011. Four trees were included for each nursery tree. Trunk diameter was measured using calipers at 10 cm above the ground for the grafted tree and about 3 cm above the ground for the own-rooted tree. The total number of leaves and total shoot length per tree were measured. Thereafter, all trees were separated into leaf, branch, trunk, thick root (≥1 mm in diameter), and fine root (<1 mm in diameter) categories.

Because the scion was grafted 20-30 cm above the ground, the trunk included the stem of the rootstock seedling. After measuring their flesh weights, the extracted part of each organ was dried and the dry matter percentage was determined. The total dry weight of each organ was calculated by multiplying the dry matter percentage and the total fresh weight of each organ.

Experiment 2. Effects of pot-culture soil volume on tree growth, yield, and fruit quality in own-rooted trees

Air layer propagation was performed on 8 Sept. 2007 in the same manner as Experiment 1. On 11 Nov., the rooted branch was removed and then planted in a small pot on 7 Aug. of the following year. The own-rooted nursery was planted in three types of pots made of non-woven fabric (15-L pot: 28×28 cm; 30-L pot: 36×30 cm; 45-L pot: 42×30 cm, in diameter and height) filled with 15, 30, and 45 L of the soil mixture described above. The between-row spacing was 1.2 m and the with-in row spacings were 1, 2, and 3 m for the 15, 30, and 45-L pots, respectively. Four trees were planted for each soil volume.

The harvest dates were as follows: 13 Aug. – 27 Sept. 2011, 17 Aug. – 21 Sept. 2012, 17 Aug. – 24 Sept. 2013, 15 Aug. – 15 Sept. 2014, and 9 Aug. – 17 Sept. 2015. The fruits were covered with a bag-shaped net in advance, and harvested ones that dropped into the net naturally. After measuring fruit weight, data on the qualities of 8–9 fruits harvested in late August-early September were recorded. Peel color (Hunter's L-, a- and b-values) was measured using a color-difference meter (CR-400; Konica-Minolta, Tokyo, Japan) at the center of the equator on the side of the fruit. Flesh firmness was determined by first removing 3-cm diameter patch of peel with a sharp knife and then using a Magness-Taylor-type fruit plunger (FT011; Effegi, Alfonsine, Italy) mounted on a plunger with a 11.3-mm diameter. The maximum force was recorded after the plunger penetrated 7 mm into the flesh through the cut surface. Measurements were recorded on both sides of the fruit and the values were averaged. Flesh was collected from the center of the equator on both sides of the fruit. Juice from the fruit was then squeezed and filtered through gauze, and total soluble solids (TSS) and titratable acidity were recorded. The TSS was measured using a refractometer (PAL-1; Atago, Tokyo, Japan). Titratable acid levels were determined by titrating with 0.1 N NaOH to a phenolphthalein endpoint and converting to citric acid content. The trunk diameter, leaf number, and shoot length per tree were measured in late December.

The dissecting survey was performed during 16-21 Oct. 2015. The trees were 9 years old at the time of the dissecting survey (Figure 2). Tree height and the longer and shorter diameters of the tree crown were measured, and then the land area occupied by the tree canopy was calculated as follows: Land area occupied by the tree canopy = longer diameter × shorter diameter × π/4.

Flesh and dry weights of each organ per tree were measured in the same manner as in Experiment 1. Leaf area was measured using an automatic leaf area meter (AAM-9; Hayashi Denko, Tokyo, Japan). A total of 30 leaves were randomly sampled from each tree. The average leaf area was calculated, followed by multiplying the average leaf area and the total number of leaves per tree.

Throughout Experiments 1 and 2, the greenhouse was heated from early December to a minimum temperature of 6°C. This minimum temperature was gradually increased from mid-February, and maintained at 18-20°C from the middle of March until the late of April during the flowering period. A fan was used for ventilation to ensure the internal air temperature remained below 35°C. The plants were watered daily by automatic irrigation. Fertilization, disease control, and pest control were all performed according to conventional procedures.

Figure 2. Effects of pot culture soil volume on tree growth in nine-year-old own-rooted 'Aikou' mango trees. Left: 45-L pot, Middle: 30-L pot, Right: 15-L pot.

RESULTS AND DISCUSSION

Experiment 1. Comparison of tree growth between own-rooted and grafted trees

The trunk cross-sectional area, total shoot length, and total leaf number of the own-rooted tree were significantly lower than those of the grafted tree (Table 1). With the exception of shoots, thick branches, and fine roots, the flesh and dry weights of each organ in the own-rooted trees were lower than those of the grafted trees (Tables 2 and 3). In particular, the fresh weights of thick roots from the own-rooted trees were only one quarter that of the grafted trees, which was attributed to the lack of root crowns on the own-rooted trees. Total fresh and dry weights of the own-rooted trees were about 56 and 51% of the grafted trees, respectively.

Table 1. Comparison of tree growth between four-year-old own-rooted and grafted 'Aikou' mango trees.

	Trunk cross-sectional area (cm^2)	Total shoot length (m)	Total leaf number (No. $tree^{-1}$)
Own-rooted	8.5	486.3	299.8
Grafted	18.3	1097.2	404.3
Significance	**	*	*

*: Significant at P=0.05, **: Significant at P=0.01 by t-test, respectively.

Table 2. Comparison of fresh weight of each organ between four-year-old own-rooted and grafted 'Aikou' mango trees.

	Above-ground part fresh weight (g)					Under-ground part fresh weight (g)			Total
	Leaf	Shoot	Thick branch	Trunk	Total	Thick root	Fine root	Total	(g)
Own-rooted	769	557	407	164	1897	108	239	347	2244
Grafted	1238	782	511	689	3220	471	320	791	4011
Significance	*	NS	NS	***	*	**	NS	*	*

NS: Non-significant at P=0.05, *: Significant at P=0.05, **: Significant at P=0.01, ***: Significant at P=0.001 by t-test, respectively.

Table 3. Comparison of dry weight of each organ between four-year-old own-rooted and grafted 'Aikou' mango trees.

	Above-ground part dry weight (g)					Under-ground part dry weight (g)			Total
	Leaf	Shoot	Thick branch	Trunk	Total	Thick root	Fine root	Total	(g)
Own-rooted	359	175	136	51	721	35	51	86	807
Grafted	580	275	185	250	1290	200	81	281	1571
Significance	*	NS	NS	***	*	**	NS	**	*

NS: Non-significant at P=0.05, *: Significant at P=0.05, **: Significant at P=0.01, ***: Significant at P=0.001 by t-test, respectively.

In this study, the ages of the own-rooted and grafted trees were calibrated to the ages of the under-ground tree parts. Since it has been reported that growth of above-ground parts is consistent with growth of under-ground parts (Fumuro, 1999), it is necessary to equalize the age of the under-ground parts. When the seedling is approximately 2 years old, the root system at the time of grafting is already developed. By contrast, since an own-rooted tree is regarded as 1-year-old when an air-layered branch is rooted, it is assumed that growth of own-rooted trees is typically less than that of grafted trees. Therefore tree growth of own-rooted trees may be less than that of grafted trees because of this younger age.

The growth of own-rooted mango trees propagated by an air layer is reported to be slower than that of grafted trees (Ram, 1993). Growth of the own-rooted 'Hiratanenashi' persimmon by micropropagation is lower than that of grafted trees at 7 years after orchard planting, whereas there is no consistent trend for the 'Fuyu' tree (Tetsumura et al., 2010). In addition, comparisons between own-rooted and grafted 'Aikou' mango trees growth, fruit yield, and quality have been performed since 2009. Large differences between own-rooted and grafted trees have not been observed (data not shown). Furthermore, in Experiment 1, there were no fruits, so all photosynthetic products were used for growth. As a result, it is possibility that accelerated growth of grafted tree which the initial growth was superior to own-rooted tree.

Experiment 2. Effects of pot culture soil volume on tree growth, yield, and fruit quality in own-rooted trees

The differences in tree growth, yield, fruit number, and average fruit weight were examined for 15-, 30-, and 45-L pots over 9 years (Figure 3). There were no significant differences in tree growth, although the trunk diameter (A), total leaf number (B), and total shoot length (C) gradually increased in all soil volumes and during each year except yield and fruit number of 8-year-old trees in 45 L-pots were significantly higher than those in 15 L-pots, and average fruit weight of 9-year-old trees in 15 L-pots was significantly higher than those of 30- and 45-L pots, there were no significant differences in yield (D), fruit number (E), and average fruit weight (F) among the soil volumes.

There were no other significant differences in tree height, trunk cross-sectional area, area occupied by the tree canopy, or leaf area of 9-year-old trees among the three soil volumes (Table 4). The flesh weights of leaves, and fine roots were greater with increased soil volume. There were no differences in shoots, trunks, or thick roots among the soil volumes (Table 5). Although fresh weights of under-ground parts were greater with increased soil volume, weights of the above-ground parts, and total trees in 30- and 45-L pots were significantly greater than those of the 15-L pot.

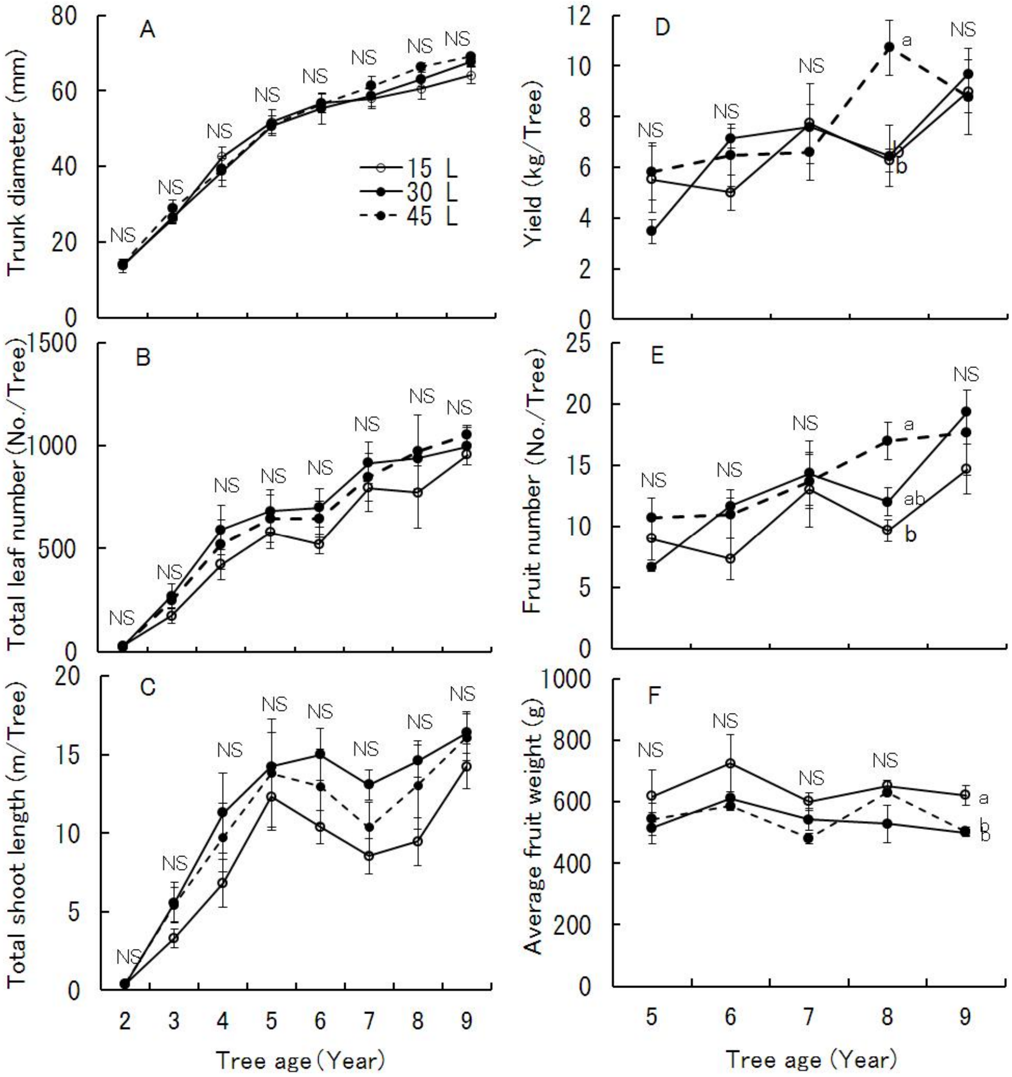

Figure 3. Effects of pot culture soil volume on trunk diameter (A), total leaf number (B), total shoot length (C), yield (D), fruit number (E), and average fruit weight (F) in nine-year-old own-rooted 'Aikou' mango trees. Vertical bars represent ± SE. Values followed by same letter and NS indicate not significantly differ (*P*<0.05) by Tukey-Kramer's multiple range test.

Table 4. Effects of pot culture soil volume on tree growth in nine-year-old own-rooted 'Aikou' mango trees.

Soil volume (L)	Tree height (m)	Trunk cross-sectional area (cm^2)	Area occupied by tree canopy (m^2)	Leaf area (m^2)
15	1.91	28.0	2.84	8.4
30	1.94	30.7	3.50	8.5
45	1.82	31.8	4.20	10.6
Significance	NS	NS	NS	NS

NS: Indicate not significantly different (*P*<0.05) by Tukey-Kramer's multiple range test.

Table 5. Effects of pot culture soil volume on fresh weight of each organ in nine-year-old own-rooted 'Aikou' mango trees.

Soil volume (L)	Above-ground part fresh weight (kg)					Under-ground part fresh weight (kg)			Total (kg)
	Leaf	Shoot	Thick branch	Trunk	Total	Thick root	Fine root	Total	
15	2.52 b[1]	1.08 a	3.84 b	0.36 a	77.80 b	1.46 a	0.49 bb	1.95 bb	99.75 b
30	2.95 ab	1.08 a	5.67 a	0.47 a	10.17 a	1.49 a	1.22 ab	2.71 ab	12.88 a
45	3.47 aa	1.35 a	5.64 a	0.42 a	10.88 a	1.49 a	1.33 aa	2.82 aa	13.70 a

[1]Values in a column followed the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Furthermore, the differences in dry weights of each organ were approximately the same as the fresh weight differences, except for fine roots and total of under-ground parts in 30- and 45-L pots were significantly greater than those of 15-L pots (Table 6). There was no effect of soil volume on fruit quality (Table 7).

Table 6. Effects of pot culture soil volume on dry weight of each organ in nine-year-old own-rooted 'Aikou' mango trees.

Soil volume (L)	Above-ground part dry weight (kg)					Under-ground part dry weight (kg)			Total (kg)
	Leaf	Shoot	Thick branch	Trunk	Total	Thick root	Fine root	Total	
15	1.12 b[z]	0.33 a	1.32 b	0.13 a	2.90 b	0.52 a	0.14 b	0.66 b	3.56 b
30	1.35 ab	0.32 a	2.06 a	0.16 a	3.89 a	0.53 a	0.34 a	0.87 a	4.76 a
45	1.56 aa	0.39 a	2.06 a	0.15 a	4.16 a	0.50 a	0.36 a	0.86 a	5.02 a

[z]Values in a column followed the same letter are not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Table 7. Effects of pot culture soil volume on fruit quality in nine-year-old own-rooted 'Aikou' mango trees.

Tree age (year)	Soil volume (L)	Peel color			Flesh firmness (kg cm^{-2})	TSS (%)	Organic acid (%)
		L-value	a-value	b-value			
5	15	35.8	13.0	8.1	0.67	15.9	0.17
	30	38.5	11.3	9.5	0.64	16.0	0.14
	45	36.1	14.1	8.1	0.73	15.7	0.16
Significance		NS	NS	NS	NS	NS	NS
6	15	39.1	20.5	13.1	0.62	16.7	0.13
	30	37.8	19.8	10.4	0.75	17.4	0.14
	45	38.6	17.4	13.4	0.81	16.5	0.17
Significance		NS	NS	NS	NS	NS	NS
7	15	37.9	18.5	12.6	0.74	16.0	0.17
	30	36.8	16.0	13.4	0.73	15.8	0.19
	45	37.0	14.8	15.3	0.80	16.3	0.16
Significance		NS	NS	NS	NS	NS	NS
8	15	35.8	17.1	12.4	0.73	16.0	0.17
	30	34.7	16.1	11.6	0.75	15.6	0.18
	45	37.5	16.2	11.9	0.79	15.9	0.16
Significance		NS	NS	NS	NS	NS	NS
9	15	36.5	10.6	13.9	0.79	15.5	0.15
	30	36.6	10.3	13.7	0.76	15.1	0.17
	45	37.2	11.7	14.5	0.80	15.2	0.15
Significance		NS	NS	NS	NS	NS	NS

NS indicate not significantly different (P<0.05) by Tukey-Kramer's multiple range test.

Since 15-L pots were overcrowded with roots, there may have been insufficient pot volume to facilitate root expansion. By contrast, 30- and 45-L pots likely provided sufficient room to allow root growth. It was hypothesized that there was no difference in tree growth between the 30- and 45-L pots because the spacing between the 45-L pots did not allow the canopy to expand fully and match the increased potential for root growth afforded by the larger pot volume.

The own-rooted ‘Dorian’ had no taproot and was short-lived (Nakasone and Paull, 1997). However, based on results from this experiment, it was considered that the 15-L pot was suitable until the tree was 9-years-old, while the 30- and 45-L pots may be suitable for long-term tree cultivation.

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Breaking dormancy by successive low and high temperature on the seed germination of *Glehnia littoralis*©

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Abstract

***Glehnia littoralis* Fr. Schmidt ex Miquel (*Apiaceae*, syn., *Umbelliferae*) is one of the typical seaside plants and is endemic to Japan, Korea, and China. The tap root has been used as a Kampo medicine and as a vegetable for the Japanese traditional dishes. In recent years, the extinction of *Glehnia littoralis* is worried about because of illegal harvesting from its natural habitats. For vegetation recovery, it is necessary to do seed propagation from seeds gathered in the same indigenous place to avoid disturbance of each ecosystem. Therefore we tried to clarify the effect of low temperature and successive low and high temperature treatments to seeds before sowing on the germination rate. Low temperature treatment promoted germination. However, germination rate of each fruit cluster was obviously different. The successive low (L), high (H) and low (L) temperature treatment remarkably accelerated seed germination compared with H and L treatments. Especially the L4H4L4 treatment caused the highest rate (58%) through these all experiments.**

INTRODUCTION

Japan has a long coastline in the country which consists of many islands. However, the natural coastal environment decreases remarkably by recent years' development activity and seashore constructions. Besides baggy cars for leisure enter into the remaining natural coast areas and have been destructed the beach ecosystem. The important vegetation of valuable seaside plants to maintain the beach ecosystem is being lost as a result. The plant which grows naturally in the location near the seashore strandline contributes to prevent blown sand and keep the ecosystem in stability. *Glehnia littoralis* Fr. Schmidt ex Miquel (*Apiaceae*, syn. *Umbelliferae*) is one of the typical seaside plants and is endemic to Japan, Korea and China. The tap root has been used as a Kampo medicine which eases the symptom of cold because of its alleviation of fever and an anodyne action (Ito et al., 2012). Moreover, in Japan, the leaf is used as a vegetable for the Japanese traditional dishes. In recent years, the extinction of *G. littoralis* is worried about because of illegal picking out from its natural habitats. For vegetation recovery, it is necessary to do seed propagation from seeds gathered in the same indigenous place to avoid disturbance of each ecosystem (Yahara and Kawakubo, 2002).

Besides it will be the result which stops the illegal harvesting when it is possible to supply the *G. littoralis* seedlings of the amount corresponding to the market demand. As a preliminarily, we have checked the effect of 24-h seed dipping in gibberellic acid (GA_3) solutions at the concentration of 0, 10, 100, 1000 ppm on the germination rate of *G. littoralis* seeds. But there was no effect of GA_3 on the promotion of seed germination. From this result, it seems that *G. littoralis* seeds have very deep physiological dormancy (Khan, 1996; Derkx, 2000; Baskin and Baskin, 2004).

In this reports, we examined the effects of low temperature and successive low and high temperature treatments on the germination rate of *G. littoralis* seeds before sowing. The successive low and high temperature treatments described as "hot and cold method" by Kamata (1987) through the series of seed germination experiments on wild *Lilium* species, especially on the so-called hypogeal germinating seed type. For example, seeds of *L. japonicum* and *L. rubellum* belong to the hypogeal type that require more than 1½ years for the start of true leaf emergence

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under natural condition (Kamata, 1987).

MATERIALS AND METHODS

We used seeds from wild plants (Experiment 1) collected from a natural habitat at the coast of Chigasaki, Kanagawa Pref., Japan and commercial ones (Experiments 2 and 3) purchased from a commercial company (Bio-plant Farm Ecoland Sansai-Kobo) located at Shibetsu, Hokkaido, Japan).

Experiment 1: Effect of low temperature on seed germination from wild plants

After collection from natural habitat, seeds were sown into five commercial garden planters and grown until maturity for 4 years under outside natural condition. Seeds from the mature plants were collected at three different fruit maturing stages: (G) green fruits stage, (GB) half the fruits had turned to brown, (B) color of almost fruits were brown. The viable seed (with embryo) numbers of respective fruit clusters were within the range between 200 and 300 in this experiment. The seeds were washed with tap water repeatedly until seeds absorbed water sufficiently, and then seeds of each fruit cluster were separately packed in a plastic bag to avoid drying and stored in a refrigerator at 4±2°C. After 4, 8, 12, 16 and 20 months from the start of low temperature treatment, germination rate of each fruit cluster was recorded. In this experiment, germination was defined as the seed with more than a 3-mm long root.

Experiment 2: Effect of low temperature on germination of purchased seeds

The method for Experiments 2 and 3 are those of Takahata et al. (2008, 2011). Purchased seeds were washed with tap water repeatedly until seeds absorbed water sufficiently, and then the seeds were sown in a 200-cell tray (Yanmar Co., Ltd., Osaka, Japan) cut in ¼ (50 seeds per treatment) filled with a commercial germinating soil mixture (Yosaku N-150; $N:P_2O_5:K_2O$ = 150:1000: 150 mg L^{-1}; Jcam Agri Co., Ltd., Tokyo, Japan). The trays watered and put in Uni-pack (J-4, 340 (long) × 240 (wide) × 0.04 (thick) mm, Seisan-nippon-sya Ltd., Tokyo, Japan). Then they were placed in a refrigerated chamber set at 5°C. The low temperature treatment was carried out for 2 to 20 weeks under continuous darkness. After the indicated period of low temperature treatment, each of the trays was moved to an germinating incubator (LH-200, Nippon Medical & Chemical Instruments Co., Ltd., Tokyo, Japan) at the set condition with 12 h-light (111 µmol m^{-2} s^{-1} PPFD)/12 h-dark and 17.5°C. The process of seed germination was recorded for 25 days. In this experiment, germination was defined as the visible observation of unfolded cotyledons.

Experiment 3: Effect of successive low and high temperature treatments on germination of purchased seeds

The seeded trays underwent the same procedure as in Experiment 2 and were treated as indicated in Table 1 in three temperature conditioned incubators as follows: low (L), middle (M) and high (H). The incubators were set at 5, 17.5 and 30°C respectively under continuous darkness. After the successive temperature treatment, each of the trays was moved to the germinating incubator mentioned above and the process of seed germination was recorded for 25 days. In this experiment, germination was defined as the visible observation of unfolded cotyledons.

Table 1. The experiment conditions of temperature and period.

Treatment[1]	Temperature (°C)			
	4 weeks	8 weeks	12 weeks	16 weeks
L4H8L4	5	30	30	5
L4H4M4L4	5	30	17.5	5
L4H4L4	5	30	5	
H8L4	30	30	5	
H4M4L4	30	17.5	5	
H4L4	30	5		
L4 (control)	5			

[1]L: Low (5°C), M: Middle (17.5°C), H: High (30°C).

RESULTS

Experiment 1: effect of low temperature on seed germination from wild plants

Low temperature treatment promoted germination of wild *G. littoralis* seed (Figure 1). However, germination rate of the fruit clusters from the different maturing stages was obviously different. The seeds of the GB stage germinated earlier, that is, half of seed germinated within 8 months. On the other hand, the G stage seeds required more than 1 year for half of them to germinate. Moreover, the germination progress was not linier, it changed step by step. This indicated that there were seeds in the same fruit cluster with varying chilling requirements for breaking dormancy.

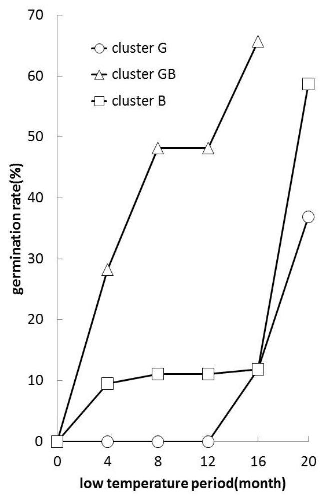

Figure 1. The germination rate of each cluster of *Glehnia littoralis* under 4°C.

Experiment 2: effect of low temperature on germination of purchased seeds

Low temperature treatment also promoted germination of purchased seeds (Figure 2). However, there was no significant tendency in the relationship between low temperature treatment period and accelerated effect of germination. Germination rate was less than 10% when the period of low temperature was less than 6 weeks and 14 weeks. In this experiment, seed treated at 12-week low temperature shown the earlier germination and the highest rate of germination (32%).

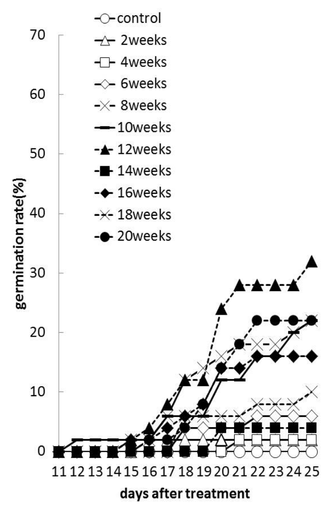

Figure 2. The germination rate of each cluster of *Glehnia littoralis* under 4°C.

Experiment 3: effect of successive low and high temperature treatments on germination of purchased seeds

The successive low (L), high (H) and low (L) temperature treatment remarkably accelerated seed germination compared with H and L treatments (Figure 3). Especially the L4H4L4 treatment caused the highest rate (58%) through these whole experiments. However, the accelerating effect declined when the H/M period between L and L was long (l4H8L4, L4H4M4L4).

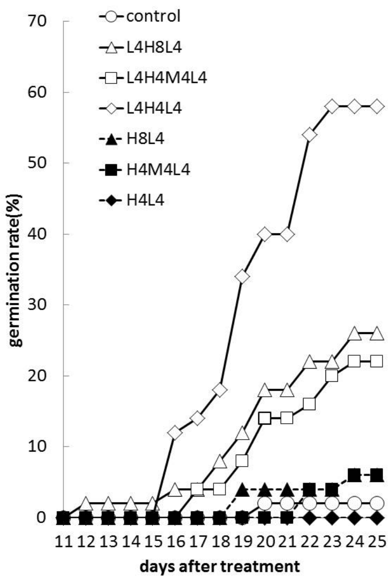

Figure 3. Effects of successive temperature treatments on seed germination in *Glehnia littoralis*. L: 5°C, M: 17.5°C, H: 30°C.

DISCUSSION

From the result of Experiment 1, *G. littoralis* wild seed has considerably deep dormancy and the level of dormancy deepness was remarkably different depending on the developmental stage of fruit and/or each individual plant. At least, the seed dormancy at the BG fruit stage was relatively light compared with the younger (G) and the older (B) stage (Figure 1). If *G. littoralis* wild seeds are sown under the natural condition without pretreatment, it is necessary for more than 2 years from seed sowing to get more than 50% of seed germination. The diversity of dormant depth seems to be functioning as one of necessary safety devices to leave next generation in the natural environment. On the other hand, the diversity is troublesome in cultivation. The diversity was also shown from purchased seeds. The low temperature treatment was effective in stimulation of germination in purchased seed, but the effect was variable (Figure 2). It seems that the variable effect caused by the coexistence of different dormancy depths in the seeds. However, it was shown that even with seeds having a deep dormant it was possible to break dormancy in a short time by the low-high-low temperature treatment (Figure 3).

From the preliminary observation of embryo development in seeds just after harvest from the natural habitat, the embryo developmental stage of the seeds was not uniform (data not shown). Thus we guess that the first low temperature accelerate the after ripening of immature embryos, the second high temperature raise the cold-sensitivity of developed embryos, and the final low temperature broke the dormancy of the embryo. There was a possibility that a longer high temperature period between low and low temperatures caused secondary embryo dormancy. In this experiment, the highest value of germination was 58% after the L4H4L4 treatment. This value will make it possible to obtain enough seedlings within a year after seed sowing to make seed propagation possible in practice.

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Weed management assessment for public flower beds©

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Abstract

A lack of participants and techniques for weeding of flowerbeds in public spaces has multiplied the difficulties inherent in local social gardening. This study was conducted to ascertain a weed threshold for management of flowerbeds in public spaces from the relation between flower plant growth and the amount of weeds remaining after weed removal activities. We planted blue salvia seedlings (*Salvia farinacea*) in a field. Later, at 31 days and 85 days after transplantation of the plants, we measured the blue salvia plant height and plant coverage. Additionally, we measured the dry matter weight of remaining weeds after 20 people had removed weeds from flowerbeds. Results show that remaining weed dry matter weight and rate of remaining weeds at 31 days after transplantation were 1.4 g m^{-2} and 1.6% when the plant height and plant coverage of blue salvia were 10.4 cm and 8.3%. The same measures at 85 days after transplantation were 10.8 g m^{-2} and 18.2% when the plant height and plant coverage of blue salvia were 47.9 cm and 56.0%. A significant positive correlation was found between the blue salvia plant coverage and the rate of remaining weeds. Results obtained using linear regression suggest a remaining weed threshold for flowerbed management based on the plant coverage of the flower plants being planted.

INTRODUCTION

For over a decade in Japan, home gardening has remained among the top 20 most popular leisure activities (Japan Productivity Center, 2015). Moreover, gardening volunteer activities by which local residents proactively manage flowerbeds in public spaces, such as local resident parks and streets, have become important social welfare activities to ensure the cleanliness, health, and safety of residential areas. However, shortages of participants and technical deficits are looming difficulties related to social gardening activities in Japan, including gardening volunteerism, because of age and a lack of new participants in activities (Otake et al., 2008; Yamazaki et al., 2011). Continuity has loomed as a daunting future difficulty (Mitarai et al., 2011, 2012). People managing flowerbeds in public spaces as social gardening activities have pointed out specific difficulties such as a shortage of participants, lack of time, and the high frequency of management activities during times of weeding flowerbeds (Iwamura and Yokohari, 2000). An minimum indispensable weeding frequency that managing members and spectators of open space flowerbeds must observe should be proposed. That effort must be sufficient to provide a "clean" area after weeding of flowerbeds in public spaces. Then weed management technologies must be developed to maintain social gardening activities.

A theory of economic thresholds can be referred from harvest sales revenue data and weeding expenses for weed control during crop production (Auld et al., 1987; Coble and Mortensen, 1992; Wilkerson et al., 2002). Similarly, a weed threshold for open space flowerbed weed management might be regarded as the degree to which remaining weeds are recognized as "clean" by spectators and management members.

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To date, rating scales such as semantic difference (SD) methods have been used for recognition of feelings such as "clean" (Osgood et al., 1957; Xiong et al., 2006; Ichihara, 2009). However, it is necessary to show recognition of feelings as "clean" in absolute measures such as the amount of weeds before or after weeding for the assessment of weed management techniques. We attempted to present a valid "remaining weed threshold" for managing flowerbeds based on the amount of weeds remaining after flowerbed weeding.

MATERIALS AND METHODS

A flowerbed was set up in a field of Tokyo University of Agriculture, Faculty of Agriculture in Atsugi city, Kanagawa prefecture. A 1.3×9.0 m section was set aside in the field. Then, the section was separated into 20 small 0.6×0.9 m plots. Blue salvia (*Salvia farinacea* Benth.; Sakata Seed Corp., Japan) was chosen as the flower to be cultivated in the flowerbed during summer. Blue salvia seeds were planted in cell trays of 180 holes on 21 May 2015. The growing seedlings were transplanted in 0.3×0.3 m into all plots on June 30. The plant height and plant coverage of blue salvia were measured in all plots at the time of 31 days and 85 days after transplantation. The plant coverage shows the rate of cover of blue salvia per small plot. Then, about 20 people weeded the small plots. We took all remaining weeds after weeding by the people. The weeds that were taken by the people and the remaining weeds which we took were put in separate envelopes for each plot. Those envelopes and the weeds inside were dried at 80°C 48 h. Then the dry weights of those weeds were measured. We calculated the rate of remaining weeds, which is the ratio (percentage) of the remaining weed dry matter weight to the total weed dry matter weight.

RESULTS AND DISCUSSION

Plant heights of blue salvia were, respectively, 10.4 and 47.9 cm at 31 days and 85 days after transplantation (Table 1). Plant coverage of blue salvia was, respectively, 8.3 and 18.2% at 31 and 85 days after transplantation (Table 1). Weed dry matter weights at the time of weeding by the 20 people were, respectively, 94.8 and 41.7 g m^{-2} at 31 days and 85 days after transplantation (Table 1). The remaining weed dry matter weights after weeding by about 20 people were 1.4 and 10.8 g m^{-2}, respectively, at 31 days and 85 days after transplantation (Table 1). The rates of remaining weeds were 1.6 and 18.2%, respectively, at 31 and 85 days after transplantation (Table 1). A significant positive correlation (P<0.01) was found between plant coverage of blue salvia and the rate of remaining weeds. Additionally, linear regression between these parameters revealed $y = 0.31x - 0.13$ (Figure 1). Furthermore, a significant positive correlation (P<0.01) was found between the blue salvia plant height and the rate of remaining weeds (Figure 2).

Table 1. Condition of blue salvia and weed at the time of weeding.

	31 days after transplanting[1]	85 days after transplanting
Plant growth of blue salvia		
Plant height (cm)	10.4±2.1	47.9±4.0
Plant coverage (%)	8.3±1.9	56.0±12.5
Weed		
Dry matter weight of weeding (g m^{-2})	94.8±33.5	41.7±22.3
Dry matter weight of remaining weeding (g m^{-2})	1.4±1.9	10.8±13.7
Rate of remaining weed (%)	1.6±1.8	18.2±14.7

[1]Mean±standard deviation 31 and 85 days after transplanting are, respectively, July 31 and September 23.

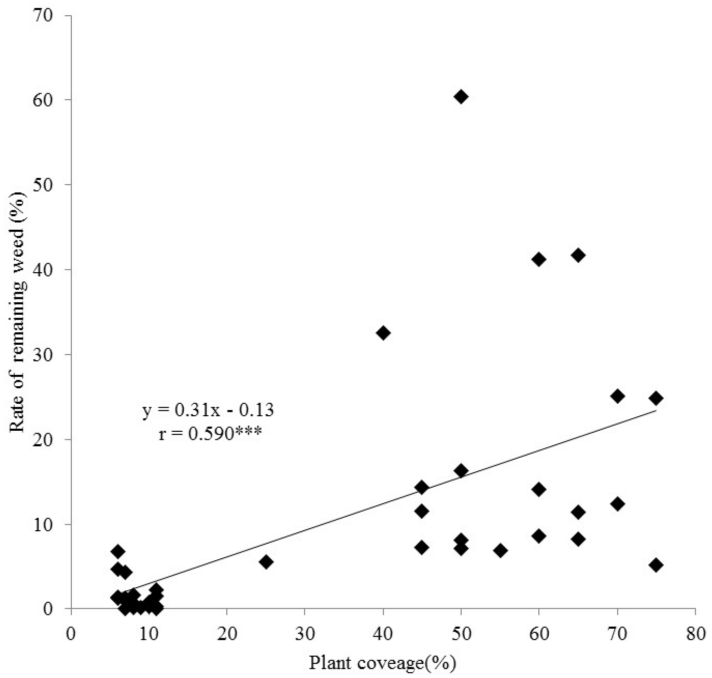

Figure 1. Relation between plant coverage of blue salvia and rate of remaining weeds.

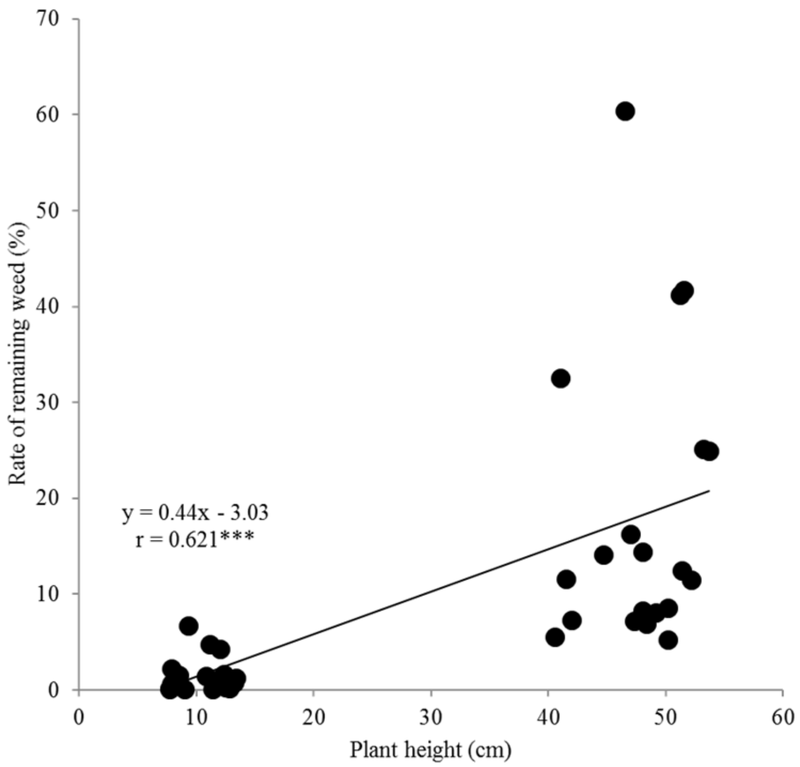

Figure 2. Relation between plant height of blue salvia and rate of remaining weeds.

The rates of remaining weeds show the extent of remaining weeds after weeding by about 20 people. This is the amount of remaining weeds judged as leaving the flowerbed “clean” after weeding by the people. This study found a significant positive correlation between plant height or plant coverage of blue salvia and the rate of remaining weeds (Figures 1 and 2), suggesting that the remaining weed threshold is presented by measuring the plant height of flowering plants planted in flowerbed of the open space. In addition, results of this study suggest that the amount of allowable remaining weeds might be greater with increasing plant height. This point must be examined for support of future studies because the only test plants were blue salvia. This study did not evaluate the actual activity of gardening volunteers. However, some possibility exists of measuring the available presentation interval and amount of weeding based on plant height or plant coverage of flowering plants transplanted in a flowerbed.

Weed management of flowerbeds in public spaces such as local resident parks and streets is indispensable for the expansion of gardening activities in the private or public domain. The period of weed-free maintenance necessary to keep an economic threshold of weeds that is well-known as a low yield cause of the crop has been presented for some crops in weed management (Hauser et al. 1975; Noguchi, 1983). However, it is necessary for control of weeds that spectators and management members regard it as being “clean,” in conjunction with the control of weeds to poor growing flower plants, in flowerbeds for retention of the landscape and amenity space. Few reports of the relevant literature have described studies of weed management of flowerbeds (Steven et al., 1997; Beddes and Hratsch, 2008) because it is not weed management in agriculture for human life support. The results of our experiment present new possibilities for establishing a basis of weed management technology in terms of the sense of what is “clean” to people in flowerbeds in amenity spaces.

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Effects of a plant enhancement liquid, FFC Vegemake©, for plant growth©

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INTRODUCTION

Since 1984, Akatsuka Garden Company has focused on the behavior of certain ions, especially iron ions in water and interactions of water molecules with them. We have continued research on various solutions to not only accelerate plant growth, but also activate physiological functions of plants. Based on this research, we have developed FFC materials such as "FFC-Ceramics" (for water improvement), "FFC-Ace" (for soil improvement) and others.

In addition, many agricultural producers in Japan have been utilizing FFC materials to rejuvenate plants and increase profits. Those producers have also explored many other possible methods of using FFC materials and consequently found good ways that benefit their actual production sites.

As a result, they have obtained many advantages over years of use, such as improved productivity, cost reduction, decreased dependence on agricultural chemicals among others. Additionally, it has been reported that "FFC-Ace" enhances the growth of plants under laboratory conditions while improving disease resistance, drought resistance, and salt stress tolerance (Ichikawa and Fujimori, 2012, 2013; Ichikawa et al., 2014, 2015; Fujita et al., 2010; Hasegawa et al., 2006; Konkol et al., 2012; Shiraishi et al., 2010; Toyoda et al., 2010).

A plant enhancement liquid is, in general, a liquid that contains no nitrogen, phosphate, or potassium, that is used for vitalizing plant growth. It contains micronutrients and various kinds of organic matter (vitamins, amino acids, etc.). It makes a higher impact via application by foliar spraying and pouring into the soil than by the usual method of conventional spraying.

FFC Vegemake© (hereinafter, referred to as "FFC-VM") is a high-safety plant enhancement liquid, which has been developed in 2016 using FFC materials. FFC-VM contains water treated with FFC ceramics, as well as a plant extract, a sugar, and an organic acid. Therefore, FFC-VM serves as a high-performance enhancer due to the effects of the ingredients, as well as the water treated with FFC ceramics.

In this study, we report an effect of foliar spraying of FFC-VM on some plants.

MATERIALS AND METHODS

Comparison of initial growth of a small turnip

Seeds of a small turnip (*Brassica rapa* subsp. *rapa* 'Kintoki-Kokabu') were sown in a raised seedling tray, which was filled with commercially available soil for vegetables. The small turnips were grown in a greenhouse under natural light for 21 days. Half of the small turnips were cultivated via foliar spraying of a diluted solution of FFC-VM (2000-fold dilution with tap water) every 3 days. The other half of the turnips were cultivated via foliar spraying of tap water only. After 21 days, the shoot fresh weight, and the dry weight of the small turnips were measured.

Comparison of growth of flower seedlings of *Calibrachoa* Million Bells®

Flower seedlings of *Calibrachoa* 'SUNbelki', Million Bells® Yellow (Suntory Flowers Co., Ltd.) were planted in a planter, which was filled with commercially available soil for raising seedlings. The planter was placed outdoors, and the flower seedlings were cultivated under natural light for 77 days. Foliar sprayings were done for all of the flower seedlings. Half were sprayed with a diluted solution of FFC-VM (2000-fold dilution with tap water) every 7 days,

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and the other half were sprayed with tap water only. Both test sections were watered with an identical amount of tap water via watering can.

Comparison of growth, fruition, and analysis of amino acids of cherry tomatoes

Cherry tomatoes seedlings (*Solanum lycopersicum* ‘Suzunari’) of were planted in a pot, which was filled with commercially available soil for raising seedlings. The seedlings were watered with tap water every 2 days. Foliar sprayings were done for the flower seedlings. One-half was sprayed with a diluted solution of FFC-VM (2000-fold dilution with tap water) every 7 days, and the other half was sprayed with tap water. After 57 days, all the cherry tomatoes were harvested and then the amount of amino acids in the liquid extracts was analyzed and measured by HPLC measurement.

RESULTS AND DISCUSSIONS

The result of the experiment of the comparison of initial growth of a small turnip is shown in Figures 1 and 2. In comparison with the initial growth, fresh shoot weight of the small turnips treated with foliar spraying of FFC-VM was approximately 1.27 times higher than that of those treated with tap water alone (Figure 1). The roots of the treated plants were more elongated. Additionally, the root hair was more well-developed (Figure 2). These results suggest that FFC-VM applied through foliar spraying accelerates growth of both shoots and roots of small turnips.

In the second experiment, the comparison of growth of flower seedlings of *Calibrachoa* 'SUNbelki’, Million Bells® Yellow (Figure 3) shows that the flower seedlings treated via foliar spraying of FFC-VM blossom much more than those treated with tap water alone (Figure 3).

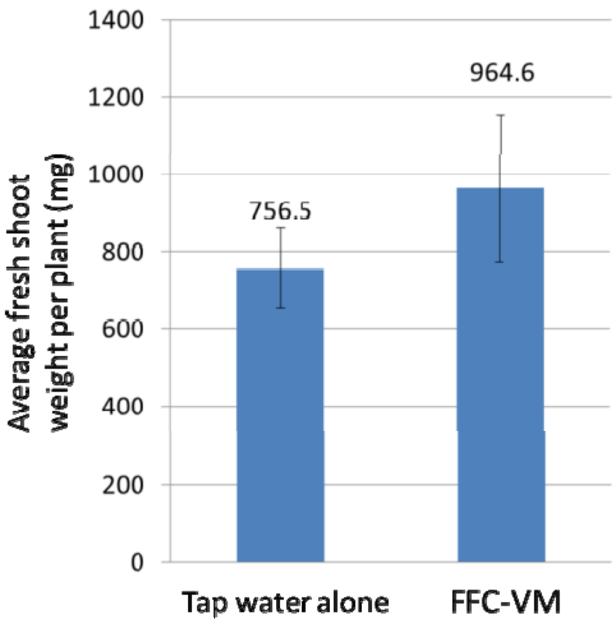

Figure 1. The experiment of the comparison of initial growth of a small turnip (*Brassica rapa* subsp. *rapa* ‘Kintoki-Kokabu’): average fresh shoot weight per plant.

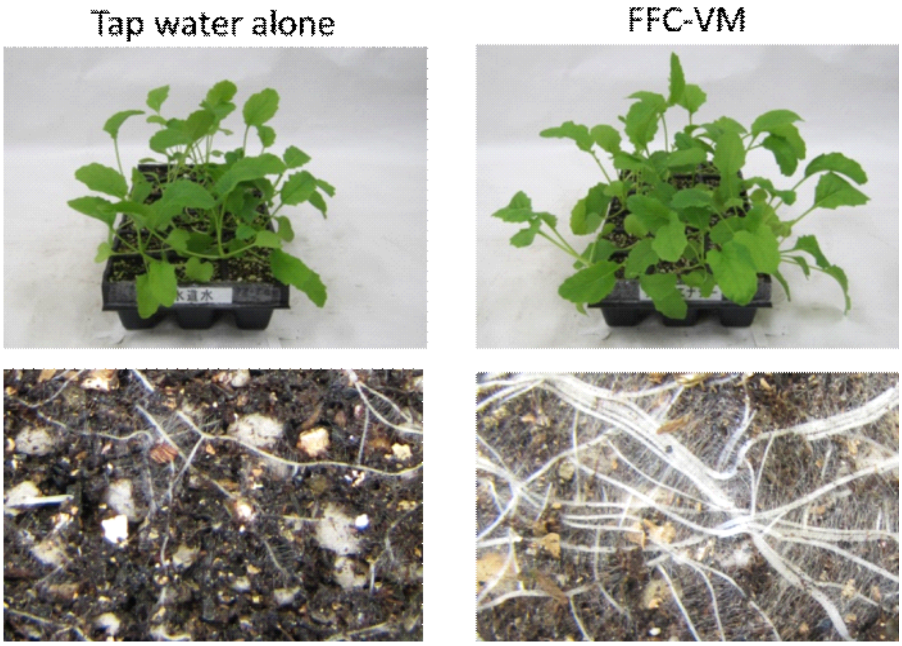

Figure 2. The experiment of the comparison of initial growth of a small turnip (*Brassica rapa* subsp. *rapa* 'Kintoki-Kokabu'): appearance of shoots and roots.

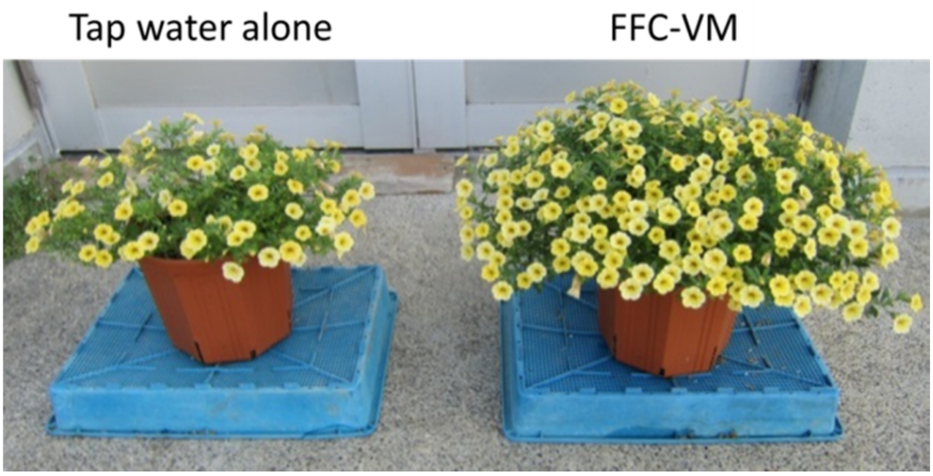

Figure 3. Comparison of growth of flower seedlings of *Calibrachoa* 'SUNbelki', Million Bells® Yellow.

The result of the experiment of the comparison of growth, fruition, and analysis of amino acids of cherry tomatoes demonstrated that the average weight of cherry tomato fruits cultivated with FFC-VM, as well as the number of fruition, was higher than those treated with tap water alone (Table 1). In addition, the concentration of glutamic acid in the cherry tomato fruits cultivated with FFC-VM was approximately 31% higher than that of those treated with tap water alone (Table 1).

Overall, these results support the effectiveness of foliar spraying of FFC-VM on overall plant growth, increases of the number of flowers, increases in yield, and improvement in overall quality of plants and crops.

Table 1. Results of cultivation experiments of cherry tomatoes (*Solanum lycopersicum* 'Suzunari').

	Tap water	FFC-VM
Average fresh weight per fruit (g) *n*=5	5.9	6.8
Number of fruit for 4 months	39	50
Glutamic acid content (μg mg^{-1} fresh weight)	1.710	2.247

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Morpho-histological consistency on petiole length elongation of *Anthurium* under partial shades©

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Abstract

In *Anthurium*, the consistency of partial shading is of crucial importance in relation to the elongation of petiole length, but the anatomical basis for these responses is a question. In this study, we investigated the effects of partial shade on the anatomical aspect of elongation changes in petioles by determining the changes in cell size, cell number, and total cell area. From a histological perspective, three developmental processes, cell size, cell numbers, and total cell area, are responsible for the length of a given petiole. The experiment was conducted by utilizing three shading treatments, i.e., full sunlight, 40% reduced light, and 60% reduced light. Morphological traits (plant height and petiole length), histological traits (cell size, cell number, and total cell area), characterizing the petioles, as well as the physiological traits (SPAD value and leaf area) characteristics were measured. We found that plant height, leaf area, and SPAD value increased linearly with increasing partial shade. In this context, cell size, cell number, and total cell area also increased with increased petiole elongation.

INTRODUCTION

Light is an important environmental information source that plants use to modify their growth and development, and it regulates and optimizes the growth and development in biotic and abiotic condition (Begna et al., 2002; Kozuka et al., 2011). In general, light is sensed by photosensors that respond to different light wavelengths (Kozuka et al., 2011) and it has diversified physiological and phenotypical function by responding of photoreceptors (Briggs and Christie, 2002; Demarsy and Fankhauser, 2009). They regulate a wide range of responses in plants, including phototropism, chloroplast movement, stomatal opening, leaf flattening, and floral induction (Sakai et al., 2001; Sakamoto and Briggs, 2002); all of which influence photosynthetic efficiency. On the other hand, the quantity of light or light intensity influences photosynthesis in plant and that accumulates the biomass and dry matter (Devkota and Jha, 2010); in addition the partition of carbon is also mediated by the quantity and quality of light (Begna et al., 2002). Consequently, low light intensity is responsible for increasing intermodal elongation (Armitage, 1991). In addition, low and high light intensity also affects cell size and thus affects plant growth.

Under low light condition, cell wall modifying proteins increase cell wall extensibility and thereby facilitate cellular expansion during shade-induced extension growth (Keuskamp et al., 2010).

Anthurium, a beautiful cut flower, can be grown in low light; because it is a tropical shade plant, it does not thrive well under high light intensities and shade must be provided for its satisfactory growth and flowering (Hlatshwayo and Wahome, 2010). The quality and quantity of diffused light are the most important factors influencing foliage plant performances under shade conditions (Jeong et al., 2009; Vendrame et al., 2004). However, the growth performance of anthurium, including cell size determination is necessary for anthurium under shade condition. Because shade stimulates cellular expansion and rapid cell division this results in increased petiole length and plant height (Schoch, 1982). Shading treatment resulted in the tallest plants and, on the other hand, smallest plants are observed

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under shade free area (Miah et al., 2008). The quality and quantity of light are the main sources that plants use to regulate and optimize their phenotypical and physiological functions through the response of photoreceptors (Demarsy and Fankhauser, 2009). Even phenotypic response to light can vary within a species, suggesting that selection may allow for development of cultivars with enhanced shade tolerance (Siemann and Rogers, 2001). Therefore, this study was aimed at understanding the petiole length variation of anthurium under partial shades conditions.

MATERIALS AND METHODS

Plant materials and treatments

Anthurium andraeanum plants were obtained from a commercial nursery in July 2012 and then multiplied at Sher-e-Bangla Agricultural University Horticultural farm. New plantlets were produced from their suckers. The experiment was arranged in partially control environment at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, during the period April 2013 to February 2014. This experiment was also carried out in a split-plot design with four replications which comprise 60 pots. Anthurium plants, more or less uniform size, were used with four leaves and a single plant was grown per pot. The size of each pot was 25 cm (10 in.) in diameter and 20 cm (8 in.) in height. Pulverized coconut husk was mixed with a small amount of soil (coco dust:soil, 10:1) as growing medium. Thereafter, three levels of light intensities were applied such as, L_0, control (100% light/full sunlight); L_1, 40% reduced light (60% of the full sunlight); and L_3, 60% reduced light (40% of the full sunlight). Plants were allowed to establish before the first sampling to end of the experiment with these treatments.

Growing and shade condition

Light intensity levels were maintained using black nylon (60 mesh) net (Black et al., 2003). A single and double layer net reduced light intensity by approximately 40% and approximately 60%, respectively. Light intensities were measured by a CEM DT-1301 Digital Lux and fc light meter (Shenzhen Everebest Manhinery Industry Co. Ltd., China). Hence, relative humidity and temperature were recorded in accordance with monthly weather report of Dhaka Weather Forecasting Department. Mitchell (1953) found that the speed and pattern of morphological development of the plant was determined by contemporary rather than previous light and temperature conditions.

Measurement and calculation

In morphological data, plant height, petiole length, and leaves number were recorded at the different days after transplanting (DAT). Plant height and petiole length were recorded in metric scale. A SPAD 502 meter (Minolta, Osaka, Japan) was used to determine relative leaf greenness (chlorophyll content), called SPAD value (Netto et al., 2005); three recently matured, fully expanded leaves were used from each plant during the experiment. Leaf area (LA) was determined by a non-destructive method using a Cl-202 leaf area meter (CID Bio-Science, Inc., USA). SPAD value and leaf area data were collected at three stages namely vegetative, reproductive, and harvesting, respectively.

Histological analysis

Five leaf petioles of anthurium grown under the three different light intensities were collected for histological studies. A 5 cm long and 4 mm diameter of petiole was taken from the midpoint from each petiole and fixed in neutral buffered formalin (NBF) for 24 h (Seago et al., 2000; Kraus and Arduin, 1997), then washed in abundant running water and dehydrated in a series of alcohol (10, 30, 50, 70, 90 and 100%) for 10 min at each concentration and embedded in a plastic petri dish. Then the petiole was cut in cross section by hand using steel blades. In order to make slides, sections were stained with 0.5% toluidine blue-color reagent for 1 minute. Then they were washed thoroughly in water. Finally, transverse sections were mounted between the slide and coverslip with 50%

glycerin, and sealed with clear nail polish. Then the slides were observed under microscope attached to the image capture and photography system, and the corresponding micrometric scales were displayed.

Image acquisition and processing

Anthurium petiole stained using DTZ were photographed at a 6 magnification using a stereoscopic zoom microscope (Nikon SMZ 1500, Japan) and a camera control unit (Nikon, SU-1). The 8-bit depth images were analyzed on a desktop or laptop computer using ImageJ software (Ferreira and Rasband, 2012). The intensity of staining was measured through the RGB color space (red, green and blue) defined by formula staining intensity values expressed as R þ G þ B/3. Intensity data represented the relative density of Zn in the grains, and was scored from 1 (less intense color), 2 (medium intense color), 3 (intense color) to 4 (very intense color) in accordance with the intensity of staining (RGB values, scale from 0 to 255).

Statistical analysis

The data was analysed by least significance difference (LSD) according to 5% level of significance and method was described by XLSTAT.

RESULTS

Plant height

The plant height was significantly tallest (29.4 cm) in 60% reduced light (L_2) at 100 DAT and the smallest (23.2 cm) was for control (L_0) at 100 DAT (Figure 1A).

Petiole length

The maximum petiole length (16.2 cm) was found in 60% reduced light at 100 DAT and the minimum (11.2 cm) was for direct sunlight at 100 DAT (Figure 1B).

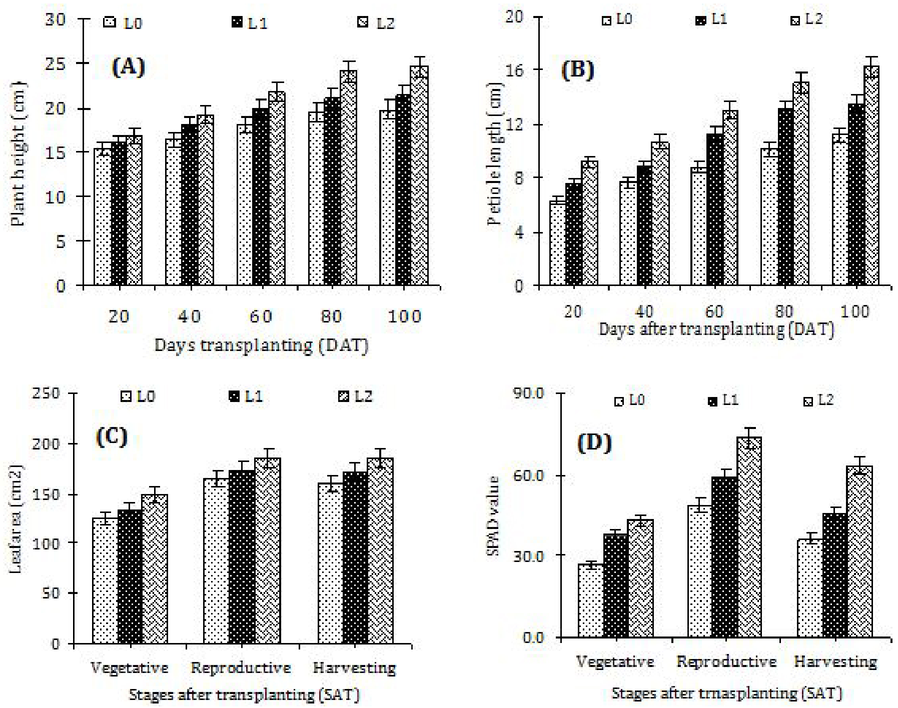

Figure 1. Treatment effects (mean ± SE) on (A) plant height, (B) petiole length, (C) leaf area and (D) SPAD value. All characters were significantly affected by treatments, i.e. L_0, full sunlight; L_1, 40% reduced light and L_2 60% reduced light.

Leaf area

Leaf area was significantly influenced by shade treatments at different SAT and the maximum leaf area (185.6 cm^2) occurred in 60% reduced light, while the minimum (164.9 cm^2) was for control at the reproductive stage.

SPADE value

The 60% reduced light (T_2) had the highest value (73.6) in the partial shade condition at reproductive stage, while the 40% reduced light (T_0) had the lowest (49.0).

Cell length

The 60% reduced light had largest cells (79.2±2.3 µm) in the petiole-length direction which was also larger than the 40% reduced light. On the other hand, the direct sunlight had smaller cells (41.4±2.3 µm) in petiole length directions (Figures 2A and 3).

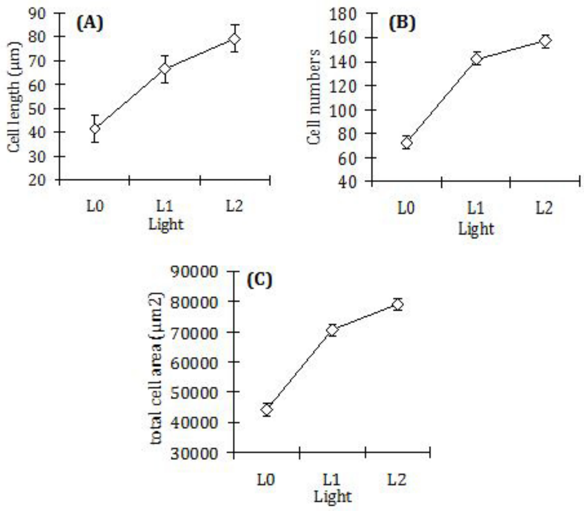

Figure 2. Treatment effects (mean±SE) on (A) cell length, (B) cell numbers, and (C) total cell area. All characters were significantly affected by treatments, i.e. L_0, full sunlight; L_1, 40% reduced light and L_2 60% reduced light.

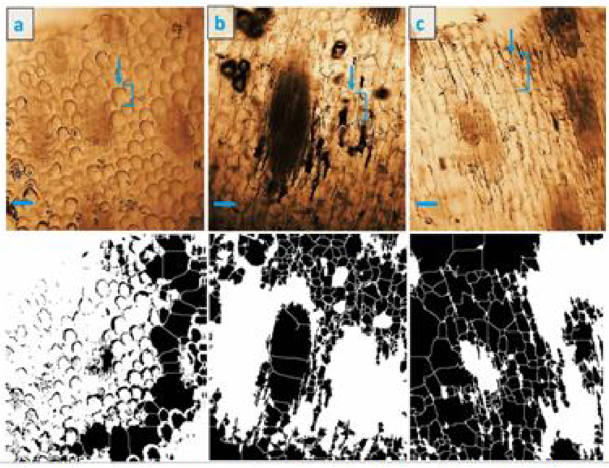

Figure 3. Photograph showing cross sectional view (histological analysis) of petioles from pink anthurium grown under (a) full sunlight, (b) 40% reduced light, and (c) 60% reduced light. Photographs were taken under a microscope with photographic outfit. Bar = 20 µm in (a) and (c) and 25 µm in (b).

Cell number

The response of cell numbers (157.3±2.1) under light treatments was increased in 60% reduced light compare with direct sunlight with the number of cells the lowest (72.6±2.1µm) in L_0 treatment (Figures 2B and 3).

Cell area

Under the shade treatments, the cell area (79108.667±772.3 µm^2) was significantly higher for 60% reduced light and the lowest (44083.6±772.3 µm^2) was found in direct sunlight (Figures 2C and 3).

DISCUSSIONS

Light is undoubtedly the most important environmental variable for plant growth and development; plants not only use radiant energy in photosynthesis, they also respond to the quantity, quality, direction, and timing of incident radiation through photomorphogenic responses that can have huge effects on the rate of growth and the pattern of development (Smith, 1994). At the end of the experimental period, anthurium had a greater height and petiole length under shade than full light treatment (Figures 1A and B). From the results, we can say that light is the fundamental aspect of plant growth, which operate as an energy source for photosynthesis and an environmental signal with regard to its intensity, wavelength, and direction. Due to the variation of treatments in Figure 1A, it is clarified that plant height was slowly increasing in trend lines at 100 DAT. Partial shading enhances the plant height versus full sunlight, which compared the plant growth under shade and it also enhances the microclimate (Medany et al., 2009). In this context, 60% reduce light contributes to make the results in plant height of anthurium. Hence, the reduction of red/far-red photon flux ratio (600-700/700-800 nm) (R/FR) of daylight present in low light promotes plant height and petiole length (Murakami et al., 1997). Germana et al. (2001) also supported these results. Khawlhring et al. (2012) similarly showed in *A. andraearum* that taller plant heights were obtained from those grown under a shade house with 75% shade. Consequently, transverse sections of same-sized petiole were also observed for identifying cell size, cell numbers, and areas in relation to different light intensity of anthurium petiole length during elongation (Figure 3). In histological analysis, longer cell size was found in 60% reduced light than control and 40% reduced light (Figure 2A). However, 40% reduced light also increased cell size. In case of diffused light, low red and far red light radiation is mediated by phytochrome (PhyB) (Smith, 1994) which stimulates indoleacetic acid and gibberellin (Kurepin et al., 2007), and increases cell size (Maddonni et al., 2002). In addition, Cookson and Granier (2006) observed that changes in leaf expansion dynamics were accompanied by a decrease in epidermal cell number which was partly compensated for by an increase in epidermal cell area. Our study investigated that the elongation of cells is controlled by partial shade in petioles (Figures 2A and 3). However, it was also apparent that the partial shade affected not only the enlargement of cells but also the number of cells in the petiole (Figure 2B). Weijschede et al. (2008) found that cell number was the main trait explaining petiole length differences among genotypes grown under high light, while both cell number and length changed in response to shading. In contrast to these results we found that only the size of cells are responsible, not the number of cells as in *Polygonum* species (Griffith and Sultan, 2006). Plants receive solar radiation and capture more energy during the growth period under shade for photosynthesis (Chella and Bakker, 1998), which increases leaf area (Reich et al., 1998). Particularly, shade induces leaf plasticity in leaf cells for expansion of leaf area (Cookson and Granier, 2006). Even more, plant cell expansion and division stimulate to increase individual leaf area in shading plants (Schoch, 1982). Stanton et al. (2010) showed that partial shade increased individual leaf area and higher specific leaf area. These results were also supported by Li et al. (2014). However, Srikrishnah et al. (2012) found in *Dracaena sanderiana* that plants grown at 50 and 70% shade levels produced the higher leaf area and biomass than plants subjected to 80% shade. During the reduced light regimes under shade, chlorophyll content increased with increase ratio of chlorophyll a/b in seagrass (Dennison and Alberte, 1982), though it does not change unit character of photosynthesis in low light. The decrease in chloroplast density is found in reduce light, which responses to UV light blocking and increase chlorophyll in 50% reduced light (Abal et al., 1994). This chloroplast is not only characterized higher number of thaylakoids per granum and higher stacking degree of thylakoids, but also broader granum in low light which promotes to increase chlorophyll flouroscence (Lichtenthaler et al., 1981).

CONCLUSION

In short, this study showed that anthurium petiole length elongation was maximum in 60% reduced light (L_2) due to the increase of cell length and cell number.

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Shoots formation by rhizome culture of *Anemone keiskeana*©

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INTRODUCTION

Anemone keiskeana Maxim. is a perennial plant classified in the *Ranunculaceae*, that grows in western part of Japan. The standard flower has 12-22 pale bluish purple sepals, lacks petals, though the flower color has rich variations, including white, pale pink, and pale yellowish brown.

The leaves emerge from the rhizomes in autumn; the scapes appear and bloom in March. Leaves wither and the rhizomes go into a dormant period in May and are therefore summer dormant. *Anemone keiskeana* often develops "brood buds" in the axils of the rhizomes (Figure 1). Brood buds are microtuber-like bodies that originate from lateral buds and in Japanese are called "mukago". These buds don't develop into lateral branches on the rhizome and easily separate from the rhizome. In pot culture separated brood buds sprout after 1 or few years from separation and form small rhizomes.

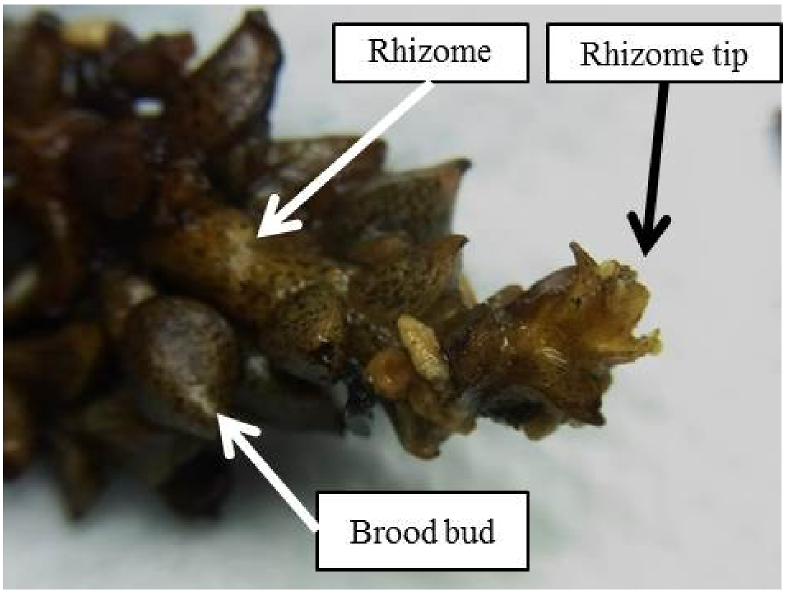

Figure 1. Rhizome, rhizome tip and brood buds of *Anemone keiskeana* in dormant period.

In this study, we aimed to establish *A. keiskeana* in a sterile culture system from cultured rhizomes segments and brood buds and develop a multiplication system.

MATERIALS AND METHODS

For this experiments, rhizomes of four clones ('Akehasu', Unknown, 'Ruri-ichige', and 'Yanadani') and brood buds of 'Yanadani' clone were used in the primary culture (Table 1). The rhizomes and brood buds were washed in tap-water and laid on moist pumice (diameter of 1-2 mm) used in gardening and called "kanuma" soil in the bottom of shallow storage containers. For keep wet condition, the containers were put in a plastic tank, and covered by plastic tray, incubated under 20±2°C, 16 h day^{-1} white fluorescent lamp

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illumination (about 1,000 Lux) condition. To reduce risk of contamination, the rhizomes and brood buds were sprayed with 1,000 mg L^{-1} Benlate wettable powder(Sumitomo Chemical Co., Ltd., Japan, containing 50% Benomyl) solution, every 3-5 days according to label directions.

Table 1. Tested organs, characteristic of sepal and origin of tested 4 clones of *Anemone keiskeana.*

Name of clone	Tested organs	Color and characteristic of sepal	Origin
Akehasu	Rhizomes	Pale pink	Ehime, collected by Akehasu
Unkown	Rhizomes	Pale yellowish brown	Unknown
Ruri-ichige	Rhizomes	Bluish purple	Ehime, collected by Y. Hiraoka
Yanadani	Rhizomes and brood buds	Pale yellowish brown plenty sepals	Yanadani, Kuma-kogen, Ehime, collected by S. Ogawa

About 20 days after start of Benlate spray treatment, the rhizomes and brood buds were used as materials of tissue culture. They were washed by tap-water, and dipped in sodium hypochlorite solution (1% available chlorine, with spreader) for about 9 mins., and then rinsed with sterilized water. Explants were prepared by cutting the rhizome into sections including rhizome tip and nine additional 1 mm thick sections. The brood buds were used intact as explants.

Basal medium for all cultures was MS medium (Murashige and Skoog, 1962) with inorganic salt used at half strength, sucrose at 30 g L^{-1}, and a combination of 1-naphthylacetic acid (NAA) and 6-benzylaminopurine (BA) at 0, 0.1, or 1 mg L^{-1} each as plant growth regulators. The pH was adjusted to 5.8±0.1 and 2.5 g L^{-1} gellan gum (Wako pure Chemical Industries, Ltd., Japan) was added before dispensing 10 mL test $tube^{-1}$ (25 mm diameters; 120 mm height).

The explants of rhizome tip sections and brood buds were placed with the cutting plane down, in case of rhizome round sections, put the cutting planes horizontally, and placed one per test tube on each medium, and then observed for every 30 days after inoculation for contamination, callus formation and shoot formation.

These were incubated under 21±2°C and 16 h day^{-1} white fluorescent lamp illumination (about 2,000 Lux) condition.

RESULTS AND DISCUSSION

Contaminations were observed in three clones except in the 'Akehasu' clone, at 210 days after inoculation. The contaminated explant rates of 'Ruri-ichige' clone were 44.4% in rhizome tip sections and 25.0% in rhizome round sections; these rates were higher than 'Yanadani' and Unknown clones (Table 2). In each explant types, the total contaminated explants rate of rhizome round section explants was 6.3%, this value was lower than rhizome tip section explants (19.4%) and brood explants (17.8%). We consider that the cause is the difference of the ratio of epidermis area to explant's surface area.

In this experiment, frequency of contamination was less than expected and we consider that one of the factors was the Benlate spray treatment. To corroborate the hypothesis, rhizome round sections and brood buds of "Yanadani" clone were treated 0, 1 or 4 times with Benlate solution spray every 2-3 days, and inoculated on hormone-free medium, in the same way. Although in all Benlate spray treatments the contaminated explants were little or nothing about 3 weeks after inoculation (data not shown).

Table 2. The relation between rate of contamination and explant types in rhizome culture of *Anemone keiskeana* (about 210 days after inoculation).

Name of clone	Rhizome tip sections			Rhizome round sections			Brood buds		
	No. of explants	No. of contaminated explants	Rate of contamination (%)	No. of explants	No. of contaminated explants	Rate of contamination (%)	No. of explants	No. of contaminated explants	Rate of contamination (%)
Akehasu	9	0	0	36	0	0	-	-	-
Unknown	9	1	11.1	36	0	0	-	-	-
Ruri-ichige	9	4	44.4	36	9	25.0	-	-	-
Yanadani	9	2	22.2	36	0	0	45	8	17.8
Total	**36**	**7**	**19.4**	**144**	**9**	**6.3**	**45**	**8**	**17.8**

Callus and shoot formation occurred from all clones, however, the frequency and amount varried depending on the clone.

Callus arose from the xylem of section planes, and as a result the callus formation happened at higher frequency in the rhizome round sections and required addition of BA (Table 3).

Shoot formation occurred even on hormone-free medium in particular rhizome tip sections (Table 4). It was noted that shoots originating from the shoot apical meristem on the rhizome tip and the axillary bud were larger than those that originated via adventitious buds. The addition of NAA inhibited shoot formation especially from shoot apical meristem and the addition of BA promoted adventitious shoot induction via callus.

After this, we will study establishment of multiplied shoots and regeneration from callus, in parallel, try interspecies crossing with other species of *Anemone*.

Table 3. Effects of plant growth regulators for callus formation on rhizome culture of *Anemone keiskeana* (about 210 days after inoculation).

PGR[1]		Rhizome tip sections			Rhizome round sections			Brood buds		
NAA ($mg\ L^{-1}$)	BA ($mg\ L^{-1}$)	No. of explants	No. of explants formed callus	Rate of explants formed callus (%)	No. of explants	No. of explants formed callus	Rate of explants formed callus (%)	No. of explants	No. of explants formed callus	Rate of explants formed callus (%)
0	0	3	0	0	14	0	0	5	0	0
0	0.1	2	0	0	14	1	7.1	5	0	0
0	1	3	0	0	15	6	40.0	4	1	25.0
0.1	0	3	0	0	15	0	0	3	0	0
0.1	0.1	3	1	33.3	16	8	50.0	3	0	0
0.1	1	4	1	25.0	15	11	73.3	4	1	25.0
1	0	3	0	0	16	1	6.3	4	0	0
1	0.1	4	2	50.0	15	7	46.7	5	0	0
1	1	4	1	25.0	15	9	60.0	4	2	50.0
Total		**29**	**5**	**17.2**	**135**	**43**	**31.9**	**37**	**4**	**10.8**

[1]PNG: Plant growth regulator.

Table 4. Effects of plant growth regulators for shoot formation on rhizome culture of *Anemone keiskeana* (about 210 days after inoculation).

PGR[1]		Rhizome tip sections			Rhizome round sections			Brood buds		
NAA ($mg\ L^{-1}$)	BA ($mg\ L^{-1}$)	No. of explants	No. of explants formed shoots	Rate of explants formed shoots (%)	No. of explants	No. of explants formed shoots	Rate of explants formed shoots (%)	No. of explants	No. of explants formed shoots	Rate of explants formed shoots (%)
0	0	3	3	100	14	3	21.4	5	2	40.0
0	0.1	2	2	100	14	1	7.1	5	3	60.0
0	1	3	1	33.3	15	1	6.7	4	3	75.0
0.1	0	3	1	33.3	15	0	0	3	0	0
0.1	0.1	3	1	33.3	16	1	6.3	3	1	33.3
0.1	1	4	3	75.0	15	6	40.0	4	2	50.0
1	0	3	0	0	16	0	0	4	0	0
1	0.1	4	0	0	15	0	0	5	2	40.0
1	1	4	0	0	15	3	20.0	4	4	100
Total		**29**	**11**	**37.9**	**135**	**15**	**11.1**	**37**	**17**	**45.9**

[1]PNG: Plant growth regulator.

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Compare the grafting methods for landscaping roses©

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To improve the production quality of roses, several grafting methods were compared. Grafting trial was performed in a greenhouse (covered with single layer polyethylene film, 7.5 m wide, 27 m long) in Kochi Agricultural College. Grafting period was from February 1 to February 6, 2016. Tested rose cultivars were *Rosa* 'Sympathie' (rambling rose), 'Ballerina' (rambling rose), and 'Sunblest', Landora® hybrid tea rose (tree rose).

Three different grafting methods were applied:

1) A: Grafting by usual way in Kochi, and covered with grafting tape (paraffin tape) and wax.
2) B: Grafting usual way and covered with "New Medel©" (http://www.aglis.co.jp/agri/agri_02/index.html).
3) C: Grafting by David's method and covered with 'New Medel©'.

For the details about David's grafting method (Figure 1), see following two websites; https://rose-sora.blogspot.jp/2015/04/grafting-roses.html (in Japanese with English summary) and https://rose-sora.blogspot.jp/2013/02/blog-post_7.html. (in Japanese).

Figure 1. In David's method, scion must be put slantingly to the rootstock.

After grafting the roses were each transplanted into 10.5-cm-deep polyethylene pot and kept in unheated greenhouse covered with polyethylene to keep the humidity up. Thirty days after grafting, the polyethylene tunnel removed. On 10 April each of 20 plants investigated about survival rate and their growth.

Results were shown in Table 1. New Medel© is used as graft material by David's method. But there were no difference between usual grafting tape and New Medel©. Usual grafting method (A) was suitable for both 'Sympathie' and 'Sunblest', Landora® hybrid tea rose, but result of David's method (C) was excellent in 'Ballerina'.

Further investigation is needed to make these differences clear.

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Table 1. Effects of several methods for grafting on both sprouting and fixation.

Cultivar	Grafting method	Length and number of sprouting shoots								Fixation (%)
		0~10 cm	10~20 cm	20~30 cm	30~40 cm	40~50 cm	50~60 cm	60~70 cm	70~80 cm	
Sympathie	A	4	1	0	1	4	3	2	6	81
	B	3	0	2	2	4	3	4	2	85
	C	7	1	5	3	3	1	0	0	65
Ballerina	A	2	0	1	0	8	6	3	0	90
	B	2	0	0	1	7	5	5	0	90
	C	3	0	3	8	5	0	0	0	84
Sunblest	A	0	0	1	1	10	7	0	0	100
	B	5	0	1	8	6	0	0	0	75
	C	15	1	2	2	0	0	0	0	25

Micropropagation of Australian native ornamental grevilleas©

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Abstract

Australian native grevilleas are very diverse in their habit and habitat. There are up to 350 species of *Grevillea* reported, although the number of species varies among authors. *Grevillea* species range in habit from small, prostrate shrubs, less than 50 cm (20 in.) to trees over 35 m (114 ft) tall. Their habitat extends from the wet tropics of Australia through temperate southern Australia and dry arid zones in Western Australia. Grevilleas are valued for their beautiful form, range of foliage, and diversity of flower colors, sizes, and shapes. Apart from their aesthetic value, they are also great garden plants, attracting native bees, butterflies, and birds, thus enriching the natural habitat. Many *Grevillea* species are propagated by seeds, but valuable, ornamental hybrids are propagated by cuttings, layering, or grafting. This paper will focus on the rapid cloning of some difficult-to-propagate cultivars of these beautiful ornamentals.

INTRODUCTION

The genus *Grevillea* is named after the eminent botanist Charles F. Greville (Olde and Marriott, 1994), is reported to contain 360 species, and is distributed throughout Australia and nearby islands. *Grevillea* belongs to the family *Proteaceae*. Plant habit ranges from small shrubs under 50 cm to tree forms, like *G. robusta*, which grows up to 35 m tall (Olde and Marriott, 1994). The OzNativePlants (2016) website provides a quick introduction to the diversity of ornamental grevilleas. Based on my readings, the three volumes of "The Grevillea Book" by Olde and Marriott (1994) provide the best reference on grevilleas.

Aboriginal Australians used various species of *Grevillea* for food (e.g., *G. annulifera* and *G. heliosperma*), medicine (e.g., *G. striata* and *G. pyramidalis*), and tool making (*G. pteridifolia* and *G. striata*) (Olde and Marriott, 1994). Their use in landscaping, owing to their diversity of growth habits, suitability to different habitats, plant architecture, variation in leaves, flowers, flower color, and nectaries attracting native bees, butterflies, and birds, are well documented by Olde and Marriott (1994).

Propagation of *Grevillea* spp. by seeds is common practice in nurseries for straight species. However, to maintain the characteristics of the hybrids for commercial applications, *Grevillea* hybrids are vegetatively propagated. Many of these hybrids are amenable to propagation by cuttings. *Grevillea* hybrids and cultivars that are difficult to propagate by cuttings are either grafted or tissue cultured in Australia. Grafting onto a species with wide adaptability to a larger geographic area is also practiced to increase the adaptability of some of the hybrids to a wider geographical area, thus enhancing their commercial potential. *Grevillea robusta* is considered to be a good rootstock for grafting grevilleas. This paper covers a brief review of the tissue culture of some cultivars of Australian native *Grevillea*.

Micropropagation of *Grevillea* has been reported for a few species (Bunn and Dixon, 1992; Watad et al., 1992; Rajasekaran, 1994; Leonardi et al., 2001; Evenor and Reuveni, 2008). Adventitious rooting of cuttings was also recently studied (Newell et al., 2003; Krisantini et al., 2006). Kennedy and De Filippis (1999) also studied response of in vitro cultures of *Grevillea* spp. to NaCl salinity. Touchell et al. (1992) also reported cryopreservation of *G. scapigera*, an endangered species. In this report, I discuss micropropagation of ornamental *Grevillea* cultivars 'Moonlight' and 'Superb', which were recalcitrant to nursery cutting production.

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MATERIALS AND METHODS

Actively growing shoot tips of grevillea 'Moonlight' and 'Superb' collected periodically from nursery stock were used as explants. They were surface sterilized by washing in Tween20® for 30 min at 200 rpm on a gyratory shaker at room temperature followed by treatment with dilute NaOCl solution (1% Cl_2) for 10-15 min. The chlorine-treated shoot tips were rinsed with sterile, distilled water 3-5 times before further treatment with 1% (v/v) PPM (Plant Preservative Mixture®) for 30 min before inoculating onto sterile culture medium. Initiation and shoot multiplication was achieved on MS medium (Murashige and Skoog, 1962) supplemented with 0.5-1.0 µM benzylaminopurine (BAP) and 0.01 µM naphthaleneacetic acid (NAA). Rooting was best achieved using ½ strength MS medium supplemented with 3-5 µM IBA. Acclimatization of microplants transferred to a porous potting mix was achieved in the greenhouse with control over humidity, light, and temperature.

RESULTS AND DISCUSSION

Contamination (fungal and bacterial) is a major issue with *Grevillea* species during the initiation phase. This is understandable as the explants were collected from nursery stock maintained in an open area. Additionally, the hairy nature of the *Grevillea* cultivars made them difficult to surface sterilize. About 30% success (30% clean cultures) was obtained in the initiation phase. These cultivars required 3-4 weeks for initiation to take place when cultured on MS medium supplemented with 30 g L^{-1} sucrose, 0.5-1.0 µM BAP, 0.01 µM NAA, and gelled with 7.0 g L^{-1} agar. Medium pH was adjusted to 5.8 before sterilizing by autoclaving at 121°C for 20 min. After 3-4 subcultures on a monthly interval, the shoot cultures grew well in the initiation medium. Murashige and Skoog medium supplemented with low concentrations of BAP was used to micropropagate shrubby grevilleas by various authors (Touchell et al., 1992; Watad et al., 1992; Kennedy and De Filippis, 1999; Leonardi et al., 2001). Woody plant medium modified with a high concentration of BAP was used to effect adventitious shoot formation from leaf explants of *G. scapigera* (Bunn et al., 1992). Similarly, *G. robusta* (a tree species) was propagated on woody plant medium containing 4.4 µM BAP in combination with 0.27 µM NAA (Rajasekaran, 1994). In this study, rapid growth of *Grevillea* shoot cultures to 5-6 cm per month allowed a monthly yield of 3-4 nodal cuttings from each shoot. This equated to a multiplication factor of 3-4 per month.

Rooting was not a problem with the *Grevillea* cultivars and rooting percentage varied between 70 and 100%. Reduced nutrient concentration and sucrose (50% MS medium + 20 g L^{-1} sucrose). Watad et al. (1992) rooted six cultivars of *Grevillea* on MS medium supplemented with no hormones (control), 1 mg L^{-1} IAA (indoleacetic acid), NAA, or IBA, and found that NAA was most effective (85-90% rooting) for rooting *Grevillea.* They also reported variation in rooting due to genetic differences among these cultivars. Bunn et al. (1992) could root microshoots of *G. scapigera* ex vitro in a mist chamber using commercial rooting powder (1.0 mg L^{-1} IBA). Evenor and Reuveni (2008) used 1.0 mg L^{-1} IBA in ½ MS medium to root *Grevillea*, although their shoot cultures grew well in WPM medium. Leonardi et al. (2001) also reported better rooting (rooting percentage, roots per plant, and root length) by using 1.0 mg L^{-1} IBA compared with 1 mg L^{-1} NAA.

Well rooted plants deflasked into a porous potting mix composed of peat, vermiculite, and perlite (20%:50%:30%) and maintained at ambient humidity over 90%, reduced light (80% shade), and reasonable heat (26-30°C max) during the first week after deflasking achieved greater than 90% survival. The same mix with a pinch of slow-release fertilizer (minus phosphorus) was excellent for further growth of micropropagated grevilleas. Grevilleas are known to do well in well-drained soil (Olde and Marriott, 1994).

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Propagation of *Cannabis sativa* for commercial production©

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INTRODUCTION

Cannabis sativa ("cannabis") has historically been an important crop. Its potential for use is not limited to agricultural uses, but also includes chemical, medicinal, and commercial uses. *Cannabis sativa* is a semi-herbaceous, annual, dioecious flowering herb, with three subspecies: *sativa*, *indica*, and *ruderalis* (Wikipedia Contributors, 2016). There is a high emphasis and importance on plant sex, depending on crop usage. Mature plant size can range from 0.6 to 1.8 m (2 to 6 ft). The leaves are compound and decussate-opposite, with leaves having three to seven leaflets, a serrate leaf margin, and a glabrous or pubescent leaf surface. Mature plants develop a woody stem, then flower, and finally senesce. *Cannabis sativa* is native to most humid and temperate parts of the world, and its use dates to ancient times (Clarke, 2016).

Propagation of *C. sativa* includes both sexual and asexual propagation methods, two of which will be discussed. The three primary methods used for propagation of *C. sativa* are: 1) clonal propagation of leafy cuttings in sterile medium (rockwool), 2) rooting of leafy cuttings in an aeroponic machine, and 3) seed germination (Hartmann and Kester, 1975).

PROPAGATION

Seed propagation

C. sativa plants grown from seed are typically hybrids of parent cultivars that come from near isogenic lines (NILs); therefore, the offspring are variable. Also, cannabis is dioecious and sexual identification is important, depending on crop usage. Propagation via seed does not ensure the sex of seedlings. Although scarification increases germination rates, it is not necessary. Seed propagation also requires the use of viable seeds. Commercial use of seed propagation in the medical marijuana industry is not viable and is time consuming. However, for hemp production, seed propagation is the most economical and viable method (Yoshimatsu et al., 2010).

Cutting propagation of leafy cuttings

The most common propagation method is clonal propagation of leafy cuttings. Mother plants are allowed to produce several lateral shoots and, once sufficient shoots have developed, they are removed. Leafy cuttings are dipped into a gel formulation of auxin (Clonex™ gel; Hydrodynamics International Inc., Lansing, Michigan, USA) and placed in sterile medium (rockwool or peat moss pellets), and then misted regularly until roots develop in about 7-14 days. Cuttings are typically placed in a humidity dome, or "mini greenhouse." Clonal propagation via leafy cutting has been shown to provide higher rooting success, and produces healthy and disease-free plants.

Rockwool cubes must be conditioned prior to use for cuttings. Two solutions should be formulated: the first is the conditioning solution and the second is the fertigation solution. For the conditioning solution, soak cubes in filtered water with a pH of 5.5 for 24 h prior to use. This is called "conditioning" the cube and is essential to rooting success. For the fertigation solution, soak cubes for 5 minutes in fertigation solution of 200 ppm N and 100 ppm liquid auxin (Clonex™ liquid), then set aside and allow to drain.

Cuttings should be harvested from disease-free stock plants under nonstressed conditions. Cuttings located at apical and primary lateral positions produce the most

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uniform plants. Cuttings from secondary branch structures not as strong. Collect turgid cuttings during optimal water conditions (from non-wilted stock plants). Use isopropyl alcohol or Physan 20 to disinfect tools (pruning shears and scalpels) used for taking cuttings. Use an auxin solution with a thickening agent, such as Clonex™ gel. Environmental conditions that increase propagation success are provided by an atmosphere that reduces water loss and maintains leaf turgidity, with optimal humidity between 75 and 90%, often achieved using humidity domes or "mini greenhouses." Ample but not excessive light and clean, moist, and well aerated rooting media should also be provided.

Aeroponic cutting propagation

Another asexual propagation method involved use of aeroponic cloning machines. The aeroponic method ensures vigorous and disease-free root growth, but is not the best method for producing healthy, vegetative plants. Plants propagated using this method tend to be susceptible to root damage during transplanting to medium, and to fluctuations in pH and EC. Commercial aeroponic cloning has been around since the late 1960s. The first aeroponic cloning machine was developed in 1983, and was called the Genesis Machine. Variations of the Genesis Machine continue to be used today.

For cuttings in an aeroponic cloning machine, a rooting water temperature of 18 to 25°C (65 to 77°F) is required for successful rooting. Intermittent misting of cuttings 3-4 times daily during the first 3 days aids in maintaining turgidity and reducing wilting damage. The use of liquid auxin at a concentration of 100 ppm in the rooting solution is crucial to rooting success. The use of unfiltered water yields rooting success as well, but not with high rates of success.

The aeroponic cloning method has its downsides as well. Aeroponic machines tend to be somewhat labor intensive, and require equipment for thoroughly cleaning the machines, along with all the mechanical components associated with the machines. Frequent replacement of the neoprene inserts is also required for a clean rooting environment, and therefore adds to the overall cost of running the machines. The machines are also susceptible to power and pump failures, which can lead to severe losses of cuttings. Cuttings grown in aeroponic machines tend to be sensitive upon transplanting as well, and are susceptible to transplant shock at a higher degree than other methods. All the factors stated above lead to overall higher start-up costs and higher operating costs, all of which need to be considered when deciding on a sustainable propagation plan.

CONCLUSION

All the methods discussed are considerably behind those used by the rest of the horticulture industry. However, these appear to be the methods with which most cannabis growers are comfortable and familiar. Every method discussed is viable in its own way. In my opinion, propagation via leafy cuttings in sterile media is the best.

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Expanding the Southwestern plant palette©

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INTRODUCTION

Exploring in habitat for plants to introduce to the nursery and landscape industry in the desert southwest can be a hit-and-miss proposition. Sometimes the plants that appear to have the most promising potential end up being a bust, while other plants that are almost an afterthought turn out to be some of the best performers in the landscape.

When searching areas for potential new plants outside of southern Arizona, I have identified two approaches in order to maximize the hits and minimize the misses. One is to identify a climate similar to the one in which you want to introduce “new and unusual” plants and go scour that region for potential plants. The other is to pick plants that already do well in said climate, find out where those are native, and go look for other plants in that area.

I would like to share some of the winners and not-yet-winners chosen from over 30 years of exploring in Mexico. Let’s take an alphabetical look at some awesome plants that have made their way into the landscape plant palette.

THE WINNERS

Agave ovatifolia

This amazing agave was first found in the state of Nuevo Leon in northeastern Mexico by Texas plantsman Lynn Lowery in the mid-1980s and distributed to various individuals and institutions in Texas without much fanfare. About 15 years after he first collected the plant, I was sent a picture of one of them and asked which agave it could be. By the time I received the picture, Mr. Lowery was no longer alive, and recognizing that it was an undescribed species, I spoke with his son-in-law who gave me the details of Mr. Lowery’s excursions to Nuevo Leon. The story is that Mr. Lowery met the Chief of Police for the town of Lampazos in Nuevo Leon, who owned a ranch in the Sierra Lampazos. He gave Mr. Lowery access to the ranch which was, and still is, home to a treasure trove of very cool plants, one of which is *Agave ovatifolia*. Mr. Lowery brought back either seed or small plants (the story is unclear) which he distributed around Texas. Fifteen years later, I contacted Jose Angel Villarreal, a botanist in Monterrey, Mexico, about the possibility of meeting up and attempting to find the Chief of Police (long retired by 2000) and obtaining permission to visit the ranch and the agaves. Ron Gass was kind enough to gather me up and drive over with me to make that happen, and Jose Angel and I formally described the plant, giving it the name *Agave ovatifolia*.

Anisacanthus quadrifidus

This medium-sized shrub with vibrant orange-red flowers is a hummingbird magnet. Ron Gass and I spotted this plant while racing along Mexico Highway 57 south of Saltillo, Mexico. The rich green leaves and show-stopping flowers were enough to make Ron screech to a stop (when it was safe, of course), turn the truck around, and regress to the plants so we could collect a few cuttings to grow and test in Phoenix and Tucson. The species has proven to be a winner for the desert southwest.

Buddleja marrubiifolia

Originally introduced by University of Arizona Professor Warren Jones, this shrub is one of the most drought tolerant plants on the market today. Shrubs in habitat are not much to write home about, but when used in the landscape the plant has a beauty and look unlike

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any other.

Cordia boissieri

This Chihuahuan Desert native is a large shrub that is frequently trained as a small tree. When in flower, the plant will stand out among other shrubs in the native habitat, and when used in a landscape, it is an eye-catching plant. In 1981, while working for University of Arizona, Professor Warren Jones and I traveled to the Falcon Dam area of south Texas to look for Tamaulipan plants that spilled across the Rio Grande and entered the Texas landscape. We came across several of these trees that were growing in grassy areas along the road leading to the dam. Stopping at one of them, we found numerous seedlings and dug some from the deep, rich south Texas soil. These survived the week-long return and were planted into 1-gal containers. They were grown on and eventually planted on the University of Arizona campus where some of them still thrive today.

Dalea capitata

This low-growing perennial to sub-shrub is a good example of a nondescript plant in habitat becoming one of the better landscape plants for the arid southwest. Ron Gass and I were traveling down Mexico Highway 57 south of Saltillo, Mexico, when he noticed a police car driving on the road. Ron, being the cautious man he is, signaled and pulled over to the side of the road to avoid any possibility of wrongdoing and so we could look at plants. While I was busy taking a few photos, Ron quietly made a few cuttings of this low-growing, roadside plant. A while after our return to Arizona, Ron brought me a couple of the plants that he had grown. One of them turned out to be this spectacular *Dalea* that we informally dubbed "policeman's *Dalea*", named for the fortuitous stop precipitated by the appearance of the policeman.

Dalea frutescens

This is one of those Gomer Pyle plants that make you stop and say "golly" after seeing it in peak bloom during the cooler fall months. In the early 1980s, my wife Carol and I took a trip to southern New Mexico and west Texas where we did some camping and sightseeing. We found a wonderful little, out-of-the-way spot to camp in the Davis Mountains of west Texas, and while looking around at the plants, I spotted one that appeared to be a *Dalea*. I proceeded to collect a handful of seeds which I later grew and identified as *Dalea frutescens*. It rewards the patient gardener with a flurry of flowers as the weather cools in the fall.

Dasylirion quadrangulatum

Long misidentified as *Dasylirion longissimum*, the name was finally clarified by Dr. David Bogler in 1998. In 1986, Ron Gass and I were in southern Tamaulipas, looking for the town of Miquihuana and *Leucophyllum revolutum,* when we saw hundreds upon hundreds of these plants dotting the hillsides. At that time, the road was dirt and went up the valley between the hills. We stopped when we figured we were as close as we would get to the plants, which were heavily laden with seed. We were able to gather some seed and grow many plants that have since found their way into landscapes throughout the southwest.

Nolina nelsonii

On that same trip in 1986, Ron and I first came upon these tall plants that resembled blue-leaved yuccas, but had no flowers to aid our identification of them. A few miles further down the road we spotted a plant loaded with seed and realized that it was a *Nolina* and not a yucca. We combined our heights by having me climb upon Ron's shoulders, and in doing so we were able to gather some seed. This seed was subsequently grown and then planted at their yard in Cochise County and used for seed production.

Yucca rostrata

Ron Gass and I collected seed of this amazing accent plant in northeastern Mexico on our 1986 trip and it has been a huge success in the landscape industry. We selected this outstanding population for its mostly tall, single-stemmed plants with narrow, flexible leaves.

THE NOT-QUITE-YET WINNERS

Cowania plicata

This is another very attractive Chihuahuan Desert shrub with rose-pink flowers. I have seen this plant several times, just not at the right time to gather any seed, and hope to one day be there at the right time so this can be tested in the desert southwest for its landscape potential. It grows in the dry regions of the Chihuahuan Desert and is found alongside other plants that have proven to be good performers in our area, which indicates this one ought to grow well here also.

Galphimia glauca

I first saw this plant on a 1986 trip to northeastern Mexico while Ron Gass and I were camped out in southern Tamaulipas. The area was filled with fascinating plants, from the tallest yuccas to the smallest cactus, but one of the plants that caught our eye was this shrub with its spikes of bright yellow flowers rising above the dark green foliage. This Chihuahuan Desert shrub is still being trialed in southern Arizona, but it has performed quite admirably and is worth adding to the plant palette in the desert southwest.

Hedeoma ciliolata

While on a trip in October 2001 with Carl and Wade from Yucca Do Nursery, we drove out to a very dry gypsum-laden hillside dotted with this wonderful little perennial plant, which did not have any seed on it at the time. My next encounter with this plant was in June 2006, and again the plants were in bloom and no seed was to be found. I finally was able to gather a small bit of seed in January 2009 while traveling to the region with fellow plant enthusiast, Scott Calhoun. I was familiar enough with the particular hill that we were able to find the plants after dark and collected a few seeds by flashlight. Three separate growers received some of the seed and none were able to get the plants past the seedling stage. This one certainly qualifies as a not-yet-winner and needs to be tested again.

***Scutellaria* species**

I collected cuttings of this undescribed species during a June 2006 trip. There were just a handful of plants growing in the limestone of a vertical road cut in the state of Hidalgo, Mexico. I was attracted to the bright red flowers set against the rich green foliage and was hoping that it would be a spectacular groundcover in landscapes of the desert southwest. I have tried growing this plant at least three times in my landscape, and have had trouble getting it established. Judging by the condition in which it grows, my first inclination was that it would not need a lot of water, and so treated it that way. Planting in full sun and in partial shade, I could not keep the soil moist enough to get the plant established. I finally put one in the well of a peach tree and it has become established, but I believe it is in too much shade to flower. My next test will be in the well of a deciduous fruit tree or on the south side of one to get more sunlight on the plant.

Zinnia juniperifolia

This is a lovely little sub-shrubby plant from slightly higher elevations in the Chihuahuan Desert Region. This is another plant that has been tough to establish in the landscape, but certainly worthy of continued testing. The orange flowers are unusual for a desert-adapted plant, yet the plant should mix nicely with big, bold accent plants and perennials with purple flowers. I will have to seek out more seed to give this another trial in the landscape.

This is just a snapshot of some of the successes and not-yet-successes from the past 30+ years of traveling the arid lands of the southwestern United States and northern Mexico.

New Zealand horticulture and lean manufacturing at Ardmore Nurseries©

P. Watt[a]

Ardmore Nurseries, 230 Clevedon-Takanini Road, Clevedon, Ardmore 2582, New Zealand.

WESTERN REGION/NEW ZEALAND EXCHANGE PROGRAM

During my time on the Western Region/New Zealand exchange program in the Western USA, my wonderful hosts, Jim and Andi Conner of Alta Nursery, showed me all around San Diego County, including nurseries such as Hines Growers, Village Nurseries, Armstrong Growers, EuroAmerican Propagators, First Step Greenhouses, Tree of Life Nursery, Olive Hill Greenhouses, and of course, Alta Nursery. I have had a very good insight into the IPPS Western Region, which has been most impressive.

I would like to provide an introduction to New Zealand horticulture and Ardmore Nurseries, where I work. I will then discuss lean manufacturing in nurseries, which my nursery has been involved with for the past 12 months.

NEW ZEALANDERS AND NEW ZEALAND HORTICULTURE

Typical New Zealanders are mostly Hobbits, such as myself, and the rest are Wizards, Dwarves, and Treefolk. Being Hobbits, we would rather identify ourselves as kiwis, which are much cuter creatures. However, I have noticed this can be confusing. Are we talking about the native bird or the fruit? That's why we call them kiwifruit to make that distinction. In America, they are just called kiwis, so just as a suggestion, you too could call them kiwifruit to avoid any confusion.

There are 4.7 million kiwis (the Hobbit variety) in New Zealand. 1.5 million of these live in Auckland. If you compare that to the population of San Diego, Phoenix, and Los Angeles, which includes 30 million people, you can see that, relatively, our domestic market is very small.

In terms of land area, New Zealand is a little smaller than Arizona, but it is a long and narrow country, 1000 miles long, so there is a lot of geographical variation from north to south, the north obviously being warmer. It is normal, even in the south, for summer temperatures to reach 90°F, but the averages are well below those of California and Arizona; they are more in line with Oregon, Washington, and British Columbia.

The combined horticultural exports of New Zealand total US$3.1 billion. Ornamental horticulture contributes virtually nothing to that total, as our export markets are out of reach to compete in that part of the industry. Our export products are mostly food crops. America contributes 15% to that revenue, importing mostly wine, apples, kiwifruit, and honey. Asia is our largest market (33%), followed by Australia (19%).

One misconception is that New Zealand and Australia are quite far away from each other. Yes, we have a friendly rivalry, like that between the USA and Canada. You may even think of us as Australia's Canada, but the distance between the two countries is, in fact, about 1,300 miles – not exactly paddling distance. Just a few years ago, there were a couple of Aussie kayakers who did just that. It took them 60 days and almost killed them.

ARDMORE NURSERIES

Ardmore Nurseries is where I work. We have a plane on our logo, because of a small commercial airport operating nearby. Students at the flight school often do stall-starts above us at frighteningly low altitudes. They keep us on our toes and entertained.

The nursery is 35 acres, which is quite large for New Zealand. Most of that land is used to grow plants in the ground. Our larger lines are planted close together, and every second one is dug out and containerized after 1 year. Those that remain are balled and burlapped,

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then sold as a second-year grade.

We also have container crops, including native species which you will be familiar with, like *Leptospermum scoparium*, which is one of my favorite plants, the source of Manuka honey, and famous for its health benefits.

Propagation has been my main role at Ardmore. We propagate about 200 taxa and grow on at least 200 additional taxa. Sizes range from 15-ft trees to groundcovers.

We sell 80% of our stock to landscapers and 20% to retailers. Our nursery is a one-stop shop for landscapers. They can drive around, pick their own plants, and hopefully visit the office on the way out.

An alliance of New Zealand nurseries shares trolleys on a swap system. Trolleys full of plants can be offloaded at a nursery destination and empty ones taken back, making the delivery process a lot quicker.

Ardmore Nurseries has four plastic tunnel houses. Only one house has bottom heat. With limited bottom heat, it can be tricky managing cuttings as they overwinter. Most woody shrubs can be held fairly easily. Also, because of limited space, we can only use the direct-stick method for short-term crops. Most cuttings crops are done in a community flat with a pumice and coconut coir medium.

I use sodium bicarbonate as a tool to spot treat liverwort around the nursery. It is also good for treating areas prone to slime and algae growth.

LEAN MANUFACTURING AT ARDMORE NURSERIES

Lean manufacturing is a model for eliminating waste and encouraging efficiency and innovation. The term was coined in 1988 to describe the Toyota production system, but the basic theories and principles of lean manufacturing stem from the Industrial Revolution. It is now used widely in the manufacturing industry.

It is interesting to apply lean manufacturing to horticulture because it is not nuts-and-bolts manufacturing. It has been useful in identifying major kinks in production. It has changed the way staff think and gets them involved. For me, thinking about improvements and ideas is not something that happens serendipitously anymore, it is something that I have time set aside for.

Visual management is a key aspect of how I assist the lean process. I create step-by-step guides and standards for various procedures. They seem a little bit like “how to suck eggs” visual aids, but they are great for setting benchmark times and showing new employees a great starting point. An important feature of the image is the inclusion of a suggestion box, so people can propose an improvement to the method.

The whiteboard is another important visual management tool. The idea is to use the whiteboard to identify problems and show anyone who looks at it the current state of affairs. It should not be used like a giant notepad that gets scribbled on and ignored. It should be structured. Examples of features on my whiteboard are a task checklist, targets (annual, monthly, weekly, and daily), health and safety notes, team responsibility checklist, ideas, upskilling material, and a record of recent successes and failures.

I like the theory of lean manufacturing, but I am skeptical of consultants that apply the theory to nurseries when they have no nursery background. I would advise you to help them understand the nursery processes, and be clear about what you want to achieve with lean manufacturing.

ACKNOWLEDGEMENTS

A big thank you to the IPPS Western Region Organizing Committee, the IPPS New Zealand Region, and all IPPS members for making this fantastic trip possible. Another special thank you to Jim and Andi Conner for taking great care of me, putting together a great series of nursery visits. I learned a lot, had heaps of fun, and cannot express how grateful I am.

A New Zealand experience: review of the IPPS Western Region member exchange for 2016©

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INTRODUCTION

The title for this year's Western Region conference is "A Different Point of View," and I was fortunate to be able to gain an absolutely different point of view in New Zealand earlier this year.

IPPS has a great program for exchanging members from one region to another. This exchange program is a unique opportunity to travel to a different region and interact with members there. This program fully embodies the IPPS motto, "to seek and to share". I was extremely honored to be chosen by the selection committee to represent the Western Region in New Zealand. It was quite a distance to go to seek, but what was shared with me was priceless.

This was the chance of a lifetime to see how the plant industry functions in a different region. Before I left, there were many questions I had hoped to answer:

- How different is the climate from the Western Region?
- What are the unique challenges facing nurseries there?
- What interesting techniques or information could I bring back to members here?
- How many Hobbits would I see?

If you are a young professional and thinking about whether or not to apply for this program, I encourage you to do so. More information and an application are available on the IPPS-Western Region website. Many of you may wish to visit New Zealand and this is a fantastic way to do so. The country is known for its scenic beauty, good wine, and adventure tourism. I don't want to say anything silly like "you should go". But, having said that, you should go! The people are wonderful, the scenery is beautiful, and the industry is fascinating.

TOURISM IN NEW ZEALAND

The New Zealand population is about the same as Kentucky and the land area about the same as Colorado. Oregon is a close match to New Zealand in terms of size, population, and climate. New Zealand shares all of the latitudes of Oregon and includes latitudes similar to Southern Washington and Northern California. The region is very similar to the Western Region in many regards. The population there is about 4.5 million compared to 4.0 million in Oregon, and New Zealand receives about 3.1 million tourists a year. This means about 6% of the population at any time are tourists. Among these tourists, 6% cited *The Lord of the Rings* trilogy as being one of their main reasons for visiting, whereas 1% said it was their only reason for visiting. That 1% of visitors translated into more than NZ$32 million in spending. With all the wonderful things to see and do, I did not get a chance to visit any Hobbit-related areas.

Tourism from China is increasing in the country, with about 222,000 visitors annually. The amount is up only 2.7%, but the length of stay is up 31%. The popularity of New Zealand is increasing due to media exposure through celebrities and TV. One reality TV show with segments in New Zealand was seen by 400 million viewers.

What does all this tourism exposure have to do with the plant industry? Visitors to New Zealand come to see the natural beauty of the country, and this is reflected in the conservation and restoration work done throughout the country. Upon completion of construction projects, the plantings around public infrastructure must use locally-sourced native plants. This ensures both a natural look to the vegetation and use of plants adapted to the local climate. With Asian countries receiving 30% by value of New Zealand's

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horticultural exports, marketing and tourism has a compound feedback effect. Promotion leads to a better perception of quality. This improved perception can lead to the ability to command higher prices, result in more visitors, and lead to increased consumption of New Zealand products in the visitor's home country.

HORTICULTURE IN NEW ZEALAND

In terms of the horticultural industry, the New Zealand market brings in over $7 billion each year. Of that amount, 60% is for export, with the largest categories being wine, apples (*Malus*), potatoes (*Solanum tuberosum*), onions (*Allium*), and avocadoes (*Persea americana*). While dairy exports account for a much larger amount (almost $17 billion), dairy production requires almost 14 times more land area. Horticulture value is about $31,000 per hectare, whereas dairy is worth only $10,000 per hectare. The top export destinations around the globe are Australia, the United States, Japan, the United Kingdom, Europe, and China. Given the geographic isolation of New Zealand, the focus is on value. Higher value/lower volume exports, such as produce, dairy products, and Hobbit films, are easier to distribute than higher volume/lower value products, such as wool.

It is clear to see that there is a growing demand for high quality products. Both exports and tourism are increasing. More people are traveling to New Zealand and demand for products from New Zealand is putting pressure on the availability of food products. Growers want new genetics. Many of the people I spoke with were concerned about the amount of time it takes to get new varieties through the strict quarantine process. To support the industry in this region, we should ask ourselves what we have and how we can work to provide it to the growers that want it.

During my time in New Zealand, there were so many wonderful things about the experience, from the culture and food to the nurseries, cities, and natural areas. But the best part about trip, far and away, was the people. Their kindness, generosity, and good humor is something I will never forget. I learned that the industry has a fairly large segment focused on locally sourced native plants, their exported food products are known for their high quality, and everyone is open and willing to share.

During this trip, I learned so much about the industry and many of its unique aspects. The challenges facing growers in the New Zealand Region are very like those familiar to IPPS members in the Western Region: 1) increasing labor costs and a shrinking pool of workers; 2) changing laws and regulations with regards to working hours, construction of buildings, and land use restrictions; and 3) new pests to fight, weeds to pull, and continuing disease pressures. Even though the market seems to be growing again, costs are rising and profits seem harder to obtain in order to invest in employees and facilities. In spite of this turmoil, many are adapting and transforming. Garden centers are becoming lifestyle centers and educating their customers that they are more than a place to get some plants and maybe a decorative pot. Now it's about helping customers to make the most out of their yard and garden. Wholesalers are finding ways of enhancing value, such as providing after-sales support to help growers to be successful with new plants and varieties. Some are supplying marketing materials and complete programs that highlight new and unique features of plants that customers might not be aware of. The companies that are showing their customers the true value of their products are the ones that will survive this transformation.

ACKNOWLEDGEMENTS

I want to say thank you for this opportunity. Many thanks to the IPPS Western Region Selection Committee, all of the IPPS New Zealand Region members, Philip and Janine Smith (who were my hosts in New Zealand), and everyone here for being a member of IPPS. This great organization is a wonderful support network for learning about our industry and how it impacts our world.

All-America Selections winners for 2016: ornamentals and edibles with proven performance for North American gardens©

D. Blazek[1,a] and E.K. Blythe[2,b]

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Abstract

Twelve cultivars, including two ornamental crops and ten edible crops, became All-America Selections (AAS) National Award Winners for 2016. In addition, six cultivars, including two ornamental crops and four edible crops, became AAS Regional Award winners for 2016. AAS awards are based on impartial trials at over 80 trial ground across North America.

INTRODUCTION

Twelve cultivars became All-America Selections (AAS) National Award Winners for 2016. AAS includes a network of over 80 trial grounds all over North America where new, never-before-sold cultivars are "Tested Nationally and Proven Locally®" by skilled, impartial AAS Judges. Only the best performers are declared AAS Winners. Once these new cultivars are announced as AAS Winners, they are available for immediate sale and distribution.

An additional six cultivars were selected as AAS Regional Award Winners for 2016. Regional winners undergo the same trialing process as national winners, but are recognized as cultivars that exhibit outstanding performance in specific regional climates.

During 2016, AAS added herbaceous perennials to the AAS trialing program. AAS worked with the Perennial Plant Association (PPA) to develop a thorough and horticulturally sound perennial trial, and PPA actively endorses this new AAS trial. Unlike the AAS single growing season trials with annuals and edibles, the perennial trials will be three-winter trials. The first AAS winners from the perennial trials will be announced in 2019.

AAS NATIONAL WINNERS FOR 2016

Brassica juncea 'Red Kingdom' (F_1 mizuna or Japanese mustard)

Foliage color of this high-yielding mizuna was a vibrant reddish-purple throughout the trial season and slower to bolt than other cultivars. This flavorful, mild-tasting green may be used as a vegetable or as an ornamental in containers and in the landscape. Bred by Asia Seed Co. Ltd.

Brassica oleracea 'Katarina' (F_1 cabbage)

This new cabbage has a perfect, smaller head size (4 in.) and shape for growing successfully in containers on patios or decks, or in the ground, and matured as much as 1 to 3 weeks earlier than cultivars used for comparison in the AAS trial. Bred by Bejo Seeds.

Brassica oleracea 'Konan' (F_1 kohlrabi)

This new cultivar was selected for its smooth, globe-shaped bulbs that can grow up to 6 in. in diameter. The sweet, flavorful bulb has an excellent texture, making it easy to slice and dice. Bred by Bejo Seeds.

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***Brassica oleracea* 'Prizm' (F_1 kale)**

Plants produce attractive, short, tight, ruffle-edged leaves and may be grown in containers as well as in-ground beds. The excellent tasting, almost nutty-flavored leaves are tender enough to enjoy in fresh salads, but also hold up well when cooked. Bred by Syngenta Vegetable Seeds.

***Capsicum annuum* 'Cornito Giallo' (F_1 pepper)**

Starting as small green fruits, the peppers develop into bright yellow jewels with a delicious sweet and fruity flavor. The peppers themselves are plentiful and durable, yet good for eating fresh. Bred by Johnny's Selected Seeds.

***Capsicum annuum* 'Escamillo' (F_1 pepper)**

These attractive, golden-yellow peppers have a wonderful sweet taste. The early bearing, high yielding plants hold their fruit off the ground for easy picking and less rotting. Bred by Johnny's Selected Seeds.

***Cucurbita pepo* 'Pepitas' (F_1 pumpkin)**

This new cultivar is named for its hulless seeds (pepitas) that lack the tough outer hull, making them easy to eat after slow roasting. Plants produce numerous, uniform, medium-sized pumpkins on healthy, disease-resistant vines. Bred by Seeds by Design and W. A. Burpee.

***Fragaria ×ananassa* Delizz® (F_1 strawberry)**

These vigorous strawberry plants are easy to grow from seed or transplant, and produce an abundant harvest throughout the growing season. The plants are a nice uniform and compact size, making them suitable for containers, hanging baskets, or garden plots. Bred by ABZ Seeds.

***Pelargonium ×hortorum* 'Brocade Cherry Night' (geranium)**

This heat-tolerant geranium features bronze leaves with green margins, along with large, semi-double blooms of cherry pink. Gardeners will find this new cultivar useful for mixed planters, containers, or garden beds. Bred by Dümmen Orange.

***Pelargonium ×hortorum* 'Brocade Fire' (geranium)**

This new geranium has unique bicolored foliage with a colorful display of semi-double, bright orange flowers. Plants keep their foliage color and flowers throughout the warm summer, then becomes an attractive transitional flower going into fall. Bred by Dümmen Orange.

***Solanum lycopersicum* 'Candyland Red' (currant tomato)**

This is the only AAS award-winning currant-type tomato. The plants have a tidier habit than other currant-type tomatoes, with the fruit tending to form on the outside of the plant, making them easier to harvest. Bred by PanAmerican Seed Company.

***Solanum lycopersicum* 'Chef's Choice Green' (F_1 tomato)**

This disease-resistant tomato produces beautiful green-colored fruits with subtle yellow stripes. The ripe tomatoes have a citrus-like flavor and perfect tomato texture. Bred by Seeds by Design.

AAS REGIONAL WINNERS FOR 2016

***Allium fistulosum* 'Warrior' (bunching onion or green onion) (Regions: Southeast, Mountain/Southwest)**

This bunching onion grows quickly and matures early, producing a very uniform crop of slender, crisp onion stalks that are easy to harvest and clean. Bred by Seeds by Design.

***Capsicum annuum* 'Black Hawk' (F_1 ornamental pepper) (Regions: Southeast, Heartland)**

Plants start flowering and forming fruit very early and keep producing through fall. Fruit turn from dark purple to red and are spicy if eaten. Bred by Seeds by Design.

***Capsicum annuum* 'Flaming Jade' (F_1 pepper) (Regions: Heartland, Great Lakes)**

Plants produce a heavy set of large, long, firm, Serrano peppers throughout the growing season, especially in cooler areas. Bred by Seminis Vegetable Seeds.

***Cucurbita pepo* 'Super Moon' (F_1 pumpkin) (Regions: Southeast, Great Lakes)**

Grown for their fruit size (up to 50 pounds) and their clean white color, these hardy plants are known for their early fruit development and vigorous growth. The yellow flesh is good for roasting or in fall harvest soups. Bred by Seeds by Design.

***Raphanus raphanistrum* subsp. *sativus* 'Sweet Baby' (syn. *Raphanus sativus* 'Sweet Baby') (F_1 radish) (Regions: Southeast, Great Lakes)**

This purple, white, and rose-colored radish produces crops of uniform size with a crispy, crunchy, and slightly spicy taste. Bred by Asia Seed Co., Ltd.

***Salvia coccinea* Summer Jewel™ Lavender (Texas sage) (Regions: Southeast, Heartland, Great Lakes)**

This is the fourth AAS Winner in the Summer Jewel™ series of Texas sage. The unique, dusty lavender-purple flower color is a delight in the garden and flower containers, and serves as a major attractor of pollinators. Bred by Takii & Co. Ltd.

In summer 2016, the first five AAS National and Regional Winners for 2017 were announced:

***Abelmoschus esculentus* 'Candle Fire' (F_1 okra) (National Winner)**

This unique red okra produces pods that are round, not ribbed, and a brighter red color than other reddish-burgundy okras. Bred by Known-You Seed.

***Celosia argentea* 'Asian Garden' (celosia) (National Winner)**

Plants of this new celosia show good branching with a semi-bushy habit and flower early with flower spikes that attract pollinators. Bred by Murakami Seed Co., Ltd.

***Citrullus lanatus* 'Mini Love' (F_1 watermelon) (National Winner)**

Shorter vines (3 to 4 ft) produce up to six fruits per plant and can be grown in smaller spaces. Bred by HM·Clause.

***Cucurbita moschata* 'Honeybaby' (F_1 winter squash) (Regional Winner: Heartland)**

Shorter vines grow 2 to 3 ft with a semi-bushy habit. Short, wide fruits are large, sweet, nutty, and meatier than similar cultivars. Bred by Seeds by Design.

***Pisum sativum* 'Patio Pride' (pea) (Regional Winner: Southeast)**

The compact plants of this pea produce sweet, uniform pods that are very tender when harvested early. Bred by Terra Organics.

More information on AAS and AAS winners is available at: www.all-americaselections.org

2016 trial garden winners at the Mississippi Truck Crops Branch Experiment Station©

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Abstract

During 2016, 109 new bedding plants were trialed for performance in Crystal Springs, Mississippi, under low-maintenance landscape conditions. The top performers among sun-loving flowering plants, sun-loving foliage plants, and shade-loving flowering plants were identified. Results from the plant trials serve as a resource for horticultural professionals, educators, and home gardeners in Mississippi.

INTRODUCTION

Plant performance varies throughout the USA because it is highly influenced by environmental factors. Therefore, it is important that new varieties are evaluated for regional performance. We trial new bedding plant material for performance in Crystal Springs, Mississippi (USDA hardiness zone 8b). This trial serves as a resource for horticultural professionals, educators, and home gardeners in Mississippi. It helps growers select new material that will likely perform well and it helps create a demand from consumers for new plant material that is adapted to this region.

This year, 109 plant entries were trialed in the garden from Ball Horticultural Company, Proven Winners, and Sakata. Four entries were trialed both in the shade and in full sun, and 27 entries were trialed in 30-cm hanging baskets. All entries were grown from seed, unrooted cuttings, or rooted plugs. Planting into raised beds began on April 15, 2015 and semimonthly ratings (1 to 5, where 5 is a perfect score) were taken from mid-April to late August based on uniform growth, flowering, leaf health, and landscape impact. Plants were fertilized, weeded, and sprayed as necessary, but deadheading was not done so as to mimic low-maintenance landscape performance. Water was supplied through drip irrigation as needed. Trial data was uploaded to a trial garden website: blogs.msucares.com/ornamentals.

SUN-LOVING FLOWERING PLANT WINNERS

Most of the entries performed very well through late June. As the summer temperatures rose, plant performance waned for some entries. Ten top-performing varieties were identified. Ornamental pepper 'Sedona Sun' (PanAmerican Seed; rated 4.46) was the year's top performing plant. Several impatiens performed very well and included SunPatiens® Compact Coral Pink, SunPatiens® Compact White Improved, SunPatiens® Compact Tropical Rose, and SunPatiens® Compact Red (Sakata; ratings above 4.2). Others in the top ten list included vinca 'Titan Pure White' (PanAmerican Seed), cleome 'Señorita Blanca' (Proven Winners), *Gomphrena* 'Ping Pong Lavender' (Sakata), and Petunia Supertunia® and Vista Silverberry (Proven Winners).

FOLIAGE PLANT WINNERS

Many of the foliage plant entries performed extremely well this year. The top performer was *Alternanthera* 'Purple Prince' (PanAmerican Seed; rated 4.83), followed by several new cultivars belonging to the *Ipomoea* Sweet Caroline series: Raven, Sweetheart Jet Black™, Bewitched After Midnight™, Bewitched Green with Envy™, Sweetheart Lime, and Light Green (Proven Winners). Two coleus cultivars also made the top ten list: 'Inferno' and

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‘Ruby Slipper’ (Proven Winners). *Artemisia stelleriana* Quicksilver™ also made the list, but had problems with heavy August rains and suffered from root rot caused by fusarium.

SHADE-LOVING FLOWERING PLANT WINNERS

Eight shade cultivars were recommended this year. Impatiens Big Bounce™ Pink and Bounce™ Bight Coral topped the list for top performers in the shade (Selecta; rated above 4.45). All cultivars from the Whopper® series of begonias (bred by Benary) made the list: ‘Rose with Bronze Leaf,’ ‘Rose with Green Leaf,’ ‘Pink with Green Leaf,’ ‘Red with Bronze Leaf,’ ‘Red with Green Leaf,’ and ‘Pink with Bronze Leaf’. They performed well in spite of hot summer temperatures.

Propagation of Gambel oak (*Quercus gambelii*) by layering©

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Abstract

Gambel oak (*Quercus gambelii*) has potential as a small, drought tolerant tree for landscapes in the southwestern United States. Vegetative propagation of Gambel oak by mound layering was examined in Kaysville, Utah, from 2012 to 2015. Layering was done by pruning trees to their base each year and then gradually mounding conifer shavings around the base of each tree as new shoot growth occurred throughout the season. Shoots were girdled and treated with auxin in July of each year or left untreated as controls, and harvested in October or November of each year. Rooted layers were transplanted into 1-gal. pots and grown in a greenhouse for observation. Rooting of treated shoots and controls increased with age of the stock plants and with use of auxin. Further research to improve survival of the rooted layers will be needed.

INTRODUCTION

Gambel oak (*Quercus gambelii* Nutt.) is native to the American Southwest, readily hybridizes with other white oaks, and has potential as a small, drought tolerant landscape tree. However, seedling trees are variable and production of superior selections of the species or its hybrids is limited by difficulties in asexual propagation. During 2012-2015, vegetative propagation of Gambel oak by mound layering was examined at the Utah Agricultural Experiment Station Farm in Kaysville, Utah.

MATERIALS AND METHODS

Stock plants of Gambel oak were established by planting a row of 18 5-gal. plants on 3-ft spacing in 2011. Irrigation was done with pop-up spray heads using a variety of timing configurations depending on the season and supplemented with hand irrigation as needed to keep shavings moist. Plants were fertilized with 0.5 lb. N per 1000 ft^2 annually. Layering was done by pruning trees to their base each year and then gradually mounding conifer shavings around the base of each tree as new shoot growth occurred throughout the season. Appropriate shoots were selected for layering and randomly assigned for controls or treatment within trees. A combined treatment of girdling (4×0.10-in. cable tie 1 cm above the shoot base) and auxin (4000 ppm indolebutyric acid and 2000 ppm naphthalene acetic acid as Dip'N Grow® in 25% ethanol applied to the 3 cm of stem immediately above the girdle) was applied in early July of each year. The data for 2013 was pooled from shoots receiving the 4000/2000 ppm auxin treatment or 8000/4000 ppm auxin treatment since there was no apparent difference in rooting between the two. As stock plants grew, the number of shoots used for layering increased from one to five per plant.

Rooted layers were harvested in late October or November by cutting the stem as close as possible to the base and then held in moist shavings at 4°C until transplanted. The number of roots per shoot, stem length, and stem diameter were measured each year. In 2015, layers were harvested on 20 November and held at 4°C until transplanted on 4 March 2016. Prior to transplanting, the diameters of the largest three roots per shoot were measured. Rooted layers were transplanted into 1-gal. pots with a 2:1 perlite and peat substrate and randomly placed in a greenhouse at 65/60°F DT/NT until budbreak, after which they were grouped by parent tree for observation.

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RESULTS AND DISCUSSION

There was a marked increase in rooting of layers from 2012-2015 for both the control (4, 8, 21, 49% $year^{-1}$, respectively) and the treated shoots (17, 35, 56, and 65% $year^{-1}$, respectively). Analysis of the probability of rooting over the 4-year period using the GLIMMIX procedure of SAS (0.05 significance level) showed a significant effect of both time and the girdle/auxin treatment. The reason for increased rooting with age of stock plant is unknown. A similar analysis of the number of roots per rooted layer showed no statistical significance due to time or treatment. Among the rooted layers transplanted, there was no significant impact of treatment on survival. However, there was a correlation between the average diameter of the largest three roots per shoot and subsequent survival. On an observational level, only 13% of controls and 21% of treated shoots from 2015 survived and grew, indicating that improvements are needed before this method is commercially viable for propagation of Gambel oak.

Increasing blue light from LEDs reduces leaf length in kale©

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Abstract

Kale (*Brassica oleracea* Acephala Group) seedlings were grown for 21 days under increasing blue light from light-emitting diodes in chambers under low or high photosynthetic photon flux density. Only leaf length was significantly affected, with leaf length decreasing as blue light increased.

INTRODUCTION

Despite years of research, the effect of light quantity (intensity) and quality (color) on plants remains poorly understood. Light-emitting diodes (LEDs) now facilitate this research because of their narrow band wavelength. Blue light (400-500 nm) has been known to reduce leaf expansion and petiole elongation is some crops (Cope and Bugbee, 2013; Cope et al., 2014; Snowden et al., 2016).

Kale is one of seven vegetables in the species *Brassica oleracea*. Kale was chosen for this study as a representative of *B. oleracea* because of its nutritional value.

MATERIALS AND METHODS

The system included 16 chambers: eight chambers at low photosynthetic photon flux density (PPFD; 200 μmol m^{-2} s^{-1}) and eight at high PPFD (500 μmol m^{-2} s^{-1}). The spectral distributions for the chambers used at each PPFD are shown in Figure 1. Kale seeds where pregerminated and then transplanted into growing media in containers. Plants were harvested 21 days after seedling emergence.

RESULTS AND DISCUSSION

Among all parameters tested, only leaf length was affected significantly by increasing blue light (Figure 2). Fresh mass and dry mass decreased, but not significantly. Percent dry mass, leaf area, and specific leaf area were not affected by increasing blue light.

Kale is less affected by blue light than other crops tested under similar conditions. Lettuce, tomatoes, and radishes are more affected by blue light than kale (Snowden et al., 2016). Wheat is less sensitive than kale to changes in percent blue light.

Our data indicate that further studies should focus on selecting wavelengths of light that enhance cell enlargement and the development of leaf area and radiation capture.

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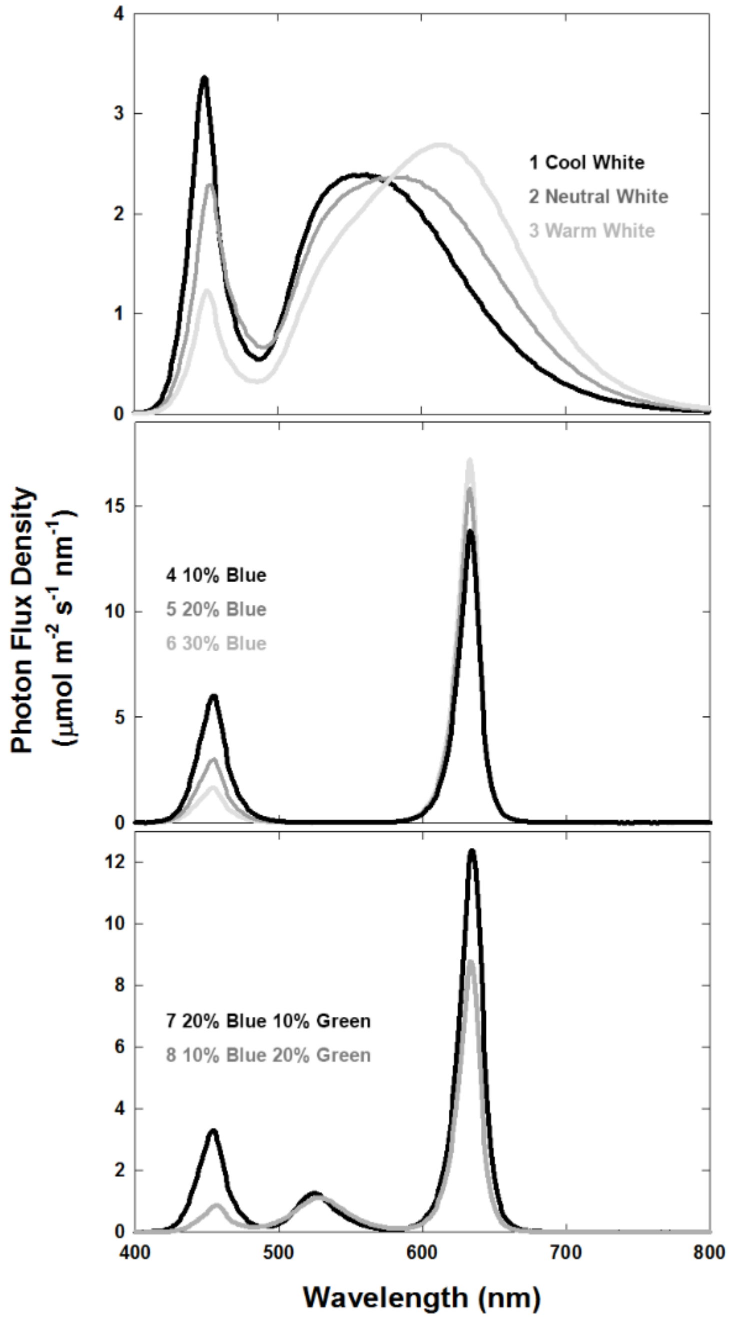

Figure 1. Spectral distributions for eight chambers used in a study examining effects of increasing blue light from light-emitting diodes on kale.

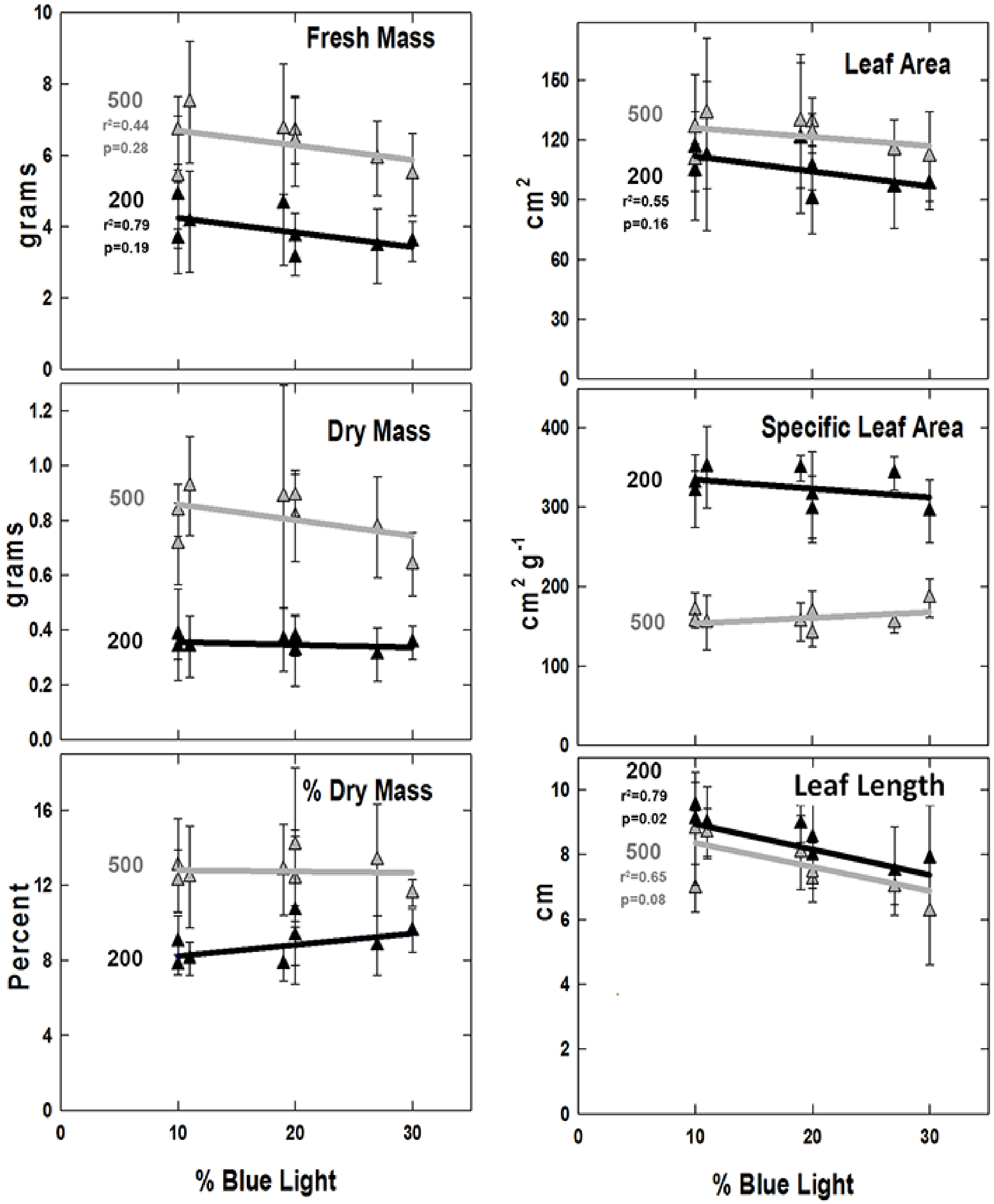

Figure 2. Responses of kale to increasing blue light from light-emitting diodes at low photosynthetic photon flux density (PPFD; 200 µmol m^{-2} s^{-1}) and high PPFD (500 µmol m^{-2} s^{-1}).

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The response of kamanomano (*Cenchrus agrimonioides* var. *agrimonioides*) root and shoot growth to pre-plant hormone soaking and simulated hydromulch establishment procedure©

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Abstract

Kamanomano (*Cenchrus agrimonioides* var. *agrimonioides*) is a federally endangered, stoloniferous, perennial grass endemic to the islands of Oahu, Lanai, and Maui. Its low-growing habit and drought tolerance make it a recognized species for restoration and a potential species for roadside revegetation. Large scale revegetation with kamanomano requires an efficient means of propagation and planting. Hydrocapping of vegetative propagules is a commonly utilized method for establishing turf, but very few studies have looked at its use with native Hawaiian plants. In this study, the feasibility of hydromulch capping of stem cuttings as a means of large-scale planting and pre-plant hormone soaks as a means to improve rooting were evaluated for kamanomano. Apical stem cuttings (20 cm long with leaves intact) were collected from nursery-grown stock plants and soaked for 24 h in either: 1) tap water; 2) 1:20 dilution of Dip 'N Grow [500 ppm indolebutyric acid, 250 ppm naphthalene acetic acid]; or 3) 1:10 dilution of Dip 'N Grow [1000 ppm indolebutyric acid, 500 ppm naphthalene acetic acid]. Treated and untreated (unsoaked control) cuttings were spread in seedling trays filled with potting medium. The cut stems were covered with hydromulch at a rate of 3,300 kg ha^{-1}. Percent rooting and number of shoots were recorded 45 days after planting. Results indicate that soaking in Dip'N Grow increased rooting percentage and shoot number. Field establishment protocols should include a 24-h preplant soak in a 1:10 dilution of Dip'N Grow to enhance rooting and shoot growth.

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Fluorescent and LED lighting effects on hydroponically grown ‘Winter Density’ bibb lettuce©

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Abstract

Food safety, environmental impacts, and efficient energy usage are increasing concerns in horticultural production systems. Producing lettuce under artificial lighting could be a solution addressing these concerns. Light-emitting diodes (LED) offer the advantages of a narrow light spectrum, low power consumption, and little heat production. The objective of this study was to compare the effects of different light sources on the growth of compact ‘Winter Density’ bibb lettuce in a non-circulating hydroponic system. ‘Winter Density’ bibb lettuce seeds were started in Oasis cubes under T5 high output fluorescent lighting in a lab. Seedlings were transferred to 5.1-cm net pots, which were placed in 1.9-L containers containing a hydroponic nutrient solution. The solution was composed of Hydro-Gardens’ (Colorado Springs, CO) Hobby Formula 10-8-22 hydroponic fertilizer with added magnesium sulfate (9.8% Mg). The lettuce seedlings were grown under red+blue+white LEDs with a light level of 121 µmol m^{-2} s^{-1} and a photoperiod of 16 h. After 10 days, half of the plants in the containers were moved under T5 high output fluorescent lighting for 10 more days. The light level was 118 µmol m^{-2} s^{-1} and the photoperiod was 16 h. At the end of the study, lettuce under LED lighting used significantly less hydroponic nutrient solution than those under fluorescent lighting. Biomass productivity (biomass produced per unit of nutrient solution used) was higher with LEDs. Electrical conductivity (EC) of the nutrient solution was lower in the LED treatment. However, there was no significant difference in the pH of the nutrient solution. Plant height, shoot dry weight, root dry weight, shoot:root ratio, total plant dry weight, partitioning of dry weight to the shoots, partitioning of dry weight to the roots, and SPAD readings did not significantly differ between light treatments. In conclusion, LED lighting was more efficient by using less nutrient solution and producing more biomass per unit of nutrient solution. Moving lettuce plants from initial LED lighting to later fluorescent lighting did not enhance the growth of hydroponically grown compact lettuce.

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Broken Arrow Nursery plants: an exploration of underutilized plants, our introductions and the future©

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INTRODUCTION

Since its inception, Broken Arrow Nursery has strived to be a premiere destination nursery that acquires, develops, and grows rare, unusual, and garden-worthy plants. We work tirelessly to offer superior quality, outstanding customer service and expert advice to gardeners and enthusiasts.

Vision

The vision of Broken Arrow Nursery is to inspire a love of plants and enrich the lives of our customers through the unique, great plants we grow and knowledge we freely share. We are breeders, collectors, propagators and promoters. In our efforts to achieve this vision we have developed and introduced a diversity of trees, shrubs and perennials through the years. This paper will provide a summary of some of our past plant introductions, a summary of a few underutilized and exceptional offerings as well as a glimpse toward future plant selections.

PAST INTRODUCTIONS

Kalmia latifolia

This exceptional state flower of both Connecticut and Pennsylvania is frequently referred to as one of the most beautiful of all flowering plants. Native throughout eastern North America, it is commonly found growing along roadways and power lines or in shaded, acidic woodlands. Wild plants typically showcase eye-catching pale pink flowers in late May and early June. Added interest is provided by their beautiful, glossy, dark green foliage. In the landscape, plants grow best in full sun or part shade in moist, well-drained, acid soil.

We tend to be biased concerning this outstanding shrub, but with good reason. Our founder, Dr. Richard Jaynes has been actively researching, breeding, and selecting improved forms of the species for more than 50 years. The result is more than 30 cultivar introductions that include a startling range of flower colors and plant habits. At the nursery we currently hold one of the largest collections of mountain laurel in the world. A cross-section of noteworthy introductions include:

- *Kalmia latifolia* 'Peppermint'. The blush-pink flower buds open to display striking near-white flowers with a unique maroon-red pattern that resembles a classic peppermint candy. Winner of the Ames Award at the 1991 Boston Flower Show.
- *Kalmia latifolia* 'Freckles'. An older, compact-spreading selection with white flowers each marked with 10 purplish-cinnamon "freckles". Plants show medium leaf spot resistance and flower nicely from a young age.
- *Kalmia latifolia* 'Sarah'. An eye-catching selection with dark red buds that open vibrant pink-red (Figure 1). Our exceptional 8-ft specimen plant always impresses visitors when in flower. The foliage is dark green and free from disease when grown in the open with some air circulation. Plants are always in high demand!

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Figure 1. *Kalmia latifolia* ‘Sarah’.

- *Kalmia latifolia* ‘Carol’. Bright, intense red buds contrast well with the near white, newly opened corollas. Open flowers darken to pink as they age. The low growing plants have broad, wavy, leaf spot resistant foliage.
- *Kalmia latifolia* ‘Firecracker’. The result of five generations of breeding work with notable parentage including the likes of *K. latifolia* selections ‘Carol’, ‘Sharon Rose’, and ‘Sarah’. Plants offer brilliant, deep red flower buds that open near white and age to pale pink (Figure 2). The overall effect is a striking, bicolor display of red buds and white open flowers. This floral affect, combined with the glossy, dark green foliage and excellent disease resistance make it a promising alternative to ‘Olympic Fire’ and other red-budded cultivars. Plants are more compact than the species maturing approximately 4 ft by 4 ft in 10 years under normal garden conditions.

Figure 2. *Kalmia latifolia* ‘Firecracker’.

- *Kalmia latifolia* ‘Keepsake’. A recent introduction that is the result of five generations of controlled crosses begun in 1966. Plants display striking raspberry-red flower buds that open to near-solid purplish burgundy flowers with a fine white edge (Figure 3). Flowers are backed by pest free, glossy, bluish-green leaves.

Figure 3. *Kalmia latifolia* ‘Keepsake’.

- *Kalmia latifolia* ‘Little Linda’. A fine addition to the miniature (little leaf) laurel group. It is the first named mountain laurel to combine miniature habit with red-budded flowers. The buds open to display white corollas which age to pink. Foliage is reduced in size, dark glossy green and leaf spot resistant. Plants display a compact-rounded growth habit.
- *Kalmia latifolia* ‘Minuet’. A distinctive, vigorous miniature laurel with pink buds that open to bright cinnamon-maroon banded flowers. The small leaves are lustrous dark green and recurve from petiole to tip. Plants display excellent branch structure and a compact-rounded form. One of the best!
- *Kalmia latifolia* ‘Tinkerbell’. A miniature laurel with heavy textured flowers that are deep pink in bud and medium pink in flower. Foliage is dark green and resistant to leaf spot. Plants show good vigor and will mature somewhat broader than tall.

Looking beyond mountain laurel

Looking beyond mountain laurel our efforts have led to a diversity of unique deciduous trees and shrubs, conifers and herbaceous perennials. Key selections include:

- *Clethra alnifolia* ‘Ruby Spice’. A rich pink flowered form of summer sweet clethra that has become quite popular in the industry. Flowers are the darkest pink to date and hold their color well in the heat of summer. Honored with many horticultural awards including the Cary Award and the Pennsylvania Horticultural Society Gold Medal. Height is 5-6 ft.
- *Hamamelis virginiana* ‘Harvest Moon’. ‘Harvest Moon’ has attractive, burgundy-flushed new growth that matures to dark green. In late fall, plants offer numerous clusters of large, lemon-yellow flowers that are closely spaced along the branches (Figure 4). The overall effect is a much showier display than is common for the species. In our trials, plants have flowered up to 2 weeks later than the species and remain showy after the foliage drops. In cultivation, plants are vigorous and assume an upright, vase-shaped habit when grown in full sun. Height is 15-20 ft.

Figure 4. *Hamamelis virginiana* ‘Harvest Moon’.

- *Hamamelis* × *intermedia* ‘Sweet Sunshine’. An upright, semi-compact hybrid witch hazel with highly fragrant, bright yellow flowers. The original plant has grown next to our main driveway for more than 30 years where it has reached approximately 18 ft in height. Plants have received strong reviews and always solicit comments from nearly all customers when in flower in late winter and early spring. Formerly listed as *H. mollis* ‘BAN Select’.
- *Ilex verticillata* ‘Sunsplash’. A variegated winterberry holly that offers bright, gold-splashed foliage throughout the growing season and respectable crops of orange-red fruit in autumn and early winter (Figure 5). The foliage quality offers a wonderful extension to the ornamental display of this noteworthy species.

Figure 5. *Ilex verticillata* ‘Sunsplash’.

- *Rubus cockburnianus* 'Razzle Dazzle'. This 2011 introduction boasts showy pink, cream, and gold mottled foliage that remains colorful throughout the growing season. The variegation pattern is intricate, and resistant to sun scald and scorch making it a valuable addition to the shrub border or prime garden position. Like the species, white dormant canes add color during winter. Plants are good garden performers growing slightly slower than the species and reaching 4 ft tall × 6 ft wide.
- *Viburnum dentatum* 'Island Treasure'. A recent introduction discovered as a branch sport in Maine. Plants offer foliage that is brightly streaked and splashed with creamy-gold variegation (Figure 6). Typical white, flat-topped flower clusters in spring followed by crops of blue fruit in autumn. Plants are vigorous, performing best in a drought free area with some afternoon shade.

Figure 6. *Viburnum dentatum* 'Island Treasure'.

- *Pinus strobus* 'Little Giant'. This plant resulted from a witches' broom found growing in Sleeping Giant State Park, Hamden, Connecticut. Plants have excellent, dark blue-green needles and develop a squat-conical habit. Our original plant has averaged 2-3 in. of growth annually and reached approximately 3 ft in height after 12 years.
- *Stewartia rostrata* 'Pink Satin'. An exciting color breakthrough for the species showcasing pale, shell-pink flowers backed by a ring of burgundy-purple bracts (Figure 7). Flowering commences in mid-May continuing for a 2- to 3-week period. Each blossom is approximately 1.5 in. in diameter with pigment coloration that radiates throughout each petal. The large, immature fruits add ornamental appeal with a rich, pinkish-red blush that stands apart from the glossy green foliage. New growth emerges in spring flushed with burgundy and develops attractive scarlet tones in autumn. Plants are well formed developing a distinctive pyramidal habit when young and averaging 6-12 in. of growth annually. Our original specimen measured 13 ft tall × 6 ft wide at 13 years of age.

Figure 7. *Stewartia rostrata* 'Pink Satin'.

- *Epimedium* 'Space Invaders'. This 2012 introduction was selected from a batch of open pollinated seedlings whose seed parent was *E. chlorandrum*. Essentially evergreen, the dark green, spiny edged, glossy foliage remains attractive into January. In April, flowering stems emerge above each 12-15 in. tall slowly spreading plant. Flowers consist of showy reflexed white sepals and 1- to 1½-in. long spurs (petals) that are pale yellow and uniquely speckled with rusty orange.
- *Epimedium* 'Raspberry Rhapsody'. This 2012 introduction was selected after 7 years of evaluation. This open pollinated seedling of *E. sutchuenense* has flowers comprised of mauve-rose spurs (petals) and pale pink sepals held above 12- to 15-in. clumps. Leaves emerge in shades of mahogany-red before becoming green during the summer. Shaded woodland sites with consistent moisture are ideal; however our plant has performed exceptionally under drier conditions.

UNDERUTILIZED PLANTS

In addition to our plant breeding and selection efforts we strive to find, propagate, and promote underutilized and exceptional plants. The following represents a small cross section of plants we feel a worthy of broader landscape consideration.

***Calycanthus floridus* 'Michael Lindsay'**

Among the best of the group! Dark, lustrous, green foliage turns soft, butter-yellow in fall. Ample dark maroon flowers emit a strong, pleasant fragrance that is reminiscent of strawberries and melon. Plants are strong growers when cultivated in rich, evenly moist soils. Height is 6-10 ft.

***Hamamelis virginiana* 'Little Suzie'**

A charming compact selection of common witch hazel with bright yellow flowers in October/November and yellow fall color. Plants are compact, tightly branched, developing a formal, rounded framework. Excellent for late season interest and valuable for smaller properties. Plants average 3-6 in. of growth annually and can be expected to reach 6 ft in height after 10-15 years.

***Hydrangea strigosa* (syn. *H. aspera* subsp. *macrophylla*)**

A dramatic and unusual hydrangea boasting large 8 in. heavily felted leaves that add unique foliage texture. Impressive clusters of lavender-mauve, lace-cap flowers add value during summer (Figure 8). Plants perform admirably in rich, evenly moist soils and have proven to be quite a bit more cold tolerant than some reports suggest.

Figure 8. *Hydrangea strigosa* (syn. *H. aspera* subsp. *macrophylla*) in flower.

***Magnolia* × *soulangeana* ‘Milliken’**

A unique, compact saucer magnolia found as a witches' broom near Rhinebeck, NY. Plants are compact and dense with short internodes and a rounded outline. In spring they flower profusely with standard sized, whitish-pink flowers.

***Nyssa sylvatica* ‘Autumn Cascades’**

A weeping selection of black gum. Plants showcase glossy, deep green leaves that develop excellent red, orange and yellow fall color. If a tree form is preferred, some staking is required to develop and maintain a central leader. Ultimately plants can obtain a framework similar to *Fagus sylvatica* ‘Pendula’.

***Ptelea trifoliata* 'Aurea'**

An elusive plant rarely propagated and offered for sale. The trifoliate leaves are bright gold in spring transitioning to lime-green by late summer. Plants are strong growing showing adaptability to varied soil conditions. Height is 8-12 ft.

Viburnum lantanoides

A standout native viburnum that is seldom available but deserving of greater landscape consideration. Plants generally have a broad, spreading habit with arching branches that often touch the ground and root in. They develop creamy-white, 3-5 in., flat-topped flower clusters in May and June followed by prolific crops of red-black fruit. The large, cordate leaves are medium green during the growing season and can turn respectable shades of yellow, pink and burgundy in fall. Plants perform best in moist, rich soils in partial shade and make a great choice for the woodland garden, naturalizing or for attracting wildlife.

THE FUTURE

The future is bright for new introductions. We continue to breed, select, and evaluate a broad diversity of trees, shrubs, and herbaceous perennials with several promising selecting planned for introduction in the coming seasons. A few noteworthy selections are listed below.

***Hamamelis virginiana* (orange-red flowered selection)**

A strong growing common witch hazel selected from a native population in Prospect Connecticut. Plants average 8-12 in. of growth annually and can be expected to reach 10 ft in height after 7 years (Figure 9). In autumn, orange-red flowers emerge with crimped petals. Flowers intensify in color as the weather cools.

Figure 9. *Hamamelis virginiana* unnamed orange-red flowering selection.

***Prunus maritima* 'Orange Marmalade'**

A beach plum selected for its large, orange fruit, prolific bloom and strong growth. Plants can be rooted in high percentages from greenwood stem cuttings and will flower and fruit abundantly from a young age. Fruit set is aided with cross pollination from other individuals. The vigorous plants can be expected to reach 5-7 ft in height over 5 years.

***Styrax japonicus* (unnamed selection)**

A vigorous Japanese snowbell selection developing a dominant central leader and pyramidal habit. The green leaves are infused with burgundy tones and remain attractive through the growing season. Abundant, 1-in. white blossoms are backed with a rich burgundy-purple calyx and supported by a similarly colored pedicel. The original plant reached approximately 14 ft tall and 9 ft wide at 11 years of age.

Foliar applications of rooting hormone at Decker Nursery©

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INTRODUCTION

Decker Nursery currently uses only over-spray methods to apply rooting hormones on softwood and dormant hardwood cuttings of woody ornamentals. We have been evolving down this path away from liquid dip and powder application methods for the last 4 years. In this presentation, I will attempt to review the history of this evolution, our current methods of application, a summary of our observations, and the current status of research on the over-spray method.

HISTORY AND EVOLUTION OF HORMONE SPRAY APPLICATION

In the 50 propagation seasons in which I have participated in my career I have used rooting hormone powders and liquid dips for the majority of those years. I have seen people covered up to their elbows in talc rooting powders, cuttings coated with dry powders 1/8 of an inch thick due to a wet stems, spilled cups of rooting liquid dripping all over the propagation table and the laps of any person unfortunate enough to be downhill of the spill, cuttings hanging outside of the container of liquid hormone as the person dipping the handful of cuttings joyfully discusses the details of last night's adventures, and rooting results, either good or bad, that defied explanation and were not able to be repeated.

Sometime back about 2010 I first heard about IBA water soluble salts offered by the company Hortus (Figure 1). Initially I was very skeptical about this method as I saw multiple pitfalls:

- Sprayer application uniformity.
- Hormone storage in a sprayer once mixed.
- Inaccurate application from one day to the next.
- Basic resistance to change.

Figure 1. Hortus tablets used to dissolve in water for hand dipping of cuttings.

We did request information and were supplied some hormone tablets that could be used to make a standard liquid dip solution. Casual testing showed the dips rooted plants successfully compared to other hormone solutions on the market but we did not try the over-spray method.

On an IPPS Eastern Region annual conference tour we happened to visit a perennial grower whose propagator made an offhand demonstration of using an electronic sprayer to

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apply Hortus IBA over some perennial cuttings. I noticed that this expensive sprayer did atomize the solution much like mist from a cutting mist system. I had now found a tool that could be counted on to apply hormone in very small droplet size with excellent coverage on both the top and bottom of the foliage. I photographed the sprayer and had one purchased when I returned from the conference (Figure 2). At this time, we also purchased a quality electronic scale to measure out grams and our first purchase of the Hortus IBA water soluble salts.

Figure 2. Electronic sprayer BP-4 by Dramm.

In our first year we primarily used hand dipped cuttings during the winter hardwood propagation season. We tried to find information on how the overspray would work on dormant cuttings on species such as *Thuja*, *Juniperus*, *Taxus*, *Buxus*, *Chamaecyparis*, *Ilex*, *Picea*, and others but no information was available. I was under the impression that the belief was that the auxin entered the plant through stomata. I used logic to make assumptions. Fresh cuttings gathered cold from outdoors in a dormant state probably did not have open stomata. We discussed things and since it took a day for the cuttings to warm up on the heated greenhouse concrete floor, we would spray three times beginning the day after the cuttings were stuck. As to rates, we decided, due to the multiple applications, to use a rate about half of the hand dipped rate (generally about 1000 ppm).

As this first winter season progressed we noticed excellent callus formation on the cuttings and that the progress of the crops as a whole seemed more uniform than the dipped cuttings. If I recall, I believe we eventually did an overspray on some of the dipped cuttings that seemed to be lagging behind. This was our first off the cuff post sticking over-spray that has eventually evolved to a standard practice for slow to root plants.

Our next summer of softwood cuttings was more dramatic. Due to the success we had the previous winter we over-sprayed our first house of cuttings for three consecutive days. We saw rooting activity quickly and at a very consistent rate. We did not have to do any post-sticking applications as most of the softwood cuttings rooted too quickly and uniformly to require this step. All things considered this summer season was a success but we did notice that we had significant losses in some certain crops.

One significant difference from a nursery like ours and a science based University style experiment is that we often change multiple environmental factors such as plug design, rooting medium recipe, hormone application method, and then try to guess which factors most likely had an effect on success or failure. We just sort of assume we are smart enough to guess correctly. In our convoluted logic to use three applications of hormone but at a lower rate to save money and attempt to avoid hormone toxicity, we neglected to take into account that some species might just need a higher rate of hormone to successfully root. Combine this with other environmental changes and I can tell you stories about how Decker Nursery could not successfully root a cutting of *Euonymus alatus* ‘Compacta’ for about 3 years; but that is a story for around the bar later in this conference.

CURRENT METHODS OF APPLICATION

Over time we have developed some basic protocols for the use of this product. These are based on experience and results, not on scientific documentation. That research still does not exist at this time.

Dormant hardwood winter cuttings are generally gathered, processed, and stuck within 10 days, and placed in a heated floor Dutch style propagation tent. After sticking they are sprayed at a rate of 1500-2500 ppm based on the species for three consecutive sprays. After about 2 weeks, they are re-spayed with IBA lightly at 2 week intervals (Figure 3). We have noticed once the cuttings progress enough to see signs of rooting that we see a jump in this rooting activity about 2 days after one of these re-applications of hormone. Spray protocols for IBA spray application are shown below.

Figure 3. Hormone application through windows of a rooting tent.

- We use only distilled water for the solution to avoid any contamination or hard water deposits in the spray nozzles.
- Each day's spray is marked by a small different colored flag so that the applicator can easily see how far back to spray on the 3-day rotation.
- We measure our hormone to mix with 1 gal of water to achieve desired rates. For instance, 1 gal of water and 30 g of Hortus IBA will yield close to 1500 ppm. Keep it simple!
- Unused hormone is stored in the sprayer and used the following day.
- All applications occur in the early morning prior to any sun related stress on the cuttings that might result in closed stomata.

Our summer softwood cuttings receive 3 days of hormone application after they are first stuck. Easy to root items might be at 500 ppm while cuttings with early dormancy, such as *E. alatus* 'Compacta', *Viburnum*, or *Rhus aromatica* 'Gro-low' might get 1500 ppm treatments (Figure 4). Any cuttings that are slow to root might get a re-application about 10 days after initial sticking. In reality, Dave Graff, one of our Senior Propagators, will roam the houses and spot target crops that he has observed to need a little helping hand (Figure 5).

Figure 4. Burning bush an example of a plant that requires higher rates of IBA in the summer.

Figure 5. Spot treating with IBA spray.

SUMMARY OF OBSERVATIONS

In the years that we have been using the over-spray hormone we have come up to some conclusions based on our observations:

- This method greatly improves worker safety. I come from a generation where I was instructed, by a State Nursery Inspector, to stick my bare arm into a 30-gal spray tank full of pesticides to stir the batch before spraying nursery stock when I was 16 years of age. I have watched propagation staff with white talc all over their hands or fingers dripping in hormone dip. In recent times, we were spending hundreds of dollars per year on latex gloves to protect the staff. Post-sticking hormone application limits exposure to one person who is wearing the proper protective gear. There is no longer any need to provide gloves to the staff. We have had five successful pregnancies amongst the staff of the Propagation Department in recent years all to give birth to healthy children. As I have somehow to date survived all these sins of my past, I have come to realize how important it is to error on the side of worker safety whenever possible.
- Over-spray of hormone, especially with multiple applications, removes almost 100% of the variables that could contribute to lack of uniform application of hormone. With an electronic sprayer, a mist is generated that rolls over, under, and through the cuttings. We immediately noticed, after switching to this method, significant

reduction in variation in rooting.

- We have seen, especially in *Buxus* and *Juniperus*, cuttings that had rotted below the soil line, root at that point downward into the medium. Obviously there was some sort of stress on the cuttings that caused the damage but the hormone re-application allowed the problem to eventually become a successful cutting (Figure 6).
- We believe that overall production is faster due to skipping the step of reaching to dip a handful of cuttings. I would estimate a 20% increase in daily production. This is easily balanced by a couple of minutes spent the next day spraying hormone over tens of thousands of cuttings.

Figure 6. A winter cutting good callus and root formation.

STATUS OF FUTURE RESEARCH

I know that as a propagator I would dread going back to hand dipping of cuttings. I would however like to see some research to clarify some of the unknowns about how these rooting hormones work.

- Are multiple hormone applications at time of sticking required?
- What are the most effective rates?
- Does time of day of application have an effect?
- What is the process or interval that is most effective for re-application of Hormone?
- Is toxicity a problem with multiple applications? We believe there may be an issue in this regard with certain *Thuja* cultivars.

Recently there has been an interest shown by Joel Kroin of Hortus to recruit researchers who might be interested in doing research at multiple Universities to try and nail down the science behind the observations. They are:

- Dr. Glenn Fain, Auburn University
- Dr. Eugene K. Blythe, Mississippi State University
- Kees Eigenraam-Rhizopan b.v., botany, Inc., Netherlands

Perhaps with the proper experimentation we can better understand how the over-spray method works and proper rates and timing.

Propagation of *Aronia* by seed, cuttings, tissue culture and grafting©

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INTRODUCTION: WHY CARE ABOUT PROPAGATING?

Aronia spp. are an important group of plants because they have great potential as ornamental landscape plants and as a novel fruit crop with nutraceutical properties. *Aronia* species are native to many parts of the eastern United States, especially the Northeast. They are deciduous shrubs that make outstanding landscape plants due to their multi-season interest in the form of white spring flowers, black or red fruit in summer and fall, and orange or red fall foliage color. They are also adaptable plants that tolerate a range of challenging environmental conditions and require little landscape care.

The dark-fruited species of *Aronia* have been promoted as a new fruit crop for the United States and appear to hold considerable potential in this capacity (Secher, 2008). *Aronia* berries have the highest levels of antioxidants of any fruit and contain high levels of anthocyanins and polyphenolics (Benvenuti et al., 2004; Wu et al., 2004). Studies indicate that *Aronia* juice and polyphenol-rich extracts possess a wide range of bioactivities, including modulation of endothelial function, blood cholesterol levels, inflammation, oxidative stress, and blood pressure (Jurgoński et al., 2008; Naruszewicz et al., 2007; Valcheva-Kuzmanova et al., 2007; Li et al., 2012). *Aronia* has been widely grown in Eastern Europe and Russia where the fruits are processed and used in beverages, wine, jelly, and baked goods (Kask, 1987). Production of *Aronia* berries in the United States has been increasing, with acreage in the Midwest exceeding 1000 hectares and two million plants (communication from Midwest Aronia Association).

THE GENUS CHOKEBERRY

Aronia, commonly known as chokeberry, has historically been considered to be comprised of three species that includes *A. arbutifolia* (red chokeberry), *A. melanocarpa* (black chokeberry) and *A.* × *prunifolia* (purple chokeberry) (Hardin, 1973). *Aronia* × *prunifolia* is considered by many to be an interspecific hybrid between *A. arbutifolia* and *A. melanocarpa* (Brand, 2010). Observations of the *Aronia* germplasm collection at the University of Connecticut (over 140 accessions) show that *A.* × *prunifolia* is a variable species that seems to exhibit a continuum of traits between *A. arbutifolia* and *A. melanocarpa*, providing support to the idea that it is an interspecific hybrid. Recently, *A. mitschurinii* has been identified as a fourth species of *Aronia* that is the large fruited type grown by orchardists (Leonard et al., 2013). This species is likely a hybrid between *A. melanocarpa* and *Sorbus aucuparia* that is approximately 75% *A. melanocarpa* and 25% *S. aucuparia*.

Flow cytometry has shown that *A. melanocarpa* exists as diploids and tetraploids in the wild, with diploids only existing in New England (Connolly, 2014). *Aronia arbutifolia*, *A.* × *prunifolia* and *A. mitschurinii* are all natural tetraploids and have not been found as diploids. AFLP analysis of the large germplasm collection at the University of Connecticut has been able to effectively group *Aronia* accessions into six taxonomic groups (Obae and Brand, 2014). These groupings are diploid *A. melanocarpa*, tetraploid *A. melanocarpa*, tetraploid *A. arbutifolia*, tetraploid *A. prunifolia*, tetraploid *A. mitschurinii* and a novel black fruited tetraploid *Aronia* that has only been found in the southwestern portions of the range of *A. melanocarpa*.

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PROPAGATION

Seed propagation

Fruits of different *Aronia* species ripen at different times of the year (unpublished data from M. Brand) and fruit harvest must be adjusted accordingly to maximize yield of viable seeds. *Aronia melanocarpa* in the Northeast ripens starting around the second week of July and continues until the end of the third week of August. Diploids ripen on the earlier end of this range and tetraploids on the later end of the range. *Aronia* × *prunifolia* ripens from mid-August to mid-September and *A. arbutifolia* ripens from late September through early November. *Aronia mitschurinii* fruits are typically ripe during the second, third, and fourth weeks of August. Fruits of *A. arbutifolia*, tetraploid *A. melanocarpa*, *A.* × *prunifolia,* and *A. mitschurinii* will often remain on plants in a shriveled up condition long after peak fruit ripe dates and can be effectively harvested for seed with reduced yields. Diploid *A. melanocarpa* fruits do not seem to persist on plants after peak ripe dates, so these should be collected during peak fruit ripeness to obtain maximum seed collection potential. In some years, especially when wet conditions exist during peak bloom time, a fungal disease (possibly *Fusicladium* or a powdery mildew), can infect fruits and cause premature fruit drop and poor seed availability. Also, drought conditions, especially during May and June, have caused nearly complete abortion of *Aronia* fruit crops.

Fruits are typically soaked for a few days to a week in shallow trays of water to soften the fruit and make seed extraction easier. Water should be changed daily. *Aronia arbutifolia* and *A.* × *prunifolia* fruits are drier, harder fruits and will take longer than *A. melanocarpa* or *A. mitschurinii* fruits to soften and be ready for seed extraction. Once fruits are softened, they are macerated to release the seeds. Small batches of fruit can be macerated by hand, but larger batches can be macerated with a hand held potato masher or a hand held puree mixer. The majority of fruit skins and pulp can be floated away from the seeds. Dry seeds and residual fruit skins and pulp can be rubbed gently to separate the seeds from the pulp and skins and the mixture can be placed in a fine sieve. A vertically oriented fan can be used to blow the lighter skins and pulp away from the seeds. Hand removal of any remaining debris will result in a relatively clean batch of seeds.

Aronia seeds are relatively small; about 2-3 mm long and 1-2 mm wide. *Aronia mitschurinii* seeds are larger than any of the other *Aronia* seeds and diploid *A. melanocarpa* seeds are among the smallest. *Aronia* seeds at maturity are comprised of an embryo axis, large cotyledons, little endosperm, and a brown seed coat. Seeds appear to have two types of dormancy. There is some dormancy associated with the seed coat. I have found that fresh *A. mitschurinii* seeds with their seed coats removed will germinate readily in vitro without any other treatment, such as chilling, while those with intact seed coats fail to germinate at all (Figure 1). With other species of *Aronia*, seed coat removal does not result in consistent and complete dormancy removal. All *Aronia* species (including *A. mitschurinii*) will have their dormancy relieved by appropriate durations of cold moist stratification. I have found that 60 days of cold moist stratification is sufficient to break dormancy of *A. melanocarpa* (both diploid and tetraploid) and *A. mitschurinii*. Best success with *A. arbutifolia* and *A.* × *prunifolia* can be achieved by extending cold moist stratification to 90-120 days. Once stratification has been completed, seeds germinate readily, usually within 10-20 days, and seedlings are easy to grow on using typical methods employed for many woody plants. In terms of relative ease of producing *Aronia* plants from seed, *A. mitschurinii* is very easy, *A. melanocarpa* is easy, *A.* × *prunifolia* is easy-moderate and *A. arbutifolia* is the most challenging, but still not difficult.

Figure 1. *Aronia mitschurinii* seed germination: left with coat on, right seed coat removed.

It is important to discuss that apomixis plays an important role in seed formation in *Aronia*, as in many other members of the Pyrinae. All tetraploid *Aronia* species appear to produce seed using apomixis (Brand, 2010). Preliminary AFLP and morphology data generated in the Brand lab suggests that diplospory, a form of gametophytic apomixis, may be at play in *Aronia*. With this type of apomixis, seed progeny will have a genotype very similar to the maternal parent and will appear virtually indistinguishable from the maternal parent. This means that seed propagation of *Aronia* can be used to produce plants without significant phenotypical variation, but provides an impediment for plant breeding. Diploid *A. melanocarpa* appears to produce completely sexual progeny, although partial apomixis cannot be ruled out at this point.

Rhizome division

Vegetative propagation by division or separation of rhizomes is an easy and highly successful method that can be used when relatively few plants are needed. *Aronia arbutifolia*, *A. melanocarpa,* and *A.* × *prunifolia* are all appropriate candidates for rhizome propagation because they are rhizomatous species, but *A. mitschurinii* is not rhizomatous due to its *Sorbus* parentage. I have used this method often to collect germplasm when out in the wild and have affectionately called the propagules "rip-ups", because that is just what they are. Most plants will have rhizome sucker shoots emerging from the soil nearby the parent plant. These can often be crudely dug or pulled from the ground to yield a plant or plants. I have been successful using this method when the plants are winter dormant or summer dormant. I have even been successful with this method during active shoot expansion. In fact, I cannot recall an instance where this method has failed.

Ideally, dug rhizome divisions should be potted immediately, or healed in some moist peat moss in containers. However, on collecting trips I have frequently just put the "rip-ups" in a plastic bag with a splash of water and let the plants ride around in the car with me for a couple of days or more without any casualties. Potted "rip-ups" will do best if placed in intermittent mist or a humidity chamber for a couple of weeks. Even if the tops of the plants wilt down, shoots die back some, and the plants look dire above ground, I have found that they are establishing in the root zone area and are usually fine. Regular fertilization of acclimated "rip-ups" often results in vigorous growth from the plant base or below ground stems. If new above ground shoot growth doesn't occur prior to the dormant season, plants usually break bud and grow very vigorously the following spring after a period of cold dormancy.

Plants produced by rhizome division will initially lack the uniformity required for commercial nursery production, but if cut back hard following dormancy they will fill in nicely within a single growing season. Certainly rhizome division has its place in the arsenal of propagation methods that can be successfully used for *Aronia*, especially for research, breeding, and plant collection purposes or when only small numbers of plants are required.

Stem cuttings

As with many woody shrub species, stem cutting propagation represents the most efficient method for large scale clonal production of *Aronia* species. *Aronia* stem cuttings can be rooted as either hardwood or softwood stem cuttings, with softwood cuttings being the preferred and easier method (Figure 2). Frequently, *Aronia* is included in lists of shrub species that can be propagated by hardwood stem cuttings, but there is very little information in the literature about this method of propagation for *Aronia*.

Figure 2. Rooted cuttings of *Aronia mitschurinii, A. melanocarpa,* and *A. prunifolia*.

On occasion, I have used hardwood stem cuttings to propagate *Aronia*, but all of my experience has been with *A. mitschurinii*. I have had success with 6-8-in. long hardwood cuttings taken in December, given a basal wound and a 3,000 ppm indole-3-butyric acid (IBA) in talc treatment. Cuttings were bundled in groups of 20 and their bases were placed in 50:50 peat:perlite medium in deep flats. Cuttings were rooted in an unheated pit greenhouse, in a humidity chamber, and bottom heat was provided, but tops were allowed to remain cool/cold. Short roots were evident at the bases of cuttings after 8 to 12 weeks. At bud break in the spring, individual cuttings were potted into quart containers. Shoot growth was initially slow, but eventually strong growth occurred. I believe similar results can be expected with other *Aronia* species, but perhaps at a less satisfactory rate.

Softwood *Aronia* stem cuttings can be rooted relatively easily with high success rates. In my experience, *A. mitschurinii* can be expected to root at levels close to 100%. *Aronia arbutifolia*, *A. melanocarpa,* and *A.* × *prunifolia* will typically root at rates between 85% and 95%, although there are the occasional genotypes that are challenging and root at rates less than 50%. Ideally, softwood cuttings from field-grown plants should be collected from mid-June through July, but I have had reasonable success with cuttings collected even toward the end of August. For container nursery stock where shoot growth is advanced in the spring, cuttings can be taken earlier than mid-June, and a second round of cuttings can be made late in the summer from new lateral shoots stimulated from previous cutting collection or pruning. Basal suckers with indeterminate growth can also be a good source of a limited number of late season softwood cuttings.

Cuttings should be 4-6 in. long and can be both terminal and non-terminal when long shoots are available. One method that works well is to wound cuttings at the base, use 3,000 ppm IBA in talc, and stick cuttings individually in cells or small pots containing 50:50 peat moss:perlite medium. Stuck cuttings should be placed in intermittent mist with 30-50% shade, but humidity chambers will also work. Rooting of most genotypes will occur in 5 to 8 weeks. Rooted cuttings can be potted up and fertilized, which will typically result in some new shoot growth, especially for cuttings stuck during the earlier part of the cutting timeframe. Cuttings are easy to overwinter in minimal heated houses and plant losses are negligible. After the dormant period, rooted cuttings can be directly potted into 1- or 2-gal containers, given controlled release fertilizer and placed directly into production growing areas.

Tissue culture micropropagation

Aronia species are generally very easy to propagate in vitro using typical shoot multiplication methods followed by rooting and acclimation. Brand and Cullina (1992) found that the most appropriate medium to use for *Aronia* shoot multiplication was Murashige and Skoog (MS) medium (1962), although Woody Plant Medium (Lloyd and McCown, 1981) will also work, but not as well. Shoot multiplication medium should contain 2-3% sucrose, 0.8% agar, and 0.5 to 1.0 mg L^{-1} benzyladenine (BA), depending on the genotype. Light levels should be between 40 and 60 μM m^{-2} s^{-1} from cool white fluorescent bulbs with a 14-16-h photoperiod. Subcultures should be performed every 6 to 8 weeks and multiplication rates of between 5 and 15 usable shoots can be expected. Both shoot tips and nodal stem segments will produce good subsequent shoot multiplication. Typically all shoot development is from axillary buds and there is little if any adventitious shoot formation, so the risk of off-type plants is minimal.

Microcuttings are easily rooted under non-sterile conditions (Figure 3) in humidity chambers and take between 10 and 21 days to root fully. A simple, but very successful treatment is to stick microcutting bases in 1,000 ppm IBA in talc. *Aronia mitschurinii* is exceptionally easy to micropropagate and produces very robust liner plants. Rooting can also be accomplished in vitro on half-strength MS medium containing 1 mg L^{-1} IBA. In vitro rooting may provide some utility for research purposes and for very valuable germplasm, but for commercial propagation purposes non-sterile rooting is ideal.

Figure 3. Microcuttings rooting ex vitro nonsterile environment.

Acclimation of rooted microcuttings is easy using typical methods where light levels are gradually increased and humidity levels are gradually decreased over a period of 14 days or so (Figure 4). Young tissue culture plantlets develop quickly in the greenhouse, especially if they arrive there in late winter and early spring when day length and light levels are increasing.

Figure 4. Microcuttings 3 weeks after acclimation.

Grafting

There are several reasons why it may be desirable to graft *Aronia*. Grafting could be used to raise the canopy of *Aronia* berry orchards to facilitate more complete machine harvesting from branches that are too low to the ground to be picked up by the harvesters. Grafting may have effects on time to first fruit harvest in orchards, it may alter fruit ripening date, and it may change fruit biochemical composition, although the potential for this is still unknown at this point. For ornamental *Aronia* plants, grafting would allow for the creation of unique growth forms where prostrate genotypes could be grafted on upright standards to produce weeping plants. Similarly, upright *A. mitschurinii* cultivars could be grafted high on standards to produce fruiting forms of *Aronia* that would have a unique, formal growth form that may appeal to gardeners.

In the Brand lab, we have primarily worked with chip bud bench grafting conducted in March and April in the greenhouse. We have used bare-root seedling rootstocks and dormant budsticks held in a cooler at 35°F. Rootstocks were grafted bare root and then potted. Mostly we have used *A. mitschurinii* 'Viking' as the scion genotype. In addition to chip budding, we have also been successful with wedge grafting using dormant 3- to 4-node scions.

Aronia mitschurinii can be grafted onto *S. aucuparia* rootstocks at success rates of at least 85%, and this value likely can exceed 95%. Successful grafts can be made close to the ground or 24+ inches above the soil line. *Sorbus alnifolia* can also serve as a compatible rootstock, but it does not seem to work quite as well as *S. aucuparia*. Successful graft unions will be less likely with *S. alnifolia* than with *S. aucuparia*, and subsequent plant growth will also be less vigorous. *Pyrus communis* is another rootstock that can be used successfully with *Aronia*, but grafting success rates may be closer to 50% and 2-year graft survival is around 85%. *Crataegus laevigata* has also been used as a rootstock for *A. mitschurinii* scions with about a 33% success rate, but scion shoot growth is weak and 2-year graft survival is around 85%. *Aronia*-*Pyrus* graft combinations produced early fall foliage coloration in comparison to own root *Aronia* and *Aronia* grafted on *Sorbus* or *Crataegus*. Most of our grafting work to date has been with *A. mitschurinii* scions, but a limited number of grafting attempts have been made using other *Aronia* species as scions and it appears that *S. aucuparia* rootstocks can be highly successful with all *Aronia* species (Table 1).

Table 1. *Aronia mitschurinii* 'Viking' Scion bench grafted in April; chip-bud; bare root rootstocks.

Rootstock species	Graft height (in.)	Successful unions (%)	First season shoot growth (cm)	Two year survival (%)
Crataegus laevigata	6	33	9.8	85
Pyrus communis	6	53	22.4	86
Sorbus alnifolia	6	50	23.4	100
Sorbus aucuparia	6	84	47.2	100
Sorbus aucuparia	24	88	41.7	100
Control: own root	6 (cutting)	96	15.6	100

Micrografting is another option we have explored for creating combinations of *S. aucuparia* root systems with *A. mitschurinii* scions. *S. aucuparia* microshoots are pre-rooted in vitro and then *A. mitschurinii* scion microshoots are micrografted onto the *Sorbus* stem using a modified wedge graft. Rootstock microshoots are cut horizontally to remove the shoot top and then a longitudinal cut about 2-3 mm long is made down the middle of the stem top. Scion shoots have a single diagonal cut made at the microshoot base. The scion microshoot is wedged into the rootstock cut and then the micrograft is returned to a culture tube to allow the graft union to form without desiccation stress to the scion. The union forms on one side of the scion and rootstock only and this is sufficient to make a strong graft union. We found that making diagonal cuts on both sides of the scion reduced the micrografting success rate.

With chip-bud grafting there will be rootstock suckering during the first two growing seasons and these must be removed to allow for scion growth only. It appears that resuckering slows down after the first two growing seasons. Rootstock suckering also occurs on micrografted plants, but appears to stop much more quickly than on conventionally grafted plants.

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Update on greenhouse coverings©

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INTRODUCTION

The covering on a greenhouse allows us to provide an environment that enhances plant growth. The main purposes are to allow light energy through (Table 1) and to restrict heat from escaping (Table 2). It also provides some wind protection.

Table 1. Light transmission.

Glazing – clear	%
Glass – tempered	90
Acrylic – double	86
Polycarbonate – single	90
Polycarbonate – double	83
Polycarbonate – triple	78
Polyethylene – single	87
Polyethylene –double	78
Polyethylene – double w/IR	78

Table 2. Heat transmission ("U" = a heat transfer coefficient, Btu/hour-square foot-degrees F).

Glazing – clear	"U"
Single glass – tempered	1.1
Single glass w/ energy screen	0.5
Acrylic – double	0.6
Polycarbonate – single	1.1
Polycarbonate – double	0.6
Polycarbonate – triple	0.5
Polyethylene – single	1.1
Polyethylene –double	0.7
Polyethylene –double w/ screen	0.5
Polyethylene – double w/ IR	0.5

The amount of light energy that is transmitted through a covering depends on the type of material, orientation and location of the greenhouse and the structural design. A comparison of covering materials is usually measured in photosynthetically active radiation (PAR) (Figure 1). This includes the light spectrum that our eyes see.

GREENHOUSE COVERS

Diffusion properties

Most glazing materials are now available with additives that diffuse light. Research has shown that although light transmission is reduced a few percent, the light will penetrate better into the mid leaf layers of tall crops on cloudy days. There is no reported difference in light transmission on sunny days. Diffuse light can also reduce scorching, lower container temperature, reduce fungal spores and decrease insect propagation.

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Figure 1. Clear and stippled greenhouse glass.

Material used

What materials are being used to cover greenhouses? A recent survey by the National Greenhouse Manufacturers Association showed that for new construction: 10% of are covered with glass, 10% with acrylic, 30% with polycarbonate and 46% with polyethylene film.

1. Glass.

Wide pane, tempered glass is standard today. Sheets, as large as 6×12 ft, can be manufactured and placed on a greenhouse. Aluminum bars with EPDM rubber gaskets are used to seal the edges. The long life and high transmittance are an advantage for high light crops, such as tomatoes, cucumbers and peppers. Except for institutional greenhouses, most glass is used in gutter-connected structures. I don't know of any double pane glass that is being installed. Stippled glass is used to diffuse light transmission and increases light transmissivity at low sun angles. Most glass installations have energy/shade screens underneath to reduce heat loss. This makes it comparable to double glazing (Figure 1).

2. Acrylic.

Available in single thickness corrugated and double wall flat sheets, most of this material is now modified with a percentage of polycarbonate or other plastic to give it better strength and a better fire rating. The warranty life has now been extended to 30 years. It is available in 8 and 16 mm thickness and in 4 and 6 ft wide sheets. Modified acrylic has been approved for institutional and garden center use.

3. Polycarbonate.

This is the most common semi-rigid material applied to growing structures. It is available in corrugated single wall material and 8 and 10 mm double wall material. Warranty is 10 years or longer. Fire and hail ratings are excellent.

4. Polyethylene sheets.

This is a semi-rigid double-wall material similar in design to polycarbonate (Solexx). It is available in 3.5 and 5 mm and requires more support to keep it from sagging. The material is white with a light transmission of 70-75% and used mostly in garden centers or for low light plants. Useful life is about 10 years.

5. Polyethylene film.

This is still the most common covering due to its low cost, ease of application and long life. Advantages include good weathering, several available thicknesses, additives such as condensate control and infrared heat inhibitor. The condensate control keeps the moisture in a film rather than droplets that drip onto the plants. Infrared inhibitor is installed as the inner layer and reduces heat loss at night by 10-20%. At an added cost of 2-3 cents ft^{-2}, the payback is only a few months from the energy saved. The IR additive may also increase early color, more compact plants and slightly accelerated plant development. For windy locations a woven poly (Solarig) or a film with a nylon scrim (Griffolyn) may be a better choice. These have more tear resistance.

Recent advances in polyethylene include photoselective properties and ultra violet blocking (Figure 2). To date film plastics have been made as three ply construction with different properties in each layer. New technology is now available to do 5 or 7-ply construction. This allows additional properties to be added. TIF (totally impermeable film) is being applied for soil fumigation. As there are no emission losses, the rate of application can be ½ of that of regular film. This same technology is being researched to use layers with different colors that will repel insects. It may also be developed to allow the outer layers to be removed when they become dirty or weathered. For example weathered poly has as much as 10% less light transmission than new poly. Another application may be to have a poly with a tougher outer skin.

Figure 2. Polyethylene film with infrared layer to reduce heat loss.

Photoselective films.

These absorb or reflect specific wavelengths of light. They can enhance plant growth, suppress insects and diseases and affect flower development. Red films such as Dupont IR and Smartlite Red film reduce PAR light and create a shading effect (Figure 3). They have also been shown to improve rose yield and quality.

Figure 3. Photoselective film.

Ultra-violet (UV).

Bees need UV to navigate. If you are using bees to pollinate plants in the greenhouse, purchasing a film that allows some of the UV part of the light energy spectrum to pass through may be important. Otherwise, UV blocking film will reduce whiteflies, thrips, aphids, and other insects. It can also control some fungal diseases.

Single or double layer poly.

Air inflated double poly is standard on all except spring season and overwintering hoophouses. The double layer reduces heat loss at night by about 35%. It also reduces moisture condensation, stress at the attachments and the rippling of the plastic on a windy day. Air inflation at ¼" water static pressure is best. A small blower with 100-200 $ft^3\ min^{-1}$ output is needed. Connect the blower inlet to outside air to reduce moisture build-up between the layers. A new product from a couple of manufacturers is a coextruded 12 mil material consist one sheet of 6 mil greenhouse grade and one sheet of 6 mil IR-AC grade. This is placed on the greenhouse at one time, sealed around the edges and then inflated. The weight of a 40×100 ft sheet is about 240 lbs. so a plastic support device on a forklift or tractor may be needed.

An anti-fogging additive may be included to prevent early morning and late afternoon fog formation in the greenhouse.

Reduced daytime heat gain.

In areas with strong sunlight, blocking part of the infrared spectrum can lower inside temperature up to 10°F. Selective pigments can be added to the outside layer in copolymer film to reflect or absorb the near infrared radiation which is useless for plant growth. Research has shown that the higher the outside temperature, the larger the temperature difference achieved by use of these films. The advantages include lower cooling costs, greater worker comfort, lower irrigation needs, reduced plant stress and improved fruit taste.

Plastic failure.

Early failure of poly can be attributed to stress as noted above, abrasion on rough surfaces and sharp edges or heat build-up in the area of rafters, purlins and extrusions. Contact with chemicals from pesticides or pressure treated lumber can also affect the life of the plastic. Poly that is left on the greenhouse during the winter is subject to cuts from blowing ice especially if there are multiple bays or hoophouses adjacent to each other. A scrim reinforce poly may be desirable in this situation.

Recycling.

Most plastic can be recycled if it is clean and bundled to exclude trapped air (Figure 4). It is sent to a recycler to shred it, remove dirt and chemicals, and process it into pellets. Much of it is reused for composite lumber.

Figure 4. Recycling plastic covering from a plastic house.

What's holding back the native shrub market?©

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INTRODUCTION

Native plant species provide support for pollinators and other ecological systems (Burghardt et al., 2009; Tallamy, 2007) and are a suitable landscape alternative to invasive plants (Gagliardi and Brand, 2007). Despite increased demand for native plants to use in developing sustainable landscapes, the pace of expansion of the native market has seemed to lag behind the apparent rise in interest (Becker, 2015). Some of the issues holding back the market for native shrubs include the need for education about landscape use, lack of liner sources for growers, poor quality of nursery stock, and lack of cultivars as well as perceived drawbacks of cultivar use.

NEED FOR EDUCATION

With familiar garden plants like forsythia, hydrangea and lilac, consumers believe they know how to use them and so they feel confident in buying them. Consumers tend to shy away from native species because they are less familiar with natives and do not see them in the neighbors' yard. The same goes for landscape designers, who often have a set list of proven plants they go to over and over again. For the native market to grow, information developed through research about how to use native plants appropriately in landscapes must be provided to growers' sales staff, landscape designers and consumers.

The adaptability of native shrubs has received only limited research attention and we don't really know how suitable they might be for challenging landscape sites. To test the adaptability of native shrubs, I have planted over a dozen native species in the ultimate challenging landscape site - a commuter parking lot on the University of Connecticut campus in Storrs, Connecticut (Figure 1). Each species provides ornamental interest, but have not been used extensively for landscaping because their landscape adaptability was unknown. Invasive Japanese barberry (*Berberis thunbergii*) and winged euonymus (*Euonymus alatus*) were also planted as controls to understand how the natives perform compared to these tough, old landscaping standbys.

Figure 1. UConn parking lot native shrub trial.

Eight native species had excellent performance (Table 1), equivalent to the invasive control plants, Japanese barberry and winged euonymus (Shrestha and Lubell, 2015; Lubell, 2013). These species are American filbert (*Corylus americana*), buttonbush (*Cephalanthus occidentalis*), creeping sand cherry (*Prunus pumila* var. *depressa*), northern bush

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honeysuckle (*Diervilla lonicera*), sweet fern (*Comptonia peregrina*) (Figure 2), sweet gale (*Myrica gale*) (Figure 3), sweetbells (*Eubotrys racemosa*), and Virginia rose (*Rosa virginiana*) (Figure 4). These pleasant findings indicate how much potential there is for expanded use of native shrubs by the nursery and landscape industry.

Table 1. Aesthetic quality index for six Connecticut native and two non-native shrub species established in a commuter parking lot on the University of Connecticut campus (Storrs, CT) evaluated in July of 2010, 2011 and 2012.

Species	Aesthetic quality index (AQI)[1]		
	2010	2011	2012
Native species			
American filbert	6.6 b[2]	7.7 b	8.8 a
Buttonbush	8.7 a	8.5 a	8.6 a
Northern bush honeysuckle	6.3 b	8.7 a	8.5 a
Steeplebush	5.0 c	6.8 c	7.7 b
Sweet fern	9.0 a	8.8 a	8.9 a
Sweet gale	8.5 a	8.7 a	9.0 a
Non-native species			
‘Crimson Pygmy’ barberry	8.6 a	8.7 a	9.0 a
‘Compactus’ winged euonymus	8.8 a	8.6 a	8.6 a

[1]All five plants per experimental unit (*n*=6; except for sweet gale where *n*=4) were rated by three people. Mean ratings are composite of separate visual ratings of 1-3 (3=best) for each density and uniformity of shape; foliage color; disease, insect or deer damage.

[2]Mean separation within columns (lowercase letters) by Fisher’s least significant difference test ($P \leq 0.05$).

Figure 2. *Comptonia peregrina.*

Figure 3. Sweet gale the next inkberry?

Figure 4. *Rosa virginiana*.

For native shrubs I have produced a guide for landscape use that lists both commonly available and under-utilized native shrubs with photographs showing landscape uses. I have also developed a manual for landscape use, propagation and production of lesser-known New England native shrubs with ornamental potential.

GROWERS LACK LINER SOURCES

Consumers are demanding more native plants from growers (Halleck, 2015). Once growers receive the message, they need to figure out how to produce the plants. Here is the typical way nurseries grow plants. Production of a new crop starts with identification of a liner source. Bought in liners are transplanted to containers. Containers are lined out in nursery growing blocks where they are irrigated, pruned, spaced, overwintered, transplanted, and re-spaced over a period of 2 to 5 years before delivery to market. During this production time, growers utilize container stock as a source of material for cutting propagation for continuing production of the crop. Growers often prefer to propagate plants from cuttings instead of seed, because cuttings produce uniform crops and the majority of consumers want uniform plants that will perform identically in the landscape.

What typically happens for native plants that are new to production is that growers are unable to locate a liner source. In those rare cases where a liner source can be found, the liners are usually available in limited supply, and what is available was propagated from seed, which typically produces non-uniform crops. Without a liner source, the only remaining option for a grower to source propagules is to collect material from the wild. To accomplish this, growers must first find an employee with a skill set that will enable them to identify the native species of interest, and to find the plants in the wild in sufficient quantity for initiating a new crop. Second, growers must be willing and able to spend the resources to send their employee out collecting over hundreds of miles. Further complicating this process is that native plants are often found in the wild on state or private lands where it is illegal to collect without permission.

POOR QUALITY OF NURSERY STOCK

Growers do not approach native production with the same quality control as they do with mainstream nursery plants, the majority of which are exotic. There is a grower mindset that people expect natives to look wild or unkempt, and while this may be true for some buyers, wild looking plants will not sell well to a broader group of purchasers. If native plants are going to sell then they have to be of the same caliber and quality as any exotic nursery plant.

What probably happens in production is that natives are the last plants to get attention, and important cultural practices, such as pruning and container spacing, are done too late or not at all. For example, in 2010 I received #2 containers of northern bush honeysuckle (*Diervilla lonicera*), a little known native that is beginning to experience more use. These plants were grown too close together in the nursery and were more upright and leggy in appearance than is typical for this plant. They would not have sold well at the garden center. In 2012 I also received plants of this species, and this time they looked really good because they had been pruned and spaced appropriately. Clearly this demonstrates that natives can be grown to the same level of quality as mainstream crops, like hydrangea or pieris, but it is not happening quickly enough.

One reason why natives do not get the attention they need during production, is that information about optimal growing conditions is not always known. To produce attractive, uniform crops in only two to five years requires a lot of water and high fertility. Plants that will not tolerate these growing conditions present a greater challenge for producers. When new plants do not grow well using already established production methods, growers have to make adjustments to accommodate the new crop. This might include altering the growing media composition, fertility level, rate of irrigation, or timing of transplanting to larger containers of salable size. An example of how growers have tweaked production for a special need by a native is with mountain laurel (*Kalmia latifolia*). By altering container media and fertility practices, growers are now able to produce stellar-looking mountain laurel.

Native plant displays at garden centers are not as showy and appealing to consumers as exotic plant displays. In part this may be because native plants are not as showy as exotics, which have been hand-picked from all over the world, but may also be because native plants are still produced in small container sizes and with lower overall quality. The result is a collection of weak looking, non-flowering plants which don't compare favorably to exotic counterparts.

LACK OF CULTIVARS

The most successful commercial nursery plants are cultivars or selections of a species with superior ornamental traits. Cultivars must be propagated asexually to preserve the desirable trait or traits, and the vegetative propagules are referred to as clones. With vegetative propagation growers have the ability to produce a very uniform crop, which, as I mentioned, is often important for landscape design. Only a small percentage of mainstream crops are not propagated asexually because vegetative propagation is not possible for one reason or another. Instead they are propagated sexually from seed.

The uniformity that comes from vegetative propagation is one aspect of what is needed to transform under-utilized native plants into sought after commercial products. In addition to uniformity, cultivars are going to present and perform better for the consuming public. Much of the success realized with exotic plants comes from the fact that superior ornamental genotypes have been selected. For any new plant, native or exotic, it is important to have cultivars because they will generate greater interest among consumers.

I experienced firsthand the problems that come with native material produced from seed. In my work to evaluate landscape suitability of under-utilized native shrubs I received seed propagated material of American filbert (*C. americana*), buttonbush (*Cephalanthus occidentalis*) (Figure 5) and steeplebush (*Spiraea tomentosa*) (Figure 6). Plants exhibited significant differences in appearance and performance right from the start. I evaluated the plants in the landscape over 3 years and noted differences in traits such as leaf shape and color, plant size, density of habit and flower production (Figures 5 and 6). Some individual plants were stellar performers and others fell short, but the lack of uniformity in the seedling grown material left me longing for cutting propagated plants. I also evaluated plants of sweet fern (*Comptonia peregrina*), sweet gale (*Myrica gale*) and northern bush honeysuckle (*Diervilla lonicera*) that were propagated asexually. These species were uniform and produced a more desirable landscape effect.

Figure 5. Seed propagated plants produce non-uniform plants, *Cephalanthus occidentalis*.

Figure 6. *Spiraea tomentosa* as a landscape plant.

PERCEIVED DRAWBACKS OF CULTIVARS

Some groups of environmentally conscience garden consumers suggest that native cultivars, or nativars, are problematic because they do not support pollinators the same as the straight species, result in a less diverse landscape, and impact wild populations of native plants through genetic drift. Research studies confirming these concerns have not been published in the scientific literature yet.

A couple of limited projects have been described on the usefulness of cultivars in comparison to wild material to support pollinators. One is a University of Vermont study that monitored pollinator visitation on 12 herbaceous perennial species and one named cultivar of each species. Preliminary reports from this project suggest that 50% of the cultivars studied supported pollinators similarly to their wild counterparts (White, 2016). Those cultivars that did not were more complex hybrids. Another study at Mt. Cuba Center in Delaware focused on four cultivars of the annual plant coreopsis. All four coreopsis cultivars attracted pollinators, but one cultivar was superior to the other three at attracting pollinators (Troy, 2013). Similar studies with other taxa are currently being conducted at the University of Delaware, in conjunction with the Mt. Cuba Center, and at the State Botanical Garden of Georgia. At UConn I established in 2015 a research planting to evaluate the effectiveness of cultivars of native shrubs to support pollinators. This planting includes six species with two or more cultivars for a total of 15 genotypes, which were selected to allow study of a range of cultivar traits.

Developing native shrubs into mainstream landscape plants will require the use of existing nursery infrastructure, which utilizes clonal propagation of selected genotypes (Wilde et al., 2015). This is the only way to generate plants that meet consumer quality standards in the quantities needed to compete with exotics in the marketplace. Change occurs slowly in the nursery industry, and adoption of more native shrubs is no exception to the rule. My research has identified a dozen native shrubs with great potential for broad landscape use. We provided several Connecticut nurseries with liner material and propagation protocols for starting production of these plants. To date, about 40% of these shrub species have been added to production in Connecticut. Over time, due to the large number of breeding efforts underway, cultivars of native shrubs should become available and this will also help natives gain more traction with the general gardening public.

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American chestnut restoration©

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INTRODUCTION

Since 1983, the restoration of the American chestnut (*Castanea dentata*) has been pursued by The American Chestnut Foundation (TACF) in partnership with a number of other organizations, research partners, and citizen scientists. The fungus that causes chestnut blight, *Cryphonectria parasitica*, was accidentally imported to the United States in the late 1800s and identified as a new pathogen in 1904. American chestnut has little to no resistance to the fungal disease and by 1950 close to 4 billion trees on 200 million acres of eastern forest had succumbed (Figure 1). Fortunately, American chestnut successfully re-sprouts from the root collar and as a result, there are still native chestnut sprout populations on the landscape. While we generally consider the species to be “functionally extinct”, occasionally trees escape blight infection long enough to flower and produce nuts, allowing for their inclusion in breeding efforts to retain the genetic diversity of the species.

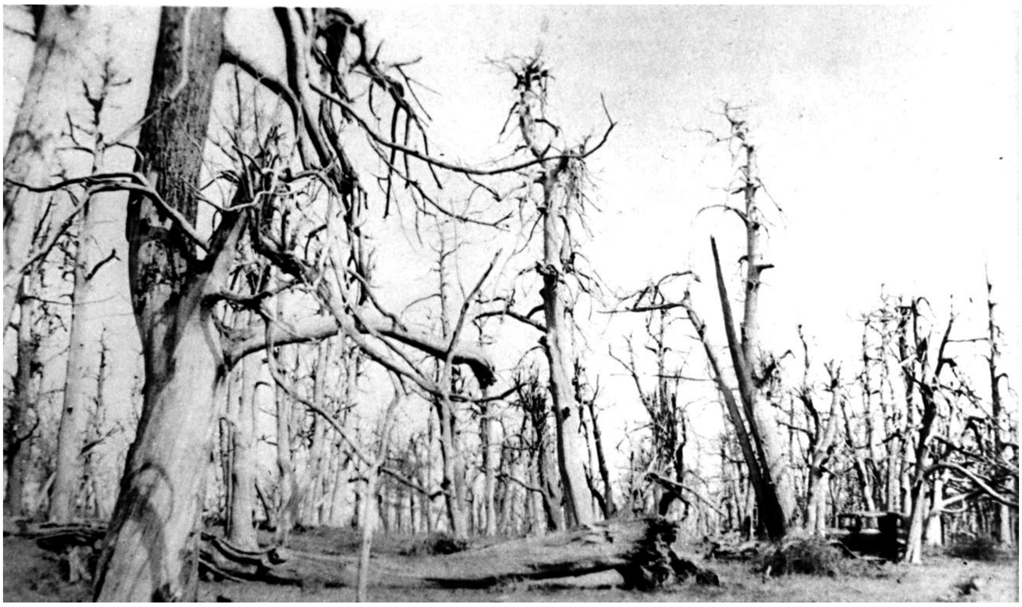

Figure 1. Dead chestnut trees in shenandoah national park (Credit Shenandoah National Park archives, copy photo by John Amberson).

The American Chestnut Foundation, along with many collaborators, has pursued three main strategies for species conservation and restoration: traditional breeding; genetic modification and biotechnology; and biocontrol through hypovirulence. Each of these efforts to restore the American chestnut has included propagating and planting hundreds of thousands of chestnuts in research plantings across the landscape. Direct-seeding chestnuts is the most common planting method, however use of bare-root and containerized stock is also standard. Grafting and micropropagation techniques have been refined within the past 20 years. Rooting cuttings is the propagation technique which has largely eluded successful application (Keys, 1978; Galic et al., 2014), and would be an indispensable tool for various

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aspects of restoration efforts should it be developed.

DISCUSSION

Breeding American chestnuts for resistance to chestnut blight has been on-going in some capacity since the early twentieth century. Early efforts focused on hybridizing American chestnut with Chinese chestnut (*Castanea mollissima*) and Japanese chestnut (*Castanea crenata*), in order to capture the pathogen resistance of these Asian species. The breeding program of The American Chestnut Foundation was developed utilizing some of the lessons learned by early breeders, and built upon earlier efforts. TACF's program utilizes an initial hybrid cross to Chinese chestnut in order to capture blight-resistance, several successive backcrosses to American chestnuts to increase the representation of the American species, as well as the genetic diversity of the breeding population, and a series of intercrosses to bolster resistance further. This program is currently at a point where we can evaluate its efficacy to-date, and determine what kinds of adjustments could be made to improve blight resistance further.

The use of somatic embryogenesis and genetic transformation are newer developments in efforts to restore American chestnut. The development of tissue culture techniques for American chestnut has been more difficult than initially anticipated, however current methodologies have become reliably successful (Maynard et al., 2014). Researchers at the University of Georgia have developed and refined methods for propagating, storing and multiplying somatic embryos from American chestnut (Holliday and Merkle, 2000). This technique allows for long-term preservation and storage of sources of special interest, and would also provide for the quick development of large, clonal populations. Work by researchers at the State University of New York College of Environmental Science and Forestry to genetically modify American chestnut by inserting genes that may confer enhanced blight-resistance have made the refinement of tissue culture techniques a necessity. Genes of interest are inserted into somatic embryos using *Agrobacterium*-mediated transformation. The embryos are multiplied, regenerated into shoots, rooted, and acclimatized (American Chestnut Tissue Culture and Transformation, 2016). The methodology for cloning of American chestnut through somatic embryogenesis has required more than a decade of refinement.

The on-going and varied interest in American chestnut restoration has necessitated the planting, or preservation, of hundreds of thousands of chestnut trees. While many methods of chestnut propagation are well-defined, there is certainly room for improvement or innovation by those in the propagation industry. The majority of chestnut planting is accomplished with direct-seeding of nuts. Containerized seedling production has increased in recent years to support early screening for blight resistance, reducing the number of trees planted in the field for breeding and progeny testing purposes. Bare-root production is used to support reintroduction and silvicultural trials. Methods for production of containerized and bare-root seedlings have been well-established, though not yet optimized.

Like most species in the genus *Fagaceae*, chestnut nuts are recalcitrant. Best practice is currently to stratify nuts in damp peat moss at approximately 3°C, however we have experimented recently with storage temperatures between -2-0°C. Nuts are typically planted the spring following harvest. Longer-term storage methods, as well as storage of large quantities of nuts for planting, are newer techniques that have not been well-refined.

Asexual propagation of American chestnut has been more difficult to complete successfully. Stem grafting by standard techniques is generally successful; however the species seems prone to delayed graft incompatibility, causing failures in the vicinity of the graft union several years after the graft has healed (Javier Viéitez et al., 2005). Tissue culture techniques have been developed and refined for dependable success, though chestnut has very specific requirements for media, light, and temperature. Rooting of chestnut cuttings is a technique that has long-eluded chestnut growers. For conservation of existing wild trees, or propagation of elite crosses or cultivars, this would be an ideal technique. Unfortunately, to date the only initial successes with rooting chestnuts have ultimately failed to produce viable trees.

SUMMARY

Interest in American chestnut restoration has maintained momentum for over a century, prompting the exploration and development of several conservation and propagation methodologies. Direct-seeding and growing containerized and bare-root seedlings are common practices, though optimization could still be explored. Long-term storage of nuts is a preservation technique that has received little attention. Grafting and micropropagation techniques are available for asexual reproduction, however rooting of cuttings is a technique that has proven exceedingly difficult for chestnut propagators but would be an invaluable tool for restoration efforts.

CONCLUSION

Restoration of the American chestnut is an on-going effort that continues to evolve. The American Chestnut Foundation, in collaboration with researchers and citizen scientists, has long-pursued a traditional breeding program to incorporate blight-resistance into native American chestnut populations. More recent work utilizing biotechnology tools show promise for advancing breeding efforts more efficiently. Enhancing blight resistance with a transgenic approach is an additional means of developing blight-resistant trees. The work to restore the species has necessitated the growing of hundreds of thousands of trees, with many more to be propagated it there future. Whether utilizing established best-management practices, optimizing existing protocols, or developing new methodologies, there are several ways in which the plant propagation industry could get involved with this important project.

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Propagation of challenging plants: creating a system that works©

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INTRODUCTION

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

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

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

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

RESEARCH PROTOCOLS

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

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

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

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do.

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

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

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

BACK TO THE BASICS

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

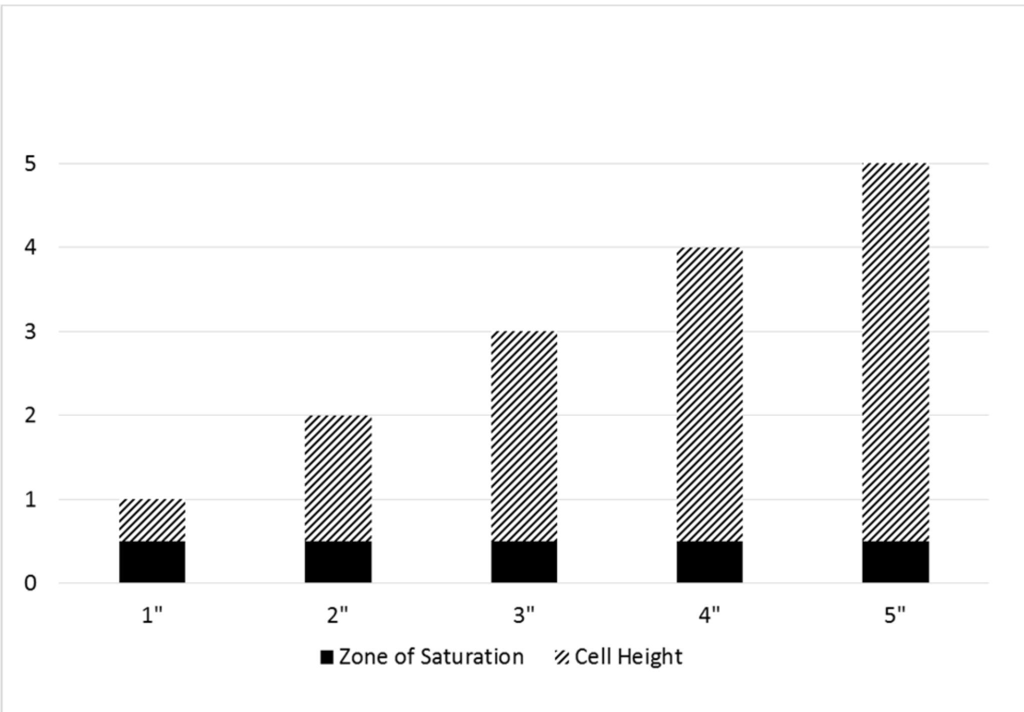

Figure 1. Saturated water zones for containers of various heights using the same medium and container diameter.

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

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

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

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

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

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

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

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

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

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

MATERIALS AND METHODS

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

Figure 2. Propagation tent setup.

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

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

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

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

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

RESULTS AND DISCUSSION

Cornus kousa 'Rutpink', Scarlet Fire® kousa dogwood

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

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

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

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

Corylus avellana

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

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

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

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

***Vaccinium macrocarpon* ‘Haines’**

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

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

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

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

Ilex

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

Figure 5. *Ilex* sp.

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

***Ilex crenata* 'Beehive'**

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

SUMMARY AND CONCLUSIONS

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

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

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Panel discussion on branding©

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INTRODUCTION

Brands and branding influence every purchase we make in our daily lives.

Traditionally, the horticulture industry has been resistant to develop and market plant brands. Though this is slowly changing, the industry has lagged behind other consumer products when it comes to offering branded products at retail.

BRANDED PRODUCTS

Let's look at herbs and roses as an example. At our retail store, Gateway Garden Center, we sell herbs in various sized pots from 3 in. to 1-gal containers. About 12 years ago we began selling a branded herb line called Sarah's Superb Herbs™. I was skeptical that the public would pay $9.99 for a pot of herbs that we would otherwise sell in a black container for anywhere from $2.99 for a 3-in. container to $4.99–$7.99 for a 1-gal. Actually, 1-gal herbs were very rare and seldom available. This new herb brand came in colored pots with large tags that also included a recipe. There was an associated charitable donation being made to Easter Seals as well. Much to my and my staff's surprise, this new brand flew off the shelves. We now sell these 1-gal herbs for at least $9.99 and upward of $12.99. They meet little consumer resistance. We always sell through the program, but better yet, we increased our profit margin on every sale made!

Likewise, we saw the same pattern with roses. There was a time when we sold roses only in black pots or bare root in peat balls. There was little marketing, and if there was, it was often centered around the numerous requirements to keep them healthy and looking good. Being highly susceptible to insect damage and disease roses required chemical sprays and fertilizers to perform well. If you wished to grow roses successfully you needed to be pretty dedicated. The selling price for these roses were as low as $5.99 and as high as $14.99. Retail garden center consumers today have little time for such work and dedication. Enter the Knockout® and Drift® family of rose brands that offer new genetics. Moving away from conventional garden tea roses, these roses were sold as durable long flowering shrubs. They were marketed as requiring little care, tough as nails, and ever-blooming. Garden enthusiast of all levels of expertise flocked to them. They are sold in distinctive and easily recognized containers with large tags that have associated point of purchase information. At retail garden centers they are sold for up to $25 container^{-1}. This increased the profit margins considerably for business that retail them. They have become the leading and most recognized plant and plant brand in the trade.

When setting out to create the American Beauties Native Plant® brand (Figure 1) I came upon a different circumstance. The brand was challenged to sell "generic" native plants in colorful branded pots with informative tags at a higher price. We also needed to collect and donate funds to the National Wildlife Federation. These circumstances presented several challenges. The primary obstacle was convincing growers this was not only possible, but profitable. The proof became evident when our customer's sales and garden center profit margins increased when compared to selling "generic" native plants in black containers that offered no point of sale materials. Fortunately, there was also a movement to promote the use of native plants nationally but little promotion or availability of these plants at retail. Consumers embraced the American Beauties Native Plant® brand because it helped solve problems in their landscapes. For garden retailers it also built upon the store within a store concept that is used by major retailers and merchandisers nationwide. The brand showcased native plants to consumers that desired them and at the same time made it easy for retail sales staff to direct customers to the "Native Plant Section" of the store. By calling

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attention to the benefits of planting native plants and highlighting their virtues sales increased for garden centers that carried the brand.

Figure 1. American Beauties Native Plant® brand.

The concept of a store within a store is foreign to garden retailers in the USA. When looking to purchase a hooded sweatshirt a few years ago I went to a Dicks Sporting Goods. I entered the store and could not find a men's section that contained hooded sweatshirts. I did find these duplicated by brand name in multiple departments. All I had to do was figure out what manufacturer or brand I preferred. The hooded sweatshirt was available in each branded department, Nike®, Adidas®, Puma®, etc. I was unable to purchase a generic one. This brings up the notion of brand loyalty and trust. How do we get consumers to identify with the brand and trust us enough to keep coming back? This is what is often lacking in retail garden centers. We might trust our local retailer, but we don't often become loyal to a plant brand. Although this is changing, there are typically not enough advertising dollars available to keep the brand prominent in the consumer's mind from year to year.

As royalty dollars from the sale of branded plant programs are allocated to advertising and promotion there will be an increase in awareness. This will influence purchasing habits and increase sales for garden retailers. Brands like Proven Winners® and Endless Summer® collections are spending the necessary resources to influence garden retailers and the gardening public.

Using brands to launch new products: a breeding company's perspective©

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Bailey Nurseries, Inc. owns and manages three consumer plant brands (Figure 1) including Endless Summer® Series hydrangeas, First Editions® trees and shrubs, and Easy Elegance® roses. We use these brands as the primary means for introducing new products developed by our breeding company, PII, and by external breeding partners throughout the world.

Figure 1. Bailey brands.

Using BloomStruck® *Hydrangea macrophylla* as an example, I will talk about how we used the Endless Summer® brand to introduce this new plant. Endless Summer® plants started with one cultivar in 2004 and changed the *H. macrophylla* market forever with this remontant new introduction backed by a consumer marketing plan and a distinctive blue pot. To fund this marketing campaign Bailey Nurseries collected a marketing fee as well as a royalty on each plant.

Over the years, we have introduced a total of four cultivars under the brand Endless Summer® Series collection. BloomStruck® hydrangea, the most recent cultivar, was introduced through the brand in 2014 (Figure 2). We put all the brand marketing tools developed for Endless Summer® hydrangea to work for BloomStruck® and it has quickly gained market share. At the end of 2015, BloomStruck® hydrangea made up 22% of all Endless Summer® Series collection sales while The Original (Figure 2) was 60%, Blushing Bride was 6%, and Twist-n-Shout® was 12%.

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Figure 2. *Hydrangea macrophylla*, ‘Bailmer’, Endless Summer® The Original hydrangea on the left and 'P11HM-11', Endless Summer® BloomStruck® hydrangea on the right.

We used the following marketing tools to successfully introduce this new cultivar under the brand umbrella of Endless Summer® in a very competitive marketplace: communication with growers; communication with retailers; brand packaging and merchandising materials; consumer communication via print advertising, digital advertising, regionally targeted billboards and radio; social media; retail events; and public plantings.

Growing using hydroponics in the Northeast©

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INTRODUCTION

Hydroponic is a very broad field with a number of growing options and adaptations. Essentially there are two generally accepted concepts that are different but with a number of hybrid adjunct developments with each of these. Although many of the hybrid systems are "one of a kind" they almost always are related to either deep pond or NFT systems.

This examination of hydroponics is undertaken with the following objectives:

- Wholesale sales of one or two crops.
- High quality produce compared to the existing hydroponic crops available.
- Consistency of the product.
- Reasonably fast maturing from seed to harvest.
- As much control as possible for the avoidance of insects and disease.
- Production from seed to harvest with minimum labor cost.
- A crop that would lend itself to our regional climate (in my case that means the Northeast of the United States).
- Using as much of my own existing equipment and greenhouse as possible and producing as much of our crop (lettuce) with the strongest profit possible.

CONNECTICUT HYDROPONIC FARM & H20 FARM

I had purchased and installed ebb and flow tables for our five greenhouses and had grown annuals flowers for 2 years using this equipment. Based on the geographic area that we are located the competition in the annual flower trade is fierce. Our market for sales was only our own garden center in an economy that was becoming very weak and unreliable. The ebb and flow tables we installed included automatic vents in conjunction with a weather station for all five greenhouses.

Realizing that the flower market was very competitive with many wholesalers, and with the large number of wholesale growers, it was possible to buy the flowers that we grew for close to the cost we had for growing our own. The period of time that we could use this equipment for annual flower growing was limited to 9 months. With both these factors in mind, I started to investigate the possibility of using this equipment for another type of growing that would allow us to use the equipment for 12 months in a less competitive market.

Our hydroponic system

I explored the concept of using this equipment for hydroponic lettuce production although the depth of the tables was less then recommended in other deep-water technology. Through our experimentation we realized that the root development didn't affect plant top growth whether it was a deep water environment where the root developed downward or grew wider in a shallower pond environment.

We decided to move forward with one greenhouse for lettuce production using all eight tables that were 5×40 ft. We used Styrofoam "rafts" with both 4 in. spacing on one table and 8 in. spacing on the other seven tables (Figure 1).

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Figure 1. Our production system.

We initially tried as many selections of lettuce that were recognizable by the buying public. We found that the best crop was the bibb lettuce (*Lactuca sativa*) because it had the shortest growing period from seed to harvest. It also developed best in the cold climate here in the northeast.

1. Aphid problems.

We did find that aphids were an issue with most of the types we experimented with. Because we are producing organically we didn't want to use pesticides but found this almost impossible. We then researched the possibility of finding a bibb lettuce selection that was aphids resistance. We were able to find a bibb selection from Europe.

2. Bolting problems.

Our next challenge had to do with “bolting.” Since bolting is the premature production of stems and flowers before the crop is harvested.

This was a difficult problem at the beginning of our production with the butterhead bibb selection. It seems that the warm temperatures caused some of our lettuce to bolt well before it was harvestable size. I looked for a selection that were historically free from early bolting and we were able to find a bibb lettuce seed type that was both aphids resistance and had almost no bolting before it reach harvest size.

I was concerned that the seed that was aphids resistant came from Europe. Since lettuce from Europe is smaller in head size to lettuce produced here in the USA. I was concerned that the marketability of this selection would be smaller than the current competition here in the USA.

We have found to our surprise that this selection has grown to size equal to the lettuce available on the market today and most of the time larger; therefore, increasing the marketability of our production. This new selection has helped our production; our pack-out rate has improved to between 90 to 95%.

3. Lettuce seed germination problems.

The germination of our seeds was a challenge. The are several options for propagation of our pelletize seeds, including rock wool, Oasis®, and a range of growing media with nutrients (we found field soil not usable). We have found that Oasis was the best with the highest germination yield for our lettuce seed and we have increased the time in the nursery from 10 days to 2 weeks. This extra time in the nursery gives the seedling additional growth.

4. Production.

We transplant the seedlings to net cups and into 4-in. spaced rafts for 2 weeks; in our 5 ×40 ft tables we can place 2000 heads. After 2 weeks, we transplant to 8-in. rafts for 2 week until harvest (Figure 2). This system has allowed us to increase our production by 35% in our existing greenhouses.

Figure 2. Our final production ready for market.

We are able to produce 2,500 to 3,000 heads ready for market weekly at an average price of $1.35 to $1.50 per head. Our labor is based on three individuals at 35 h weekly with one of these individuals driving for deliveries for 10 h weekly. We have found that our largest costs are as follows: the clear clam shell for each head and the harvest and packing time.

We feel that part time growing of hydroponic produce in the greenhouses when the greenhouses are not being used for flowers is counter-productive to the development of a hydroponic business. In a wholesale environment where the client is looking for consist weekly produce and strong quality with the same consistency.

CONCLUSION

In conclusion it is possible to convert existing greenhouses to hydroponic growing. Anyone doing this should identify the market they would like to service and rehab their existing greenhouses or purchase new ones.

A look at GMOs, GAO and GE plants as they apply to horticulture©

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The fundamental question presented to this panel discussion is: what is the role of GMO (genetically modified organism), GAO (genetically altered organism), and GE (genetically engineered) plants in horticulture. To make sense of that assessment some background information and definitions as to what these acronyms mean is in order. The science of horticulture means plants grown for food, ornament, or function that is different from those plants that are grown for agricultural purposes. In brief, tomatoes are horticultural, wheat generally is not except (Australian Office of Gene Technology, 2005) where it is grown for ornamental purposes, same thing applies to corn and *Panicum* sometimes yes and sometimes no, forest trees and lawn trees are horticultural, cotton is horticultural but soybeans are not, all fruit trees and fruits of any kind on woody or herbaceous plants apart from the grains are horticultural. Seaweed for consumption is agricultural but seaweed grown for the aquarium industry is horticultural. The use of any kind of plant for medical purposes brings it into the fold of horticulture. Definitions and clarity are the rule of the day when considering complex issues such as this.

Approximately 100 years ago plant pathologists discovered that *Agrobacterium tumifacens*, a naturally occurring plant pathogen, was capable of causing a genetic transformation in infected plant tissue (Newhouse et al., 2010). This development showed in later years that specific gene transfer can occur with either the natural infection of *Agrobacterium* or by an artificial infection of the bacteria. Geneticists and plant pathologist then learned that the *Agrobacterium* mechanism can be tailored to introduce foreign genes into plant tissues. The race to use this new technology was on (Wikipedia, 2016).

In today's world we are barraged by the use of the acronym GMO and in some cases GE when referring to plants and other organisms that have foreign gene components. However, the technologies of today are vastly more complex than a simple gene transfer from *Agrobacterium* or by biological application (read gene gun). As the situation becomes more diverse and complicated than the use of terms such as GMO become part of the common vernacular but as it has done so the specific definition of the GMO moniker has lost its meaning.

A study of the history of plant production over the ages demonstrates that even people with limited plant genetic understanding could and did encounter hybrids of a range of plants, with the likes Mendel and Darwin coming to mind. With the increasing advent of human transportation of plants, seed and scion wood dating back to the activities of the Chinese in Asia to the European explorers to the agents of Kew from England, trafficking in plants ultimately lead to wholesale trading of bizarre genetics in hybrids. Plants from India or China naturally had no interaction with those of Western Europe or the Americas and vice-versa, but ease of transportation and scientific inquiry lead to a great mix-up of plant genetics (Azad et al., 2013). Explorers of all kinds paved the way from massive genetic interactions that prior to the ages of advanced transport simply could not and did not happen. The modern corn of agriculture is but one example of a significant diversion from natural genetic compositions (Morroni et al., 2008). So what is the correct nomenclature of a modern corn plant, *Zea mays* as compared to tenosite (*Zea diploperennis*, *Z. perennis*, *Z. nicaraguensis*, *Z. mays* subsp. *huehuetenangensis*, *Z. mays* subsp. *parviglumis*, and *Z. mays* subsp. *mexicana* (Wikipedia, 2016). Is this complex we know as corn, a hybrid? Surely by any definition it is substantially genetically altered from the starting species. Would it be prudent then to attach the label genetically altered organism, GAO, to described the transformation of

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this as well as thousands of other modern day plants such as the New Guinea impatiens (Dan et al., 2010).

New techniques have come to the forefront and well away from the initial work with *Agrobacterium* and biologistical (gene gun methodologies) interventions. Relatively new technologies are coming to us wholesale with the advent of CRISPR-Cas 9, ZFN, zinc-fringe nuclease, and TALEN transcription activator—like affector nuclease(Bortesi and Fischer, 2015; Dan et al., 2010). What sets these advances apart from simple gene transfer which generally applies to the moniker, GMO (National Academies of Sciences, Engineering, and Medicine, 2016) is that they do not use gene transfer as a mode of action, rather they used gene manipulation. The US Department of Agriculture, APHIS (Waltz, 2016) and the European Conference on Plant Breeding (Lusser et al., 2011) do not consider plants developed from gene manipulation from within the plant by means such as CRISPR to be GMOs. Since that is the case then a more suitable designation is required so that a better understanding of what these plants are, a case can be made for the use of a GAO or a GEO which better describes the status of a particular plant that has been altered but not infused with a gene or genetics from a foreign species but rather a rearrangement of an existing genome or the inclusion of a closely related species. The Europeans go further in stipulating that if a foreign gene is indeed introduced the designation of a GMO resides upon the origin of the introduced gene. For instance a gene from *Lolium* (rye) inserted into a *Triticum* (wheat) is NOT a GMO due to the family connections of the two genera, whereas a newly developed American chestnut (*Castanea dentata*) which contains a gene from *Triticum* is a GMO (Bortesi and Fischer, 2015; Ohlemeir, 2015; Powell, 2016).

With this understanding of the nature of the various acronyms for genetically modified, genetically altered, and Genetically engineered plants we now can tackle their roles in horticulture.

Horticultural uses of plants abound but the bulk of plants that are genetically modified, altered, or engineered usually fall into two groups. One is the fruit and vegetable world and the other is the medicinal plant world. A third category that is gaining prominence is trees for lumber, pulp and other industrial purposes. Ornamentals or environmental plants make up the fourth and smallest category. It is a short list, carnations (*Dianthus*), *Gladiolus*, *Lilium*, *Petunia*, *Rosa* (roses) and cotton (mainly agricultural but techniques can carry over to ornamental forms). For greenhouse operations plants such as cucurbits (squash, cucumbers, watermelons, etc.), *Citrus*, *Musa* (banana), eggplant, tomato, are in the offering.

A closer looks (Table 1) shows the plants being researched and for what purpose. Plants for the nursery and greenhouse trade are very limited and perhaps rightfully so. The economic engine that would drive genetic alteration is simply not there because the markets involved are not big enough to push ornamentals (Bruening and Lyons, 2000) or common nursery crops into the genetic modification world. This coupled with much of our products going into reclamation and remediation circumstances automatically disqualifies a genetically altered product. Forestry production nurseries and those propagation nurseries involved in medicinal plant production are of course an exception.

Does the nursery industry as a whole have a future with genetically modified plants? In general no, markets are insufficient and the industry as a whole is resourceful enough so that if *Potentilla fruticosa* A is not adequate the trend is to adjust to *Potentilla* B, rather than systematically trying to improve A. It is years of work and diligence to bring even one non agricultural plant into the market via a genetically altered or improved program and the costs override the benefit of the so called improvement. Genetically altered plants over all have increased layers of complexity that the nursery industry is either unable or inadequate to address. The causes for the lack of adjustment could be either technological or economical. The advent of a unique plant via this route might be a complete flop on the receiving end while the industry might be able to cope with the changes within the plant, the consumer may well not be so fortunate. Without large scale testing of end use the chances of a "design" flaw showing up and rendering a plant useless is significant (Castle, 2009). A plant crashing with a huge magnitude of research dollars behind it could be a serious risk. It seems certain that the standards set by conventional plant breeding via hybridization, chemical, and radiation mutation work will continue to prevail. That being said, the advent of new technologies such as CRISPR could offer new inroads to traditional plant breeding. Recombinate DNA technology will still be viable but used less due to the specificity of CRISPR and similar techniques which is not always the case with recombinate technology. With an increasing distrust by the public towards plants with labels such as GMO and the advent of the CRISPR and related techniques will take precedence as a plant derived from such work is not a GMO and theoretically might be more accepted in the market place. Perhaps the most significant use of CRISPR and related technologies is the induction of sterility into invasive plants that do have significant industry status, such as *Euonymus alatus* 'Compacta' and *Berberis thunbergii*. Novel forms or colors of flowers will probably not make it to the garden party rapidly due to the significant costs involved (Chakravarthy et al., 2014).

Table 1. Genetically altered horticultural plants either available or being researched.

Plant	Technique	Research goals	GMO/GAO	Reference
Agaricus bisporus	Crispr-CAS 9	Diminished oxidative browning	GMA	Waltz, 2016
Castanea dentata	Gene insertion from wheat	Chestnut blight immunity	GMO	Newhouse et al., 2010; Powell, 2016
Catharanthus roseus	*Agrobacterium* transfer	Increase in rooting and pharmaceutical production	GMO	Zarate and Verpoorte, 2007
Camellia sinensis	*Agrobacterium* transfer	Delaying post harvest senescence	GMO	Mohanpuria et al., 2011
Carica papaya	*Agrobacterium* transfer and RNA silencing	Virus resistance	GMO	Azad et al., 2013
Carya illinoinensis	*Agrobacterium* transfer	No specific goals spelled out	GMO	McGranahan et al., 1993
Cichorium intybus	Onion gene transfer	Increase metabolite harvesting	GMO	Matvenna et al., 2011
Citrus species various	Gene insertion from *Arabadopsis*	Citrus greening disease resistance	GMO	Ohlemeir, 2015
Cryptomeria japonica	*Agrobacterium* transfer	No specific goals spelled out	GMO	Taniguchi et al., 2008
Cucurbits various	*Agrobacterium* transfer	Drought and insect resistance	GMO	Morroni et al., 2008
Eucalyptus camaldulensis	*Agrobacterium* transfer	Improvement of wood quality and increase in rooting of cuttings	GMO	Ho et al., 1998
Fragaria	*Agrobacterium* transfer	Disease resistance	GMO	Hanhineva et al., 2009
Gentiana macrophylla	*Agrobacterium* transfer	Increased metabolite production	GMO	Tiwari et al., 2007
Gladiolus species	Antisense reinsertion via CRISPR or similar technology	Virus resistance	GMA	Kamo et al., 2010
Gossypium species	*Agrobacterium* transfer	Herbicide tolerance, insect resistance	GMO	Chakravarthy et al., 2014
Hypericum perforatum	*Agrobacterium* transfer	Improved pharmaceutical production	GMO	Franklin et al., 2009
Impatiens walleriana	*Agrobacterium* transfer	Novel flower colors, disease resistance	GMO	Dan et al., 2010

Table 1. Continued.

Plant	Technique	Research goals	GMO/GAO	Reference
Juglans species	*Agrobacterium* transfer	Disease resistance	GMO	Michler et al., 2006
Liquidambar styraciflua	*Agrobacterium* transfer	Insect resistance	GMO	Dowd et al., 1998
Malus domestica, several	CRISPR and related techniques	Non-browning upon oxidation	GMA	Waltz, 2016
Musa acuminata	CRISPR and similar techniques	Disease resistance	GMA	Castle, 2009
Pinus taedea	*Agrobacterium* transfer	Increased terpinoid production	GMO	Tang and Tian, 2003
Populus species, various	Various techniques	Increased disease resistance, increased growth profile, increased wood production, insect resistance, modified lignin concentrations	GMO	Mathews and Campbell, 2000; Powell and Maynard, 1997
Prunus domestica	Crispr	Disease resistance	GMA	Scorza et al., 2013
Rosa hybrids	*Agrobacterium* transfer	Flower color manipulation	GMO	Australian Office of Gene Technology, 2005
Saussurea medusa	*Agrobacterium* transfer	Increased metabolite production	GMO	Fu et al., 2006
Solanum tuberosum	CRISPR or similar techniques	Non-browning upon oxidation	GMA	National Acadamies of Sciences, Engineering, and Medicine, 2016
Solanum lycopersicum	Antisense reinsertion via CRISPR or similar technology	Flavor enhancement	GMA	Bruening and Lyons, 2000
Nicotiana species	Bacterial gene transfer	Increase uptake of methylmercury from contaminated soils	GMO	Heaton et al., 1998
Tylophora indica	*Agrobacterium* transfer	Improved pharmaceutical production	GMO	Chaudbhuri et al., 2005
Ulmus species	*Agrobacterium* transfer	Dutch elm disease resistance	GMO	Gartland et al., 2003

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Evaluating hydrangea performance©

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HERITAGE MUSEUMS AND GARDENS—A QUICK HISTORY

Heritage is located in Sandwich, Massachusetts, the first significant town on Cape Cod at the northern end of the Cape Cod Canal where it joins Cape Cod Bay. Sandwich was an important seaport and shipbuilding site in the seventeenth and eighteenth centuries. Farming was well practiced too and the present bounds of Heritage were originally contained within Shawme Farm which Charles Dexter purchased in 1921.

Dexter was a successful textile manufacturer in New Bedford, Massachusetts and was active in civic affairs, photography, the violin, and was also a keen yachtsman. He initially just spent summers at the Farm where he first began hybridizing vegetables. Later, he expanded his activity to rhododendrons and kalmias. The rhododendron collection at Heritage is substantial; the kalmias make up a more modest group. Over the 20 plus years Dexter resided there, the farm was converted to a country estate. He remained an active hybridizer until near his death in 1943.

The Lilly family of the Eli Lilly Company succeeded Dexter. They were profound collectors and the expansive garden site was perfect for the establishment of museums to house their significant collections. The Lilly's were dedicated to creating buildings and facilities that were replicas of significant originals in American design. The extraordinary Looff Carousel was purchased in 1971 and integrated into a building complex containing rare American art. The substantial Lilly Antique Auto Collection contains only American-made automobiles and is housed in a superb replica of the Round Barn from the Shakers of Hancock Village in Pittsfield, Massachusetts.

Today, Heritage Museums & Gardens serves more than 130,000 visitors annually.

THE NORTH AMERICAN HYDRANGEA TEST GARDEN

The Test Garden got its start at the hydrangeas 2015 Conference that was held at Heritage in July of last year. This was the first major all hydrangea event in the USA since 2005 and featured a strong technical program with supportive participants and attendees, and it took place in a very favorable cultural location for hydrangeas. All positives! The idea of creating a "Test Garden" was conceived and initiated by Dr. Mike Dirr. The idea fell on very fertile soil too as Heritage was already committed to expanding their hydrangea presence.

So let's fast forward to July 2016. Great ideas move quickly and Heritage Museums & Gardens is now home to a national hydrangea test garden where new hybrid cultivars of hydrangeas will be planted, grown, and studied by professional growing experts from across the country. Phase 1 of this 5-year development program was completed early in July. This initial project phase was extensive in content and totally supports the Heritage goal of the North American Hydrangea Test Garden becoming the most comprehensive collection of the genus in the United States. The Test Garden was dedicated and opened on 12 July 2016.

Designed by Horticulture Director Les Lutz, the Test Garden covers a very favorable planting site in terms of topography and sun/shade conditions. Significant hardscape has already been included—a major water feature (Figure 1), and stone steps and shell walkways that allow visitors to stroll among an unprecedented range of hydrangeas and complimentary perennials. Strategically located across the main road from The Cape Cod Hydrangea Society's existing All Hydrangea Display Garden, the total hydrangea area showcases the depth and breadth of these iconic plants for Heritage visitors.

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Figure 1. Major water feature in garden.

Plant-wise, the Test Garden will predominantly contain the newest hydrangea releases introduced to the retail market each year. Additionally, several significant "old standards" will be included to provide direct and immediate performance comparisons. And, unlike the more widely spaced, hydrangeas-only planting format of the Display Garden, perennials have been incorporated into the total Test Garden layout to simulate a more conventional home landscape planting arrangement. This approach was chosen to offer home gardeners examples of which plants might pair well together.

Operationally, Heritage horticultural staff will monitor many hydrangea plant performance criteria and gauge how these cultivars perform in coastal New England, one of our country's major markets for hydrangeas. Documentation will be an important function—photographing, collecting data, and reporting this information in a concise fashion that will assist participating hybridizers and growers in their analysis of significant attributes necessary to perfect new hydrangea cultivars.

The Test Garden continues Heritage's collaboration with the Cape Cod Hydrangea Society. Begun in 2008 with a modest initial planting of the species *Hydrangea macrophylla*, this Display Garden now boasts 8 species and more than 160 cultivars. The older, long established hydrangea cultivars dominate this collection and will surely stimulate some interesting comparative assessments.

The North American Hydrangea Test Garden initiative is being led by Dr. Michael Dirr, horticulture professor emeritus at the University of Georgia and author of over 300 scientific and popular publications. Additional on-site direction and support comes from Heritage's Curator of Hydrangeas, Mal Condon, and Director of Horticulture, Les Lutz.

Test Garden partners include leading professional growers; Bailey Nurseries (creators of the Endless Summer® Series of hydrangeas), Star Roses & Plants (Ball Hort), renowned plant expert Dr. Dirr and his wife Bonnie, The Cape Cod Hydrangea Society, and the American Hydrangea Society (Figure 2).

Figure 2. Test garden partners.

Figure 3 shows the 2016 through 2018 design and planting plan for the total Test Garden. The planting areas combine interesting topographical planes with good mixes of sun and shade conditions, thus enabling more complex evaluation assessments.

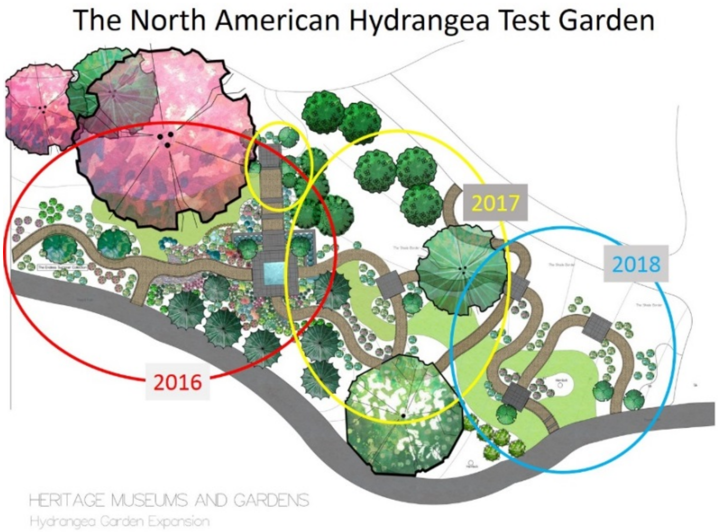

Figure 3. The Test Garden development plan, 2016, 2017, 2018.

PLANT PERFORMANCE EVALUATION, *BIGLEAF HYDRANGEAS*

Why will *H. macrophylla* be the major species of study? They are by far the most significant commercial species with their great bloom forms, color, character, and likeability. But, they're the least cold hardy of the six species commercially offered in the country. And, they are especially popular here on Cape Cod with our typically moderate maritime coastal climate. Cold hardiness is normally Zone 7 and our Heat Zone Index is just 1—totally reflective of our cool summertime temperatures.

But the last three winters have been quite different and we've had unhappy summers without *H. macrophylla* blooms. Let's examine this past winter of 2016. Overall weather temperatures were much milder than the previous 2 years. December through early February was unseasonably mild with average daily temps often being well above freezing. But suddenly, from February 12th through 15th, the first of our two significant freeze events occurred. That bitter cold blast during that short 4-day period effectively "flash-froze" all above ground *H. macrophylla* tissue. Note the low readings on the graph below—minus 7 on the 14th and minus 4 on the 15th (Figures 4 and 5).

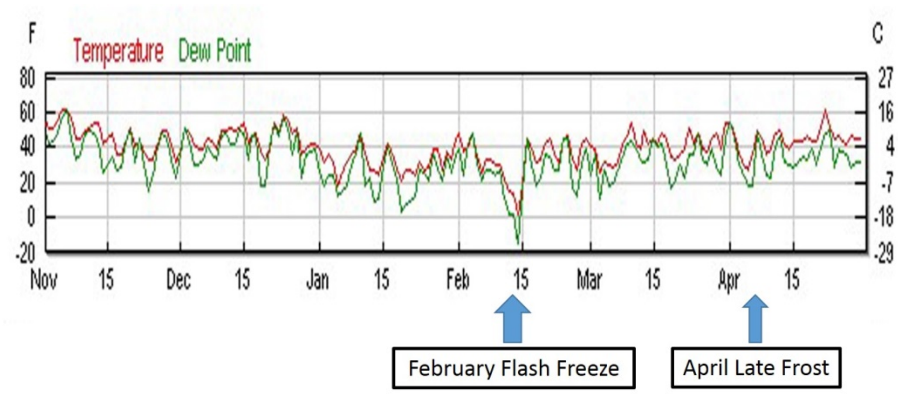

Figure 4. Temperature and dew point graph from November through April.

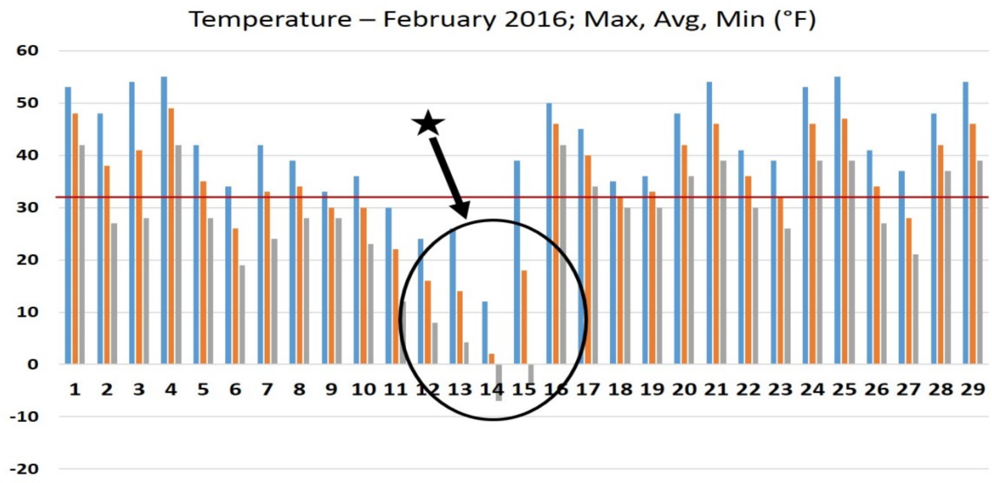

Figure 5. Temperature readings for February showing the minimum, average, and maximum.

Mild temps returned after the 15th and continued until April 5th and 6th when sub-freezing temps (mid 20's in most Cape locations) frosted the emerging new basal growth from the plants. Note in the photos below that new growth had redeveloped by mid-May but stem bud survival was very minimal (Figure 6).

Figure 6. New growth redeveloping by mid-May after April 5th and 6th sub-freezing temps frosted the emerging new basal growth. Endless Summer® hydranges shown are: top left, 'The Original'; top right, 'Blushing Bride; bottom left, Twist-n-Shout®; bottom right, BloomStruck®.

Although these photos show a very disappointing mid-spring growth condition, these cultivars did expand favorably as shown in the following photos taken just a couple of weeks later (Figure 7).

Figure 7. New growth 2 weeks after the results shown in Figure 6. Endless Summer® hydranges shown are: top left, BloomStruck®; bottom left, Twist-n-Shout®; bottom right, Twist-n-Shout®; top right, Lady in Red a non-Endless Summer® hydrangea.

Best "home garden" solutions for poor *Hydrangea macrophylla* blooming

Select the repeat blooming (remontant) cultivars—like the Endless Summer Series. Some of the older varieties exhibit good re-blooming capability too and are definitely worth considering—like 'Penny Mac', Lady in Red, 'Decatur Blue', and 'Nikko Blue'. Note the new late developing blooms on the 'Penny Mac' below (Figure 8). This photo was taken on 20 September. Although it is unlikely these late inflorescences will develop fully before a killing frost (typically around Thanksgiving on the Cape), it does illustrate the cultivar's propensity for reblooming.

Figure 8. New late developing blooms on *Hydrangea macrophylla* 'Penny Mac'.

You can also grow your most loved *H. macrophylla* in pots. Come late fall—after a killing frost—it's easy then to move them to an unheated location out of the weather for the winter. And you can plant additional *Hydrangea species including paniculata, arborescens, serrata,* and *quercifolia* also. I noticed a lot more cultivars of these species in Cape Cod gardens this summer.

PLANT PERFORMANCE EVALUATION, BIGLEAF HYDRANGEAS

The test garden plantings feature a mix of hydrangeas interspersed with perennials, a plan such as one might pursue in their own home garden. These new *H. macrophylla* introductions will be evaluated on several parameters: winter and bud hardiness, bloom count and quality, reblooming capability, sun tolerance, disease and pest attack, and general growth characteristics.

Winter and bud hardiness

Cold and wind are equal threats to bud survival. The desiccating effect of the often very dry winter winds can easily kill *H. macrophylla* buds. Exposed tip buds typically fail in the adversely cold and windy conditions so common to our winters in the Northeast. Stem bud survival is generally much better and those cultivars that bloom well off their lower lateral branches survive quite well with good blooming come the following summer. While *H. macrophylla* plants and buds prefer a mild, narrow temperature range, they can handle consistent cold, but not sudden or fluctuating cold as we experienced this past February.

Bloom count and quality

Normal Cape Cod summer weather allows plants to be grown in more direct sun. Plants are somewhat reduced in size (less internode stretching) and flower-bud count increases resulting in higher bloom count. On the downside, the increased sun does tend to burn the blooms, particularly the paler colors. Bloom "firmness" is a desirable quality aspect. Some newer cultivars, originally developed for cut flower production, offer almost "rigid" blooms capable of lasting many days in a vase. Several of these cultivars have been introduced into landscape plant production, i.e., the "Everlasting" series of *H. macrophylla* cultivars (Figure 9). The challenge with these plants is their cold hardiness; are they capable of blooming reliably following winters colder than zone 7.

Figure 9. *Hydrangea macrophylla* 'Hokomathyst', Everlasting® Amethyst hydrangea.

Reblooming capability

This is totally about how well and how quickly a plant develops new flower buds. Endless Summer® Twist-n-Shout® hydrangea is a very strong rebloomer, perhaps the best we've observed to date. Endless Summer® 'The Original' generally does well too. Other newer introductions, advertised as "rebloomers," have shown mixed results to date. In our most critical "test," all stem tips are pinched in July to evaluate the number of new inflorescences that develop by late August and into September (Figure 10). It is a very true test of reblooming. Some older cultivars are good rebloomers as well and this fact has been known for some time.

Figure 10. This picture shows rebloom developing in September on 'Twist N Shout'.

Sun tolerance

Plants having medium green, matte finish leaves commonly wilt in the afternoon sun. This group of *H. macrophyllas* includes 'Nikko Blue', 'Penny Mac', Endless Summer® 'The Original'. As we have previously noted, these are the same cultivars that possess the best reblooming characteristics. Watering does not cure the wilting problem; once the sun passes and the plants are in shade, wilting subsides fairly quickly. Siteing these cultivars in an afternoon shade location is much preferred. *Hydrangea macrophylla* plants having shiny dark green foliage —and dark bloom pigment—tolerate the same sun conditions much better. Shown in Figure 11 is 'L.A. Dreamin', a recent introduction offered by Star Roses & Plants that possesses these attributes. Other *H. macrophylla* cultivars showing good sun tolerance are 'Mathilda Gutges', 'Masja', 'Alpenglühen', and 'Merritt's Supreme'—all old time cultivars that do not rebloom—seems like a great breeding opportunity might be waiting with crosses of these old-timers with the newer rebloomers.

Figure 11. *Hydrangea macrophylla* 'L.A. Dreamin'.

Disease and pest attacks

Leaf spotting, mainly *Cercospera*, but also anthracnose, does develop under our cooler and sometime wetter weather conditions. Overhead watering worsens these conditions and surface irrigation will be installed throughout the Test Garden in 2017. Spotting in general is cultivar specific also.

Powdery mildew is a lesser aliment in our climate but does develop later in the summer—August, early September. It also shows strong correlation with certain cultivars.

The leaf tier moth is a more recent pest found amongst the Heritage hydrangea plantings. This clever little beast glues the first set of leaves below a flower bud up and over the bud to enjoy his dining in complete privacy. We have observed this mostly on our *H. arborescens* but have also seen it to a minor extent on a few *H. macrophylla* cultivars as well.

Spider mites have become more of a problem on our *H. macrophylla plants* over the last several years owing to our warmer and dryer summers. The uppermost stem tips are sucked dry and in the most severe cases, become embrittled, easily crumbling in pieces. August is the peak attack month and again we see some cultivar sensitivity, particularly on the fleshier, shiny leaved cultivars.

General growth characteristics

Ultimate plant maturity—plant size—may take more growth seasons than were trialed initially by the breeders/developers. And plant size is important especially in current times as gardens are getting smaller and size does matter.

Stem count in a mature plant can be quite variable; modest stem density can make for a loose "open" plant. Dense stem development may appear favorable but often creates expansive basal crown growth, making for more difficult pruning, and poorer total plant form. Pruning is a true best practice for virtually all hydrangea species and *H. macrophylla* can definitely prosper from correct application of this task.

TRACKING OUR PROGRESS

Check the Heritage website www.heritagemuseumsandgardens.org for timely reports on our evaluations of the Test Garden hydrangeas. And if your travels bring you near Cape Cod, by all means do come and visit and see for yourself.

Evaluation of hop cultivation feasibility in Connecticut©

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INTRODUCTION

Hop (*Humulus lupulus*) cultivation and brewing has a long tradition that started with the first settlers in the Northeastern of the United States. Disease pressure and the enactment of Prohibition moved production to the Pacific Northwest starting in the 1800s, which currently constitutes the largest production area worldwide (FAOSTAT, 2013). However, interest in hop cultivation in the Northeast has increased in the last few years led by New York State and Vermont. The increasing popularity of the microbrew culture, local brewpubs, home brewing, and the growing demand for regional products have created a new niche for hops in New England. Brewing beer in Connecticut is on the rise as well, because of the high water quality (Paul Dockter and Lamott, personal communication). The commercial production of hops in Connecticut has just started.

Location, climate, and cultivation practices, e.g. fertilization and irrigation, influence the characteristics and quality of hops. To initiate hop production, proper research, a well-prepared work plan, and a good source of start-up capital for the trellis system, and equipment such as a hop harvester, and a drying oven are required. Hop plants will typically produce their full yield after the third year. Once the trellis system is ready, the rootstocks are crowned, 2 to 3 bines are trained on twines, and additional shoots are pruned in the spring. During the summer, the work tasks include fertilizing, irrigating, scouting and controlling diseases and pests. The harvest of the cones is usually from mid-August to mid-September depending on the cultivar (Figure 1). Processing after harvest includes drying in kilns or a drying oven and pelletizing the cones. Not only proper cultivation, but also a well-planned disease and pest management program is important to achieve high hop quality. The best method to control diseases and pests is through integrated pest management, which requires knowledge of diseases and pests and includes chemical applications as well as biocontrol methods, planting resistant or tolerant healthy varieties, phytosanitary measures (such as crowning, pruning, removing diseased leaves or plants and removing lower leaves), weed, irrigation and fertilization management. For decisions regarding appropriate measures, weekly scouting for symptoms and insects as well as observation of the weather conditions and weather forecast are required.

Figure 1. Hop cones of the cultivar 'Cascade'.

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Downy mildew, caused by *Pseudoperonospora humuli*, is a major disease worldwide and the most damaging disease in the Northeast U.S. Disease outbreaks occur during wet weather, high humidity, and temperatures from 8 to 23°C, which are very common weather conditions for New England. Downy mildew can infect all parts of the plant. Stunted and chlorotic hop shoots, called spikes, often with grey to black sporulation underneath the leaves in the spring, are the first symptoms and are signs of a systemic infection (Figure 2). Further, the leaves show angular lesions delimited by veins and sporulation may form on the underside of the leaf (Figure 3). Infection of inflorescences and cones may lead to 100% yield losses. Lesser amounts of infection can reduce the quality and marketability of the cones due to discoloration and reduction of the acid content.

Figure 2. Basal spikes resulting from downy mildew and black sporulation on the underside of the leaves.

Figure 3. Lesions and sporulation on the leaf undersurface caused by downy mildew.

Disease management is based on timely fungicide application depending on the weather and prediction as well as planting resistant or tolerant varieties, sanitation practices (e.g., planting healthy rhizomes, crowning in the spring, and removing infected spikes) and harvest time (Mahaffee et al., 2009; Gent et al., 2010a, b). Other important diseases for hops are powdery mildew, which was recently observed in New York State (Miller, 2016), and verticillium wilt, which occurs in the Pacific Northwest, but hasn't yet been observed in the Northeast.

Several pests such as two-spotted spider mites, Damson-hop aphids, potato leafhoppers, Japanese beetles, and hop flea beetle may infest hops. Spider mites are very common in hops as well as other crops and ornamental plants. They feed on leaves, cause yellow spots, silver and bronze discoloration and produce a web on the underside of the leaves. If the mites infest the cones a total yield loss may occur. The population can increase very rapidly in hot and dry conditions. Beneficial insects and predatory mites may control small populations, but above the economic threshold insecticides with a low effect on these predators should be used (Mahaffee et al., 2009; Gent et al., 2010a).

A novel pest, which has had a big impact on hops in the Northeast, is the potato leafhopper. The symptoms are necrosis of leaves, and browning of the outer edges and tips forming a distinctive "V", called hopper burn, yellowing of leaves at the tip followed by necrosis and leaf curling (Figure 4). Further symptoms are shortening of internodes, stunted growth, fewer flowers and reduced cone production. Until recently, there has been no economic threshold level, but the University of Vermont currently recommends control at two leafhoppers per leaf. Leafhoppers can be controlled by organic or conventional chemical insecticides, but also by predators (Kittell-Mitchell and Darby, 2011). Trap crops, plants which are preferred by the pest, seem to be a promising alternative choice.

Figure 4. A young potato leafhopper and necrosis of the leaves "hopper burn", where the outer edges and tip turn brown and forming a distinctive "V".

The main objective of this study was to evaluate the feasibility of growing hops in Connecticut. Therefore, the growing characteristics, yield, and susceptibility to diseases and pests of five hops cultivars—AlphAroma, Cascade, Newport, Perle, and Summit—at high and low trellis systems in two locations (Figure 5) were analyzed over 3 years.

Figure 5. Hopyard systems at the Lockwood farm in Hamden (left) and at the Valley Laboratory in Windsor (right), Connecticut.

MATERIALS AND METHODS

High and low trellis systems were installed in 2013 at the Valley Laboratory in Windsor and at the Lockwood farm in Hamden, CT (Figure 5). Five cultivars—AlphAroma, Cascade, Newport, Perle, and Summit—were planted at both locations. In the spring the first shoots of the hops plant were pruned and in May trained to the trellis set up. Additional shoots were pruned frequently. Lower leaves were removed to reduce disease pressure. The plants were inspected on a routine basis to identify and record pests and diseases. In August and September, depending on the cultivar, the cones were harvested by hand and the yield and quality were determined.

RESULTS AND DISCUSSION

To evaluate the feasibility of growing hops in Connecticut, we analyzed growing characteristics, yield, diseases and pests of five different cultivars. Yields from 2014 and 2015 showed that the cultivars Cascade and Summit had the most well-adapted growth (Table 1). The harvest and yield evaluation for 2016 is still in progress at this time and cannot be included in this paper. The high trellis set up was more reliable for 'Cascade', 'Newport', 'AlphAroma', and 'Perle', whereas, 'Summit', a semi-dwarf cultivar, had higher yield on the low trellis system. 'Perle', a German breeding line, had weak development and growth and poor yield.

Table 1. Yields (cones) per vine (g) in the years 2014 and 2015 at the Valley Laboratory, Windsor Connecticut.

Cultivar	High trellis		Low trellis	
	2014	2015	2014	2015
AlphAroma	132.7	64.2	34.4	40.8
Cascade	341	97.5	258.5	93.5
Newport	174.4	44.4	120.2	39.1
Perle	72.5	19.8	72.8	9.3
Summit	256.3	65.0	312	127.8

Furthermore, diseases and pests were scouted and evaluated over the season. Downy mildew, spider mites, and potato leafhoppers were observed every year, but were controlled with rigorous pest management. Downy mildew appeared in the first planting year and every year since (Table 2). A significant outbreak was observed at Lockwood Farm in Spring 2016 (Table 3), but after downy mildew disease evaluations were recorded, disease was controlled with appropriate measures such as spraying fungicides and removing infected shoots. 'AlphAroma', which is described as tolerant to downy mildew, had by far the most symptoms. Spraying fungicides, removing weeds and redundant sprouts as well as stripping the upper leaves helped to reduce the spread of disease. Forecasting in association with a management program, which is utilized in the Pacific Northwest might be required in the Northeast as well (Gent et al., 2010b). Spider mites were observed but were controlled by predatory mites (*Amblyseius andersoni*) and by horticultural oil as well as insecticides. Potato leafhoppers appeared unexpectedly in 2015 and caused greatly reduced yields compared to the year before. In general, the yields in 2015 were lower because of the leafhopper damage and drought stress due to reduced irrigation. The data showed that intensive scouting for diseases and pests as well as a proper irrigation management are necessary to produce optimal yields. In New England, growers will face difficulties with diseases and pests, but should be able to achieve maximum yields using improved management techniques. Hop trials in Vermont showed consistently lower than standard yields compared to the Pacific Northwest (Darby et al., 2015). However, the hops had good quality characteristics, as defined by Alpha and Beta acids and hop storage index (data not shown). Growing hops in the humid Northeast might be a challenge, but with good start-up capital, a well-prepared work plan, and a rigorous integrated pest management program, hops seem to be a promising crop for Connecticut.

Table 2. Downy mildew infected plants 2013, 2014, and 2015 at the Valley Laboratory; high trellis: 'AlphAroma', 'Cascade', and 'Perle' each with 25 plants; 'Newport' with 20 plants; 'Summit' with 5 plants; low trellis: each 20 plants.

Cultivar	High trellis			Low trellis		
	2013	2014	2015	2013	2014	2015
AlphAroma	0	0	11	6	6	13
Cascade	0	0	1	0	0	6
Newport	0	0	4	0	0	6
Perle	0	0	0	0	1	1
Summit	0	0	0	0	6	0

Table 3. Downy mildew infected plants Spring 2016 at the Valley Laboratory; high trellis: each 25 plants; low trellis: 'AlphAroma' with 19 plants; 'Cascade', 'Perle', and 'Summit' each with 20 plants; 'Newport' with 18 plants.

Cultivar	High trellis		Low trellis	
	Infected plants	Number of spikes	Infected plants	Number of spikes
AlphAroma	18	7	14	9
Cascade	6	0	5	0
Newport	5	0	9	0
Perle	11	0	4	0
Summit	-	-	15	7

Growers and people interested in hop production recently formed and incorporated the Connecticut Hop Growers Association and commercial farming of hops took full swing in 2015 with approximately sixteen acres planted among farms consisting of an acre of hops or larger. Connecticut has now seen 2 years of harvest involving at least 10 different cultivars. Over the course of the next five years farmers and investors have begun to plan and diversify their farms into hop acreage, with the potential for planting another 100 acres. Having a new pelletizing facility constructed centrally in the state has encouraged farmers into investing land and time into planting the perennial crop.

SUMMARY

Interest in hop cultivation in the Northeast of the USA has risen in recent years because of the popularity of microbrew culture, local brewpubs, home brewing, and the demand for regional products. This study examined the feasibility of hop cultivation regarding yield, growing characteristics, and susceptibility to diseases and pests in Connecticut. Five cultivars: AlphAroma, Cascade, Newport, Summit, and Perle were evaluated in low and high trellis systems at two locations over 3 years. 'Cascade' and 'Summit' were identified as well suited for Connecticut and the high trellis system resulted in better growth and yield with the exception of the semi-dwarf cultivar Summit. 'Perle', a German breeding line, had the weakest growth and lowest yield. Downy mildew, the most damaging disease in the Northeast, spider mites, and potato leafhoppers were observed, but could be well controlled by intensive scouting and IPM measures. This study demonstrated the feasibility of hop production in Connecticut by using proper varieties, cultural practices, and a well-established integrated pest and disease management program.

CONCLUSION

The general feasibility of growing hops in Connecticut can be proven with this presented study. Data evaluating growth, yield and disease/pest development demonstrated that 'Cascade', a very popular cultivar in the USA, and 'Summit' seemed to be promising cultivars for hop cultivation in Connecticut. 'AlphAroma' is not recommended for cultivation in New England because of high susceptibility to downy mildew, or 'Perle' because of weak performance. Further cultivar evaluation will be conducted with ten additional cultivar planted in 2016 at both locations.

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New Plant Forum©

Compiled and Moderated by C. Tubesing
Presenters:

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Berberis thunbergii f. *atropurpurea* 'NCBT1', Sunjoy Mini Maroon™ Japanese barberry PPAF
Callicarpa 'NCCX2', Pearl Glam® beautyberry PPAF; CBRAF
Hibiscus 'Rosina', Pollypetite™ hibiscus PPAF; CBRAF
Viburnum cassinoides 'SMNVCDD', Lil' Ditty® witherod viburnum PPAF; cbraf
Viburnum 'NCVX1', Shiny Dancer™ viburnum PPAF

T. Brotzman[2,b]

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Hamamelis virginiana 'Ice Queen'
Hamamelis virginiana × *H. vernalis* 'Winter Champagne'
Hamamelis vernalis HAP#1002 (*H. vernalis* 'Holden' × *H. vernalis* 'Amethyst')

S. Castorani[3,c]

[3]North Creek Nurseries, Inc., Landenberg Pennsylvania, USA.

Erigeron pulchellus 'Lynnhaven Carpet'
Eriogonum allenii 'Little Rascal'
Monarda punctata

B. French[4,d]

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Carpinus caroliniana 'JN Select A', Fire King™ musclewood PPAF

S. French[5,e]

[5]Mt. Cuba Center, Hockessin Delaware, USA.

Coreopsis integrifolia 'Last Dance'
Coreopsis tripteris 'Gold Standard'
Pachysandra procumbens 'Silver Streak'

R. Hesselein[6,f]

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Calycanthus floridus var. *glaucus* 'Burgundy Spice' PPTBS

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Andropogon gerardii 'Blackhawks' PPAF
Geum 'Coppertone Punch' PPAF
Sedum 'Peace and Joy' PPAF
Sedum 'Pillow Talk' PPAF

W. Mezzitt[8,h]

[8]Weston Nurseries, Inc./Hort-Sense, Hopkinton, Massachusetts, USA.

Ilex opaca 'Weston'

Andropogon gerardii 'Blackhawks' PPAF

Andropogon gerard 'Blackhawks' big bluestem is a 2016 Intrinsic Perennial Gardens introduction. Deeper green foliage of this big bluestem selection takes on a deep purple background in mid-summer, deepening to dark purple and near black in some parts of the plant (Figure 1). Upright 5 ft+ tall plants will stand out in the landscape, especially with other tall grasses. For full sun, average soil.

Figure 1. *Andropogon gerardii* 'Blackhawks' foliage.

Berberis thunbergii f. _atropurpurea_ 'NCBT1', Sunjoy Mini Maroon™ Japanese barberry PPAF

Introducing the first ever sterile, rust resistant ornamental barberry. This dark, burgundy-purple barberry has a dwarf, low mounded habit that makes it both colorful and sensible (Figure 2). It forms both flowers and fruit but does not set viable seed.

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Figure 2. *Berberis thunbergii* f. *atropurpurea* 'NCBT1', Sunjoy Mini Maroon™ Japanese barberry showing the low mounded habit.

Callicarpa **'NCCX2', Pearl Glam® beautyberry PPAF; CBRAF**

A whole new look for callicarpa! No longer just a plant for colorful autumn berries, this new hybrid has attractive purple foliage to provide season-long color (Figure 3). White summer flowers and large purple-violet berries add to the attraction. This vigorous, upright plant looks neat in a container and the garden. Developed by Dr. Tom Ranney of North Carolina State University.

Figure 3. *Callicarpa* 'NCCX2', Pearl Glam® beautyberry fruiting plant.

Calycanthus floridus **var.** ***glaucus*** **'Burgundy Spice' PPTBS**

'Burgundy Spice' sweetshrub represents a radical color change in *Calycanthus* foliage, with lustrous deep burgundy leaves throughout the summer (Figure 4). Richard Hesselein and Daryl Kobesky selected for darker foliage over a number of years, coming up with two beautiful purple colored sports. We chose the best one to name *C. floridus* 'Burgundy Spice'.

The maroon flowers appear in May and June, and have the classic mango and pineapple fragrance of good sweetshrub selections. The fall foliage adds another season of enjoyment, turning attractive shades of yellow and amber.

Figure 4. *Calycanthus floridus* var. *glaucus* ‘Burgundy Spice’ foliage.

***Carpinus caroliniana* ‘JN Select A’, Fire King™ musclewood PPAF**

Carpinus carolinian a ‘IN Select A’ was selected by Michael Vanny at Johnson’s Nursery in about 2003 for its consistent orange-red fall color (Figure 5), fast growth rate, excellent form and branching, and superior hardiness.

Figure 5. *Carpinus caroliniana* ‘JN Select A’, Fire King™ musclewood.

The tree was selected from a crop of 563 seedling whips. Most trees in the crop were damaged by a severe snowless winter. Their roots froze out. The majority of the crop was grubbed. It was an open winter and frost penetration was extremely deep. Twelve trees of the 563 had shown good orange or red fall color the previous fall, had good growth rates, and were not damaged by the severe winter. ‘IN Select A’ was the best of these 12 trees.

The tree has an upright branching habit as a youngster and develops a round head with age. A 7-year-old plant from a graft in Wisconsin will be about 1-3/4 in. in caliper and have a head on it that is 5 ft wide by 6 ft tall. This is considerably faster than a typical *C. caroliniana* seedling of upper Midwestern U.S.A. seed provenance. 'IN Select A' has no serious insect or disease problems.

'IN Select A' 'is useful as a specimen plant because of its outstanding ornamental and carefree characteristics. Like others of this species, it has beautiful smooth gray bark that is similar to beech trees. It is especially valued in the winter time. It has an orange-red fall color that reaches its greatest intensity when grown in full sun. The plant could also be used as a broad screen for sun or shade as it will tolerate both. Care should be taken to mulch all *C. caroliniana* plants because of their roots sensitivity to quick freezes.

'IN Select A' should be grafted onto seedling *C. caroliniana* rootstock for best results. This cultivar has outstanding production characteristics. A 5-ft-branched tree can be easily grown in a container from a graft in 2 years time. Because of its rapid growth rate it should outperform other *C. caroliniana* cultivars of northern provenance in the marketplace. It is an excellent choice for people wanting to become familiar with this fine, little known, native tree.

Marketing and licensing for Fire King™ is being handled by Upshoot, LLC.

***Coreopsis integrifolia* 'Last Dance' fringeleaf tickseed**

Coreopsis integrifolia 'Last Dance' is a selection by Sunny Border Nursery (Figure 6). *Coreopsis Integrifolia* is likely the least known species of Coreopsis and well underappreciated. Native to Florida stream banks, it likes wet soil, though average garden soil is fine. It is reliably hardy to Zone 5. *Coreopsis integrifolia* 'Last Dance' has beautiful, disease resistant foliage. Our one Horticulturist has never seen a disease spot on it. It is the last *Coreopsis* to flower, beginning in early October. There are several median plantings in Delaware with great preliminary success. At Mt. Cuba Center it is planted at our entrance, right on the edge of the road. This road is heavily treated for snow and ice in the winter and these plants do not suffer from that. It responds well to full sun and part shade conditions. Blooming late in the season it is slow to emerge in the spring. The rhizomatous growth makes it very easy to propagate by divisions. We are currently propagating from cuttings taken August 18, 2016 at Mt. Cuba Center greenhouses. UPDATE: 10/5/16—rooted cuttings potted, rooting success of cuttings 93%.

Figure 6. *Coreopsis integrifolia* 'Last Dance' flowering plants.

***Coreopsis tripteris* 'Gold Standard' tall tickseed**

Coreopsis tripteris 'Gold Standard' is a new introduction from Mt. Cuba Center for 2016 (Figure 7). It is not widely available, yet. North Creek Nurseries is carrying. It was selected from seed collected in Jefferson County, Alabama. I remember cleaning and sowing this seed in the greenhouse in 2009! It is very winter hardy and experienced a span of harsh winters a few years ago. This is a full sun plant and unlike the straight species does not flop or break. The branches are held upright and extremely sturdy. 'Gold Standard' is slightly shorter than the straight species but will still reach 5 to 6 f tall. It blooms in late July for two solid months. We had mildew in the greenhouse on rooted cuttings this summer, but that cleared up with applications of Zerotol and increased air circulation. There was no mildew on the garden plants and otherwise it is disease resistant. It is a rhizomatous plant, spreading slowly, approximately 2 ft in 3 years. In the greenhouse we began 2016 with 11, 2quart sized stock plants for our first cuttings in May. We took a series of five cuttings until flower buds set in late July. We have nearly 500, 1-qt pots to date and we are not a production greenhouse. One can see how quickly it can be multiplied. Additionally, stock plants are a sellable 3 gal, blooming plant in September. There is a propagation protocol, posted by myself, on the Native Plant Network for the straight species which was based on these plants.

Figure 7. *Coreopsis tripteris* 'Gold Standard' flowering plant.

***Erigeron pulchellus* 'Lynnhaven Carpet' Robin's plantain or fleabane**

This outstanding form of *E. pulchellus* was selected for its relatively large grey-green, pubescent foliage (4 in.), dense, mat-forming habit and astonishing ability to thrive in a wide range of challenging conditions (Figure 8). In early May, individual flower stalks give rise to lightly tinted lavender flowers with a yellow inner eye. Foliage remains less than 6 in. and forms a tight groundcover, while flowering stems top out at just over a foot tall. Originally found growing on the 27-acre property of Clarice Keeling of Virginia Beach, Virginia. 'Lynnhaven Carpet' was named after Virginia Beach's Lynnhaven River by plantsman Charles Cresson. An easy to grow, carefree native perennial perfectly suited for moderate sunlight to full shade. Also deer resistant with a USDA Hardiness Zone 5(4)-9.

Figure 8. *Erigeron pulchellus* 'Lynnhaven Carpet' in flower.

Eriogonum allenii **'Little Rascal' shale barrens buckwheat**

This beautiful, long-flowering workhorse is a durable plant that thrives in urban plantings, rock gardens or any consistently dry site. It is drought tolerant and durable. With a tidy, low-growing habit of gray-green, paddle-shaped leaves, it bursts into flower with dense umbels of golden yellow flowers (Figure 9) that age to various shades of bronzy orange in the late summer. A wonderful little plant at 18-24 in. tall, it provides habitat and nectar for valuable pollinator species such as butterflies, honeybees, bumblebees, and hummingbirds. It is also a great selection for those who enjoy cut flowers. USDA Hardiness Zone 5-10.

Figure 9. *Eriogonum allenii* 'Little Rascal' in flower.

Geum **'Coppertone Punch' PPAF**

'Coppertone Punch' is a 2016 Intrinsic Perennial Gardens introduction (Figure 10). Semi-double saturated-orange flowers in May have shorter petals on top of the full size petals for a layered look. The flowers are borne on airy green stems 18 in. plus tall. Semi evergreen hairy foliage on 10×12-15 in. clumps look good all season. Moist rich soil is ideal, but average soil is suitable. Full sun.

Figure 10. *Geum* ‘Coppertone Punch’ flower.

***Hamamelis vernalis* HAP#1002 (*H. vernalis* ‘Holden’ × *H. vernalis* ‘Amethyst’)**

Hamamelis vernalis HAP#1002 is an unnamed hybrid from Holden Arboretum using *H. vernalis* ‘Holden’ × *H. vernalis* ‘Amethyst’ (Figure 11). It has excellent dark green leaves, good autumn leaf color, and good disease resistance. HAP#1002 has red flowers and is in flower between Thanksgiving and Christmas—the only selection we are aware of that does this. Not patented or trademarked, not in general commerce.

Figure 11. *Hamamelis vernalis* HAP#1002 (*H. vernalis* ‘Holden’ × *H. vernalis* ‘Amethyst’) flowers.

***Hamamelis virginiana* × *H. vernalis* ‘Winter Champagne’**

Purchased as *Hamamelis virginiana* but is probably a H. *virginiana* × *H. vernalis* hybrid—leaves have glaucous undersides, Named by Brotzman’s Nursery. Orange flowers between Halloween and Thanksgiving, do not persist into the New Year with a mild fragrance (Figure 12). A large multi-stem shrub, approximately 12 ft and is not patented or trademarked.

Figure 12. *Hamamelis virginiana* × *H. vernalis* 'Winter Champagne' in flower on 25 December 2012.

Purchased as *Hamamelis virginiana*, grew to approximately 12 ft tall, drowned in 2013, named by Brotzman's Nursery. Flowers yellow between Halloween and Thanksgiving and flowers remain intact and colorful into the New Year, usually until early February (Figure 13). All flowers open in the fall but have the ability to persist through the winter without completely drying out or dropping off. The only selection we are aware of that has this characteristic.

Figure 13. *Hamamelis virginiana* 'Ice Queen' in flower on December 2012.

***Hibiscus* 'Rosina', Pollypetite™ hibiscus PPAF; CBRAF**

A most unusual and beautiful dwarf *H. paramutablis* × *H. syriacus* hybrid. This ball-shaped shrub has large, rounded, pure lavender-purple flowers with soft ruffled edges and no center eye (Figure 14). Very dark green leaves provide striking contrast. Developed by Polly Hill Arboretum on Martha's Vineyard.

Figure 14. *Hibiscus* 'Rosina', Pollypetite™ hibiscus flowering plant.

***Ilex opaca* 'Weston'**

I first noticed this holly as a volunteer seedling in the 1980s growing beneath a planting of several mature cultivars that my grandfather, Peter J. Mezitt, had installed as a windbreak on the edge of his driveway in the 1950s. One of the cultivars in that group was 'Nelson West', a long-time favorite of mine because of its unique narrow foliage and sufficient winter hardiness to perform well in this location, but sadly a male with no fruit. The seedling that we later named 'Weston' was about 5 ft. tall when I noticed it, and it showed similar leaf characteristics to 'Nelson West', but it also bore fruit—a pleasant surprise (Figure 15). So I rooted a number of cuttings that winter. Within a couple years these propagated plants produced flowers, and to my dismay, some were obviously male. Sorting out and discarding the males, I returned to the original volunteer and saw that I had actually taken cuttings from two volunteers whose trunks (now about ¾" diameter) wrapped around each other. Identifying the true female, I cut and applied herbicide to the severed trunk of male volunteer. Unfortunately, their two root systems were apparently intertwined, so both volunteer seedlings were killed, and we lost the original plant. Luckily I was still able to propagate from the female plants I had rooted earlier.

Figure 15. *Ilex opaca* 'Weston' form.

By the 1990s we had sufficiently evaluated this holly's performance in containers and open-field plantings to realize it was worthy of a cultivar name, so I initially called it 'Mae West' (I don't believe we've sold it using that name). When young it grows rapidly and quite upright, readily trainable to a single trunk, perhaps well-suited for narrow spaces. It has thrived for many years with minimal foliage damage in our Zone 5 winters in the open field, full sun and wind, flowering normally each spring and producing a lot of fruit, making a fine cut branch over the holidays. After a few more years and further testing, we realized that this was an unusually-precocious cultivar, reliably producing profusions of smaller-than-typical berries that were as appealing as its foliage. At that point I chose to discard its original moniker and name it 'Weston' as a more appropriate designation for this superior cultivar.

Monarda punctata

We adore the genus *Monarda* for so many of its wonderful properties including fragrance, ease of growing, willingness to naturalize an area reliably and all of the wonderful things that it can do for beneficial insects and pollinators (a pollinator magnet) (Figure 16). It is the equivalent of a juice bar at the gym for nectar loving/needing insects! We sought out a native *Monarda* to add to our ecological line and landed swiftly on *Monarda punctata*. It produces an aromatic stand that ranges in heights from 6 in. to just shy of 3 ft tall. In bud, it forms saffron-colored rosettes in whorls along the top half of the stem. When the whorls release, watercolor-painted petals with little freckles are exposed and later mature to a soft pinkish-dawn color. These painted petals hold at the end of the flower spike for weeks upon weeks as they peek out through what appears to be leaf bracts. It also resists all other kinds of mites that could impact the bees because it is incredibly high in thymol. USDA Hardiness Zone 3-9.

Figure 16. *Monarda punctata* in flower.

***Pachysandra procumbens* 'Silver Streak'**

Pachysandra procumbens 'Sliver Streak', Silver Streak Allegheny pachysandra was selected at Mt. Cuba Center gardens in 2009 (Figure 17). The original plants are of unknown origin. It was selected for striking silver blotches on a green background. This is the winter look, which I think is unique since one can enjoy longer than if it would be only the new growth which emerges differently. In fact, the new growth is traditional green which changes to this silver blotching in late summer, early fall. There is no bronzing in winter. Plants grow well in shade to part-shade and will handle dry shade once established. This *Pachysandra* is highly pH adaptable from acidic to strongly alkaline.

Figure 17. *Pachysandra procumbens* 'Silver Streak' plants.

***Sedum* 'Peace and Joy' PPAF**

An Intrinsic Perennial Gardens introduction. Bears blue-green foliage reminiscent of *S. sieboldii* in tight compact clumps, only reaching around 12 in. high and up to 15 in. wide (Figure 18). Bicolor magenta pink flowers begin in September. Place in full sun, well drained soil.

Figure 18. *Sedum* 'Peace and Joy' in flower.

***Sedum* 'Pillow Talk' PPAF**

A 2016 Intrinsic Perennial Gardens introduction. Substantial plants with hybrid vigor reach 18-24 in. tall and wide. 5-6 in. flower heads of deep pink and magenta stand out from the crowd (Figure 19). Large, gray-green foliage is held on rose colored stems and at times displays reddish edges. Fall color is chartreuse and pink. This selection is resistant to *Rhizoctonia.* For full sun to light shade, well-drained soil is best.

Figure 19. *Sedum* 'Pillow Talk' in flower.

Viburnum cassinoides **'SMNVCDD', Lil' Ditty® witherod viburnum PPAF; cbraf**

Outstanding dwarf viburnum is a puffball of creamy-white flowers in late spring (Figure 20). The fruit eventually turns black and remains on the plant to provide winter interest and food for songbirds. An adaptable, easy to grow landscape shrub that is perfect for mass plantings, foundations, and the outer edge of water gardens. Native.

Figure 20. *Viburnum cassinoides* 'SMNVCDD', Lil' Ditty® witherod viburnum flowering plant.

Viburnum **'NCVX1', Shiny Dancer™ viburnum PPAF**

An extraordinary compact viburnum, noted for its waxy leaves that are tinged with an attractive red margin. Abundant ivory flowers adorn this shrub in spring (Figure 21). The dark green, heavily textured, semi-evergreen foliage turns burgundy-red in late autumn. This easy to grow, adaptable landscape plant was developed by Dr. Tom Ranney of NCSU by crossing *V.* 'Huron' with *V.* 'Chippewa'. Use either parent as a pollinator for a crop of persistent dark red fruit.

Figure 21. *Viburnum* 'NCVX1', Shiny Dancer™ viburnum plant.

Using a novel cover crop blend to increase the sustainability of ornamental plant nursery production©

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Standard nursery ornamental tree production is conducted in fields maintained by extensive use of mechanical (tillage) and chemical (herbicide) inputs. Not only is this costly and labor-intensive, but multiple passes over fields results in soil compaction and formation of deep plow layers that impede drainage and root growth, and the absence of plant cover leads to soil erosion. Cover crops are a logical means of increasing sustainability, however studies have shown that the highly-competitive cover crops traditionally used in agronomic settings (e.g. buckwheat, winter rye, perennial ryegrass and trefoil) can reduce nursery crop growth. The tillage radish (*Raphanus raphanistrum* subsp. *sativus*), a relatively new cover crop to the U.S., is being used in agronomic settings to reduce soil compaction, hold nutrients, limit runoff, and reduce herbicide applications during the winter months. The ability to aerate the soil well below compacted plow layers has intrigued farmers and opened the avenue for uses in other industries, including perennial plant nurseries. However, the use of tillage radish as a cover crop in nursery settings has yet to be tested in a controlled, replicated production setting. In addition, combining the annual tillage radish with a perennial such as red clover (*Trifolium pratense*) offers the opportunity for a single seeding pass to provide cover crop for the duration of multi-year crops such as those in woody plant nurseries, where the perennial clover establishes during tillage radish growth and fills-in the following season after the radish has died. Three tree species were lined-out in fields prepared using standard nursery practices: honeylocust (*Gleditsia triacanthos* f. *inermis* 'Skycole', 'Skyline' honeylocust, red oak (*Quercus rubra*) and White spruce (*Picea glauca*). The cover crop blend consisting of the annual tillage radish and perennial red clover was sown in late August into September. Seeds were sown in a single pass using a rear mounted Land Pride Primary Seeder (drop seeder with packer rollers) with light soil agitation from belly mounted cultivators. Data collection included tree caliper, measurement of leaf chlorophyll content using an Opti-Sciences CCM-300 fluorescent ratio chlorophyll content meter, and a visual evaluation of weed pressure and overall appearance of the trees using a 1-5 scale. An unexpected finding of this study was that Honeylocust canker (*Nectria* spp.) infection was greatly reduced in the cover crop plot (5% infection vs 94% infection in the control plot managed using tradition weed control measures). It is believed that these trees arrived from a west-coast producer with the canker fungi already present, and environmental factors related to the presence of the cover crop and/or reduced exposure to herbicides affected the trees' susceptibility to canker symptom development. Caliper measurements of red oak revealed slight (although not statistically significant) increases in diameter of trees in the cover crop treatments. This is unlike previous studies that found reduced growth in production fields using other species of cover crops. This is an important finding, since reduced growth has been a major barrier to the widespread use of cover crops in the nursery industry. Caliper data for honeylocust was skewed due to the high incidence of canker and subsequent early harvest in the control plots and is therefore not reported here. Chlorophyll content measurements of the three species did not reveal any statistically significant differences between the cover crop and control treatments. Ordinal evaluations of general tree appearance and within-row weed pressure were both superior within the cover crop treatments. In addition, soil erosion was noticeably reduced in the cover crop plots. Cost analysis revealed that over the first two years total costs of the cover crop treatments

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averaged \$130 $acre^{-1}$ vs. \$250 $acre^{-1}$ for traditional nursery practices in the control plots.

Evaluation, propagation, and tissue culture of hybrid white oaks (*Quercus*) for the urban environment©

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Asexual propagation of oaks has proven difficult for the majority of *Quercus* species using traditional methods of grafting or rooting cuttings, with the exception of *Q. robur*. In order to develop improved oaks, clonal propagation methods are required along with an increased diversity of *Quercus* germplasm.

Cornell's Urban Horticulture Institute (UHI) has been working towards addressing limitations in propagation and germplasm diversity through its long-term white oak breeding program. This program was initially developed between 2004-2006, when over 345 unique genotypes of hybrid white oaks were generated using 40-parent species from North America, Europe, and Asia.

The goal of this project has been to develop elite oaks with enhanced characteristics such as stress tolerance (drought, high pH, cold hardiness, pest, and disease resistance) and ornamental quality. On an annual basis, stock plants are coppiced, forcing juvenile shoots from the stumps. These shoots can then be used for tissue culture establishment, to induce rooting using a stool bed method or allowed to grow to be evaluated.

To date the UHI progress has included the development of a modified stool bed technique to asexually propagate oaks via rooting that has successfully been used on a range of hybrid oaks. In 2016 an assessment was done of the hybrid oaks' capacity to osmotically adjust.

Osmotic adjustment, a drought tolerance mechanism in plants, was assessed using a vapor pressure osmometer. Screening of select hybrids was carried out in greenhouse experiments to determine their tolerance of high pH soils, a common stressor in urbanized environments. Hybrid oak seedlings have been field grown at Cornell Horticulture Section's research site in USDA Zone 5b (-15 to -10°F) allowing for assessment of cold hardiness. Disease pressure (anthracnose and powdery mildew) and pest pressure (scale, Japanese beetles, aphids, and galls) was qualitatively assessed and genotypes exhibiting high degrees of resistance were selected as candidates for tissue culture establishment.

Use of the modified stool bed method was successful in the clonal propagation of oaks. The number of trees produced each year remains low, limiting the viability of this method for large-scale nursery adoption. As a result, tissue culture methods are actively being developed by the UHI to overcome these limitations in production. Tissue culture (TC) was first trialed by UHI lab members in 2014 through 2015 with the successful establishment and multiplication of six genotypes of interest using methods developed for *Quercus* species *alba, bicolor,* and *rubra.* Although these TC methods exist for oaks they lack consistency required for adoption by commercial laboratories. Research is focusing on optimization of protocols for oak tissue culture as well as establishment of elite hybrids in culture.

While the methods developed by other researchers to date have been shown to be effective there are still a number of limitations including; failure of specific genotypes to establish in culture, episodic growth causing shoots to eventually die in culture, phenolic exudation from ex-plants reducing establishment and multiplication efficiency and ex-plant death, limited capacity for establishing oaks from mature stock plants, and location on stock plant (basal shoots vs. outer canopy) where shoots are harvested for use in tissue culture significantly affecting establishment success.

Research has continued in the 2016 season focusing on the establishment and multiplication phase of tissue culture. In this growing season successful establishment of an

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additional 14 hybrid white oak genotypes in tissue culture was achieved. Experiments have varied and include; induction of whole shoots into culture compared to individual nodal buds allowing for increased efficacy in establishment of oaks, use of the anti-oxidant PVP-40 as a phenolic exudate inhibitor in oaks and study of its interactions with plant growth regulators in tissue culture, experimentation with cytokinin meta-topolin for shoot multiplication phase, evaluation of combined effects of cytokinins (BAP, Zeatin) and auxin (IAA) on establishment and multiplication of *Q. bicolor*.

Future research aims to increase the total number of genotypes of interest into culture, development of an optimized establishment and multiplication protocol, experimentation with the rooting and acclimatization phases of tissue culture, and eventual release of elite hybrid white oaks to the green industry and public.

The U.S. National Arboretum was assigned to be the International Cultivar Registration Authority for *Cercis*©

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INTRODUCTION/SIGNIFICANCE TO NURSERY INDUSTRY

Redbuds are a significant nursery crop for much of the American nursery industry. Eastern redbud (*Cercis canadensis*) are endemic and widely distributed from Canada to Florida. Southern variants (subsp. *texensis* and var. *mexicana*) grow natively in the southwest and a western species (*C. canadensis* var. *orbiculata*) grow natively west of the Rocky Mountains. In addition to the native American taxa, several Asian taxa are cultivated and represent a significant nursery crop in the United States. Although cultivated for over a century, there has recently been a large increase in the number of named cultivars on the market. With the large increase in named cultivars, it will be beneficial to the green industry and gardeners to create a checklist with cultivar description and general identifying information to help differentiate cultivars.

According to the latest (2014) USDA Census of Horticulture Specialties, redbuds were the fifth most valuable deciduous flowering tree crop in the USA, seventh most commonly grown flowering deciduous tree, and fourth highest value flowering deciduous tree per plant sold ($26.76 plant^{-1}). Redbuds were grown in 1,272 nurseries in 44 states.

The popularity of redbuds is due, in part, to the availability of cultivars with diverse leaf color, habit, and flower color. Additionally, redbuds can be grown in a very wide range of environments and have very few diseases or pests.

NAMED CULTIVARS INCREASING

The increase in the number of named redbud cultivars has risen at an almost exponential rate since 2000 (Figure 1). To date, there are at least 70 named cultivars of redbud that have been named and described. Fifteen have been patented, 10 have trademarks, and 33 released since 2000.

INTERNATIONAL SOCIETY FOR HORTICULTURAL SCIENCE - NOMENCLATURE AND CULTIVAR REGISTRATION COMMISSION

International Society for Horticultural Science administers the International Cultivar Registration Authorities (ICRA) via the Nomenclature and Cultivar Registration Commission. Chief aims are:

To prevent duplicated uses of cultivar and group epithets and ensure names follow the latest edition of International Code of Nomenclature for Cultivated Plants (ICNCP).

It is voluntary, non-statutory system (no legal protection of plant name), self-policing of nomenclature, International in scope, depends on cooperation of everyone involved with creation and marketing of new plants, and all that is required is submission of name and descriptive information to ICRA.

Most popular cultivated plants have an ICRA (e.g., *Quercus, Buxus, Iris, Magnolia*, etc.). For plants without ICRA (e.g., *Deutzia, Hydrangea, Hypericum*, etc.), they are submitted to Unassigned Woody Genera ICRA (currently the U.S. National Arboretum). The U.S. National Arboretum was assigned to be the International Cultivar Registration Authority for *Cercis* in 2015.

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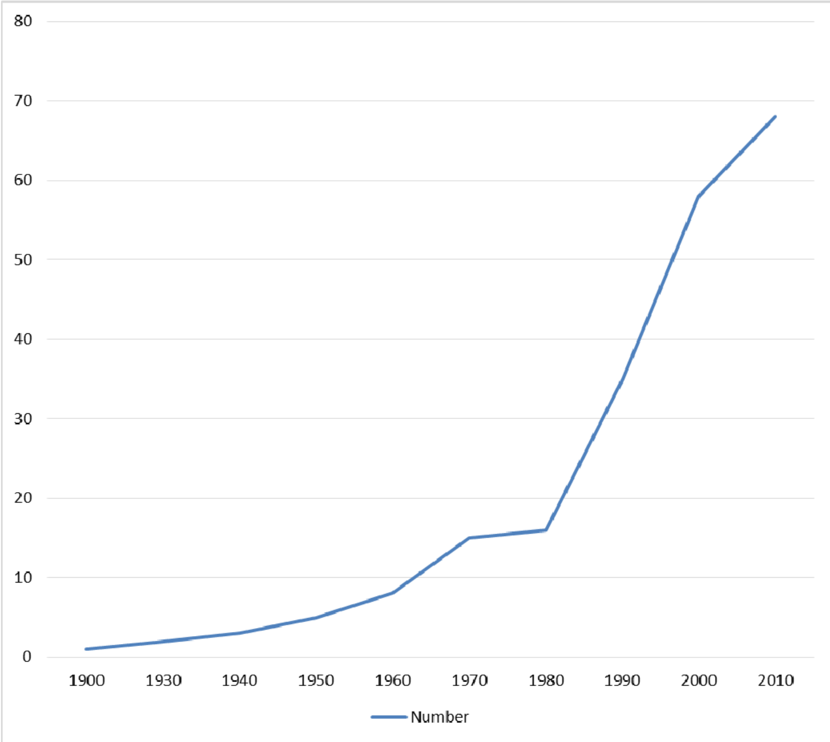

Figure 1. Approximate number of named *Cercis* cultivars by decade (1900-2016).

Micropropagation of *Vitex agnus-castus*©

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INTRODUCTION

Vitex agnus-castus or the chaste tree is a large shrub that is important as a medicinal and an ornamental plant. It is well known for its medicinal properties in hormone regulations (Snow, 1996); research is actively being conducted to prove the medicinal properties of the shrub (Van Die et al., 2013). In addition to being an important herbal medicine, the shrub also possesses ornamental properties with promising marketable value (Dirr, 2015). The shrub has fragrant palmately compound leaves and produces spikes of lavender flowers in the late summer that attract pollinators (Gilman and Watson, 1994). It can grow in many types of soil with good drainage and the shrub does not attract deer. Lastly, *Vitex* is not known to be affected by any major pest or diseases.

Vitex has a few weaknesses (Dirr, 2015); the shrub has an aggressive growth habit and can grow up to 20 ft in length and width. This quality likely deters home owners and landscape architects to use *Vitex* in a landscape. Another weakness of *Vitex agnus-castus* is that it has limited flower colors. Currently the flower colors that are available commercially are limited to two: purple-blue and pink. Lastly the shrub is not cold tolerant or hardy in zones colder than zone 7 (USDA Plant Database). This limits the landscape or area that the plant can be used.

Considering the economic potential of *Vitex*, a breeding program will be able to improve *Vitex* as an ornamental plant. An important step to this goal is to outline the micropropagation protocols for this plant.

MATERIALS AND METHODS

Surface sterilization

Cuttings were taken from plants, approximately 3-5 months old, growing in the greenhouse. Cuttings were wrapped in wet paper towel and transported into the laboratory in a closed container. The apical meristem and the leaves were removed and the cuttings were cut to 7-10 cm. The cuttings were then individually washed under warm running water for 30-60 s before they were stirred in soapy solution for 30 s. The cuttings were washed under running water for another 30-60 s to remove the soapy solution. After washing, the cuttings were placed in Magenta™ boxes containing 200 ml of sterile water and placed under the laminar air-flow hood before they were soaked in 10% bleach (8.25% NaOCl) solution for 15 min. with occasional stirring every 5 min. After 15 min., the cuttings were washed three times with sterile water to remove any bleach solution. Then individual nodes with internodes removed were cultured into test tubes containing 10 mL half strength Murashige and Skoog (MS; Murashige and Skoog, 1962) nutrient medium, 30 g L^{-1} sucrose, and 6 g L^{-1} agar micropropagation grade (Phytotech Laboratories®) with pH calibrated to 5.70-5.75. The explants were then placed under florescent lights and allowed to grow for 4 weeks. Contamination and survivability of explants were recorded after 4 weeks (Table 1).

Shoot multiplication

For shoot multiplication media, full strength MS medium was prepared with 30 g L^{-1} sucrose, 6 g L^{-1} agar and the pH calibrated to 5.70-5.75 before the medium was autoclaved. The medium prepared was poured into Magenta™ boxes with 40 mL box^{-1} and 5 explants were cultured into each box.

The explants used for the experiment were maintained in full strength MS media. The

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explants were cut into approximately 2.5 cm in length with the apical meristem removed to remove apical dominance. Twenty explants were used for each treatment with a total of 10 treatments including the control. The treatments were control (no growth regulators), 0.1 mg L^{-1} BA, 0.5 mg L^{-1} BA, 1.0 mg L^{-1} BA, 5.0 mg L^{-1} BA, 0.1 mg L^{-1} 2iP, 0.5 mg L^{-1} 2iP, 1.0 mg L^{-1} 2iP, and 5.0 mg L^{-1} 2iP. The explants were allowed to grow for 4 weeks before the number of shoots and the length of shoots produced were recorded.

Rooting

For rooting media, full strength MS medium was prepared with 30 g L^{-1} sucrose, 6 g L^{-1} agar and the pH was calibrated to 5.70-5.75 before autoclaved. Twenty explants were used for each concentration tested and the explants were maintained in full strength MS medium supplemented with 1 mg L^{-1} BA. The explants were cut to 2.5 cm in length, each with the apical meristem included on the explant. The explants were cultured in medium supplemented with either IBA or NAA at concentration of 0.1 mg L^{-1}, 0.5 mg L^{-1}, 1.0 mg L^{-1} and 5.0 mg L^{-1}. Five explants were cultured into one Magenta™ box and they were allowed to grow for 4 weeks before the number of explant rooted and the length of primary roots produced were measured.

Acclimatization

Rooted explants that were maintained in MS medium supplemented with 1 mg L^{-1} IBA were used for the experiment. The explants were washed under running water to remove tissue culture medium before they were potted into Magenta™ boxes containing sterile 50:50 mix of perlite and peat moss. Four explants were placed inside each box and thin transparent plastic bags were used to loosely cover the top of the magenta boxes. The explants were then placed under fluorescent light for 4 weeks. The explants were watered with 15-ml sterile water on the first day and every 2 days after or as needed. After 1 week, a vertical slit with 0.5 cm in length was made on the plastic cover and the length of the opening was doubled every 4 days. On the 4th week, after 2 days with the opening of the slit to be 8 cm, the explants were taken to the greenhouse and potted into 4-inch pots and were placed under shade cloth. The survival of the explants was recorded at the end of the 5th week.

RESULTS

Surface sterilization

Table 1 summarizes the result of surface sterilization method. Cuttings taken from the greenhouse were sterilized before they were cultured individually in test tubes. Fifty nodes were obtained from the sterilized cuttings and after 4 weeks in culture, three test tubes were observed to be contaminated. The success of the procedure was calculated to be 94%.

Table 1. Result of surface sterilization method on *Vitex* plants; cuttings were successfully introduced into sterile environment with 94% success rate.

Number of explants/nodes	Number of contaminated explants	Percent success
50	3	94

Shoot multiplication

1. BA media.

Figures 1 and 2 show the results of 20 explants grown on different BA concentrations for four weeks. The explants in the control medium produced an average of 2.4 shoots at 1 cm in length while the medium supplemented with 0.1 mg L^{-1} BA produced an average of 3.2 shoots at a length of 1.1 cm. Medium supplemented with 0.5 mg L^{-1} BA produced 5.6 shoots at 1.1 cm in length while medium with 1.0 mg L^{-1} BA produced the greatest number of shoots with 7.5 shoots at 1 cm in length. Lastly, the 5.0 mg L^{-1} BA medium produced 6.2 shoots on average at 0.6 cm in length.

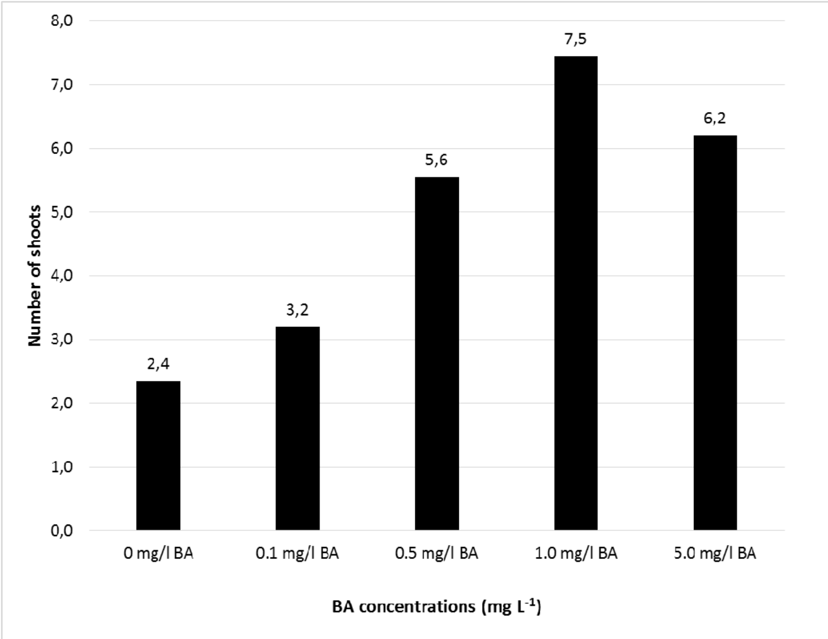

Figure 1. Average number of shoots produced when *Vitex* explants were grown in different BA media after 4 weeks.

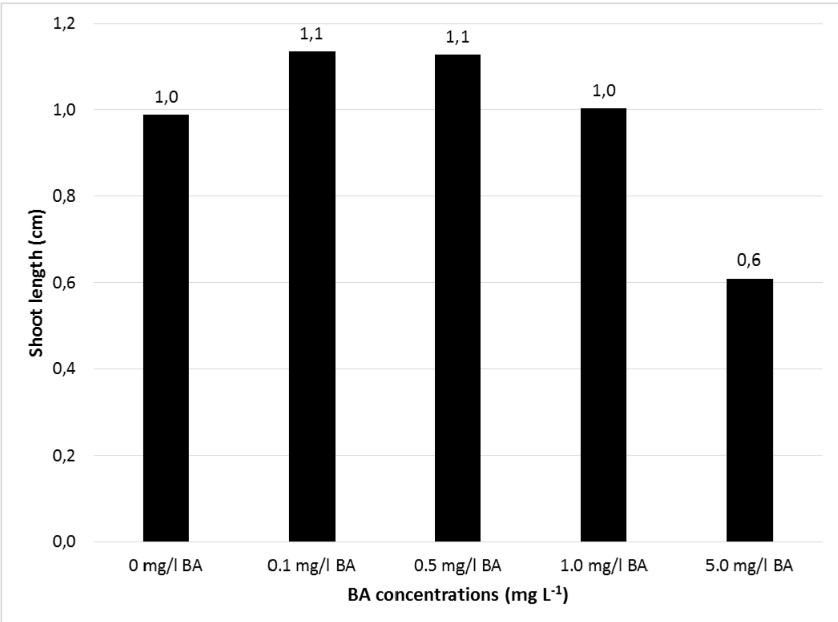

Figure 2. Average shoot length of *Vitex* cuttings when explants grown in different BA media after 4 weeks.

2. 2iP media.

Figures 3 and 4 show the result of 20 explants grown in different 2iP concentrations for 4 weeks. The control medium produced an average of 2.7 shoots at 2.7 cm in length, 0.1 mg L^{-1} 2iP medium produced 3 shoots with length of 1.4 cm, 0.5 mg L^{-1} 2iP medium produced 3.8 shoots with length of 1.3 cm, 1.0 mg L^{-1} 2iP medium produced 3.8 shoots with length of 0.8 cm and 5.0 mg L^{-1} 2iP medium produced 5.0 shoots with length of 0.9 cm.

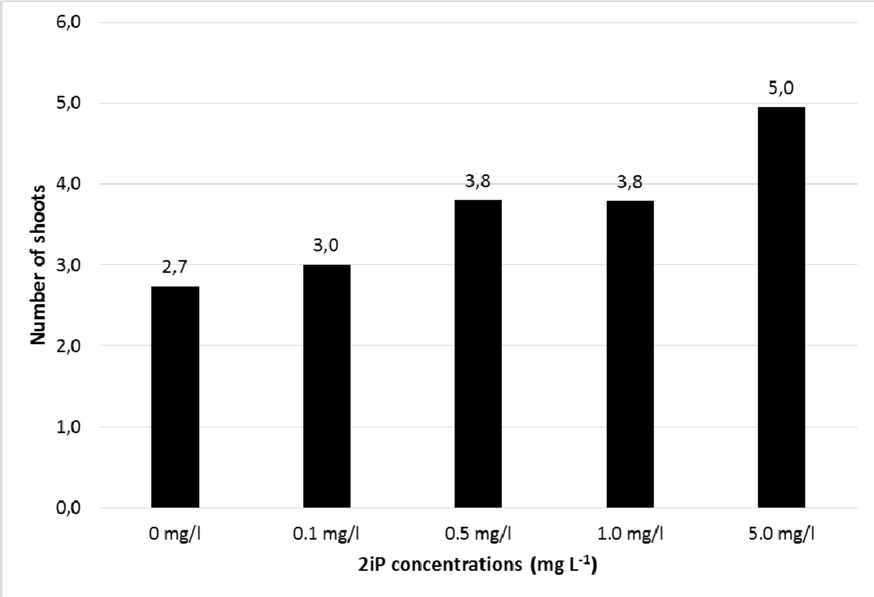

Figure 3. Average number of shoots produced on *Vitex* explants when grown in different 2iP media after 4 weeks.

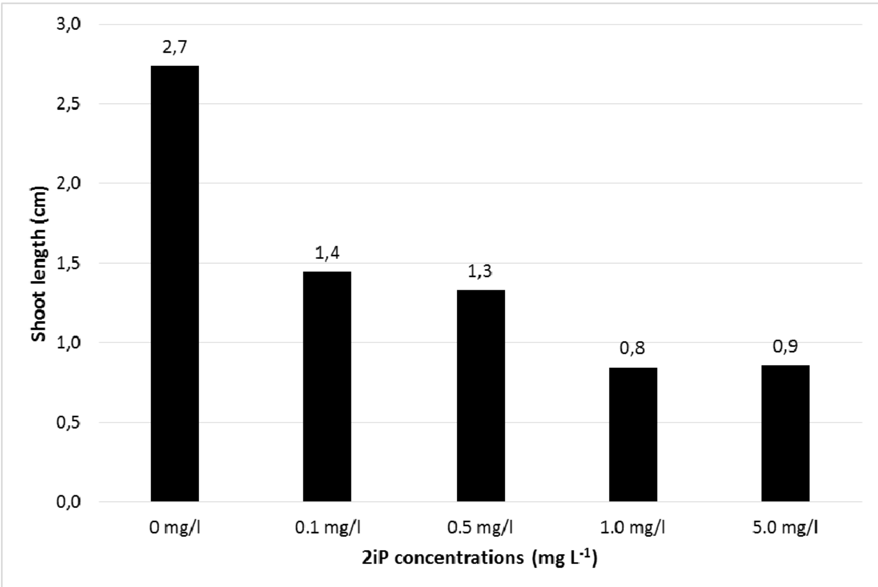

Figure 4. Average shoot length on *Vitex* explants when grown in different 2iP media after 4 weeks.

Rooting

1. IBA media.

Twenty explants of *Vitex* were cultured in media supplemented with different concentrations of IBA for four weeks. The control medium had 30% of explants rooted with root length of 0.5 cm, while 0.1 mg L^{-1} IBA had 35% explants rooted with length of 0.8 cm (Figure 5). The medium supplemented with 0.5 mg L^{-1} IBA had the greatest number of rooted explants with 65% explants rooted with the root length of 1.8 cm; 1.0 mg L^{-1} IBA and 5.0 mg L^{-1} IBA media both had 55% rooted explants with root length of 2.3 cm and 2.1 cm, respectively (Figure 6).

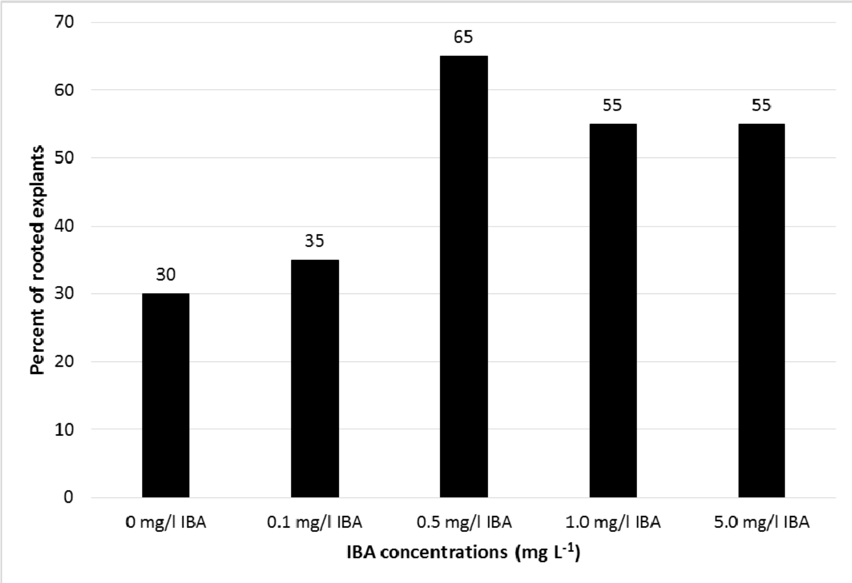

Figure 5. Percentage of *Vitex* explants that rooted after growing in different IBA media for 4 weeks.

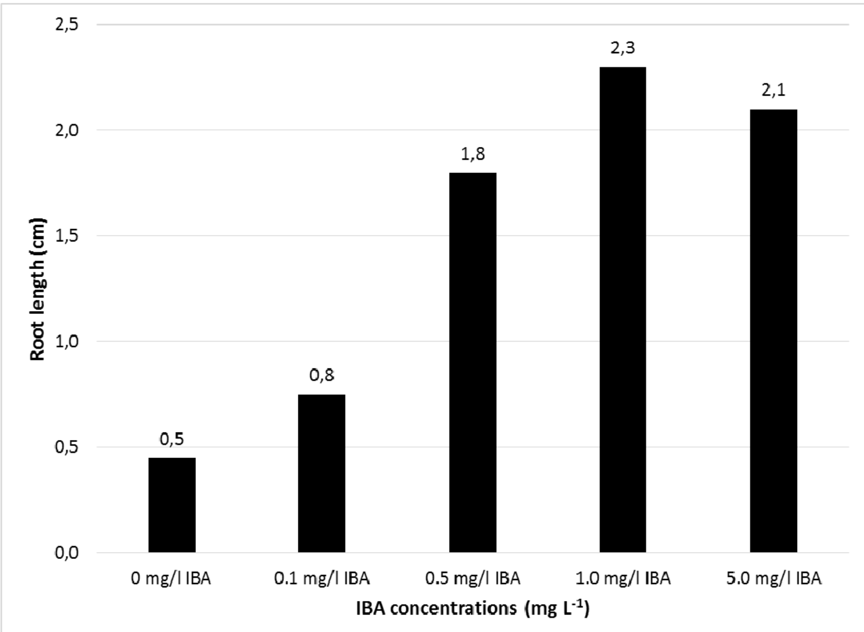

Figure 6. Average root length produced by *Vitex* explants that were grown in different IBA media after 4 weeks.

2. NAA media.

Twenty *Vitex* explants were cultured in media supplemented with NAA at different concentrations for four weeks. The control medium and the 0.1 mg L^{-1} NAA medium both had 35% explants rooted with 1.4 cm and 0.9 cm root length, respectively (Figure 7). The 0.5 mg L^{-1} NAA medium had 40% explants rooted with length of 1.3 cm while 1.0 mg L^{-1} NAA medium had only 30% explants rooted at 0.7 cm in length. The greatest number of explants rooted was observed in the medium supplemented with 5.0 mg L^{-1} NAA with 65% explants rooted with 2.4 cm root length (Figure 8).

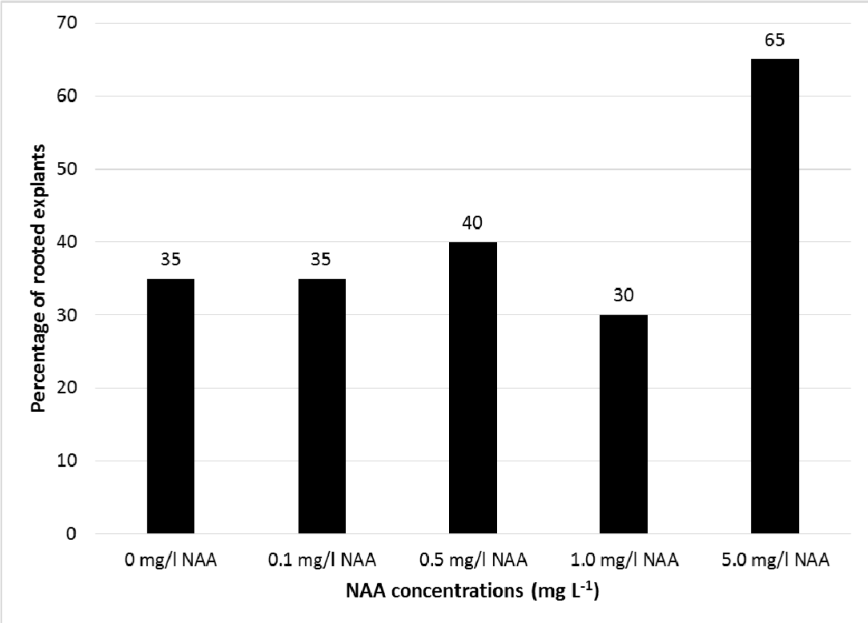

Figure 7. Percentage of rooted *Vitex* explants after 4 weeks of growing in different NAA media for 4 weeks.

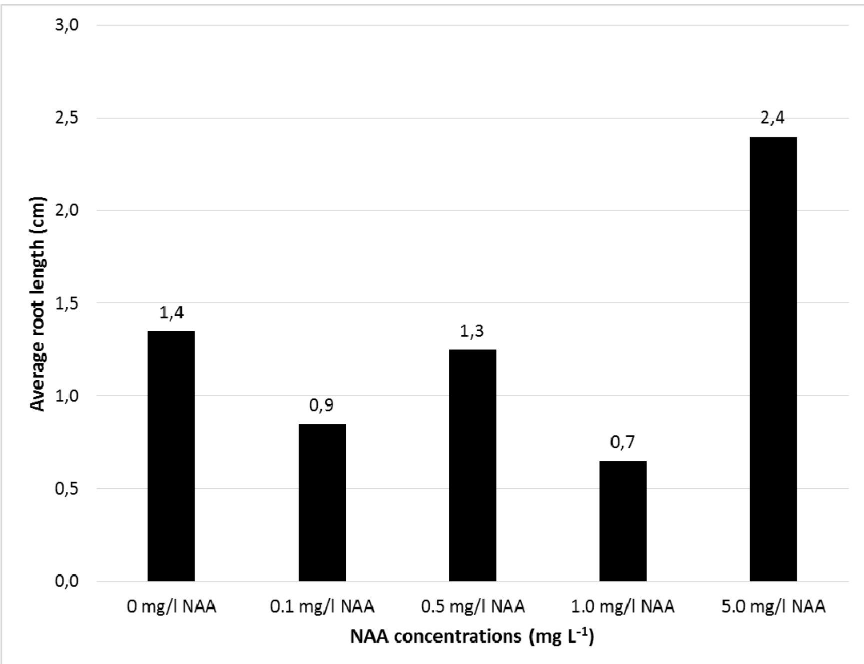

Figure 8. Average root length produced by *Vitex* explants grown in different NAA media after 4 weeks.

Acclimatization

Table 2 summarized the result of the acclimatization protocol. Twenty rooted explants were used for the experiment and 17 explants were successfully transferred into the greenhouse with a survival percentage of 85%.

Table 2. Twenty rooted explants were used for acclimatization experiment with 85% success rate.

Number of explants	Media	Number of survival explants after 5 weeks	Survival percentage
20	50:50 perlite:peat moss	17	85

DISCUSSION

Surface sterilization

There were two objectives for the surface sterilization experiment. The first objective was to eliminate any contaminants on the cuttings and the second objective was to ensure the survival of the explants that undergo the sterilization treatment. The contaminants on the cuttings' surface were eliminated through physical and chemical methods. The contaminants were physically removed from the surface of the cuttings by washing the cuttings under running water combined with stirring the cuttings in the soapy solution. After physically removing contaminants from the surface, 10% bleach solution soaked was used to further decontaminate the surface of the cuttings.

The surface sterilization method successfully sterilized 47 nodes out of 50 nodes from the cuttings taken from the greenhouse. The success rate was reported to be 94% and the nodes that were successfully sterilized started growing new shoots after 3 weeks in tissue culture.

The container used in the experiment contributed to the success rate of sterilizing the cuttings. Prior experiments of surface sterilization used Magenta™ boxes with 5 nodes cultured into one box and the success rate was much lower as compared to using test tubes (data not included). The use of test tubes allowed physical isolation of explants after the sterilization method. When magenta boxes were used, contamination from one explant will result in the loss of five explants that were in the same container. Thus, the use of test tubes prevents any recalcitrant spores or contaminants that were not removed during the sterilization procedure to spread to other explants.

Shoot multiplication

Two phytohormones were compared to determine the optimum cytokinin for shoot multiplication of *Vitex*. The explants grown in the control media contained no phytohormone supplement and produced on average of 2.4 shoots. The media supplemented with 0.1 mg L^{-1} BA produced 3.2 shoots, 0.5 mg L^{-1} of BA produced 5.6 shoots, 1.0 mg L^{-1} of BA produced 7.5 shoots and the highest concentration of BA tested of 5.0 mg L^{-1} produced 6.2 shoots after 4 weeks of growth. The average length of shoots produced for each of the concentrations tested were 1.0 cm for the control, 1.1 cm for 0.1 mg L^{-1} BA, 1.1 cm for 0.5 mg L^{-1} BA, 1.0 cm for 1.0 mg L^{-1} BA and 0.6 cm for 5.0 mg L^{-1} BA.

For explants grown in media supplemented with 2iP, 0.1 mg L^{-1} 2iP produced 3.0 shoots, 0.5 mg L^{-1} 2iP produced 3.8 shoots, 1.0 mg L^{-1} 2iP produced 3.8 shoots and 5.0 mg L^{-1} 2iP produced 5.0 shoots on average. As for the average length of shoots produced on 2iP supplemented media, shoot length was 1.4 cm for 0.1 mg L^{-1} 2iP, 1.3 cm for 0.5 mg L^{-1} 2iP, 0.9 cm for 1.0 mg L^{-1} of 2iP and 0.9 cm for 5.0 mg L^{-1} of 2iP.

The supplemented phytohormones used in the experiment promoted shoot production. The number of shoots in the supplemented media produced more shoots as compared to explants grown in the control media. The length of shoots that are produced decreased as the amount of phytohormone was increased. This is expected as the explants were forced to divert energy expenditure towards shoot production instead of shoot elongation.

The greatest number of shoots produced from media supplemented with BA was 7.5 shoots at the concentration of 1.0 mg L^{-1} and the shoot length is 1 cm on average. The greatest number of shoots produced from media supplemented with 2iP was 5.0 shoots at concentration of 5.0 mg L^{-1} with the average shoot length of 0.9 cm. This showed that BA was better at promoting shoot production compared to 2iP and the optimum BA concentration to be used to for shoot production was 1.0 mg L^{-1}.

Rooting

In the control media with no auxin supplement, 30% of explants formed roots after 4 weeks of growth. With media supplemented with IBA, 0.1 mg L^{-1} IBA had 35% rooted explants, 0.5 mg L^{-1} IBA had 65% rooted explants and both 1.0 mg L^{-1} IBA and 5.0 mg L^{-1} IBA had 55% rooted explants each. The average length of roots produced in the control media was 0.5 cm, 0.8 cm for 0.1 mg L^{-1} IBA, 1.8 cm for 0.5 mg L^{-1} IBA, 2.3cm for 1.0 mg L^{-1} IBA and 2.1 cm for 5.0 mg L^{-1} IBA.

For media supplemented with NAA, 0.1 mg L^{-1} NAA had 35% rooted explants, 0.5 mg L^{-1} NAA had 40% rooted explants, 1.0 mg L^{-1} NAA had 30% rooted explants and 5.0 mg L^{-1} NAA had 65% rooted explants. The average length of roots produced were 0.9 cm for 0.1 mg L^{-1} NAA, 1.2 cm for 0.5 mg L^{-1} NAA, 0.7 cm for 1.0 mg L^{-1} NAA and 2.4 cm for 5.0 mg L^{-1} NAA.

Based on the data obtained, the auxins used in the experiment promoted rooting in the explants since more explants rooted in media supplemented with auxins as compared to the explants grown in the control media. The concentration of IBA with the highest percentage of rooted explants was 0.5 mg L^{-1} with 65% explants rooted after 4 weeks of growth with an average root length of 1.8 cm. for NAA. The concentration that had the highest percentage of rooted explants was 5.0 mg L^{-1} NAA with an average root length of 2.4 cm. it can be concluded that the auxin IBA is more effective at inducing root production in *Vitex agnus-castus* as compared to NAA since IBA was able to achieve 65% rooting at concentration of 0.5 mg L^{-1} while it requires 5.0 mg L^{-1} NAA to achieve the same percentage of rooted explant.

Acclimatization

Acclimatization of explants was achieved by controlling the humidity of the growing environment. Rooted explants were taken off tissue culture media and the roots were washed thoroughly to avoid any fungal growth from any sucrose residue. During the first week of acclimatization, the humidity of the growing environment was not altered and the explants were allowed to adjust to the new growing condition without sucrose supplement. This allowed the explants to start or increase its photosynthetic machinery. In the second week of acclimatization, the humidity of the growing environment was decreased starting with a vertical slit of 0.5 cm and the length of the slit was doubled every 4 days to gradually decrease the humidity of the growing environment. Some damaged leaves were observed during the second week but the damage was minimal.

From the 20 explants tested for the acclimatization experiment, 17 explants were successfully introduced into the greenhouse. In the greenhouse, the plants were placed under shade cloth to limit light exposure before they are exposed to full sunlight.

SUMMARY

The experiments designed in the research achieved their goals. The surface sterilization method successfully introduced greenhouse cuttings of *V. agnus-castus* into sterile environment with 94% success rate. For shoot multiplication, the cytokinin BA proved to be more effective compared to 2iP and the optimum concentration to use was 1.0 mg L^{-1} of BAP. To induce rooting, the auxin IBA proved to be more effective compared to NAA and the optimum concentration to use was 0.5 mg L^{-1} with 65% explants rooted after 4 weeks. Lastly the acclimatization protocol successfully introduced 85% of rooted tissue culture explants into the greenhouse.

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IPM techniques for unique horticultural situations©

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INTRODUCTION

This presentation discusses various integrated pest management (IPM) strategies that were developed in response to situations where using conventional pest control practices, or materials were impractical or could be deemed unsafe. I have been a practitioner of IPM for over 35 years now. I use less conventional pest control products than I previously did. My philosophy is and has been to move towards a less or non-toxic solution in my horticultural endeavors.

I will now discuss some of these methods I have come up with to deal with several situations where conventional methods may have been impractical. These methods while admittedly may be unorthodox, could be adapted to your particular horticultural operation, in order for you to deal with a similar situation.

MATERIALS AND METHODS

Dealing with insect pests of flowering perennials can be complicated. The issue of exposing bees and butterflies to chemicals means that treating for insect pests in a flower border limits your options.

Some of the "new tools" I have adapted for IPM methods are sponge and bristle paint brushes. A wet/dry vacuum, power washer, aquarium or laboratory pipe brushes, and rubber and cotton gloves. These days I employ insect traps to monitor and remove as many adults insect pests in a given situation. Then I implement a low toxic or targeted product to treat other life stages of an insect pest. In one example, I have been encountering sunflower moth, *Homoeosoma electellum*, in a number of perennial gardens. This pest typically infests coneflowers (*Echinacea*). Now, while this pest is cyclic, and may or may not reappear the next season, they cause cosmetic damage to flower heads. When I see the typical mounding of excavation and caterpillar frass on the top of the flower heads, I set out traps. I then use pruners to remove the infested flower heads. Then I treat the remaining flowers on that plant, and nearby plants with *Bacillus thuringiensis* var. *kurstaki*.

Bacillus thuringiensis variety *kurstaki* has been shown not to be detrimental to bees. I do however; wait until later in the day or even early evening, when the bees are less likely to be visiting these areas, to apply the product via trigger sprayer. I continue to monitor the traps and flowers to evaluate the population levels for several weeks after this protocol has been implemented.

Water features such as fish ponds and pond less waterfalls have been popular over the years. Often these garden additions feature specimen trees and shrubs to compliment the water feature. These plants are sometimes sited near or right next to the water feature. As they mature, these plants can overhang or come in contact with the water itself. If one of these plants becomes infested with an insect pest, or infected with a particular disease, conventional treatments should not be used. This is especially true if there are fish in the pond or there are birds or amphibians that frequent the water feature. In one instance I had to treat a good sized mugo pine, *Pinus mugo*, that was over hanging a waterfall that connected to a koi pond. This pine was 60% covered with scale insects. I decided to use a power washer to remove the insects with pressurized water. I first had to erect a plastic sheet under and around the branches of the pine that over hung the water. This was done to prevent the water and the needles or insects from washing into the water stream. After washing off a majority of the insects, I carefully applied horticultural oil, by way of a paint brush and a trigger sprayer, to cover the remaining scale insects. The plastic barrier was left in place for several hours. Any oil or water that dripped off, or plant material that was

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knocked loose, was collected with a wet/dry vacuum cleaner. The plastic with any remaining debris was then removed. The pine was evaluated for the next several months. If visible signs of scale insects were detected, the treatment method was repeated.

Mealy bugs and aphids are typical pests of both herbaceous and woody plants. Applying dust to aphids is an effective control method. I have also used a solution of household ammonia and dish soap to remove and reduce aphid populations on a range of herbaceous plants. This combination gives the aphids an "upset stomach." It may not kill them out right, but it does get them to drop off or move off of the treated plant. I combine a tablespoon of each product in 1-gal container and then transfer the product to a trigger sprayer. Then this solution is sprayed over the insects. An alternative method is to use two gloves, one rubber and one cotton or fabric glove to "rub" the insects off of plant stems. The rubber glove is put on first, then the cotton glove over the rubber one. Then you dip your hand with the gloves on, into the ammonia and soap solution. Squeeze your fingers together to remove the excess water, and then use the gloved hand to remove as many of the aphids as possible.

Plant diseases that infect leaves create certain problems. With regards to crab apples in landscape situations, in addition to the disease itself, there is also the problem of removing the fallen leaves. Often time's reinfection can occur when the leaves or even fruit is not removed. Typical beds under these trees usually have some type of processed mulch product over the soil. When raking the leaves, the mulch often is removed as well. This causes double work. When I encounter this situation, I will, with the client's approval, replace the wood mulch, with a decorative stone product. In one project to date, I used tumbled glass, instead of stone, as mulch. This makes clean up easier. The heavier product isn't removed as easily. What I do in addition to the stone is to employ a wet/dry vacuum. I vacuum up the leaves, and if there is fallen fruit, that as well. This eliminates the possibility of reinfection by fungal or bacterial leaf diseases. This would be in addition to a product to treat these diseases, if such a product was used. If you do decide to use a rake, there are rubber headed rakes which are quite handy at collecting the leaves from the top of the stones in the bed.

I have used brushes that are used to clean aquarium pipes or even bird feeders, to remove mealy bugs and scale from intermediate conifers, and deciduous trees and shrubs. These are especially good when the insects get into the secondary branches, and even the crevices of the bark itself.

In certain weed invasion circumstances, spraying a weed control product over the top of a bed or border may not be a good idea. I have used either a bristle or sponge paint brush, along with an organic weed control product, Scythe®, to spot treat various broad leafed weeds that have found their way into beds and borders.

Wilt Pruf®, which is an anti transpirant product, can be used to treat black spot disease of roses. It does not have the resistant issues that typical fungicide products can develop. It is a beta-pinene polymer compound, when combined with water forms a terpene emulsion. This creates a barrier to the fungal hyphae. Of course if there is a heavy rain, or the rose plants are watered overhead, this product must be reapplied. Given its organic polymer nature, it makes an excellent product in an IPM program.

Other types of traps I have used for urban garden pests are fly and wasp traps.

These types of traps are situated away from sitting or eating areas of a garden or landscape; thus collecting these insects away from people. This reduces the risk of food contamination, or people or animals being stung. When the traps are full, the insects are disposed of. I empty the traps into a bucket of hot water to neutralize the insects.

Lastly, with the news these days about mosquitoes and the diseases they carry, municipalities as well as home owners fogging and spray regimes, have come to the fore. While large whole sale spraying is done for urban areas, home owners can use a number of mosquito traps on the market to collect these biting insects instead of constantly putting out various chemicals, which require frequent application. These traps range from a few hundred dollars each, to upwards of $500 or more. I have used several different configurations, and I can say that they definitely work. These devices reduce mosquitoes in the area that they are installed in. Most employ a light unit, and some combine the fan, light, and a carbon dioxide canister to further attract the insects to the trap.

While these methods are not typical of usual horticultural protocol, there are instances where chemical exposure to non-target species is not desired. Also exposing people and household pets will cause liability issues. Looking for low or non-toxic methods to reduce or even eliminate pest infestations or infections is worthwhile.

Challenges of introducing new plants©

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INTRODUCTION

New plant introductions are the lifeblood of the ornamental horticulture industry. Growers and retailers at all points in the supply chain can gain commercial advantage and retain customer interest by continuously improving and updating their product range by offering novel crops. New introductions can offer other advantages too, such as reduced production costs and faster production times.

It is important for breeders and introducers of new plants to understand the most important elements for success.

ELEMENTS FOR SUCCESS

A good plant

It may seem obvious, but the first and most important element of the new plant introduction process is to ensure that the plant is good. If the plant has been developed in-house, then it is vital to conduct an effective evaluation and small-scale production trial before committing to volume production. If the variety has been developed externally, then in-house trials or review of production by third parties will help to determine the qualities of the plant. Naturally, it pays to be cautious – experience shows that whilst a plant may perform in one way at one nursery, it can perform quite differently in a different nursery that employs different media, structures, pest control, etc.

The new introduction should be distinct and offer something that your existing product range does not—but that does not mean that your new plant programme should be limited to blue roses and black hyacinths. Plants that are incremental improvements on existing varieties can offer more subtle advantages in product performance and production characteristics that may not be obvious at first glance—but those advantages may be enough to make the plant easier to sell or more efficient to produce.

What's the story?

The choice of new plants in the market today is greater than it has ever been. So, it is important to consider the story that goes with the new plant that you intend to launch. This can be harder with introductions that offer only incremental improvements over existing plants, but it is not impossible.

You should consider the benefits that makes the plant attractive to your customers (and potentially to your customer's customers). But you should also look for other aspects of the story. For example, messages like "Bred in the UK" work well for certain audiences—clearly that message would work well in the United Kingdom, but it can also work well in other markets (for example: Germany, where British origin is associated with quality).

Other stories that might help to promote the plant could include:

- The new cultivar is the first of its kind.
- The breeder is donating royalties to charity.
- The breeder has a particularly good reputation or is well-known.
- The plant has environmental benefits (reduced chemical use, reduced heating requirement, and pollinator friendly).

Ensure the supply chain is in place

No matter how much of the production process you deal with in-house (and with more vertical integration in our industry, it is increasingly common for growers to carry out

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multiple stages of the production process within a single organisation, even if not at a single location), your new cultivar launch will not involve your own organisation in isolation. You will need to consider all players in the supply chain, both suppliers to you and those that you supply.

Ensure that you have the supply of young plant material that you need. This may mean working with a young plant grower or unrooted cutting supplier to ensure that they have mother stock in place. These suppliers may be in third countries. Be sure to understand if there are exclusivity arrangements in place, perhaps with territorial limitations—and, if not, try to understand the extent of supply to other players in your market. You may need to work with the breeder or breeder's agent to ensure that the correct licensing is in place.

Discuss the new cultivar with your key clients. Will they support you with promotion? Would offering a limited exclusive arrangement help to get their support and marketing effort? There is little value in offering a great new plant if you do not have customers who will buy it.

Often the breeder of the new plant, particularly if they have engaged an agent, will be involved in this process. Agents will frequently work in cooperation with growers and retailers to ensure that the supply chain is in place from end-to-end, including having some sort of "plan B" if things go wrong.

Communication is key

Just about the most important aspect of any new product launch is communication. Ensure that internal communication within your organisation is effective. Even more importantly, ensure that communication with the other organisations in the supply chain is effective. Be sure that you know who is involved and what their roles and responsibilities are. The breeder or their agent can have a role to play here in coordinating communication, but this will only work if everyone cooperates—and cooperation is not a strong point in the horticulture industry! Don't wait until the situation has gone horribly wrong before speaking up—if there is a potential problem on the horizon, talk to the breeder or their agent and to the other people in the supply chain. It is in their interests to work with you to find a solution and they will have increased confidence with you if you are honest. Failure to be honest and a disaster that can be blamed on you means that their confidence in your organisation will be lost and you will find it harder to be involved with future new plant launches.

Getting the message out there

It is likely that, during the development and build-up stages, the new product launch will remain confidential to those parties that are directly involved in it. However, the time will come when you need to begin shouting loudly about what you are doing—and there is likely to be a role and benefits for every party in the supply chain. To be seen to be connected to a successful new plant launch can enhance your organisation's reputation.

Firstly, be sure who is coordinating promotion and publicity and what everyone's role is. Often, coordination will be done by the breeder or their agent, but it may also be done by a retailer or wholesale grower. Have clear and agreed embargo dates for information.

Your marketing and promotion can include many different elements:

- Point of sale materials: plant labels, bed cards, posters. Think outside the box to set yourself apart from the crowd.
- Websites, social media—not just to promote the plant, but also to build community and to share information (such as cultural advice, supplier details, launch dates).
- Trade shows—IPM Essen, Plantarium, Four Oaks, and National Plant Show.
- New plant competitions, awards and trials—take care with novelty rules for new plant competitions, which can be arcane.
- Retail shows—focus on the shows with the biggest media presence like RHS Chelsea Flower Show (probably the best opportunity worldwide).
- Press contacts—it might be useful to employ a specialist PR agency.

What can go wrong?

Things will go wrong. Planning ahead will go a long way to avoiding problems, but we are dealing with a living product, so inevitably there is always something unexpected. Consider the following:

- Supply and supply chain problems—it is not always possible to quickly switch suppliers if there is a problem, but for non-exclusive product it can sometimes be possible. The breeder or breeder's agent may be able to help with this.
- Production and post-sale performance problems—it is important to conduct proper evaluation and production testing. Does the plant require a cold period to flower? Is it winter hardy? Are there unusual pest or disease issues?
- Not having enough plants—this might seem a nice problem to have, but your plant is only "new" once and you need to maximise the opportunity. You are unlikely to get those missed sales next year as, by then, the attention of customers might have moved on to the next novelty. Don't be tempted by a "soft launch" to avoid risk—once you launch, all the publicity and media opportunities that go with a new product will have been lost as it is no longer new. Avoiding risk generally means missing reward.
- Failures in communication—the least excusable of errors and the easiest to avoid! Crop running two weeks late due to a cool spring? Tell someone!
- Somebody else launches something similar before you launch your plant—the hardest problem to avoid. There are three options when this happens: tough it out and go for your launch regardless; scale back your launch; scrub your launch entirely. Once you become aware of a competing product, talk to the other parties in the supply chain, particularly the breeder or agent, and decide on the best way forward.

Things will go wrong. Learn from your mistakes.

But when it all goes well…

There are so many benefits for your organisation in launching new plants; including competitive advantage, increased sales, enhancement of reputation, improved relationships with suppliers and customers. It can even help with recruitment if you are seen to be a market leader. Market leaders tend also to attract more new product opportunities because success breeds success. Putting the best procedures in place with an enthusiastic approach will help to ensure the best possible outcomes.

Adding value the European way©

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INTRODUCTION

In Dutch industry adding value is usually linked to marketing: Point of sale materials like product labels, and packaging. But adding value can mean different kinds of things in nursery production. In this presentation I will indicate several trends on the continent, developments, and examples of added value for nurseries in several countries.

ADDED VALUE FOR NURSERIES

Drones

Drones will be the future on several nurseries, and in fact it is already present at some. Boys with toys? Maybe. But the main reason why nurseries are now looking at drones is the added value of this flying technique (Figure 1).

Figure 1. Drone in nursery.

The most simple thing is that flying a drone above your nursery with a camera for making a movie can be more spectacular than the latest James Bond. More nurseries are using drones for a company presentation to show customers what they produce, how big their crop is, and which techniques they're using for the best quality. That's a marketing benefit of drones.

The biggest benefit that growers expect will be big data of their crops, like leaf area index, amount of biomass, and presence of diseases. Data on soil conditions is also available including: are there are some spots on your field where plants grow less; is there something wrong with the soil, such as drainage, organic matter, amount of nutrients?

A drone and a special camera can see differences that you can't see with your own eyes. Afterwards you can take soil samples, or use more sensing techniques on your machinery for more data. Combined with Global Positioning System (GPS) you can fertilise or spray more precisely.

In addition, the first drones are now being developed for actually spraying a nursery. They can take, for example, 10 L of liquid in the air, and spray from above with a boom and nozzles. A flying tractor, indeed.

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In Holland everybody has to map their fields for government use to shoe how many acres of every crop they're growing. The first grower used a drone for this which was easy, fast, and accurate. He's now thinking (out of the box) of using a drone for measuring tree quality; when you can make 3D images of the girth, you can put this data into your stock of sale. No more measuring a tree by hand with a tape and writing down the data in a book.

Robotics

Robotics will also be the future. A lot of nurseries already use a potting robot, but is that really a robot when they pick up a row of plants, and put them on a conveyor belt? According to experts from universities, a real robot can handle diversity, it can detect a difference like a different colour of a plant, and then decide on it's own what to do with it such as take it out for despatch or leave it and drive to the following plant.

The added value of robotics has already proven at fruit growing nurseries—they put a robotic system on a tractor, they teach the robot how to drive and what to do (like mowing grass or spraying trees), and then the robot just playbacks the program at night or when the weather conditions are best for the spraying result.

On several American nurseries little robots do the work that people find boring: putting potted plants in a field, spacing them, or pick them up again. These American nurseries save a lot of labour costs and their staff have more time for doing real craftsman work.

Prototypes are now being developed for more added value, like weed control. But there's a challenge, a robot has to distinguish the real plants from the weeds, otherwise it can destroy those real plants. And it has to distinguish different kinds of lights. In morning light weed can look different than in the evening, and the soil can also matter.

Adding value with machinery

When adding value with machinery it all comes down to capacity and speed. A Swiss factory build a machine for lifting out five rows of forestry and hedging seedlings at the same time. When soil and weather conditions are right, the nursery (in Holland) uses the machine for lifting seedlings as much as possible (Figure 2). Storage capacity is also needed then.

Figure 2. Forest seedling bed lifter.

Another trend on some nurseries is weed control with a big capacity—spraying three or even seven beds at the same time (Figure 3).

Figure 3. Danish weed control machine in seedling beds.

Also still a trend on nurseries is the use of one machine for several purposes like drilling bore holes for planting, weeding, and making rootballs. In addition a Dutch nursery is using special equipment for pruning hedging plants for medicine supply. The nursery is complety run by GPS, and hedging elements are lifted by this machine (Figure 4). And what about sorting out forestry and hedging plants automatically? This is being done by a one and only machine so far running in Zundert.

Figure 4. Hedging elements lifted by a machine.

Growing systems

These can also add value. A few Dutch tree nurseries invested in a gutter system made of air pot material to have the benefits of air pruned roots and the benefits of a closed system for watering and fertilisation (Figure 5). The gutters are also labour friendly by being installed at a height of approx. 1 m. Different growing media were tested, and they concluded that trees in gutters with coconut fibre grow as good as in peat.

Figure 5. Trees growing in gutter system.

Several nurseries grow their trees now in slotpots, again with the benefits of air pruned roots, and the handling benefits of ordinary containers. They say that air pots are too labour intensive because the potting up has to be done right on the field, as air pots don't have a bottom. Therefore they have to replace air pots for despatch by something with a bottom, or they have to burlap it. But on the other hand, Italian nurseries like air pots for growing big specimen trees. If they won't sell this year, they can easily grow a few more years in the same air pot.

Dutch councils ask more for trees with their own roots so they don't have the disadvantages of grafted trees which can occur with different species such as no delayed incompatibility or a lot of maintenance because of suckers from the rootstock. A few Dutch nurseries have specialized in trees with own roots it gives them extra value on the market (Figure 6).

Figure 6. A field of Dutch trees on their own roots.

Sustainable production

This is becoming more important on both the amenity market as well as the retail market. But how can you show that kind of production? With a certification scheme that proves you produce according to standards. Or by showing customers what's happening on your nursery.

A trend in Dutch agriculture is now the use of drip irrigation, mainly on fields of potatoes and lilies, and on a single nursery with ornamental trees and fruit trees (Figure 7). That kind of irrigation is much more efficiently than irrigation guns, because the water drips right into the root system. It's common on nurseries in Oregon to keep the trees growing even in a dry season. And also common on fruit tree nurseries in Italy.

Figure 7. Drip irrigation fruit trees

Different forms of trees

This can also add value. A big Italian nursery, for instance, developed a fruit tree for better growth and crop results. Instead of one graft, every tree has two grafts and therefore two similar growing leaders (Figure 8).

Figure 8. Italian Bibaum® fruit trees.

Several nurseries are specialized in big specimen trees, but also in big specimen plants, or even climbers in huge container sizes. All for instant impact in a garden or a landscape project. Added value? Yes, but the production and logistic costs are also added, so the pre-investment will be higher than average tree and shrub sizes.

Also the risk will be higher, looking at unusual weather thanks to climate change. The chance of storms, heavy rainfall, hail, drought, and extreme frost is becoming larger. Last summer the south of Holland received so much rainfall that even higher grounds couldn't drain it quickly. Tree fields were flooded for days. After that the area was hit again, but now by a supercell, a thunderstorm with hail as big as tennis balls. Crops were lost forever.

What can nurserymen do against extremely weather? Ensure their crop, but Dutch insurance is too expensive according to them, and their own risk is too high. One tree nursery with a gutter system invested now in a hail net which is common to protect fruit orchards. One thing is for sure: risk management is a part of running a nursery.

Added value in marketing

Point of sale material is inevitable to sell a plant in retail. That begins with a product label. But what is a good label? Written in different languages, to please consumers in different countries? Using symbols to show the customer to remove the pot before planting and water it enough?

A Dutch retail expert judged product labels made by nurserymen. According to her a label adds value when it doesn't show useless information, it has to be simple, neat and it's positive when the label, pot, and plant look together like a union.

Another label example is fruit from your garden, grow your own: a picture of red berries and 'Vitamin C' says it all.

When the plant is distinctly different from other taxa, there's a trend in branding. Like the Brazel Berries®, compact growing *Vaccinium* selections bred in Oregon, put on the market by a German nursery. It was the best novelty at the last IPM Essen show (Figure 9).

Figure 9. Brazel Berries®, compact growing *Vaccinium* selections bred in Oregon, put on the market by a German nursery.

A nursery from Austria introduced at the IPM Essen show a new brand of *Ilex crenata*: 'Robustico', which means competition for Dark Green® Japanese holy ('Icoprins11') and 'Blondie' PBR. Customers hardly see a difference between *I. crenata* 'Robustico' and *Buxus*.

Also seen at the IPM Essen show: KiwiBerry, kiwifruit (*Actinidia*) the size of grapes that you can eat in total. A German nursery designed the label with a kids look, to make a difference between a male and a female plant, and to promote this product as a healthy kids snack (Figure 10).

Figure 10. A label with a kids look to make a difference between a male and a female plant.

Some trends seen at the Salon du Vegetal in France: Silence ça pousse! (Be quiet, it's growing!) is the name of a famous French gardening show, big nursery of Minier has got the exclusive rights to use this name on labels of different garden plants.

According to this French trendhunter, the colour yellow is now in fashion. Garden plants who show a contrast with yellow, are best suited for a yellow pot and yellow label. Should the grower paint his hair yellow too?

In the same area as the French show is a big nursery specializing in liners of hydrangea—three million per year. They developed a niche product: a hanging basket with eight rooted cuttings. The result will be a big flowering hydrangea basket.

How can you add value to a retail product when it's sold with bare roots and no leaves? Wrap an attractive package around it as a Dutch nursery introduced at last Plantarium show. The box should be easy to carry and inside the customer finds five roses, enough to plant a rose garden of 1 m^2.

Making gardening simple to customers, that's also the idea behind several hedging plants concepts which are on the market for years now. Like "Ten plants for 2 m of hedging."

Promoting the product outside the nursery can also add value. Years ago big American nurseries designed promotion trailers for their branded shrubs: "Now appearing at a garden centre near you". Those kind of trailers you can see now also on motorways on the continent.

Consumer labels and certification schemes are being used more and more on the continent. They promise customers that the plant is produced, for example, in a responsible way towards the environment and staff, like Fair Flowers Fair Plants.

In France a lot of growers use the national labels Plante Bleue, Label Rouge, and Fleurs de France, because they say French consumers like to buy French made products. But the rules to get a label are not that tight: you can use Fleurs de France when 50% of the production time was in France. Then the liners could be imported from Holland.

Promoting national grown product

You can see this in several EU countries. In the German landscape and along motorways, it's even a law to use German provenances. Trees and plants should be grown in the same area as where the seeds are coming from. This trend of native planting started in

Bavaria, where growers have to be certified by the EAB system: that proves the genetic quality of the plants.

A few years ago the German nursery association set up a national native system with their government, called ZgG. For this, Germany is divided in six provenance areas. When a grower wants to deliver trees in one area, they have to be grown in that same area. But also growers outside that area, even in a different country, are welcome to join the German system. They have to grow along the system standards: started with seeds coming from one particular area. The certification is added value to growers.

That German system for natives is a German legislation. Is that added value when you are obliged to use it, and when you don't, you simply can't supply the market?

Same question you can ask regarding EU legislation of foreign pests and diseases. Passports are required for several nursery products within the EU trade. Will it be more? If you look at what happened over the last 10 to 15 years: organisms that are dangerous to the industry and the green space. Quarantaine organisms such as Asian longhorned beetle and *Xylella fastidiosa*. Quality diseases like *Phytophthora ramorum* and ash dieback.

The phytosanitary service of Lombardy set up a special system to detect early symptoms of the beetle. They made a grid with GPS, where all host plants are located and checked a few times a year. Added value? Could be. Important for nurserymen is also, can you trust a system like that?

Responsible sourcing of growing media in the UK©

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In 2011 the UK government passed an Environment White Paper which included ambitious targets for peat reduction. The targets aimed for no peat in retail growing media by 2020 and none used by professional growers by 2030. The voluntary targets have helped to change the perceptions and actions of the entire industry. Peat use is gradually falling and most importantly, there is now an acceptance that other materials can enhance the performance of plant growth either in conjunction with or as a complete replacement for peat.

A task force was formed in response to the White Paper that included all stakeholders in the industry—manufacturers, growers, retailers, NGOs, and Defra (Department for the Environment, Food and Rural Affairs) and after 5 years of extensive deliberations the Responsible Sourcing Scheme was created. The scheme enables manufacturers and users of growing media to understand and measure how their choice of growing media materials impacts on seven criteria; energy use, water use, social compliance, habitat and biodiversity, pollution, renewability, and resource use efficiency. Sourcing materials responsibly is about making deliberate, educated choices to minimise those impacts but the scheme incorporates a need to constantly revisit and challenge thresholds in order to maintain best practice. The criteria have been defined as being able to differentiate more responsibly sourced from less responsibly sourced materials and it is hoped that it will enable users of the scheme to improve the sustainability of this part of their businesses. The intention has been to make the scheme globally relevant with reference to documents and standards applicable to all countries. Another strength of the scheme is that all growing media materials will be judged and scrutinized equally.

Users of the scheme—normally manufacturers, will be independently audited and will need to provide evidence to support the core that they are claiming. It is hoped that the scheme will be ready for use during 2017. Further information can be found at: https://hta.org.uk/committeesgroups.html

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Technical sessions, Monday morning, 24 October 2016©

L.M. Miller[a]

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The 41st Annual Meeting of the International Plant Propagators' Society-Southern Region of North America convened at 7:30 am at the Westin, Virginia Beach Town Center, Virginia Beach, Virginia with President Laura Miller presiding.

PRESIDENT LAURA M. MILLER

President Miller welcomed everyone to Virginia Beach, Virginia for the 41st Annual Meeting of the International Plant Propagators' Society-Southern Region of North America. She thanked Local Site Committee Co-Chairs, Matt Sawyer and Jim Owen, and their committee and volunteers for the long hours in arranging the excellent tours, hotel, other planning activities and all their attention to detail. She welcomed students, first time attendees and new members, asking them to stand and be recognized. Miller thanked the Executive Committee, and Dave Creech's Sponsorship Committee, which raised $33,500 in cash sponsorships, plus $15,000 in-kind sponsorship - which was outstanding. Miller encouraged the membership to visit and show their support of our sponsors during the meeting. She encouraged all members to make new members and first-time attendees feel welcome—share with them and seek from them. She called for good questions and enthusiastic participation at the Tuesday night question box.

Miller announced that this is the fourth year our region has participated with the European Region (Great Britain & Ireland) in the *Early-Career Propagator Exchange* program between the two regions. She recognized Lance Russell from Great Britain (European Region), who was hosted by Brie Arthur and the SRNA. Leanne Kenealy of the Southern Region of North America was our designee to the European Region. Both of these early-career professionals had an incredible exchange experience in our respective regions. This is the fifth year we are doing the *Vivian Munday Young Horticultural Professional Scholarship Work Program (Vivian Munday Scholarship).* We currently have four young professionals: Judson LeCompte (Mississippi State University), Shea Keene (University of Florida), Crystal Connor (University of Florida), and Debaline Saha (University of Florida) who are making a strong contribution to this year's program. Miller thanked Program Chair and 1st Vice-President, Kevin Gantt, for the excellent program and slate of speakers he assembled.

PROGRAM CHAIR KEVIN

Program Chair Kevin Gantt welcomed all members, guests and students. He thanked the membership for the opportunity to serve them, and then reviewed the scheduled program. The Question Box, scheduled for Tuesday evening, was to be co-chaired by Laura Miller and Kevin Gantt. He then introduced the first moderator, Alex Neubaur.

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Going nuts: continuing a 40-year-old woody ornamental breeding program©

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INTRODUCTION

The Rutgers University Woody Ornamental Breeding Program began in 1960 under the direction of Dr. Elwin Orton. He was initially charged to develop a holly (*Ilex* species) breeding program with the ambitious goal of crossing *I. opaca*, our native eastern holly, with the English holly, *I. aquifolium*. The main premise was to develop an improved plant for the holiday cut branch market that expressed the excellent glossy foliage and berry display found on the English holly combined with the cold hardiness and wide adaptation of the American species. Dr. Orton, a scientist trained in classical corn genetics at the University of Wisconsin, accepted this responsibility and put in a tremendous effort to achieve this goal. Unfortunately, however, after over a decade of tedious work, Dr. Orton abandoned the *I. opaca* × *I. aquifolium* project, largely due to genetic incompatibilities between the two species. Fortunately, during this time he also did selection and breeding work within *I. opaca* alone, which yielded several cultivar releases. These include *I. opaca* 'Jersey Princess', 'Jersey Knight', 'Dan Fenton', Jersey Delight', and most recently 'Portia Orton'. All are female except 'Jersey Knight', and several have become well known in the nursery and landscape trade especially noted for their excellent dark green, glossy foliage. Besides *I. opaca*, Dr. Orton also worked with Japanese holly. *Ilex crenata* 'Beehive' was his best known release—a plant selected from more than 21,000 seedlings derived from crossing *I. crenata* 'Convexa' × *I. crenata* 'Stokes'. 'Beehive' was selected for its mite resistance, cold hardiness, and compact form. In addition, he also released several dwarf forms of the species—'Green Dragon' and 'Dwarf Pagoda' were the most widely known (Galle, 1997).

HYBRID HOLLIES

In the late 1960s, Dr. Orton began a program of interspecific hybridization among a number of different *Ilex* species to generate novel cultivars. One approach was the crossing of *I. verticillata* (winterberry holly) with *I. serrata* (Japanese winterberry) at a time when the deciduous hollies were not as widely used in the landscape. With this cross, he hoped to reduce the vigor of *I. verticillata* and, conversely, to increase the size of the more diminutive *I. serrata*—while improving fall leaf color, berry color and number, and the persistence of the berries into the winter. This goal was achieved with the release of *Ilex* 'Harvest Red' and 'Autumn Glow', as well as a companion hybrid male pollinizer named 'Raritan Chief'. These three cultivars are still commercially available today.

Another noteworthy interspecific hybrid released by Dr. Orton was *I.* 'Rock Garden', an extreme dwarf plant of unique form with attractive foliage and large red fruit. It resulted from a cross of a seedling of *I. aquifolium* × *I. pernyi* with a seedling of *I. integra* × *I. pernyi*. 'Rock Garden', released in 1984, is considered to be the first dwarf-statured plant with a "holly-type" leaf introduced to commerce (Galle, 1997). Another more recent hybrid plant worthy of mention is *I.* × 'Rutzan' Red Beauty® holly ([*I. rugosa* × *I. aquifolium*] × *I. pernyi*), which was released in 2003. It has small, dark-green, spiny leaves similar to the Meserve hollies (*I.* × *meserveae*), but is single stemmed rather than shrub-like, requiring very little pruning. Plus, it bears heavy crops of large, red fruit—and has proven resistant to deer browse in tests across many regions.

A final plant to mention is *I.* × 'Winter Bounty', which is an *I. ciliospinosa* × *I. latifolia* hybrid with very unique plant form, long spineless leaves, and extremely heavy berry display

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(Figure 1). To date, this novel, publically-released plant has not yet found its place in the landscape—hindered somewhat by its palatability to deer. Hopefully, its unique beauty will encourage the industry to examine it in the future (Figure 1). A much more complete description of the various *Ilex* cultivars released from Rutgers can be found in Molnar and Capik (2013) and Galle (1997).

Figure 1. *Ilex* ‘Winter Bounty’ holly. Public release from Rutgers University.

While no additional *Ilex* crosses are being made at this time, we have preserved a core collection of genetic resources that were assembled and developed over more than four decades. We have narrowed the collection to less than 400 accessions and will continue to examine them to identify individuals that may show merit for release or breeding in the future.

HYBRID DOGWOODS

Besides hollies, Dr. Orton was well-known for his work with hybrid dogwoods (*Cornus* spp.). While he released several pure *C. florida* cultivars (‘Rutman’, Wonder Berry® flowering dogwood; ‘Rutnam’, Red Beauty® flowering dogwood; and ‘D-383-22’, Red Pygmy® flowering dogwood), he is credited with being the first person to hybridize *C. florida* and *C. kousa* (*C.* × *rutgersensis*). From his work started in the 1970s, Dr. Orton released a series of excellent F_1 hybrid plants in the early 1990s; the most popular was ‘Rutgan’, Stellar Pink® dogwood, a vigorous, upright plant with light-pink floral bracts. Other F_1 introductions from this time period include ‘Rutban’, Aurora® dogwood; ‘Rutcan’, Constellation® dogwood; ‘Rutlan’, Ruth Ellen® dogwood; ‘Rutdan’, Celestial® dogwood; and ‘Rutfan’, Stardust® dogwood, all of which have white floral bracts but vary in the shape of the bracts and their growth habits. 'KF1-1’, Saturn™ dogwood, while from crosses made during the same time as the original set of releases, was not introduced until 2007. To many of us who have seen the original tree in bloom, it may be the best of all the F_1 hybrids.

In 2011, ‘KF111-1’, Hyperion® dogwood, an extremely vigorous and showy backcross to *C. kousa*, was released, which is slowly becoming known in the nursery trade. Over this time period, Dr. Orton also worked with *C. nuttallii*, the Pacific Coast dogwood, and released the hybrids ‘KN4-43’, Starlight® (*C. kousa* × *C. nuttallii* F_1); ‘KN30-8’, Venus® dogwood (a backcross to *C. kousa* known for its giant white bracts), and Rosy Teacups® dogwood PP 26211 (an advanced generation hybrid with medium-pink colored bracts *C. kousa* × *C. nutallii*). When comparing these plants to the Stellar® hybrids derived from *C. florida*, an increase in bract size, striking white bract colors, excellent dark green leaf color, and resistance to leaf curling during drought appear to be some of the strongest contribution of the *C. nuttallii* parents. See Orton (1985, 1993), Orton and Molnar (2005), and Molnar and

Capik (2013) for additional details on the Rutgers dogwood releases.

TAKING THE REINS: IT'S TIME TO GO NUTS!

I officially became responsible for the ornamental breeding program in 2008; however, in 2006 I began working closely with Dr. Orton to prepare for the likely transition. I examined the existing program in detail and tried to find a place where I could make a valuable contribution to the breeding of dogwoods in a program that has been ongoing for decades and already very successful.

Does the world really need a new white-bracted hybrid dogwood?

The breeding objective that stood out was the development of novel kousa and hybrid dogwoods with dark pink (and possibly red) bracts similar in color to those found on *C. florida* 'Cherokee Brave', 'Red Pygmy', or forma *rubra*. Dr. Orton had been working on this goal since the very beginning of the dogwood program in the 1970s (Orton, 1985; Orton pers. commun.)—yet he was not satisfied. The challenge (or problem) presented to me was how to realistically build on his previous efforts. Dr. Orton had performed thousands of hand crosses over several decades with many different combinations of pink kousa and hybrid dogwoods—and was not able to reach a bract color level substantially better than with *C. kousa* 'Satomi' or 'Rosabella'. He was able to get more consistent color expression and increased numbers of flower heads, but not the depth of dark pink color necessary to claim it as a "true" pink bracted kousa. Note: in New Jersey 'Satomi' tends to only be pale to light pink in most years. Many of the pink plants he selected from his crosses over the years seemed to have reduced vigor and poor growth habits. Thus, when taking over the program I did not know exactly where to begin in terms of which plants to cross or what new germplasm to acquire.

I decided to take a more haphazard approach. Since dogwoods are self-incompatible, we could generate tons of diversity and variation to select upon by growing out large open-pollinated (OP) populations. Dr. Orton had assembled an excellent germplasm collection for me to work with that included his best selections with pink floral bracts and, most notably, a number of rare fertile interspecific hybrid offspring (most are sterile). Over the decades, he created one of the world's most unique big-bracted dogwood crossing blocks with contributions from *C. florida*, *C. kousa*, and *C. nuttallii* (albeit in a variety of genetic combinations).

To start the next chapter in the Rutgers dogwood breeding program, my research technician John Capik and I systematically collected OP seed off of almost every plant in the collection and grew out large seedling populations (over 3,000 trees). We had no grand expectations on what we would find, but knew that we would see a lot of segregation of traits and maybe could get lucky with a unique combination of genes. Regardless, I knew that the process would teach us a lot about dogwoods and dogwood selection as we raised them and watched them grow to maturity.

By 2010, many of the trees from the first seed collection effort began to flower. There were lots of very beautiful white-bracted dogwoods, including hybrids and pure kousa types (hard to determine exactly what they are since pollen parents are unknown), and many light pink-bracted plants similar to what Dr. Orton had selected in the past. These trees promptly got cut down. What we didn't expect is that we would also recover some excellent, never-before-seen, dark pink bracted forms including a variety of shapes, sizes, and shades of pink color (Figure 2). In addition, numerous trees had good health and vigor, breaking through what Dr. Orton would have claimed was linkage or genetic drag (or inbreeding depression) associated with breeding with genes for pink color in dogwoods coming from a narrow genetic base. The most surprising finding was that many of the darkest pink seedlings came from mother plants that were only blush pink in color (or white in hot years). These are plants that we would have never purposely used in hand crosses to develop dark pink offspring, which may partly explain why Dr. Orton never recovered a dark-pink type earlier on when the germplasm to do so clearly existed in his collection. We are now studying the inheritance of this new dark pink color to better explain what we are seeing.

Figure 2. Range of colors and shapes of new seedlings expressing pink floral bract at Rutgers University in 2010. Insert on bottom right shows extreme range from very light pink blush to deep pink. Insert on bottom left shows size range and color variation.

Sometimes you just get lucky!

Over subsequent years of flowering, while we were impressed with the first 2 years' worth of seedlings and thought that we might have some potential dark-pink releases in those populations, it wasn't until some of the trees planted in 2009 flowered that we knew we had something special. One tree stood out immediately; it flowered heavy for the first time at only 4 years from seed (Figure 3). This was in contrast to most seedlings planted in the field that year that flowered at 5 years or later. In addition to flowering early, the tree had the darkest pink colored bracts (almost fuchsia) that we had ever seen (Figure 4). They glowed bright pink at a distance like no dogwood tree Dr. Orton nor we had seen before (Figure 5). I immediately thought it must be too good to be true; we kept quiet and waited for next year to see how it would perform.

Figure 3. Dogwood seedling field at Rutgers University in 2012. While most trees have few or no flower heads, one tree had many and its floral bracts were the darkest pink we had ever observed.

Figure 4. *Cornus kousa* 'Rutpink', Scarlet Fire® dogwood floral bracts at peak color.

Figure 5. The best attribute of 'Rutpink', Scarlet Fire® dogwood may be that it glows pink at a distance on a sunny day.

In 2013, the color was excellent again and with more flower heads on the 1-year-older tree, it was even more striking! We decided to propagate it that year to back it up and start to develop a stock block if needed. In 2014, the color was astounding again. At that time we started to consider releasing the plant and sent bud wood to a few nurseries to test its propagation attributes and build-up numbers. In 2015, the tree had great color again and by now the first propagated plants also bloomed dark pink. This is when we decided, despite the tree's relatively young age, to file for a patent (US PP28311 P3) and also share information with the nursery industry on its existence.

After several years of quiet deliberation, we decided to name the tree *C. kousa* 'Rutpink' Scarlet Fire® dogwood, in honor of the Rutgers University mascot the Scarlet Knight® and to also reflect the bright, fire-like glow of the plant in the landscape on a sunny day. To date, plants have been distributed to more than 20 test locations around the country. They are being propagated by five licensed nurseries. Wholesale and limited retail sale started in 2016, with many more expected in 2017. So far, the trees are doing very well in liner production in Tennessee and Oregon. They are vigorous, free from disease, and form well-branched propagules. Only time will tell how successful the plant will be, as it is still in the very early stages of wider testing, utilization, and sale. We are excited about its potential as well as using it and its siblings in breeding.

We continue to use the wide germplasm base developed by Dr. Orton to focus on developing highly novel dogwoods that are attractive, healthy, and well-adapted and can be clearly differentiated from Scarlet Fire® dogwood and other exiting dogwoods in the market place. This would include developing plants with very large bracts, different bract shapes and colors, and interesting growth habits (upright, weeping, and mounding). We are also working with pure *C. florida* where we have identified a new source of powdery mildew resistance, and are currently moving the resistance genes into plants with excellent bract displays and a range of white to pink and red colors.

HAZELNUTS

Hazelnut production and resistance to eastern filbert blight

Before I was hired to run the ornamental breeding project in 2008, I had been working since 1996 on a nut tree research and breeding project at Rutgers. This was started by my mentor and world-renowned turfgrass breeder, Dr. C. Reed Funk. After a few years of examining the potential of many different temperate nut trees species, we decided to focus almost solely on hazelnuts (*Corylus* spp.). World production of hazelnuts is based on the European species *Corylus avellana*. Around 70% of world production comes from the Black Sea region in Turkey—and 15 and 5%, respectively, from Italy and the USA—primarily in the Oregon Willamette Valley. Other places of production include Spain, Chile, Azerbaijan, the Republic of Georgia, France, and China.

While production has been attempted in the eastern USA since colonial times, the disease eastern filbert blight (EFB) has made it largely impossible (Molnar et al., 2005). Eastern filbert blight is caused by the fungus *Anisogramma anomala*, which is endemic to a wide area east of the Rocky Mountains where it is associated with our native hazelnut *C. americana*. While EFB causes severe stem cankers and subsequent plant death of the European species, our native hazelnut is resistant or very tolerant. Small cankers can be found infrequently and rarely cause stem death. Unfortunately, however, our native hazelnut has very tiny, thick-shelled nuts and other attributes making it unsuitable for commercial production.

Fortunately, over the past two decades a lot of progress has been made identifying *C. avellana* plants that are resistant to EFB. At Rutgers, in close collaboration with Oregon State University, we made a number of seed-based germplasm collections of *C. avellana* across its native range in Europe and the Caucuses, grew many thousands of trees, and exposed them to the fungus. While most trees died, about 2% of the plants were found to be resistant and early tests are showing this resistance to be highly heritable. When combining these new plants with the work already ongoing in Oregon, we collectively have access to resistant parent plants from Spain, Turkey, Italy, Russia, Crimea, Georgia, Estonia, Latvia, Moldova, Chile, Poland, and Serbia (Capik et al., 2013; Colburn et al., 2015; Muehlbauer et al., 2014; Leadbetter et al., 2016). With our native *C. americana*, which hybridizes readily with the European hazelnut and produces fully fertile offspring, we have a very substantial pool of genetic resources to use in breeding for nut producing cultivars, pollenizers, and for ornamental landscape plants. Based on our substantial progress so far and huge market demand for the nut—the future of hazelnut production in the eastern USA looks very bright.

Ornamental hazelnuts

With many EFB-resistance genes available and the ability to hybridize between different species in the genus, it is now possible to focus efforts onto a wide array of ornamental types. Within *Corylus* there exists purple leaf types, yellow leaf types, contorted stems, highly dissected "cut leaf" types (*C. avellana*), bright red and pink fall colors, small multi-stemmed shrubs (*C. americana*) to stately single trunk trees (*C. colurna* and *C. chinensis*), and peeling bark (*C. fargesii*) (Capik and Molnar, 2010). Our most exciting progress to date has been on backcrossing the purple leaf gene from *C. avellana* 'Rote Zeller' into our native *C. americana*, which is very cold hardy, EFB-resistant, has a compact, attractive growth form, and good fall color. Early on, we identified a chance hybrid seedling (*C. americana × C. avellana*) with purple leaves (likely an OP hybrid seedling crossed with *C. avellana* 'Rote Zeller', a widely grown sources of purple leaf color). In 2004, we crossed it with a "hybrid" seedling purchased from a nursery in Minnesota that looked very much like pure *C. americana*. We grew out the offspring and were impressed by their growth habits and color displays, with some expressing a more persistent dark purple leaf color and even nice fall color in some years. Unfortunately, at 5 years old all of the trees from this generation started to develop EFB.

We then decided to widen the gene pool and cross one more generation back to pure *C. americana*. We assembled a collection of clonal *C. americana* from the USDA NPGS repository in Corvallis, Oregon, representing select, improved plants from many regions across the native range. In total, we chose 14 parent trees to use in crosses representing 10 different states of origin. We collected pollen from the best five purple hybrid trees from the first generation of crosses, bulked the pollen, and used it as a common pollen "parent" on the 14 different *C. americana* selections. From this we harvested about 2,000 seed, germinated the seed keeping only the purple leaf seedlings (50% had green leaves) and planted them in the field for evaluation in 2010 (about 600 trees).

We exposed them to EFB by tying diseased sticks into the canopy of the trees and through natural spread from nearby heavily infected plots. By 2015, half of the trees were removed due to EFB or poor purple color retention of the leaves into the summer. However, we had a surprise this year! They flowered and set nuts for the first time and we recovered some of the most colorful nut husks (involucres) on a diversity of plants (Figures 5-7). We never expected we could get such bright, showy colors.

Figure 6. Diversity of husk types and striking red color found in *Corylus americana* backcross hybrids at Rutgers, and, at center, the color of leaves in late June in New Jersey.

Figure 7. Branch of *Corylus* showing display of red-color husks later in summer that can contrast well against the green leaves.

Now the job becomes identifying the best plants out of this population of very novel trees. In 2016, we selected the top 10 based on color retention and husk display; these were further selected to the best 2-3 that merit further testing and release. Propagation and testing are currently underway with the hopes for a release in 2018 or 2019, depending on performance across a range of locations and ease of propagation. These trees also produce tasty, edible nuts! Thus, these true edible ornamental plants may add some diversity to the palate of species available in the landscape—while potentially adding to the palate of homeowners as well!

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Changes in the physical, chemical, and hydrologic properties of pine bark over twelve months of aging©[a]

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INTRODUCTION

Pine bark is one of the most commonly used organic horticultural substrate components in the southeastern USA, but it can also be one of the most variable. It may be used fresh, aged, or composted, and aging and composting times may vary between suppliers or even for the same supplier at different times of the year (Jackson, 2014). Aging refers to the stockpiling and weathering of bark in windrows prior to its use, with no fertilizer additions or pH adjustments, and no attempt to control the moisture content (Pokorny, 1979). While aging is most commonly used in the southeastern USA, interest in fresh pine bark has increased because of its lighter weight, which reduces transportation costs (Fields et al., 2012).

In addition to variability within pine bark substrates, variability exists within the literature on these substrates as well, with discrepancies in the findings from the few studies that have investigated differences in pine bark age. Self and Pounders (1974) have shown that many plants can be grown in fresh pine bark, however Laiche (1974) reported reduced plant quality due to difficulty maintaining adequate moisture levels during the first 3 months after transplanting. Fresh pine bark has been shown to have higher air space (AS), lower container capacity (CC), and lower available water content when compared to aged bark, which could require changes in irrigation management (Bilderback et al., 2005).

The duration of aging, pre-processing conditions, and manufacturing methods can alter the physical properties of pine bark substrates (Bilderback et al., 2005), and aged bark should theoretically hold more water due to an increase in the percentage of fines (Jackson, 2014), increased uniformity of particle sizes, and decreased hydrophobicity due to the decomposition of wood and cambium (Bilderback, 2002).

Although there are no universally accepted standards for the physical properties of horticultural substrates, the Southern Nursery Association (SNA) provides suggested ranges for the best management practices (BMP) of horticultural substrates for nursery production. These ranges are 50-85% for total porosity (TP), 10-30% for AS, 45-65% for CC, and 0.19-0.70 g cm^{-3} for bulk density (BD) (Bilderback et al., 2013). If substrates are within these ranges, irrigation and nutrient programs may be managed more efficiently (Bilderback et al., 2005). Hydration efficiency (HE), defined as the ability of a material to capture and retain water in the fewest number of water applications (Fields et al., 2014), is also an important property of a horticultural substrate in terms of water management. It has been reported that fresh pine bark may be difficult to hydrate (Pokorny, 1979).

MATERIALS AND METHODS

Pine bark acquisition and sample preparation

To investigate the changes in physical, chemical, and hydrologic properties of pine bark at different ages, a long term, commercial-scale study was implemented at TH Blue, Inc., a pine bark supplier in Eagle Springs, North Carolina (NC) on 20 August 2015. Fresh longleaf pine bark (*Pinus palustris* L.; Jordan Lumber Company, Mt. Gilead, NC and Troy Lumber Company, Troy, NC) was hammermilled and screened through a 5/8 in. screen on site, and the fines were then placed in three piles (replications) of 191 m^3 (250 yd^3) each (Figure 1), approximately 17×10.1×3.2 m (55×33×10.5 ft). Beginning at time zero and every 4 weeks

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for a period of 12 months, the piles were turned, and 1 week after turning stratified subsamples were taken from three different heights (top, middle, and bottom) at depths of 1-4 ft to account for variations in pile depth and height. The stratified subsamples were mixed into one composite sample for each pile replication and tested for physical, chemical, and hydrologic properties. Results from samples taken at 0, 3, 6, 9, and 12 months of aging are presented here.

Figure 1. The long term, commercial scale pine bark aging study located at T.H. Blue, Inc., Eagle Springs, North Carolina. Pine bark fines (5/8 in.) were placed in three pile replications and aged for 12 months.

Physical properties

Physical properties (CC, AS, TP, and BD) were determined using the NCSU Porometer procedure (Fonteno and Harden, 2010). Three replications from each pile were measured, equaling nine replications per age. Data were subjected to Tukey's Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, NC, USA).

Chemical properties

Electrical conductivity (EC) and pH were measured with a pH/EC meter (HI 9811, Hanna Instruments, Ann Arbor, Michigan) using the 1:1 dilution method. Three replications from each pile were measured within 2 days after sampling, equaling nine replications per age. One hundred mL of sample material was mixed with 100 mL deionized water, stirred, and allowed to equilibrate for 15 min. before measuring. Data were subjected to Tukey's Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, NC, USA).

Hydrologic properties

Hydration efficiency (HE) of the pine bark samples was determined by measuring the water retention of 10 consecutive hydration events as described by Fields et al. (2014). Four replications from each pile were measured, equaling 12 replications per age. Samples were dried down from 60% moisture by weight (moisture content at sampling) to 50%. The moisture contents of the hydration events were measured by volume in order to make comparisons to CC, which is a volumetric measurement. For comparison purposes across each age, HE values were assigned. The HE value is the number of hydration events required to bring the sample to CC. For example, if CC was reached at the first hydration event, a HE value of 1 would be achieved. Container capacity data were subjected to Tukey's Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

Over the course of 12 months of aging, CC and BD increased while AS decreased, and values for TP, although different for different ages, showed minimal changes over time

(Figures 2 and 3). The changes in CC, AS, and BD while TP remained consistent is likely due to an increase in the percentage of fines as the bark decomposed (data not shown), resulting in a shift to smaller pore sizes in the same total pore volume. Container capacity increased from 36% at month zero to 51% at month 12 (Figure 2), with months zero and three falling below the BMP guidelines and having lower values than months 6, 9, and 12. Air space decreased over time, from 43% at month zero to 32% at month 12. Air space values for all ages were higher than the BMP guidelines. Bark aged nine and 12 months had BD values that fell within the lower limit of the suggested BMP range of 0.19 to 0.70 g cm^{-3}.

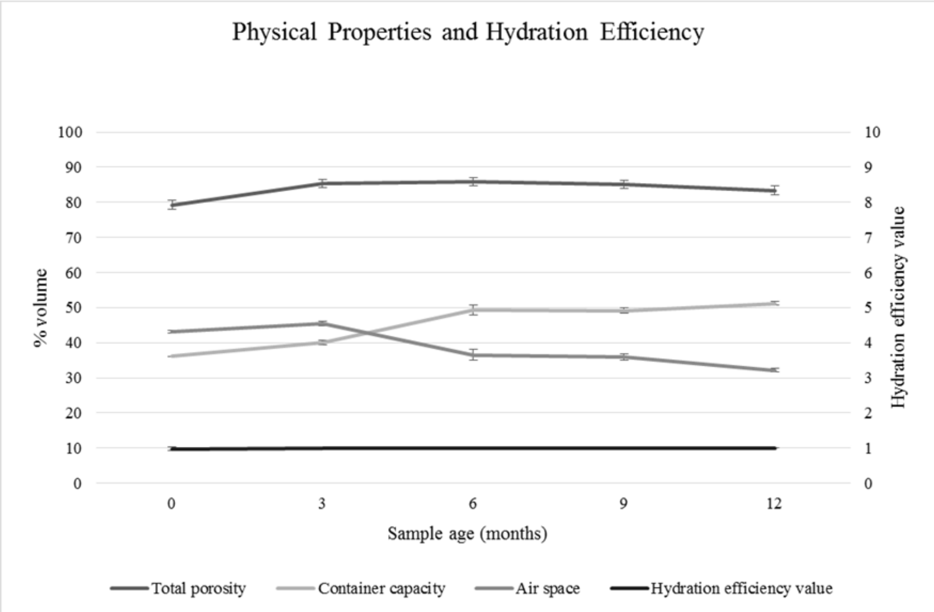

Figure 2. Changes in physical properties (total porosity, container capacity, and air space) and hydration efficiency values for pine bark sampled at five different ages (0, 3, 6, 9, and 12 months).

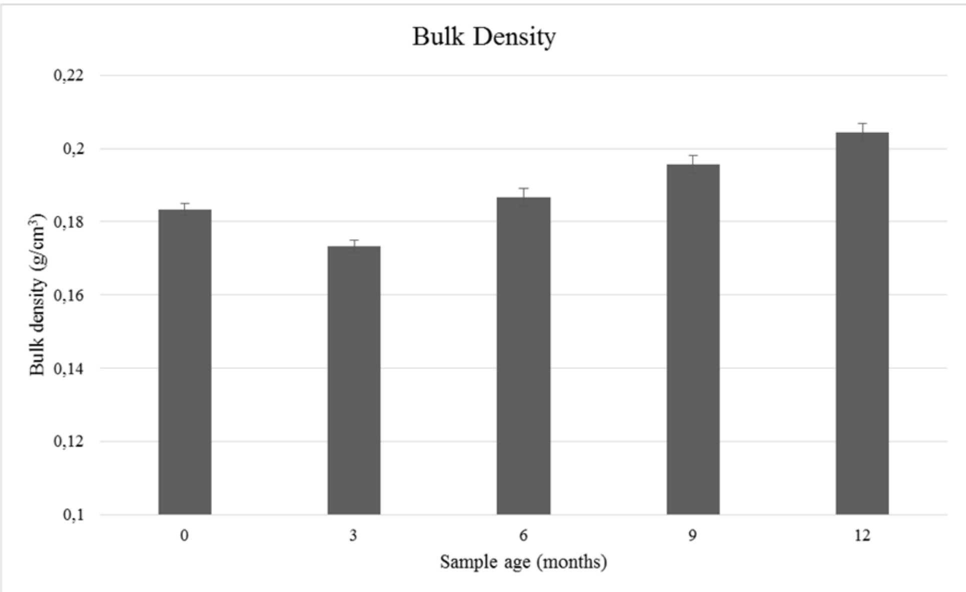

Figure 3. Bulk density of pine bark sampled at five different ages (0, 3, 6, 9, and 12 months) determined using the NCSU porometer method.

The pH increased over the course of 12 months from 4.2 to 4.5, which is within the range of 4.1-5.0 described by Pokorny (1979). Electrical conductivity decreased from 0.06 to 0.03 (Figure 3). An increase in pH with a decrease in EC over time is indicative of aerobic activity, which is to be expected in a normal pine bark processing operation. Although the changes in pH were different over the five different ages, the rise was not substantial, which agrees with Pokorny's findings. Lemaire et al. (1998) also reported an increase in pH over the course of 6 months for pine bark compost, although it was unclear if the pine bark was truly composted instead of aged.

Despite the differences in the physical properties between the different ages of bark, HE values were within .97 to 1.00, which means that the CC of the material at 50% gravimetric moisture content was reached within one hydration event for all ages (Figures 2 and 4). Months 0, 3, and 6 had lower values for container capacity than months 9 and 12; however, all CC values were within 40-46% (Figure 5).

The results from this study show that pine bark fines aged from 6 to 12 months have physical properties closest to the SNA BMP guidelines, but fresh pine bark had equivalent HE values as aged bark at 50% moisture content. This suggests that wetting fresh pine bark may not be an issue under normal production conditions; however, other factors such as AS and CC need to be taken into consideration in terms of irrigation management when using fresh bark. This study also illustrates the importance of frequently checking bark supplies and establishing a good relationship with the bark supplier in order to ensure product consistency.

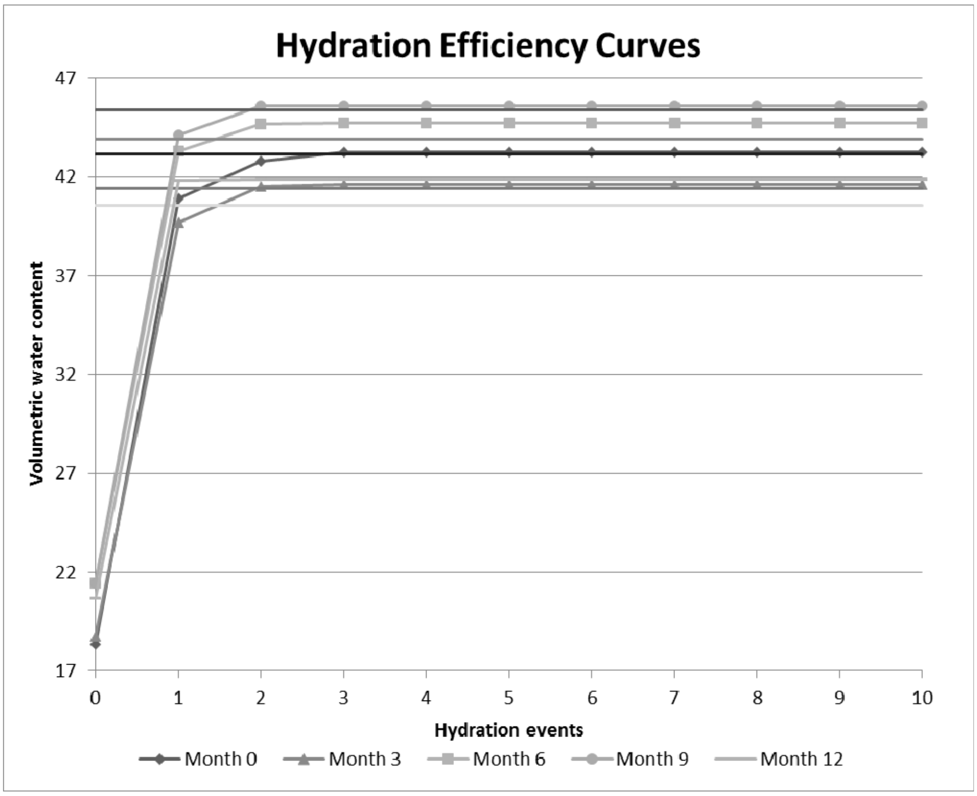

Figure 4. Hydration efficiency curves for pine bark sampled at five different ages (0, 3, 6, 9, and 12 months) at 50% gravimetric moisture content, with container capacity for each age represented as solid lines of the same color. Means separations are shown for container capacity at each age.

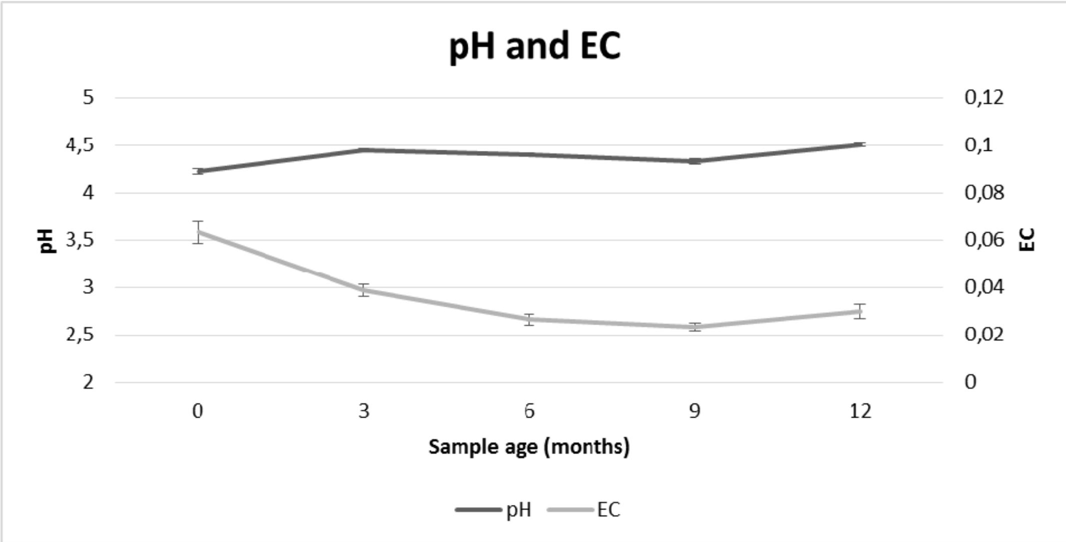

Figure 5. pH and EC of pine bark sampled at five different ages (0, 3, 6, 9, and 12 months).

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Impacts of preemergence herbicide formulation on cost and weed control efficacy for container nursery crop producers©[a]

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Abstract

This research was conducted to study the impacts of herbicide formulation on the cost and efficacy of common preemergence herbicides. Granular and spray-applied formulations of flumioxazin, indaziflam, pendimethalin + dimethanamid-P, and prodiamine were evaluated for control of four weed species including dove weed (*Murdannia nudiflora*), crabgrass (*Digitaria sanguinalis*), eclipta (*Eclipta prostrata*), and spotted spurge [*Euphorbia maculata* (syn. *Chamaesyce maculate*)].

INTRODUCTION

Research has shown nursery growers often spend up to $4000/acre on hand weeding in containers (Mathers, 2003). In terms of "over-the-top" applications, only certain annual grasses can be controlled selectively (Derr, 1993; Senesac and Neal, 1992), necessitating the need for preemergence herbicides (Derr, 1994).

Preemergence herbicides are available as either granular or spray-applied formulations (dry flowables, liquids, emulsifiable concentrates, etc.). There are advantages and disadvantages associated with each formulation in terms of application, applicator skill needed, and cost. Briefly, spray-applied formulations are more economical, can be applied to wet foliage, can be applied more uniformly, and have been shown to provide superior weed control in certain instances (Bartley et al., 2014). Granular formulations require no special equipment in order to apply, can be applied in areas inaccessible by booms or large sprayers (i.e., shade houses), and more active ingredients are available in granular formulations for over-the-top applications. The objective of this trial was to compare efficacy of four preemergence herbicide active ingredients for control of common summer annual nursery weed species and to determine which species would be most problematic depending upon active ingredient. Average chemical cost savings growers could achieve by selecting spray-applied or granular formulations was also calculated by collecting price data from multiple sources.

MATERIALS AND METHODS

This research was conducted at the Mid-Florida Research and Education Center in Apopka, Florida and at the Gulf Coast Research and Education Center in Wimauma, Florida in 2016 using similar methodology. Nursery containers (1.3 gal, 10 in. diameter, 6 in. depth) were filled with substrate comprised of equal parts pine bark and peat (50:50, v/v) plus standard fertilizer and amendments. After pots were filled, equal amounts of doveweed (*Murdannia nudiflora*), crabgrass (*Digitaria sanguinalis*), and eclipta (*Elipta prostrata*) (in Apopka) or equal amounts of crabgrass, eclipta, and thickhead (*Crassocephalum crepidiodes*) (Wimauma) were hand sown to the surface of each container, ensuring that all seeds were evenly distributed across the container surface. Granular or liquid formulations of flumioxazin, indaziflam, dimethenamid-P + pendimethalin, or prodiamine were applied on 13 and 21 April in Wimauma and Apopka, respectively. Spray-applied formulations were

[a]Second Place – Graduate Student Research Paper Competition

applied using a CO_2 backpack sprayer calibrated to deliver 20 gal. per acre using an 8004 flat fan nozzle (TeeJet Technologies, Glendale Heights, Illinois, USA) at a pressure of 30 psi while granular formulations were applied to each pot separately using a hand-shaker. All pots were irrigated using over-head sprinklers and received 0.5 in. total per day via two separate irrigation cycles. The experiment was designed as a completely randomized design with six single pot replications per treatment at each location. Data collected included weekly counts of each weed species for 12 weeks. At approximately 12 weeks after treatment (WAT), all weeds were cut at the soil line and shoot fresh weights were determined individually for each species. All data were subjected to ANOVA using the PROC GLM statement in SAS (SAS 9.4, SAS Institute, Inc., Cary, North Carolina, USA). Fisher's Least Significance Difference Test was used to separate out the means and all differences considered significant at $p \leq 0.05$. Significant differences observed in weekly weed counts were reflected in fresh weight data; therefore, for the sake of brevity only fresh weight data will be discussed.

RESULTS

Formulation comparisons

1. Crabgrass.

Fresh weights showed prodiamine, pendimethalin + dimethenamid-P, and indaziflam provided similar control of crabgrass and there were no differences observed between formulations (Table 1). Of herbicide treated pots, the highest fresh weights were recorded in pots treated with flumioxazin, but no differences were observed in formulation. In Wimauma, no differences were observed in any herbicide treatment (or formulation).

2. Eclipta.

In Apopka, there was no difference in eclipta fresh weights between formulations of flumioxazin, indaziflam, or prodiamine; however, pots treated with the granular formulation of pendimethalin + dimethenamid-P contained significantly higher fresh weights (35.4 g) than pots treated with the spray-applied formulation (5.0 g). Treatments of pendimethalin + dimethenamid-P (EC), indaziflam (both formulations), and flumioxazin (both formulations) resulted in lower fresh weights than pots treated with prodiamine (either formulation). In Wimauma, the spray-applied formulation of flumioxazin provided better control of eclipta when compared to the granular formulation while the reverse was true for prodiamine.

3. Doveweed.

In terms of formulation comparison, the only difference observed was that pots treated with the granular formulation of indaziflam had lower fresh weights when compared to pots treated with the spray-applied formulation of indaziflam. No other differences in formulation were observed between any of the herbicides. Flumioxazin (both formulations), indaziflam (G), and pendimethalin + dimethenamid-P (both formulations) provided significantly greater doveweed control compared to prodiamine.

4. Thickhead.

No differences were observed in formulations of any herbicide with the exception of prodiamine in which application of the granular formulation resulted in lower fresh weights than the spray-applied formulation.

Table 1. Efficacy of granular and spray-applied herbicides for preemergence control of selected weed species.

Herbicide	Formulation[1]	Rate (lbs ai/A)[2]	Example cost/A[3] ($)	Weed shoot fresh weight (g)			
				Crabgrass	Eclipta	Doveweed	Total fresh wt (g)
				Apopka			
Flumioxazin	G	0.37	300	136.3 bA[4]	14.2 bcB	0.8 cC	151.3 ab
Flumioxazin	DF	0.37	106	119.2 bA	16.0 bcB	0.0 cC	135.2 b
Indaziflam	G	0.04	385	26.0 cA	0.0 cB	11.2 cA	37.2 c
Indaziflam	SC	0.04	200	0.0 cB	0.0 cB	32.1 bA	32.1 c
Pendimethalin + dimethanamid-P	G	2 + 1.5	365	1.7 cB	35.4 bA	0.1 cB	37.2 c
Pendimethalin + dimethanamid-P	EC	2 + 1.5	112	0.0 cB	5.0 cA	0.0 cB	5.0 c
Prodiamine	G	1.5	440	1.7 cC	88.1 aA	51.4 aB	141.8 b
Prodiamine	L	1.5	60	0.4 cC	99.7 aA	42.4 abB	142.5 b
Control	-	-	-	174.7 aA	6.2 cB	4.9 cB	186.2 a
LSD 0.05	-	-	-	36.4	24.8	15.2	35.6
				Wimauma			
				Crabgrass	Eclipta	Thickhead	Total fresh wt (g)
Flumioxazin	G	0.37	300	0.1 bA	1.2 abA	1.1 bcA	2.4 bc
Flumioxazin	DF	0.37	106	0.0 bA	0.1 cA	0.0 cA	0.1 d
Indaziflam	G	0.04	385	0.2 bB	0.9 abcAB	1.0 bcA	2.1 bc
Indaziflam	SC	0.04	205	0.0 bA	0.0 cA	0.0 cA	0.0 d
Pendimethalin + dimethanamid-P	G	2 + 1.5	365	0.0 bA	0.8 abcA	0.2 cA	1.0 cd
Pendimethalin + dimethanamid-P	EC	2 + 1.5	112	0.0 bA	0.0 cA	0.0 cA	0.0 d
Prodiamine	G	1.5	440	0.0 bB	1.3 abA	2.0 bA	3.3 ab
Prodiamine	L	1.5	60	0.0 bB	0.3 bcB	3.2 aA	3.5 ab
Control	-	-	-	1.4 aA	1.5 aA	1.7 bA	4.6 a
LSD 0.05	-	-	-	0.8	1.0	1.2	1.6

[1]G = granular; DF = dry flowables; SC = suspension concentration; EC = emulsifiable concentrates; L = liquid.

[2]Rate (lbs ai/A) = pounds of active ingredient per acre.

[3]Example cost was derived by calculating average price of leading brand names sold by multiple distributors and calculated on a cost per acre basis using the highest recommended label rate of each product. Prices will vary considerably based upon distributor, brand name or generic, location, shipping, tax rates, and quantity purchased. Price information is included for educational purposes only and should not be considered an advertised price by any entity.

[4]Means within each column followed by the same lower-case letter and means within each row followed by the same upper-case letter are not significantly different based upon Fisher's Protected LSD test (P=<0.05).

No significant differences were observed when comparing spray-applied and granular formulations of the same active ingredients in Apopka. Of herbicide treated pots, pots treated with flumioxazin and prodiamine had greater total fresh weights compared with pots treated with indaziflam or pendimethalin + dimethenamid-P. In Wimauma, pots treated with spray-applied formulations of flumioxazin and indaziflam had lower fresh weights compared with pots treated with granular formulations of the same active ingredient. Of all herbicide treatments, lowest total fresh weights were recorded in pots treated with spray applied formulations of flumioxazin, indaziflam, and both formulations of pendimethalin + dimethenamid-P.

Weed prevalence by active ingredient

1. Apopka.

For pots treated with flumioxazin, crabgrass was the most prevalent weed species, followed by eclipta and doveweed. Indaziflam provided very effective control of eclipta (0.0 g fresh weight) and the predominate weed species in pots treated with indaziflam was crabgrass and doveweed for the granular formulation; doveweed was the only species in the spray-applied formulation as all crabgrass and eclipta were completely controlled (Table 1; Figure 1). Eclipta was the predominate weed in pots that were treated with pendimethalin + dimethenamid-P. Similarly, for pots treated with prodiamine, eclipta was the predominate species followed by doveweed and lastly crabgrass.

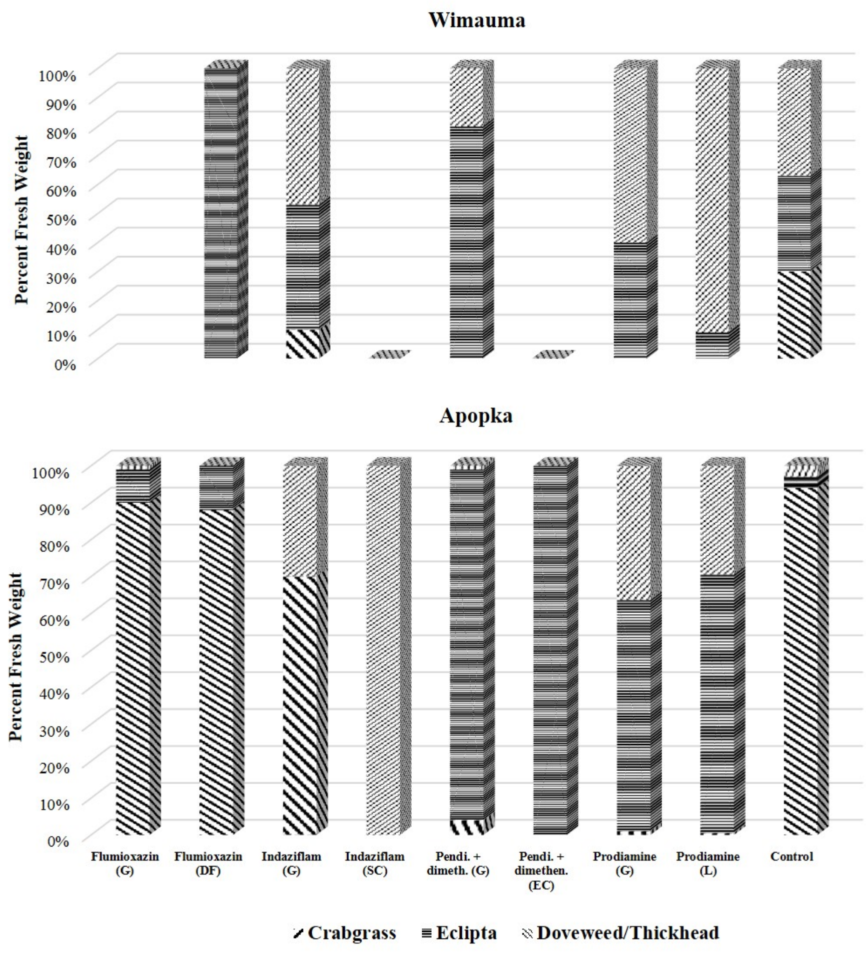

Figure 1. Weed prevalence by species in each herbicide treatment (percentage of each weed species).

2. Wimauma.

Few differences were observed in weed fresh weights between the herbicide treatments and weed growth was considerably less for all species in Wimauma when compared to weed growth in Apopka. Species distribution similar among most treatments with the exception of indaziflam granular in which thickhead grew larger than crabgrass, prodiamine granular in which eclipta and thickhead grew larger than crabgrass and the spray-applied prodiamine in which thickhead grew larger than both eclipta and crabgrass.

DISCUSSION

Results from this trial indicate that in general, granular and spray-applied preemergence herbicides provided similar control. However, it should be noted that in this study granular products were applied to each pot individually and carefully distributed across the container surface. Research has shown that in real-world scenarios, granular preemergence herbicides typically result in high variability (up to 250%) from one pot to another within a container block (Barker and Neal, 2016), and if the application is not made correctly, poor weed control will result. It should also be noted that all weed species evaluated in this trial have relatively large seeds. Previous research evaluating the impact of herbicide formulation for small-seeded broadleaf weeds (*Euphorbia maculata* or spotted spurge) has shown increased levels of control from spray-applied formulations of flumioxazin compared to granular (Bartley et al., 2014). Results of this study also illustrate how weed species prevalence will change depending upon active ingredients that are applied for control. For example, prodiamine, a dinitroaniline herbicide is highly effective on grass weeds. Crabgrass grew poorly in pots treated with prodiamine but as this active ingredient is also largely ineffective for eclipta or doveweed, those species became prevalent. The reverse was true for pots treated with pendimethalin + dimethenamid-P; in these pots, crabgrass was controlled with pendimethalin (also a dinitroaniline herbicide) and doveweed was controlled well by dimethenamid-P which has a different mode of action. Dimethenamid-P also has activity on eclipta, but typically does not result in complete control of high infestations. As evidenced in part by this study, it is important to rotate through various modes of action throughout the year in order to achieve desired results.

Given that few differences were noted in this study, growers should consider several factors which choosing between herbicide formulations. First, crop safety and tolerance should be the primary concern. While granular herbicides may provide increased safety in certain cases, there are several liquid preemergence herbicides which are labeled for over-the-top applications to hundreds of ornamental plants including isoxaben and dithiopyr (Gallery®SC and Dimension®, Dow AgroSciences), dimethenamid-P and pedimethalin (Tower® and Pendulum® 3.3 EC, BASF Corp.), and prodiamine and s-metolachlor (Barricade® and Pennant Magnum®, Syngenta). For field crops and in situations where directed applications could be made (as well as non-crop areas), flumioxazin (SureGuard®, Valent Corp., USA) and indaziflam (Marengo®, OHP Inc.) could be used. A standard 50 lb. bag of granular preemergence herbicide could cost approximately $75; in this case, treating an acre at the highest label rate (ex., 200 lbs.) would cost $300. To treat the same acre with a comparable liquid herbicide could be expected to cost approximately $55. For a 50-acre nursery making three applications per year, switching to spray-applied herbicides would be estimated to result in savings of $36,750 ($45,000 annual cost for granular vs. $8,250 cost for liquid) which does not include labor cost savings associated with liquid applications.

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Cardinal temperatures and thermal time for seed germination of industrial hemp (*Cannabis sativa*)©[a]

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INTRODUCTION

Hemp (*Cannabis sativa* L.) has been grown for its fiber, oil-rich seed, and psychoactive resins for over 6000 years (Hermann, 2008). Today, it is estimated that over 25,000 different food, fiber, and medicinal products can be derived from the hemp plant (Johnson, 2015). Most modern production of industrial hemp currently occurs in China, Canada, and European countries. Section 7606 of the Kentucky Agricultural act of 2014 has authorized the production of industrial hemp through cooperation of state Departments of Agriculture, farmers, and university pilot research projects (Kaiser et al., 2015). Prospective industrial hemp farmers in states such as Kentucky will rely on high quality commercial seed in order to support the development and cultivation of a new crop.

Seed germination and dormancy are primarily regulated by moisture and temperature, of which temperature can initiate or inhibit germination of imbibed seeds, as well as control the rate of embryo growth towards germination once germination has been initiated (Bradford, 2002; Roberts, 1988). Seasonal changes in temperature are primary environmental stimuli for seeds to lose primary dormancy. Hemp seeds are considered non-endospermic and non-dormant with a high embryo to seed ratio (Parihar et al., 2014).

Three “Cardinal” temperatures usually describe the broad response of germination to temperature (Cave et al., 2011). Germination does not occur below the minimum temperature (T_b), or above a maximum (T_c), while germinating most rapidly in the optimal range (T_o). The germination rate of a given seed fraction increases linearly between T_b and T_o when the germination rate (inverse of time to germination of a specific seed fraction) is plotted against temperature (Bradford, 2002). The germination rate decreases linearly between T_o and T_b, but in some cases there is a plateau in germination rate around T_o, as well as variation in T_c among individual seeds in a given population.

The objectives of this study were to investigate seed germination in industrial hemp (*C. sativa*) at different constant temperatures to establish base, optimum, and maximum temperatures and to determine thermal time to germination. This information will be useful for establishing industrial hemp production guidelines in more southern latitude’s than that of the Canadian hemp industry which is currently a major source of commercial planting stock.

MATERIALS AND METHODS

Seed source

Seeds of seven hemp (*C. sativa*) seed cultivars (‘Georgiana’, ‘Tisca’, ‘Finola 15’, ‘Finola 14’, ‘Canda 15’, ‘Canda 14’ and ‘Victoria’) were obtained from the company Hemp Oil Kentucky. Seed was stored in a 10°C cold-storage room.

Standard germination

Seeds of hemp (*C. sativa*) cultivars ‘Georgiana’, ‘Tisca’, ‘Finola 15’, ‘Finola 14’, ‘Canda 15’, ‘Canda 14’ and ‘Victoria’) were placed in plastic Petri dishes (100×15 mm) and placed in a lighted incubator (8 h light, 16 h dark at approximately 60 µmol s^{-1} m^{-2}) at 20-30°C. Standard germination counts followed the International Seed Testing Association (2008) rules. Four replications of 25 seeds for each seed lot were germinated in Petri dishes on two pieces of

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grade 8001 germination paper (Stults Scientific Co., Mt. Holly Springs, Pennsylvania, USA), moistened with 6 mL of deionized water, and sealed with parafilm (Bemis Flexible Packaging, Neenah, Wisconsin, USA). Germination was under alternating cycles of 16 h at 20°C and 8 h at 30°C. Standard Germination counts occurred at 7 days. Three of the high-germinating lots were chosen for subsequent experiments investigating thermal time.

Thermal time

Germination was measured at temperatures ranging from 3 to 42°C. Two, 25-seed replicates of each of the 'Georgina', 'Tisca', and 'Victoria' cultivars were placed in Petri dishes in each of six columns spanning the temperature gradient produced by a thermogradient table (Figure 1). The thermal gradient was produced by pumping chilled water from a recirculating water bath (Polyscience, Niles, Illinois), and heated water from a Neslab RTE-211 water bath (Neslab Instruments Inc., Portsmouth, New Hampshire, USA) into opposite ends of an aluminum reservoir plate framed with Plexiglas (Figure 1). The water baths were connected to four valves on opposite sides of the table with a hose clamp and flexible Tygon R-3606 tubing (Norton Performance Plastic Corporation, Akron, Ohio, USA). Temperature was measured each time germination data was recorded with a Taylor 1441 E temperature probe (Taylor Precision Products, La Cruces, New Mexico, USA) by placing a row of empty petri dishes filled with water to correspond to each column along the gradient.

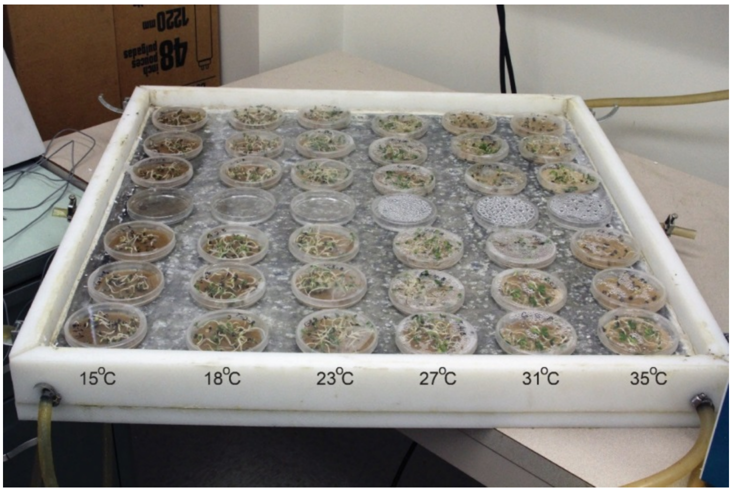

Figure 1. Thermogradient table.

Seeds were observed up to five times per day on the first day when germination was rapid, and then gradually reduce to once per day until no additional germination was observed. Seeds were counted once the radicle protruded from the seed coat 2 mm. Experiments occurred at 3 temperature ranges due to the limitations of the thermogradient table, but were replicated and repeated.

Viability

A viability test was conducted to distinguish between dormant and non-viable (dead) seeds that did not germinate at 42°C. Fifty non-germinated seeds were moved from the thermogradient table into a lighted incubator (20-30°C) for 14 days to determine if germination would resume. After 14 days, seed had not germinated and embryo's where removed from the pericarp and seed coat removed with forceps for staining. The excised embryos were soaked in 0.1% TZ solution (2,3,5 triphenyl tetrazolium chloride) at 20-30°C for 18 h. Another study was conducted following these results by incubating two replicates of 25 imbibed 'Georgiana' seeds at 42°C in an incubator for 24, 48, 72, and 96 h before staining in a 1% TZ solution. Seeds were evaluated and separated into viable and non-viable seeds. Viable seeds were either totally stained or stained greater than 1/3 of the radicle or cotyledon. Non-viable seeds were either unstained or stained less than 1/3 of the radicle or cotyledon.

Data analysis

Data collected from Petri dishes were used to calculate germination percentage as well as T_{50} values (days to reach 50% germination) at each temperature to describe speed of germination. Germination rate was modeled by plotting the reciprocal of days taken to reach 50% germination against temperature.

RESULTS AND DISCUSSION

Standard germination

Standard germination for the 'Georgina', 'Tisca' and 'Victoria' seed lots were high (greater than 70%), while the other's performed poorly (Table 1). Georgiana was selected for further investigation to allow for more repetitions.

Table 1. Standard germination in seven industrial hemp accessions.

Accession	3-day count	7-day count
Georgiana	65	81
Victoria	61	91
Tisca	63	73
Finola (2014)	12	12
Finola (2015)	55	58
Canda (2014)	12	12
Canda (2015)	25	27

Cardinal temperatures

Estimates for the low and high cardinal temperatures occur at 3 and 42°C, respectively (Figure 2). The optimal temperature for germination was between 19 and 23°C, where germination percentage was highest and germination speed was high (Figure 2). Final germination of 'Georgiana' hemp seeds sown on the thermogradient table was highest (between 86-88%) at 10 to 23°C and decreased with increasing temperatures above 27°C with a supra-optimal limit of 42°C where no germination occurred. Similarly, in a study by Parihar et al. (2014), there was no significant difference in final hemp seed germination recorded at 20, 25 and 20-30°C. However, in their study germination was not observed at 15°C and thermo-inhibition occurred at 30 and 35°C. This suggests that commercial hemp seed is a cool season germinator similar to brassica crops. Non-germinating seeds at 42°C were examined for viability using a 0.1% TZ solution and were over 70% viable after 4 days. This suggests that these seeds were either thermally inhibited or induced into secondary thermal dormancy.

Time to 50% germination (T_{50}) decreased with increasing temperature and was lowest at 35°C, although the T_{50} for 29, 31, 35, and 37°C were not significantly different. Conversely, germination speed (T_{50}) became slower with increasingly lower temperatures between 19 and 10°C (Figure 2). The faster germination rate at temperatures above optimum is not typical in seeds of most species where time to 50% germination gets slower at supra-optimal temperatures (Bradford, 2002). However, in some species, germination rate tends to plateau at supra-optimal temperatures (Orozco-Segovia et al., 1996) as observed in 'Georgiana' hemp seeds (Figure 2).

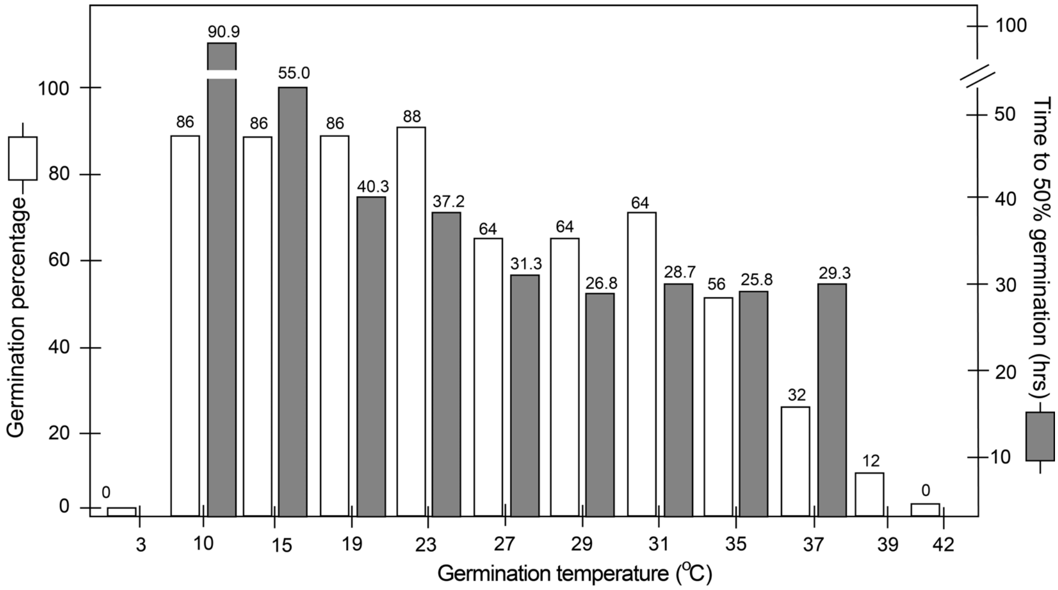

Figure 2. Germination percentage and speed in 'Georgiana' seeds at different temperatures.

Thermal time

Plotting the reciprocal time (hours) to reach 50% germination (G_r) against temperature showed a linear relationship of increasing germination rate with increasing temperature between 15 and 29°C (Figure 3). The regression equation generated from this data provides a putative thermal time model to predict time to 50% germination, where the cumulative Gr at Tx for each hour sums to 1.

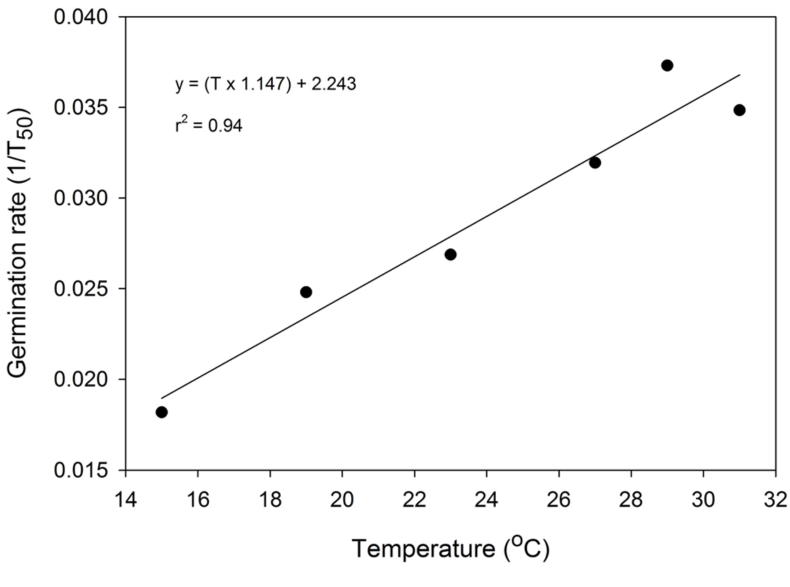

Figure 3. The relationship between temperature and germination rate in 'Georgiana' seeds.

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Scheduling propagation year round©

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INTRODUCTION

Baucom's Nursery is a company in North Carolina that grows a diverse product line. We grow annuals, poinsettias, mums, cactus, ornamentals, Easter lilies, roses, azaleas, pansies, and an assortment of other plants. It is a tremendous challenge to schedule these plants in propagation with our objective to have them saleable at the optimum time. We propagate from cuttings every week of the year. Below is a list crops propagated on a monthly basis.

- January - Leyland Cyprus (*Cupressus* × *leylandii*), arborvitae (*Thuja*), annuals
- February – finish winter shrubs, annuals
- March – annuals
- April – annuals, cactus
- May – annuals, mums, ornamentals
- June – mums, poinsettias, ornamentals
- July – mums, poinsettias, ornaments
- August – mums, poinsettias, ornamentals
- September – ornamentals
- October – ornamentals
- November – ornamentals
- December – ornamentals and spring annuals

ORNAMENTAL PROPAGATION

We use a homemade formula in January or February to establish our ornamental schedule for the year.

- We look at our sales history over the past four years. Is there a trend? Is our sales history remaining the same, declining or increasing?
- What is our current saleable inventory? What is available for current sales and what inventory is growing for the future?
- We seek communication from our sales staff. Through their interactions with our customers, they are able to obtain information regarding our future sales.
- During spring it is important to track sales and to have an understanding of when the sales occurred. If there was a shortage, did it occur early or later in the spring? This helps to determine plant numbers for the propagation season.
- What is our current liner inventory?
- The propagation list established in February may be evaluated in June or July and numbers adjusted according to spring sales.

The majority of our liners are grown in a 21-cell pack and many are planted with two cuttings per cell. The liners are overwintered in a heated greenhouse, attempting to maintain above 0°C (32°F). In North Carolina, in our area, around mid-April we look at the long range weather forecast and if it is favorable, we begin planting. Our program is to plant liners straight into a 3-gal container.

POINSETTIA PROPAGATION

In 2016, we stuck 110,000 poinsettia cuttings. Our sales staff provides data that is helpful in determining numbers and colors. This year our color percentage is 80% red, 12% white, 4% pink and 4% assorted. Scheduling is important so that we have adequate color to be shipped into stores. We want our sales season to be from the week of Thanksgiving and hopefully all of our plants are in the stores by the 20th of December. In recent years, our

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customers have demanded poinsettias showing good color on what they call “Black Friday.” We needed a variety that would color up naturally for that date. We grow three different red poinsettia cultivars that will color up at different times. We grow *Euphorbia pulcherrima* ‘Premium Red’ for Black Friday, ‘Protégé Red’ would be the next to color and the last red to color would be ‘Prestige Red’. Our scheduling also includes our first plant growth regulator (PGR) which is applied d propagation. We use B-NINE and Cycocel.

MUM PROPAGATION

In 2016 we stuck 200,000 mum cuttings. We completed our mum scheduling in terms of color, number and flower dates the same way as with our poinsettias, by communicating with our sales staff. Our color ratio for mums this year was 50% yellow, 15% red, 15% purple, 10% orange and 10% white. Here is an example for a mum schedule for a 15-cm (6-in.) containers, with one cutting per pot direct stuck during propagation. We allow 14-16 days from the time the cutting is stuck until it is completely weaned off the mist. Under natural conditions, we then allow 8 weeks until the 6 in. mum has flowered.

If we direct stick 3 cuttings in an 30-cm (8 in) pot, we normally add 2-3 weeks longer for flowering.

Our formula for scheduling and growing after propagation is not foolproof, but I hope this has been helpful and informative as you schedule in your work.

Plant gems from China©

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INTRODUCTION

A lot of plants native in China thrive in landscapes across the USA. Chinese plant germplasm has been continuously introduced to the USA, and used in breeding and selection. So many new cultivars with Chinese genetics have been introduced in the landscape plant market. The Chinese love plants and particularly enjoy 10 "traditionally famous flowers": lotus (*Nelumbo nucifera*), sweet olive (*Osmanthus frangrans*), peony (*Paeonia suffruticosa*), azalea (*Azalea* spp.), chrysanthemum (*Chrysanthemum* spp.), mei flower (*Prunus mume*), daffodil (*Narcissus* spp.), rose (*Rosa* spp.), camellia (*Camellia* spp.) and cymbidium (*Cymbidium* spp.). Public and university breeders have focused on these taxa. In addition, many species and cultivars commonly grown in China may be of interest to growers and landscape professionals in the USA, which this manuscript will be focused on.

PLANT SPECIES AND CULTIVARS

Sweet olive (*Osmanthus fragrans*)

There are mainly four types of sweet olives, Auranticus Group, Luteus Group, Albus Group, orange and Semperflorens Group. Ever-blooming sweet olives have peak blooming in the fall like the others, and continue for about 6 months although not as profusely. Recently there are three variegated cultivars: 'Yinbian Caiye' with white leaf margins on mature leaves and red, white, and green on new growth, 'Yintian Cai' with red-margined maroon leaves maturing to white-margined green leaves, and 'Pearl Color' with pink new growth.

Camellia (*Camellia azalea*)

The exciting development in camellia breeding has mainly involved *Camellia azalea* (Synonym: *C. changii*), an unusual evergreen species with leaves and flowers similar to azaleas. It flowers from summer to fall and has the potential to flower year around under optimal growing conditions. Palm Landscape Co. in Guangdong Province, China has released 15 cultivars, six in 'Xiari/'Summer' ('Fenqun', 'Fendai', 'Qixin', 'Guanghui', 'Guangchang', and 'Hongrong'), seven in 'Xiameng'/'Summer Dream' ('Wenqing', 'Kejuan', 'Hualin', 'Yanping', 'Xiaoxuan', 'Chunling' and 'Yulan') series, 'Xiayong Guose', and 'Xiafeng Relang'.

Mei flower (*Prunus mume*)

Mei flower made its way to the top two (the other one being peony) finalists to be considered as the national flower. Many cultivars grow in the Yangzi River and Yellow River areas (USDA Zone 6-8). It's probably the earliest flowering *Prunus* in early spring. Numerous filaments add to the beauty of delicate flowers. Its bright green young stems make very nice contrast against white, pink, and red flowers. Some white cultivars include 'Xiao Lve' (small earliest flowering cultivars with green sepals; white flowers and filaments), 'Wan Fu Tiao' (late flowering, multiflora, young stems and flowers of different colors, and variegated flowers), 'Fanxing Gongfen' (pinkish white) and 'Shangbi Chuizhi' (white flower on pendulous stems), and pink and red cultivars 'Dongfang Zhusha' (bright red), 'Fanhua Zhusha' (red sepals; pink petals), 'Yinxu Zhusha' (white filaments; pink petals) and 'Taige Zhusha' (pink).

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Taiwan cherry (*Prunus campanulata*)

This is probably the best cherry for warm climate (>Zone 8) with cultivar colors range from white to red.

Winter sweet (*Chimonanthus praecox*)

Winter sweet is called “la (December on lunar calendar) mei (*P. mume*)” in Chinese, and flowers start earlier than mei flower. It is one of China’s favorite plants because not many species flower right around the most important Chinese holiday: the Spring Festival (aka Chinese New Year). Depending on the weather, plants could continuously flower into March or even April in some Zone 6 areas. The waxy flowers have very long postharvest life, and thus also serve as a popular woody cut stem. There are 19 registered cultivars. Petals range from whitish translucent to bright yellow and inner sepals range from whitish translucent to dark maroon. Common cultivars are included in Table 1.

Table 1. Flower characteristics, sepal color and flowering time of common winter sweet cultivars in China.

Name	Flower characteristics	Inner sepal color	Outer sepal color	Flowering time[1]
Bao Chun	Urn	Maroon hue	Light yellow	Late-Dec. – mid-Feb.
Caotang Yunxiang	Bowl	Maroon	Light yellow	Early-Nov – late-Jan.
Huang Qing	Urn, bell, large	Yellow with purplish red	Light yellow	Early-Dec. – early-Feb.
Hua Hudie	Bell, fragrant	Yellow with red	Golden	Dec. – Jan.
Huantian Xidi	Bowl to plate, densely, apex reflex	Yellow	Light yellow	Mid-Dec. – early-Feb.
Jinling Hongzhuang	Open, sepals pointed, fragrant	Purplish red	Golden	Late-Dec. – mid-Feb.
Jinse Yangguang	Bowl	Golden	Golden	Dec. – Jan.
Lv Yun	Open, sepals pointed	Light yellow	Light yellow	Jan. – Feb.
Qianyun Jindie	Open, Long sepals	Yellow	Yellow	Late-Dec. – Feb.
Si Nian	Bell, apex reflex	Light maroon	Light yellow	Early-Dec. – mid-Feb.
Wai Gang	Open like lotus	Light yellow	Light yellow	Late-Nov – Jan.
Xiaran Qianyu	Bell, densely	Reddish white	Creamy	Early-Jan. – late-Feb.
Xiang Yi	Ball, Sepals incurvate	Yellow with red	Yellow	Mid-Dec. – late-Jan.
Xingfu Huaxiang	Open, apex reflex, large, fragrant	Yellow with purplish red	Yellow	early-Dec. – early-Feb.
Xingguang Canlan	Bowl	Golden	Golden	Dec. – Jan.
Yangzhou Huang	Open bowl, apex reflex	Golden	Golden	Jan. – Feb.
Yingbei Hanzhu	Urn, Sepals incurvate	Whitish yellow with red	Whitish Yellow	Jan. – Feb.
Zhongshan Bai	Open, large	Yellowish white	White	Late-Dec. – late-Feb.
Zao Hong	Urn, Sepals incurvate	Reddish	Yellow	Mid-Nov. – late-Jan.

[1]Flowering time is based on observations in Yangtze River area.

Chinese tulip poplar (*Liriodendron chinense*)

The main difference between Chinese and American tulip poplar (*L. tulipifera*) is the leaf shape (deeper lobes for Chinese) and leaf pubescence (absent in Chinese). It has a gorgeous fall color.

Shaanxi euonymus (*Euonymus schensianus* ‘Jinsi Diao Hudie’)

‘Jinsi Diao Hudie’ (butterfly on golden thread) has long (>20 cm) stems where red fruits with four wide and obtuse wings hang from. Red seeds are exposed when mature, increasing the ornamental value.

Japanese pagoda tree (*Styphnolobium japonicum*)

Styphnolobium japnoicum f. oligophylla has 1-2 palmate leaves at the end of petiole. 'Pendula' ('Dragon Claw' in Chinese) is often grafted and looks like green parasol. Its winter appearance (branching structure) after leaves fall is very attractive too. 'Golden Stem' has golden leaves in the spring and fall, and golden new growth and chartreuse foliage in summer. In winter young and two-year-old twigs are both golden color.

Fragrant black locust (*Robinia pseudoacacia* 'Idaho')

Similar to the species, it has pink clusters of flowers and is more fragrant.

Golden elm (*Ulmus pumila* 'Jinye')

'Jinye' (golden leaf in Chinese) has golden leaves in the spring and fall and golden new growth and chartreuse foliage in summer. It is very vigorous and tolerates heavy pruning.

Taiwanese rain tree (*Koelreuteria elegans*)

This Taiwan native is a popular broadleaf evergreen landscape tree with clusters of golden yellow flowers in the summer and rose colored fruit capsules in the fall.

Sloanea sinensis

Called "monkey tree", as the round fruits' color resembles monkeys, *Sloanea* has delicate white flowers in summer and fall.

***Euscaphis japonica* (syn. *Euscaphis konishii*)**

From South China, this plant does not get noticed until the fruits turn red - starting September and mature to open up to show black seeds inside through March.

Formosan gum (*Liquidambar formosana*)

The gum balls are softer and less woody, and thus less a pedestrian hazard, than the U.S. species. It has great fall color, too.

Yunnan maple [*Acer coriaceifolium* (syn. *A. cinnamomifolium*)]

Yunnan maple is evergreen in warm climate and has bright red samaras.

Soapnut tree (*Sapindus mukorossi*)

Soapnut tree is a big landscape tree and great for fall color in a warm climate.

Wilson's dogwood [*Cornus wilsoniana* (*Swida wilsoniana*)]

If profuse white terminal flowers are not attractive enough to some. However, the bark is a magnificent mottled and exfoliating combination of green, gray, white and reddish brown.

Fragrant rosewood (*Dalbergia odorifera*)

The wood is very fragrant and demands a high price for the furniture market. Big leaves are alternate and imparipinnate. Numerous small axillary flowers turn to samaroid fruits.

Chinese yew (*Taxus chinensis*)

The red fruits when mature brightens the landscape.

Cyclocarya paliurus

Its leaves are alternate and pinnate. The most interesting about this tree is the axillary fruiting spikes with green nutlets and greenish white leathery disc wings about 3-6 cm, which resemble big round elm samaras.

‘Yang mei’ (*Myrica rubra*)

Although in the same genus as *M. cerifera*, ‘Yang mei’ is a large broadleaf evergreen dioecious tree producing red strawberry-like edible fruits in summer.

Gulf Coast Appalachia—a new frontier: exploring the trees and shrubs of the Red Hills of Alabama©

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INTRODUCTION

What imagery springs to mind when meditating south Alabama? Sun-bleached white beaches, deck chairs beneath the scant shade of swaying palms, azaleas blossoming between the low lying limbs of moss strewn live oaks? Maybe a "cheeseburger in paradise" along our self-described "Redneck Riviera?"

That is all a pleasant reality, and yet, in the midst of the Coastal Plain, only some 85 airline miles from the Gulf of Mexico, a vastly different and magical landscape unfolds. A narrow belt stretching across the state contains piney hills, bisected by steep ravines carved since the Eocene by fast-flowing creeks and streams. All lead to what has been called "America's Amazon"—the biologically rich Mobile River Delta. This geological and botanical treasure is known as the Red Hills, receiving the name from the iron-rich soils that once sprouted massive tracts of longleaf pine (*Pinus palustris)* forests. In the mesic soils between the ridgetops, one finds the richest woody tree diversity in North America.

William Bartram explored the upper Mobile Delta, including the Red Hills in 1775-1776. Combining his botanical knowledge with love of poetry when he wrote in *Travels:* "We encamped on the banks of a rivulet amidst a spicy grove of the *Illicium Floridanum*." Bartram described vast unbroken plains of dogwood forests and some of the largest hardwood trees he encountered in all his journeys (Sanders, 2002). Much of the majesty, most of the pine character, but little of the plant diversity, was removed by the time botanist, Roland Harper, wrote in the 1943 monograph, *Forests of Alabama*: "The red hills are an area occupied by the various Eocene formations, a belt about 50 miles wide extending all across the state. This region comprises several different geological belts, some of which would show significant differences in vegetation if studied closely enough" (Harper, 1943). That turned out to be an understatement—as today the *Biota of North America Project* lists the area as the center for small tree diversity in North America (above Mexico.)

Here, one can find six species of magnolia growing on a single hillside. In the spoken words of internationally-acclaimed biologist, E.O. Wilson: "… it was Bill (Finch) that pointed out that whereas the southern Appalachians had been considered the headquarters of oak diversity, with 14 kinds of oak species known just in the southern Appalachians—places like the Great Smoky Mountains National Park, Bill discovered that here in the Red Hills alone there are 24. That's probably the world record. The largest number of oak species in a concentrated area" (Raines, 2016).

The Red Hills lies in some of the most southerly latitudes in the USA (hardiness zones 8a and 8). It is native to such woody shrubs such as *Rhododendron minus* var. *minus, Hydrangea quercifolia*, and *H. arborescens.* Montane herbaceous plants include *Tiarella cordifolia* var. *austrina, Heuchera americana,* and *Panax quinquefolius*. Two of America's most recent and distinctive new species were discovered in the Red Hills: *Rhododendron colemanii* and *Hamamelis ovalis*. The incredible diversity may be partly explained by the geology. In brief, a narrow band of limestone hills extends across the lower belt of the Red Hills, sometimes producing outcrops with abundant lime-loving vegetation. Above the limestone belt is a mix of Burhstone hills and iron rich strata. One can witness typically high pH-dependent plants adapted to neutral to acid soils, and acid-loving plants extending into higher pH soils.

Some 15,000 years ago, during the height of the last ice age, the high Appalachians were mainly snow covered peaks punctuated in spruce forest (Adams, 2016). The Red Hills

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served as a refugium for such species as *Kalmia latifolia*, *H. quercifolia*, and countless oaks, maples, and Ericaceous flora. Some 12,000 years ago, the ice receding, the Red Hills began to repopulate the southern Appalachians, which descend into north-central Alabama.

The potential to exploit this area's botanical treasures for use both in gardens and in hybridizing for superior traits has barely been touched. Those of us "Zone 8'ers" who grew up reading the garden books of Sargent and Taylor can attest to the frustration of reading cold hardiness ratings with no mention of heat tolerance. Strong, but still anecdotal evidence from the Piedmont and coastal Carolinas, as well as Southeastern Texas, suggest amazing heat tolerance of some Red Hills species—thought to be high-altitude only. The sweltering Alabama summers, with high rainfall, have perhaps induced a level of disease tolerance that has not been thoroughly examined. Further, there is a vigor trait inherent in many populations. For instance, on the dry pine-beech slopes, *R. alabamense,* described as low-growing of 1.5-1.8 m (1.5-6 ft), will grow to more than 4.6 m (15 ft). Along the creeks below, *Illicium floridanum* will produce large flowers [8 cm (3 in.)] and bloom during the spring and fall. Among the rhododendrons, taxonomists' worst fears are realized—as speciation becomes less a concept and more a coin toss. Intergradation appears to take place among the ancient groves of several native azalea species.

OUR AREAS OF INTEREST...THUS FAR

Hamamelis ovalis S.W. Leonard

Hamamelis ovalis is encountered frequently in this region. It is surprising just how long this species remained "undiscovered". The large, felted leaves had been dismissed as a variation of *Hamamelis virginiana*. Since most populations bloom from December into January with yellow flowers, not unlike *H. virginiana,* the plant had been overlooked. The later blooming populations seem to have a higher percentage of orange and red flowers. We have begun growing some of the late blooming populations from seed. The long dormancy period for seed (up to 18-24 months) does not lend itself to a nurseryman's patience. This year we soaked our September-collected seed in sulfuric acid for 10 min., and planted directly thereafter.

Rhododendron colemanii R. Miller

Rhododendron colemanii is another new species that was long dismissed as a late blooming *R. canescens* or color variation of *R. alabamense*. However, it is dissimilar in many physical attributes—and turned out to be a tetraploid (*R. canescens* and *R. alabamense* are diploid)—thereby bestowing its species status. The palette of flower color in the species rivals *R. calendulaceum*, the later bloom season, (late April to mid-May in the Red Hills), extends the season into warm temperatures. Some clones are highly perfumed, rivaling *R. alabamense* for heady fragrance (Zhou et al., 2008).

Growing *R. colemanii* clones from wild-collected cuttings has run the gamut from highly successful to extremely disappointing. We are hopeful nursery-grown plants may give us heavier cutting wood. For best results, soft cuttings with terminal leaves removed are taken in May, quick-dipped with 1000 ppm Dip N' Grow, and placed in 8.9 cm (3.5 in.)-deep cells containing coarse perlite and coarse vermiculite (Dirr and Heuser, 2006). It is important to snip any flower buds that form thereafter to help induce new growth. Root initiation takes place within 30 days, and at 60 days we top-dress with Osmocote Plus 15-9-12 as a slow-release liquid fertilizer. By September we usually see a stolon emerge and can bump the plants up into a slightly larger container—since it is vital to have continued growth before winter.

Rhododendron minus var. *minus* S.D. Coleman

A Georgia nurseryman, Dan Coleman, suggested that in the southern Chattahoochee River basin of Georgia and Alabama—*R. minus* was distinct horticulturally, and more attractive in flower, than the ecotypes from North Carolina. Ecotypes of the species are found scattered in the Red Hills and can vary greatly in appearance and flower. The plant is smaller and more compact than Appalachian forms, growing in association with *K. latifolia,* which it strongly resembles. The predominant bloom color is lavender, with less pink infusion than more northerly populations. In a recent discovery of it in Conecuh County, Alabama by Ron Miller, Tom Ranney, and Clarence Towe it had brilliant pink trusses of flowers. Their 'Southern Cerise' has been a star in the nursery—as it is easy to propagate and shows a bit more compact habit and forgivable nature. Rooting and production success approaches 85% with the same regimen as for *R. colemanii*. Crosses with a lavender form from Monroe County, Alabama produced progeny with a pleasing palette of lavenders and pinks with some strong contrasting yellow blotches. Cutting trials have begun on three selections from the cross.

What else is out there in them-thar hills?

Viburnum, Vaccinium, and deciduous *Ilex* from the region are candidates for more study. *Magnolia acuminata* var. *subcordata* has been used extensively in hybridizing with Asian species for deciduous yellow-flowered selections. Some Red Hills individuals with strong yellow pigment have been recently discovered and may be useful in hybridizing. Southerly forms of *K. latifolia* tend to have less flower diversity than those in the northeast, but a recent discovery of a shrub with a rich pink corolla shows promise as both a Zone 8b garden plant and breeding parent. Our botanical-minded friends who tend to explore with an eye to the ground level tell me the herbaceous plants are a rich tapestry, with perhaps new and endemic species yet to be discovered? The Red Hills indeed, may be one of America's last botanical frontiers!

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Trulieve: the production of medicinal marijuana in Florida©

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INTRODUCTION

This paper reports on the process of starting the first legal medical marijuana production and dispenser facility in northwest Florida—Trulieve. Trulieve is now a Florida licensed medical *Cannabis* provider, http://trulieve.com/about. The product produced is low THC-*Cannabis*, which means a patient will not get "high" from the low dosage. The goal is for medical pain relief, as well as the control of seizures—some epileptic children suffer from as many as 100 seizures per day. The plants are produced at an unknown location in Quincy, Florida—for an extraction process to infuse into medical devices via oral syringe, capsule, tincture, or vaporizer. In Tallahassee, the dispensary sells products using *Cannabis* extract—from capsules to vaporizer use (Steven Jiwanmall, 29 Sept 2016. Insiders: A look at medical *Cannabis* in Florida, http://www.wtxl.com/insiders/insiders-a-look-at-medical-cannabis-in-florida/article_edddc022-89ad-11e6-a4ea-03bc56885560.html).

COMPASSIONATE CARE ACT

- Spring 2014: medical marijuana amendment is placed on the November ballot.
- May 2014: legislation passes "Compassionate Care" Act. The Florida legislature is Republican controlled.

FOR A NURSERY TO QUALIFY

- 30 year license by Florida Department of Agriculture.
- License has to be at 400,000 plant production level.
- Product must be available by 1 Jan. 2015.

LEGISLATIVE PROCESS

- Fall 2014: (1) Rule making sessions begin/New Venture; (2) legal challenges to the rules; (3) lottery system is thrown out.
- February 2015: Special rule making body appointed by Florida Department of Health. There are five people from each region, plus doctors, and other stakeholders.
- July 2015: New rules survive legal challenges and the application period begins. Applications are due by July 2015.
- July 2015: Applications are due to the Florida Department of Health. The waiting period begins. There is no timetable to notify applicants.

APPLICATION PROCESS

- The three parts of an application include: (1) Cultivation—growing, (2) Processing, and (3) dispensing. This is vertical integrated system—from seed to shelf. Our application document has over 1,900 pages (Figure 1).
- 23 November 2015: The Florida Surgeon General calls "winners" and tells them they will be awarded a license. The clock starts ticking. Non-awardees have ability to challenge those who received licenses.

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Figure 1. Our medicinal marijuana application had over 19,000 pages.

DEADLINES FOR WINNERS TO MEET

- Ten days to post a $5 million dollar performance bond.
- Seventy-five days to request Cultivation Authorization.
- Two hundred and ten days to request Dispensing Authorization.

THE WORK BEGINS

- 8 February 2016: We notify Florida Department of Health that we are ready to begin cultivation.
- 29 February 2016: Department of Health inspects facilities and Trulieve receives authority to cultivate.
- 3 March 2016: First plants are received (Figures 2-4).
- 1 July 2016: Trulieve is given authority to begin processing.
- 20 July 2016: Trulieve is given authority to begin dispensing at our dispensary in Tallahassee, Florida.
- 23 July 2016: The first medical marijuana dispensary in Florida holds its grand opening.

Figure 2. Early stages of medicinal marijuana production in a controlled environment agriculture (CEA) system.

Figure 3. Later stages of medicinal marijuana production in a controlled environment agriculture (CEA) system.

Figure 4. Final production stage of medicinal marijuana with flower heads ready for harvest.

ACCOMPLISHMENTS

Eight months from the day we received notification of being awarded a license, we accomplished:

- Building a growing and processing facility in Quincy, Florida.
- Building and opening the first medicinal marijuana dispensary in Florida.

ISSUES WE FACE

- Growing marijuana is still illegal at the federal level.
- Banking issues. Transactions are done in cash with customers, and the difficulty of getting business loans through normal channels.
- IRS 280E accounting.
- Emotional.
- Security concerns about protecting production and dispensing facilities, transporting product and conducting financial transactions on a cash basis - with greater potential for robbery.

What are they teaching kids in school these days? A look at plant propagation courses at North Carolina State©

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INTRODUCTION

North Carolina State University currently offers several plant propagation courses to a number of different student audiences: HS 121 (Plant Propagation for Associates degree students), HS 301 (Plant Propagation for Bachelor's degree students), and HS 203 (Home Plant Propagation for certificate students and Bachelor's degree students pursuing majors unrelated to Horticultural Science). Some of these students are majoring in horticulture, and others are just taking a plant propagation class an elective out of interest. Some of the students want to propagate plants at home as a hobby while others plan to make a career in commercial horticulture.

Even the delivery of the course materials vary as some of these courses are taught in person on campus, while one of them—(HS 203)—is also taught online for distance education students. The students who want to learn about our craft have a wide range of goals. Despite their differences, my teaching goals in these classes are the same.

GOAL ONE: EQUIP STUDENTS WITH A FULL SUITE OF TECHNICAL SKILLS IN PROPAGATION

Plant propagation is first and foremost an applied science. A plant propagation class cannot be complete without giving students the opportunity to put the techniques and scientific principles that they learn about in lectures into practice. Students pursuing a minor, Associates degree, or Bachelor's degree in Horticultural Science at North Carolina State are required to take a plant propagation course in person and on campus—which includes a 3-h laboratory period once a week.

During this laboratory period, students practice and experiment with techniques including: cuttings (stem, leaf, root, and culm) from herbaceous and woody species, grafting, budding, tissue culture (Figure 1), layering, bulb scaling and twin-scaling, controlled pollination and hybridization (Figure 2), fern spore germination, seed germination, seed scarification, and seed stratification.

Figure 1. A student at North Carolina State learns how to tissue culture Mexican feather grass (*Nasella tenuissima*).

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Figure 2. A student performs a controlled hybrization on petunias.

For my Home Plant Propagation course, we cover the same skills required for the courses for Horticultural Science majors, but from the perspective of hobbyist propagation for the homeowner. Emphasis is placed on learning techniques that are better suited for home plant propagation such as division (Figure 3) and layering. This course is taught both online and in person, but even online students must engage in hands-on practices of these skills. Online students view a series of videos instructing them on techniques before attempting them on their own at home. They then submit photos of their efforts to the course website where they can also view photos posted by their classmates (Figure 4). Discussion between students regarding strategies for effective propagation at home based on these shared photos is an essential part of the course.

Figure 3. Students in Home Plant Propagation (HS 203) practice division.

Figure 4. A photo submitted by a distance education student taking plant propagation online, showing how they are propagating stem cuttings at home.

GOAL TWO: ENCOURAGE STUDENTS TO USE PROBLEM-SOLVING SKILLS IN REFERENCE TO PLANT PROPAGATION

Any educator will tell you that problem-solving skills are important for students in any area of study, and plant propagation is no exception. In all of my classes, I try to present students with problems in the realm of plant propagation that have yet to be solved. Sometimes this may involve describing a plant that no one has yet figured out how to effectively propagate for commercial production. Sometimes I challenge them to think of ways to use the technical skills that they have learned in their lab period to overcome a particular problem (Figure 5).

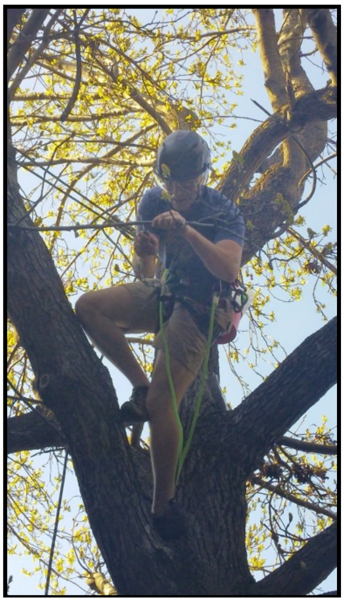

Figure 5. A student air layers a tree in an effort to get an own-rooted plant of a species that is normally grafted and difficult to root by stem cuttings.

During lecture periods, I give examples of how others in the industry have leveraged propagation techniques to overcome horticultural challenges and ask the students to present ideas on how they would meet these challenges. Some days we discuss the scientific principles underlying propagation and why certain techniques are effective. In these discussions, questions posed by both myself and by the students may not have an answer. I use these opportunities to encourage the students to dig deeper into the topic through research on their own time.

Assignments in my classes are also designed to encourage students to research topics independently. Although millennial college students are "digital natives," they often lack experience and knowledge of how to use the technology of today to find answers to questions. I believe that learning how to utilize the internet and other resources in this way is key to the success of students. Smart phones and other personal devices make memorization of facts less important than it once was. Students entering the workforce today must learn how to use these tools to find the information they need and to assess the quality of the information that they find.

GOAL THREE: EXHIBIT PATIENCE AND PERSISTENCE THROUGH PROPAGATION

The same technological devices that make finding information and solving problems so quick and relatively effortless can also create an expectation for instant answers and results. Plants rarely offer either. Many students taking plant propagation classes are surprised by how long it takes a cutting to form roots for a particular species or become discouraged when the first tree they have ever grafted is not successful. Frequently students assume that a plant is dead simply because it has not shown much visible change after a month or more.

As part of my teaching strategy, I try to select propagation activities and species that represent a range of levels of difficulty. Some plants that we take cuttings will root in a matter of weeks, and this quick response builds confidence and excitement in students. However, other techniques that we practice will have a low rate of success and prove difficult for students to master the first time. My goal is that they would see failure as a normal part of the process of learning. When they reach the workforce, I hope that they see such experiences as a motivation to persist in honing their skills and as an opportunity to learn from what did not work. If a student has a plant that dies, I require that they hypothesize as to why it died and propose a solution if they were to attempt to propagate that plant again.

Allowing students to experience failure in class does result in expressions of disappointment and frustration. However, at the end of the semester, when students look back at all the plants they have acquired as a result of their efforts, many of them also express sentiments similar to that of a student who said: “Failing is kind of challenging but also rewarding! I like doing well but failing also makes you consider what could have gone wrong—and shows you differences between different plants and practices.” I hope that encouraging this type of perspective through plant propagation courses will benefit students not only in future plant propagation endeavors, but in their careers and lives once they leave North Carolina State.

Woody ornamentals for a 21st century landscape: a Texas perspective©

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INTRODUCTION

Stephen F. Austin University's SFA Gardens comprises 128 acre (58 ha) of on-campus property at Stephen F. Austin State University (SFA), Nacogdoches, Texas. Tree, shrub, and herbaceous perennial evaluation at SFA Gardens is scattered across gardens and landscapes. Soils are generally well drained, slightly acidic, and the native flora is dominated by pine, oak, river birch, sweetgum, sycamore, Florida maple, hornbeam, elm, hackberry, pecan, and hickory.

Nacogdoches is Zone 8b with an average annual rainfall of 1219 mm (48 in.). June through August is characteristically hot and dry. 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 2010 and 2011, Nacogdoches experienced all-time record drought and heat. The SFA Gardens lies in the floodplain of LaNana creek and flooding is a reality usually occurring every 3 to 5 years. However, we had two big floods in 2015 and one in 2016. All predictive NOAA and NASA models show Texas moving to hotter times, more dry spells and more heavy precipitation incidents. While Virginia is predicted to be a bit hotter—precipitation stays about the same and more frequent violent weather events are expected.

EMERGING THREATS IN TEXAS

Many scientists accept that the rate of current ecological transformations are a major threat to biodiversity. The implications of this "sixth extinction" is not lost on the scientific community. There's a strong documented reduction in the wide diversity of plants, and it is due to a myriad of factors, including the alteration and loss of habitats, introduction of exotic species and genetically modified organisms, pollution, climate change—and the overexploitation of resources. Collectively, the trends and models for the future, suggest a science-based and prudent approach is needed to deal with emerging threats.

Two recent threats in Texas have emerged. First, the Texas A&M Forest Service confirmed 23 May 2016 that occurrences of the emerald ash borer, *Agrilus planipennis*, had been found in Harrison county in northeast Texas. Native to Asia, this pest was first detected in southeast Michigan in 2002 and has invaded states and killed ash trees in great numbers. While ash generally makes up less than 5% of the Texas forest, the urban landscape is more greatly affected. The prognosis to date is dire. Without extensive treatments, the trees do not survive. Some cities in the war zone are proactively removing healthy ash trees and replanting. If anyone has ever seen the great expanses of green ash in some of the bottomlands of the Red River near Bossier, Louisiana, the scale of the coming devastation is quite dramatic, to say the least.

Crape myrtle bark scale (CMBS), *Eriococcus lagerstroemiae*, can now be categorized as a real threat to *Lagerstroemia* and a number of other important plants. It is easy to identify. During the white crawler stage which when pressed produces a pink juice that is quite distinctive. In severe infestations, branches die, blooms are small and unattractive, and there's often a heavy deposit of honeydew and sooty mold. This creates the perfect environment for aphids, ants, and wasps. Crape myrtle bark scale is thought to move to susceptible plants in the air or by birds and small animals. First discovered in 2004 in Richardson, Texas, this scale insect has marched across the Gulf south and is just beginning on the east coast. By 2012 it had spread to Ardmore, Oklahoma, and Shreveport, Louisiana.

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In 2013, it was reported in Tyler, Texas; Houma, Louisiana (60 miles southwest of New Orleans); and Germantown, Tennessee (near Memphis). In January 2014, it was confirmed in Little Rock, Arkansas. Since then, the occurrences have increased to the point we can now conclude this pest is widespread. The pest was recently identified in Nacogdoches, Texas, at a local restaurant and the condition of the trees indicated the infestation had been there several years. Homeowners, nurserymen, and landscapers who notice symptoms of scale insect infestation on crape myrtles should contact their local county extension office (Gu et al., 2010).

PROJECT AT MOODY GARDENS, GALVESTON ISLAND, TEXAS

In 2016, SFA Gardens embarked on a project at Moody Gardens, Galveston, Texas that will: (1) characterize the soil, topography and drainage patterns of Moody Gardens, (2) establish a long term platform for acquiring, evaluating, and propagating plant materials that show promise under the soil, water, and climate conditions of Moody Gardens, (3) establish research projects with root zone treatments that mitigate soil conditions to allow for better growth and performance of test plant materials, (4) establish an outreach program to educate the public via social media, workshops and seminars, about the results of this research project, and, (5) propagate and grow the most successful plant materials for further testing at Moody Gardens and other locations on Galveston Island.

This project is a first for Galveston Island in that it establishes a long-term platform for plant materials testing. The plot is less than 2 m above sea level and windy conditions off Offatt Bayou exacerbate aerial salt damage. Hurricane Ike in 2008 is a benchmark for high water levels in that it inundated much of the island with sea water. Ocean water at a salinity of 36 parts-per-thousand (ppt) [average sea water—34.7 ppt; fresh water 0-0.5 ppt] and Offatt bayou bay water at 18-24 ppt moved across the island for over 36 h. Consequently, the island lost 55,000 old live oaks, many quite old. Many other species succumbed. There is strong evidence that annual high tide levels are increasing and “clear day high tides” and “nuisance flooding” events are becoming more common.

The project has built about 1.6 (1 miles) of 2.4 km (1.5 m-wide) beds using off-island sand and composted pine bark tilled in and mulched with the same. A trellis system will be completed during the next month. The project is intended to serve as a long term platform for salinity research and for comparing new ornamentals that perhaps have both soil and aerial salt tolerance. Our responsibility is to find and acquire potential ornamental candidates, plant them in groups of five, map their location, and evaluate performance for 3 years. After a few years, promising plants will be dug and placed into the Moody Gardens landscape, into civic projects on the Island, or discarded. New plants will be rotated into the plots.

The current plot includes the following in multiples of five: *Acacia anisophylla*, *Allagoptera arenaria* (seashore palm), *Malacomeles denticulata* (syn. *Amelanchier denticulate*) (Mexico form), *Butia capitate* (jelly palm), *Butia capitata* × *Syagrus romanzoffiana* (Mule palm), *Callicarpa rubella*, *Chamaedorea radicalis*, *Chamaerops humilis* (green form of Mediterranean fan palm), *Chamerops humilis* (blue form of Mediterranean fan palm), *Eucalyptus* LLC1 (cold hardy introduction by Mark Crawford), *Euscaphis japonica* (Korean sweetheart tree), *Ficus afghanistanica* subsp. *afghanistanica*, *Grevillea robusta* (silky oak), *Hibiscus dasycalyx* (Neches river rose mallow), *Hibiscus hamabo*, *Ilex vomitoria* (Yaupon, coastal), *Leucophyllum langmaniae* ‘Lynn’s Legacy’ (Texas sage), *Livistonia chinensis* (Chinese fan palm), *Myrcianthes fragrans* (twinberry), *Nannorrhops ritchieana* (Mazari palm), *Parrotia persica* (ironwood), *Phoenix canariensis*, (Canary Island date palm), *P. sylvestris* (silver date palm), *Populus nigra* (black poplar), *Prunus* ‘Purple Pride’, *Punica granatum* (pomegranate, five cultivars), *Quercus canbyi* (Canbyi oak), *Q. rysophylla* (loquat leaf oak), *Q. virginiana* (live oak, coastal), *Rhapis excelsa* (lady palm), *Sabal mexicana* (Mexican palmetto), *S. minor* (dwarf palmetto), *S.* × *brazoriensis* (Brazoria palm), *Salix babylonica* (syn. *Salix chinensis*), *S. humboldtiana* (Humboldt’s willow), *S. nigra* ‘HSC weeping’, *Serenoa repens* (blue form saw palmetto), *S. repens* (green form saw palmetto), *Sophora affinis* (Eve’s necklace), *S. secundiflora* (Texas mountain laurel), *Taxodium* (Nanjing

Botanical Garden), *Taxodium* 405 (Nanjing Botanical Garden), *Taxodium* 406 (Nanjing Botanical Garden), *Taxodium* 407 (Nanjing Botanical Garden), *Taxodium* 502 (Nanjing Botanical Garden), *Taxodium* 'Oaxaca child', *Trachycarpus fortunei* (windmill palm), *Washingtonia robusta* (Mexican fan palm), *Yucca gloriosa* var. *tristis* (syn. *Yucca recurvifolia*) (soft yucca). Numerous plants will be added as this project progresses.

Two master of science thesis projects are underway. Elaine Harris, Environmental Science, is testing three species (*H. hamabo*, *Q. virginiana*, and *Taxodium* '406') in plots that include with and without raised beds, with and without gypsum, and with and without incorporated bark. Survival has been good on all treatments after one growing season. Height and diameter growth are also being measured as plant response variables. Select soil chemistry parameters, including sodium adsorption ratio and electrical conductivity, have been monitored along with sea spray aerosol Na and Cl input via dry-fall and wet-fall. Elaine Fowler, a biology student, is studying the mycorrhizal association of salt-tolerant plants in the research plots and to determine the effects of soil treatments on bacteria, actinomycete, pseudomonad, and fungal populations.

HIGHLIGHTS OF THE SFA GARDENS PLANT EVALUATION PROGRAM

The mission of the SFA Gardens is to assemble a wide range of woody ornamentals, plant them in a landscape setting and evaluate their performance over many years. Major collections include clones and genotypes of baldcypress, maple, oak, Chaste tree, hydrangea, crapemyrtle, and camellia. The focus of this work has been described in previous *Combined Proceedings of the International Plant Propagators Society* and many are covered in the author's blog: https://dcreechsite.wordpress.com/

The bald cypress collection is represented by over 136 genotypes or cultivars with special emphasis on clones introduced by the Nanjing Botanical Garden, Nanjing, China. Most of those are numbered selections of controlled crosses between Montezuma cypress and baldcypress (*T. distichum* var. *mexicanum* × *T. distichum* var. *distichum*). Currently, one selection 'T406' has demonstrated good form, no knees, fast growth rate, salt and alkalinity tolerance and, most important, good resistance to leaf blight, *Cercosporidium sequoiae* (Ellis and Everh.) W.A. Baker and Partridge. Clones and genotypes from high-rainfall, high-humidity areas generally have less defoliation associated with the presence of this leaf blight fungus (McDonald et al., 2008).

Acer saccharum subsp. *skutchii*, the Mexico mountain sugar maple, is rarely encountered in Mexico, where it is endangered, and in USA collections. This species features good heat and alkalinity tolerance, fast growth and adaptation to the Gulf South—including central Texas in sites where sugar maples generally perform poorly because of soil alkalinity issues. The SFA Gardens has a research plot of 277 seedlings planted in 2011 and seven selections made purely on the basis of form.

The Mexico oak collection includes several species that are close to USA champs, including: *Q. rysophylla*, loquat leaf oak; *Q. canbyi*, Canbyi oak; *Q. polymorpha*, Monterrey oak; *Q. grisea*, gray leaf oak, *Q. germana,* Royal oak; *Q. tarahumara*, basin leaf oak. Our most recent acquisition, *Q. insignis,* features the largest acorns in the genus and will be planted in the winter, 2016.

The crapemyrtle collection is located in the SFA W.R. Johnson coliseum parking lot and along nearby LaNana creek. This planting is a cooperative project with the program at LSU, Hammond, Louisiana, under the direction of Allen Owings. The focus of the project is to compare and evaluate the latest varieties of crapemyrtles, with particular attention to bloom period and foliage quality.

Finally, the most recent development centers on fruit variety evaluation with the recent plantings of 17 varieties and selections of pecans, a vineyard with 56 varieties and selections of muscadine grapes, a planting of 70 fig varieties, a planting of over 100 genotypes and cultivars of blueberries—and finally, an evaluation plot for golden kiwifruit, *Actinidia chinensis*; it received some interest due to good crops in 2014 and 2015, and a modest crop in 2016.

CONCLUSIONS

The SFA Gardens has been planting uncommon, rare and unusual trees and shrubs since 1985. Collections include many ornamentals common to the landscapes of the South, providing a germplasm repository for interested nurserymen, landscapers and botanists wanting to compare plant performance, obtain cutting wood, or simply make observations in the garden.

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Recycled water quality dynamics and implications for ornamental crop production©

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INTRODUCTION

Capture and reuse of agricultural runoff for irrigation was first adopted primarily for environmental protection (Skimina, 1986). Over the past 30 years, this practice has evolved to be an important sustainability strategy for many ornamental crop production nurseries. However, until very recently, little was known about recycled water quality dynamics in runoff containment ponds (Hong et al., 2009). In that 2009 study, we discovered through continuously monitoring that water quality in a containment pond fluctuates dramatically over time with pH being mostly alkaline. To determine whether this fluctuation and alkaline pH prevalence also occur in other containment ponds, we have since expanded the monitoring program to include nine ponds in Virginia, two in Maryland, and one in Mississippi through a joint project with University of Maryland and USDA ARS Southern Horticultural Lab (http://www.irrigation-pathogens.ppws.vt.edu/). This expanded monitoring demonstrated that dramatic fluctuation and alkaline pH prevalence are common in containment ponds (Zhang et al., 2015a, b, 2016). This presentation uses a small subset of the Virginia data to illustrate this and some other major findings and discuss their potential implications for ornamental crop production.

CONTINUOUS MONITORING OF WATER QUALITY

Water quality monitoring was performed in eight recycling irrigation ponds and one adjacent small stream at three nurseries in eastern Virginia (VA1 and VA3) and central Virginia (VA2). At nursery VA1, the first pond, labeled VA11, receives storm water and irrigation runoff directly from ornamental crop production areas. Water flows from VA11 to VA12 through a culvert. When VA12 is full, water can flow into VA13 by opening a sealed culvert. Both VA12 and VA13 are pumped for irrigation. VA10 is a small stream that flows along the perimeter of the nursery and does not receive any runoff water from the nursery production areas. At nursery VA2, three ponds (VA21, VA22 and VA23) have a similar arrangement of water flow. However, VA21 has a large holding capacity thus water in this pond seldom overflows into VA22 unless there is a severe storm with heavy rain. VA23 receives water from VA22 through a connecting culvert and is the only pond used for irrigation. VA31 and VA3X at nursery VA3 are not connected. VA3X receives some runoff water from nearby agronomic crop fields outside of the property, while VA31 directly receives irrigation and precipitation runoff from production areas at this horticultural facility.

A multiprobe Sonde (Figure 1) was anchored in the middle of each selected pond and set to continuously record surface water quality. Water quality parameters monitored included temperature, pH, oxidation-reduction potential (ORP), electrical conductivity (EC), turbidity, dissolved oxygen (DO), chlorophyll *a*, and blue-green algae, plus the depth at which water quality data were taken. Recorded data were communicated directly from four Sondes in VA10, VA12, VA 21, and VA23, respectively, to an office computer via telemetry systems and Verizon satellites or manually downloaded from other Sondes. Sondes set for real-time data communication were programmed to record data every 15 min., while the others recorded data hourly.

As shown in the computer screenshot (Figure 2), the system was programmed to have a background photo showing a pond where water quality was being monitored and different gauges showing real-time water quality data in the pond with pH, DO, EC and depth on the

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top, while chlorophyll *a*, blue-green algae, turbidity, temperature, and ORP at the bottom. The gauge in the middle was a system status gauge; a green check indicates that the system works properly, while a red cross would mean that the system is out of service.

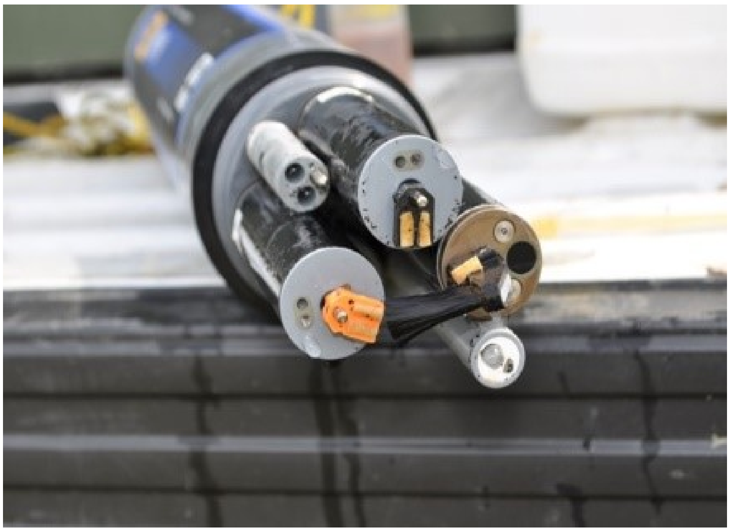

Figure 1. A multiprobe Sonde set to continuously monitor water quality.

Figure 2. Real-time data communication via a telemetry system and Verizon satellites.

RECYCLED WATER QUALITY DYNAMICS

Water quality fluctuation and alkaline pH prevalence are common in recycling irrigation ponds

As illustrated with water pH and DO in three ponds and one adjacent stream over a 5-week period from April to May 2011 (Figure 3), recycled water quality fluctuated dramatically over time. The degree of fluctuation was proportional to the load of nutrients that nurture algal bloom and cycling. The more nutrient load, the greater degree of fluctuation! For example, water pH in VA12 receiving runoff water overflowing from a small sedimentation pond fluctuated from 6.4 to 9.5 during this short period of time. In contrast, water pH in VA10 receiving no runoff water from production areas had little fluctuation with readings consistently at slightly below 6.0. Likewise, much greater degree of water pH fluctuation was observed in VA21 than VA23. Similar patterns and differences were also seen in DO between two pairs of ponds/stream. These new data support our previous finding (Hong et al., 2009) and demonstrate that water quality fluctuation and alkaline pH prevalence are common in containment ponds.

Recycled water quality also may fluctuate greatly within a day

There also were diurnal patterns of water pH and DO fluctuation in these ponds/stream, bottoming around 6 A.M. and peaking between 4 and 5 P.M. (Figure 3). As with their seasonal patterns, these diurnal patterns were closely related to photosynthesis activities in ponds. When the sun rises, algae and other photosynthetically active agents remove carbon dioxide, a weak acid, from water to make carbohydrate while releasing oxygen. Consequently, water pH and DO goes up. This process is expedited as temperature rises. Thus, recycled water pH, DO and temperature fluctuate almost simultaneously. These diurnal fluctuations depended upon the nursery location, nutrient load, and the time of year. The greatest pH difference from the lowest to the highest point of day across all ponds monitored was 3.5 units.

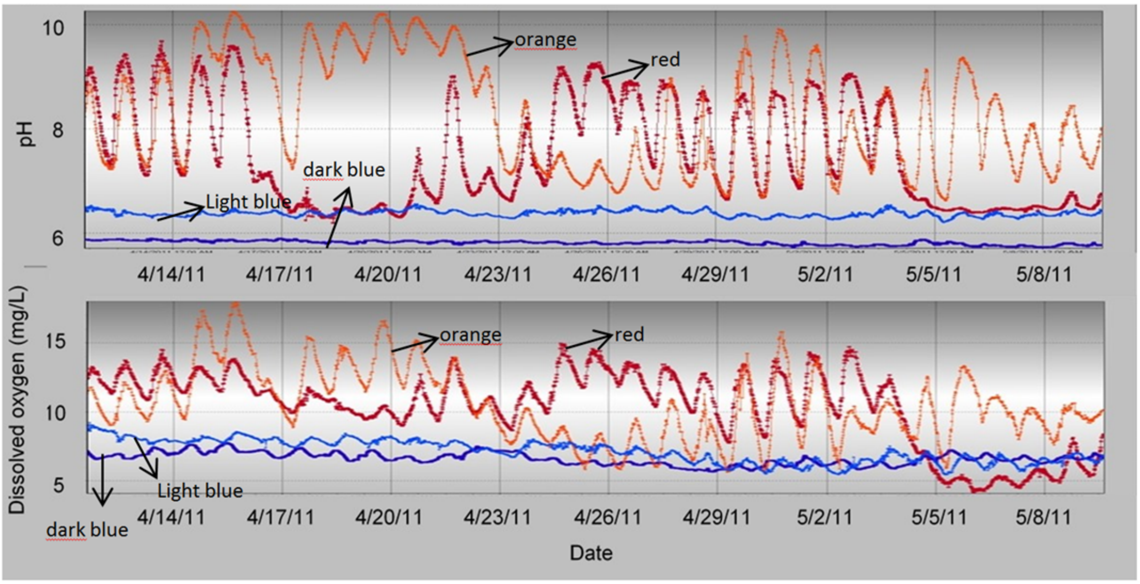

Figure 3. Seasonal and diurnal fluctuation of water pH and dissolved oxygen in VA10 (dark blue), VA12 (red), VA21 (orange) and VA23 (light blue).

Recycled water quality varies at different depths of water column

Recycling irrigation ponds generally are shallow. The depth of water column across all ponds and stream we monitored ranged from 0.8 to 3.9 m (Zhang et al., 2016). It was found by surprise that water column was thermally stratified from April to October in all the ponds including the shallowest sedimentation pond, with the warmer and lighter water on the surface layer (epilimnion), cooler and heavier water in the bottom (hypolimnion), and a transition zone in the middle (Metalimnion) (Zhang et al., 2016). This thermal stratification prevents water mixing within water column, pushing surface water quality fluctuation to the extremity (Zhang et al., 2015a). As a result, water pH is normally 1 or 2 units higher at surface than at depth of water column.

IMPLICATIONS FOR ORNAMENTAL CROP PRODUCTION

As we have just begun a steep learning curve on recycled water quality dynamics, our knowledge about its impacts on ornamental crop production is largely not known at this time. Here we will use water pH as an example to discuss how it may affect crop growth and quality, nutrient availability, and the performance of chlorination, a water treatment technology that is widely used in the ornamental horticulture industry.

Growth and flower quality of some ornamental crops

Per the general irrigation water quality guidelines (Yaeger et al., 1997), recommended pH range for ornamental crop production is 6.5 to 7.0. Once pH goes above 7.0, the degree of problem increases. A recent study with peony (*Paeonia lactiflora* Pall.) has clearly shown that irrigation water pH negatively impacted plant growth and quality in a number of ways (Zhao et al., 2013) For example, plants irrigated with water at pH 7.0 produced the largest and most colorful flowers, while those irrigated with water at pH 10.0 did not have flower at all. Similar water pH impacts were observed in another study with marigold (*Tagetes* spp.) Plants irrigated with water at pH 7.8 produced fewer flowers and had a lot more yellowing lower leaves than those irrigated with water at pH 6.4 (Valdez-Aguilar et al., 2009). Recycled water pH is mostly alkaline (Hong et al., 2009). How this range of water pH may impact the growth and quality of other ornamental plants is yet to be determined.

Nutrient availability

Nutrient availability is subjected to pH (Yaeger et al., 1997). Among the micronutrients most prone to prevalent alkaline pH are iron, manganese, copper, and zinc. If recycled water is used for irrigation, these elements should be the first to be checked when potential nutrient deficiency issues emerge. Many nurseries now use Actino-Iron® as a fungicide and in some cases also as plant growth enhancer. Whether there is a linkage between increased use of recycled water for irrigation and the benefits of applying Actino-Iron® at production facilities is a worthwhile question for horticulturists to look into in the future.

Chlorine performance

Chlorination remains the most cost-effective water treatment today but its performance is really subject to water pH due to its chemistry (Hong and Richardson, 2004; Hong et al., 2003). There are two major species of free chlorine in water: hypochlorous acid (HOCl), a strong sanitizer, and hypochlorite (OCl), a weak sanitizer. Hypochlorous acid is estimated to be 20 to 80 times more effective than hypochlorite in controlling *Escherichia coli* (White, 2010). These two free chlorine species are in equilibrium in water, depending upon pH (Figure 4). At pH 5.0 to 5.5, all free chlorine is hypochlorous acid. This is the pH range at which chlorine is most efficacious. As water pH increases, hypochlorous acid portion of the free chlorine drops rapidly while hypochlorite portion increases equally. As a result, chlorine performance decreases sharply, by 25% at pH 7.0, 74% at pH 8.0, and 90% at pH 9.0. As the most likely pH range for recycled water is 8.0 to 9.0 or even higher, so treating such water without prior-acidification, a large percentage of chlorine dollars would be lost.

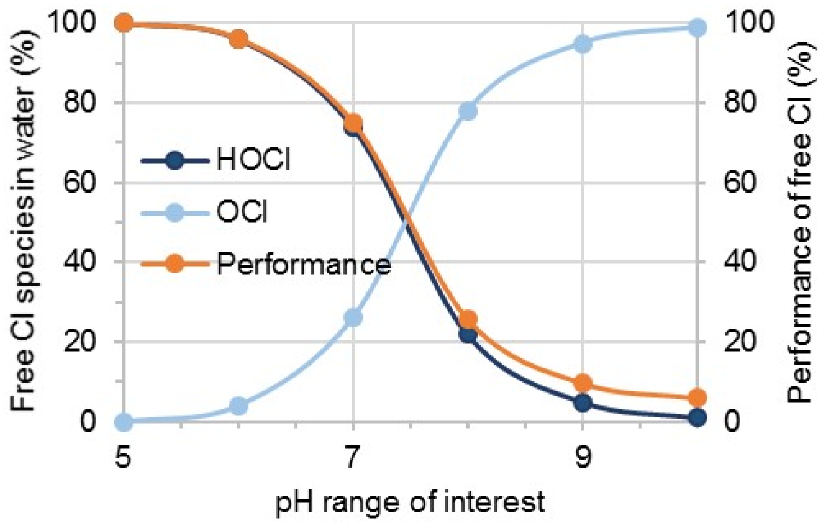

Figure 4. Water pH and chlorine performance (Assuming that OCl efficacy is 1/20 of that of HOCl).

RECOMMENDATIONS

Based on what we have learned so far about recycled water quality and its potential impacts, taking a few simple steps outlined below will help improve crop quality and productivity and stretch your investment dollars.

1) A multi-pond recycling system is ideal if you can afford it. The system should have a stepwise water flow with runoff from all production areas being captured in the top pond. Water should be pumped out from the bottom pond for irrigation use, as did nursery VA2.
2) Place the pump inlet in the middle or slightly below in the water column because its water pH could be a couple units lower than that of surface water and such a pH decrease will chlorine performance and other benefits.
3) If your chlorination system turns on automatically when irrigation is cut on, irrigate crops in the morning when water pH at its lowest point of the day. This will also improve the performance of your chlorine dollars.

Not every grower has the luxury to implement all three recommendations above. But recommendations #2 and #3 could be easily implemented at every and each nursery - requiring no or little additional investment. These two recommendations alone should greatly mitigate the negative impacts of recycled water quality on crops while stretching the chlorine dollars. In cases where recommendations #2 and #3 are not sufficient—the next step is to check water pH regularly, and adjust as needed for the optimum chlorine performance, crop quality and productivity.

ACKNOWLEDGEMENTS

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Using mind control tactics to manipulate employees©

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INTRODUCTION

Honestly, this paper will not teach you "mind control", but it will give you a slightly better understanding of working with people. The thing about people is that we are all the same, yet we are all so very different. But as you begin to understand how this uniqueness manifests in others and what drives certain behaviors, we can learn to alter our behavior and communication. This will help in better anticipating and strategizing in working with different personalities to accomplish goals and tasks.

What makes a business successful? Maybe it's the right idea at the right time, maybe a high quality product? But what I and many others would argue is that one of the most important factors is having a good team. What good is a great, new idea without the people to back it up and see it to fruition? How do you continue to produce a quality product without a team to create, manage, and distribute it?

Think of it from a financial standpoint. I have heard countless conversations in the industry about labor being one of the biggest expenditures in the business. If you have a job to do, you want someone who is well suited for that job that will do it well. You would not buy a screwdriver to use it as a hammer. Obviously it is capable of doing the job of a hammer, but without using its full ability. Utilizing the skill and talents of employees should not be any different.

We all have a different set of mental tools that we are comfortable using. We all may have access to the same basic tools—but prefer a particular tool or set of tools for a particular project. These unique sets of preferences give us our distinct personalities and make us appear similar or dissimilar to others.

This is the concept of personality or trait psychology. The purpose of which is to make sense of these different preferences and how they drive our behavior. It about perceptions—how you perceive yourself, how you perceive others—and how other people perceive us.

If I was 2.4 m (8 ft) tall, I would perceive everyone around me as short. I would wake-up and wonder why I am surrounded by so many short people. It is not that everyone around me is short, just that I am really tall. That is an obvious physical difference, which you cannot ignore. However, personality differences are not as obvious.

These perceptions drive the way you communicate with others. If you are not aware of these different views, your brain runs on autopilot and assumes that each interaction you have goes a certain way, and that you have no control. But you can have control! Our brains are made up of systems of patterns that process communication and drive our behavior. So, if we recognize those patterns in our brains and notice them in others, we have more control over how our interactions pan out.

The idea of personality assessment and "typing" can be used to create a framework based on preferences for you to understand yourself better and more effectively and relate to others. There are many models that you can use in the business world to facilitate a more cognizant self-awareness.

MYERS BRIGGS TYPE INDICATOR

The purpose of this paper is to focus on the Myers Briggs Type Indicator, http://www.myersbriggs.org/. It is one of the more popular assessments, and has been used by businesses since it began in 1944. It starts with four overall temperament groups (Table 1).

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Table 1. The four overall temperament groups of Myers Briggs.

Guardians:	**Rationalists:**
Organized	Pragmatic
Honest	Strategic
Dependable	Independent
Responsible	Objective
Humble	Efficient
Hard-working	Ingenious
Artisans:	**Idealists:**
Adaptable	Inspiring
Loyal	Unique
Laid-back	Flexible
Fun-loving	Passionate
Artistic	Altruistic
Curious	Creative

Temperament groups

1. Guardians.

First are the Guardians; dependable, hardworking, and honest. This group makes up the biggest percentage of the world's population, and a good thing too, because they are the backbones of society. These are your worker bees, they are here complete the task at hand. These people value tradition above all else, like military and police, but also thrive as determined business men and women. Think of that person in the office who you know you can always count on to get a task completed. You know you can give them a list and they will see it to completion exactly as you wanted. This type respects authority and has a strong sense of right and wrong. They make good supervisors and managers. They want everyone to follow the rules and are here to enforce them.

2. Artisans.

Secondly are the Artisans; fun-loving, adaptable and living in the moment. They are connected with the world around them in a mentality of spontaneity and are adventurers. They see the world for what it is: in the current moment and want to embrace it all. They are creative in solving the problems you are facing, excel in crisis situations, and do not hold on to things too long. You'll often find these types of people in sales, in entertainment, or as self-employed business owners. They want to do things their way and need the freedom to do so! They are here to have fun and many want to share that with those around them. These types are not afraid of risks which can lead them to great success or failures.

3. Rationalists.

We also have Rationalists; the analytical, pragmatic problem solver, strong, independent, self-contained, determined, and logical. These are the people that always have an ingenious new way of getting systems in place and coming up with strategic plans. They value intellect and competence. You have a brain in your head—and the rationalists think you ought to use it. They are very forward thinking, always 4 or 5 steps ahead of the game. They tend to be lawyers, scientists, and engineers. Incredibly goal driven individuals that are insatiable until their achievement is met. To rationalists, work is work and play is work. They are constantly searching for new knowledge and a new way to challenge themselves. This group makes up a small percentage of the overall population but these are the people that change the world.

4. Idealists.

Lastly are the Idealists; warm, inspiring, trying to make the world a better place. This group values harmony above all else. Often times you will find them in service professions where they can thrive helping others; kind-hearted, loving, and romantic in their view of the world. They excel at reading people, and you will find that you can count on them. This type is constantly thinking about the future, always coming up with ideas on how to make things better for everyone involved. The creator of the Myers Briggs Type Indicator (MBTI) was an idealist. She developed MBTI during WWII as a way for women to understand their strengths and find new careers they would excel at. This was during the period when men were off fighting in the war—and it was critical to find new talent to fill the needs of industry and business. She wanted to create a better working community with the circumstances they had been given. Idealists are passionate about their interests and care deeply for the world around them.

DIFFERENTIATING FACTORS WITHIN EACH CATEGORY

As mentioned before, the four groups only start to categorize the various Myers Briggs Types. There are also differentiating factors within each category that break them up farther and give each individual one of 16 types: introversion vs extroversion, intuition vs sensing, feeling vs thinking, and judging vs. perceiving. Each one of the 16 types is much more specific and describes each individual's perception of the world in much more detail. The following is a list of the overall 16 personality types and which temperament group each falls into (Table 2).

Table 2. The 16 personality types[1] within each temperament group of Myers Briggs.

Guardians:	**Rationalists:**
ISTJ – Introversion, sensing, thinking, judging	INTJ – Introversion, intuition, thinking, judging
ISFJ	INTP
ESTJ – Extroversion, sensing, thinking, judging	ENTJ – Extroversion, intuition, thinking, judging
ESFJ	ENTP
Artisans:	**Idealists:**
ISFP – Introversion, sensing, feeling, perceiving	INFJ – Introversion, intuition, feeling, judging
ISTP	INFP
ESFP – Extroversion, sensing, feeling, perceiving	ENFJ – Extroversion, intuition, feeling, judging
ESTP	ENFP

[1]Extraversion (E) or Introversion (I); the way you take in information: Sensing (S) or Intuition (N); how you make decisions: Thinking (T) or Feeling (F); how you deal with the world: Judging (J) or Perceiving (P).

Understanding which group you fall into is key because even though you may perceive yourself in a positive light, those that are different or opposite of you may read your behavior in a negative way (Table 3).

Table 3. Perception of the four temperament groups of Myers Briggs.

Guardians:	**Rationalists:**
Stubborn	Cold
Overly cautious	Insensitive
Inflexible	Arrogant
Judgmental	Overly analytical
Intolerant	Condescending
Artisans:	**Idealists:**
Overly dramatic	Sensitive
Flaky	Perfectionistic
Unreliable	Burn out easily
Easily Bored	Impractical
Impatient	Easily stressed

The reality is that if one is unaware of the differences in perception—you will only view yourself as the positive side—and be oblivious how others may perceive the negative side. Unfortunately, if you are interacting with someone whose preferences are opposite of yours—you also tend to see them with a negative perception. The inflexible Guardians stomp out the impractical passion of the Idealists. The Artisans become too unreliable for the overly analytical Rationalist to take seriously. These misunderstandings cause struggles in communication and turbulence in relationships—leaving people of diverse types feeling misunderstood—and especially leaving the Idealists unhappy about the lack of harmony.

Carl Jung, considered the father of personality psychology has a quote that states, “Everything that irritates us about others can lead to an understanding of ourselves.” Begin to think about those you regularly interact with. Realize that when you are struggling with someone there are ways to facilitate better interactions.

We all have the same tools, we just use them differently, and you are likely going to work with a mix of all the different types. Start by trying to meet those other types on common ground (Figure 1).

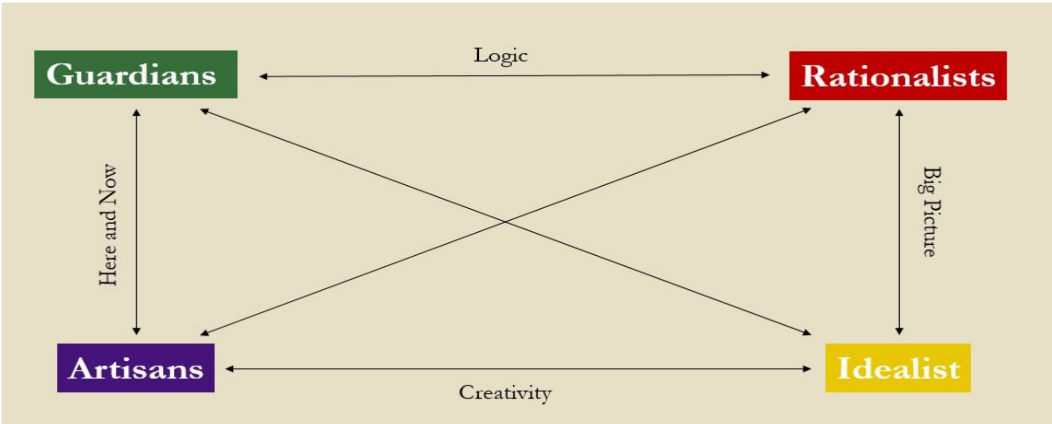

Figure 1. Finding common ground among the four temperament groups to positively interact.

Guardians and Rationalist both value logic. So if you are a Rationalist working with a Guardian—talk logistics. Artisans and Idealists relate to one another’s creativity. Guardians and Artisans both share a value for things that are tangible in the here and now—the things one can see, taste and touch. Whereas, the Idealist and Rationalists see the big picture, and share a vision of what could be instead of what is.

As you start to work with your opposites be aware that you have got a little more adjusting to do to build the communication bridge there. But it is not impossible. Here are some examples of effective ways opposites can communicate and work together.

Example 1

An Idealist manager wants to come up with a better, more efficient way to cover cold frame houses. He or she has noticed the old way causes too many tears and takes too much time. The Guardian subordinate that has been with the business for a couple years, receives an email from the idealist saying, “Hey, come up with a new way of doing this.” That Guardian will feel paralyzed. They are being asked to change something they are comfortable with for some period and have not been given a whole lot of direction. In a better way to approach this project, the Idealist should explain what was not working before—and that they need to fix the problem. Give the Guardian some options. Use their input and ideas to help sort through the details, what can and cannot be done, and together find a solution that benefits everyone. And once there is a plan, he or she will see it to completion exactly as described. Hence, both parties (personality types) feel fulfilled. The Guardian gets to fix a problem with a practical solution and the Idealist gets to see a new concept to fruition, creating a sense of harmony by having all parties on the same page.

Example 2

An Artisan and Rationalist are working on what plants to order for the following spring. The Artisan wants to hit the ground running: what is new, exciting, and shiny. They want to try it All—and do it right now. The Rationalists are pragmatic. They want to think about is and grasp the logic. What did we grow last year? What is a new worthwhile plant? How many *Hydrangea paniculata* cultivars do we actually need to grow? They want to make a plan, a budget, and focus on the big picture. But before the Artisan feels trapped and the Rationalist is overwhelmed—they can meet in the middle. Allow the Artisan to focus on what is new and better. Let the Rationalist explain what is possible and what the purpose is.

The more aware you become of these personality differences, the better you will be at altering your behavior to facilitate better communication. This enables one to become a better manager and become more adept at placing people in tasks that are better suited for their strengths. Many of us have heard the Einstein quote, "Everybody is a genius. But if you judge a fish by its ability to climb a tree it will live its whole life believing it is stupid."

Go back to the analogy of the screwdriver. Each of these different personality types are capable of doing jobs that are outside their preferences, but it will stress them and they will not feel fulfilled. Think of the different jobs in the nursery industry and what kind of people might be best for those jobs—or what different types can bring to those jobs. IPM and quality control (QC) management are constantly changing. You have to constantly put out fires, work with multiple moving parts and can develop creative solutions. This is where an Artisan can thrive—able to focus in the moment and conquer the issue. But they might need the help of a Guardian to see that they check every box and do not miss the details.

A nursery grower needs to have a plan and understand the big picture. This is where a Rationalist's natural skills can be utilized. Managing people can be difficult. Trying to find ways to make everyone happy can be challenging for many types, but that harmony seeking Idealist can really use their strengths to help. This does not mean that a Guardian will not make a great grower or manager—but they may need support from other types, too.

All of these things come back to creating an environment where your employees can thrive. Creating better communication and giving them tasks that make them feel they are contributing. These are the important things that keep employees around for years. The take home messages is to make yourself AWARE. Be aware of this new way of thinking and use it to recognize similarities and differences in people. Be self-aware; understand how you communicate, what you bring to the table, and what your strengths and weaknesses are. Finally, be aware of others. Understand that there is no ideal "normal person." Each of us is born with different gifts, unique ways in which we use our minds, values, and feelings to live every day.

Effects of Tween® 20 on growth and drought tolerance of coleus 'Wasabi' (*Plectranthus scutellarioides*)©

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INTRODUCTION

Water is essential for drinking, personal hygiene, power production plants, and agricultural food and animal production. Some 97.5% of the global water supply is unusable salt water. From the remaining 2.5% of fresh water, only a third can be withdrawn from the environment for use. Roughly 70% of all the fresh water drawn from the environment is used for irrigated agriculture (Seckler et al., 1998). Because irrigated agriculture consumes such a large percentage of the available fresh water, optimizing irrigation efficiency in all sectors of horticulture and agriculture is critical. Moe and Rheingans (2006) estimated that 50% less water could be used for irrigation if highly efficient irrigation practices were adopted.

One way that water use efficiency (WUE) on the physiological level can be enhanced is by decreasing the transpiration rate while increasing or maintaining a steady state of carbon fixation on a leaf level basis. Yang (2008) discovered that by applying 100 ppm of the non-ionic surfactant Tween® 20 (polyoxyethylene sorbitan monolaurate, $C_{58}H_{114}O_{26}$) with irrigation water, it was possible to decrease the transpiration rate in *Impatiens hawkerii* 'Celebrate Salmon' grown in soilless media by roughly 50% while maintaining the same growth as the control plants. The same experiment was repeated in a hydroponic system with the same impatiens species with the addition of *Spathiphyllum floribundum* 'Viscount' with similar results. In a different study, Kubik and Michalczuk (1993) showed that foliarly applied Tween® 20 could decrease transpiration rates in strawberry plants.

Water use efficiency does not intrinsically equate to drought tolerance. The objective of this study was to determine effects of Tween® 20 on drought tolerance in response to altered transpiration rates. Coleus was selected as the study plant because it readily wilts under drought stress making it an ideal plant to observe. A second goal of this study was to determine if product application frequency would affect drought stress. A final goal was to compare the performance of Tween® 20 with that of two similar commercially available soil conditioning products: Aqua-Gro® L with PsiMatric Technology and Hydretain® ES Plus. Both of these products advertise that they can reduce watering by up to 50%, which is similar to what was discovered with Tween® 20. If Tween® 20 does not outperform the established products it may have limited market viability.

MATERIALS AND METHODS

Plant material

Single rooted cuttings of coleus [*Plectranthus scutellarioides* (L.) R.Br. 'Wasabi' (syn. *Solenostemon scutellarioides* 'Wasabi')] from Tagawa Greenhouses, Brighton, Colorado were transplanted into 16.5 cm (6.5-in) azalea pots filled with Fafard 3b. Immediately after transplanting into azalea pots all plants were watered in with a 200 ppm 20-10-10 liquid fertilizer until water was uniformly leached from the pots.

Chemical materials

Three low toxicity, organic chemicals were tested in this project for their effect on plant growth, drought tolerance, and soil moisture retention. Tween® 20, a nonionic surfactant, was the primary product being investigated. Hydretain® and Aqua-Gro® L, commercially sold and used as soil conditioners, were included in the experiment to

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compare with Tween® 20. Concentrations of 100 ppm Tween® 20; 320 ppm Hydretain®; and 100 ppm Aqua-Gro® L were selected for this experiment based on previous research and product labels.

Irrigation

Plants were irrigated through a drip irrigation system. Each product was injected into a drip irrigation system with a D14MZ2 Dosatron injector (Dosatron, USA). Uniform water output was accomplished with 3.2 gph Woodpecker pressure compensating emitters (Netafim™). At each irrigation event, plants were watered for 60 s providing an output of 200 mL.

Experimental design

The experimental design was a two-way factorial with repeated measurements on soil moisture. Plants were arranged on a single greenhouse bench in a completely randomized block design. The two factors investigated were product type and the application timing of the product. Plants were either treated with Tween 20, Aqua-Gro L, Hydretain, or no product (control). The second factor was timing of application. For each product type, the product was applied only during the first irrigation event (after the initial watering), applied at every irrigation event, or only applied on the last irrigation event before the period of drought stress. A third factor was to take soil moisture measurements at multiple times throughout the experiment. The experiment consisted of 10 treatments, including the control (Table 1). The treatments were designed based on three different drought tolerance products (Tween 20, Hydretain, and Aqua-Gro L) and three different application times (every irrigation, initial irrigation only, and final irrigation only) giving a total of 3×3 = 9 treatments plus the control (no drought tolerance product) = 10 treatments.

Table 1. Visual symptoms of drought based on a 0-3 scale. 0 = no wilt; 1 = minor wilt; 2 = moderate wilt; 3 = severe wilt.

		Drought rating		
Product	**Irrigation**	**Mean**	**Mean difference (± SD)**	***P***
Control	Control	2.60	-	-
Aqua-Gro L	Everytime	2.46	-0.1429 ± 0.85	0.66
	First	2.46	-0.1429 ± 0.85	0.66
	Last	2.46	-0.1429 ± 0.85	0.66
Hydretain	Everytime	3.00	0.4286 ± 0.84	0.19
	First	2.89	0.2857 ± 0.85	0.38
	Last	2.75	0.1429 ± 0.85	0.66
Tween 20	Everytime	2.89	0.2857 ± 0.85	0.38
	First	3.00	0.4286 ± 0.85	0.19
	Last	2.75	0.1429 ± 0.85	0.66

1. Timeline.

Beginning 2 days after plants were transplanted and initially watered in, plants were irrigated once in the morning, every other day for a period of 9 days equaling a total of five irrigation events during the 9-day period. The final day of irrigation doubled as the initiation of the drought phase of the experiment. Including the final day of irrigation, the drought phase of the experiment lasted 10 days. On the tenth day plants were observed and given a drought rating based on visual symptoms of wilt. Above ground shoots were harvested to determine dry weight. Plant size index was measured the day after the final irrigation by averaging the plant height, width at widest point, and width perpendicular to widest point.

2. Soil moisture retention and evapotranspiration.

Soil moisture readings were taken twice a day on the day plants were irrigated: once at

7:00 A.M. prior to irrigation and once at 11:00 A.M., which was 2 h after irrigation. Soil moisture data was not taken on the days in between irrigation events. Beginning on the final day of irrigation, soil moisture readings were collected at 7:00 A.M. daily for 10 days until the termination of the experiment. Evapotranspiration for a given day was calculated by subtracting the 7:00 A.M. from the 11:00 A.M. reading of the previous day.

RESULTS AND DISCUSSION

Drought tolerance

In physiological studies one of the most common tools used to quantify drought or other ecophysiological stress is the chlorophyll fluorescence meter. It was our original intent to utilize this tool, however malfunctions occurred and it could not be used. Plants were rated on a visual scale of 0-3, 0 being no signs of drought and 3 being heavy signs of drought (Figure 1). On the 10th day after the last watering, visual ratings were given to plants and there was no difference among any treatments or the control (Table 1).

Figure 1. Visual drought rating (left to right). 0 = no wilt; 1 = minor wilt (1-2 leaves); 2 = moderate wilt (3-5 leaves); 3 = heavy wilt (majority of leaves).

Evapotranspiration

Evapotranspiration (ET) was measured by taking the soil moisture content after irrigation one day and then subtracting from it the soil moisture content taken two days later immediately prior to the next irrigation. The difference in soil moisture content was the percent water by volume lost from ET. There were no overall differences or differences on a daily basis between treatments (Figure 2). A soil moisture sensor is considered a good tool for gauging when to water, but it is not capable of precise measurements, therefore in future studies, ET will be measured gravimetrically.

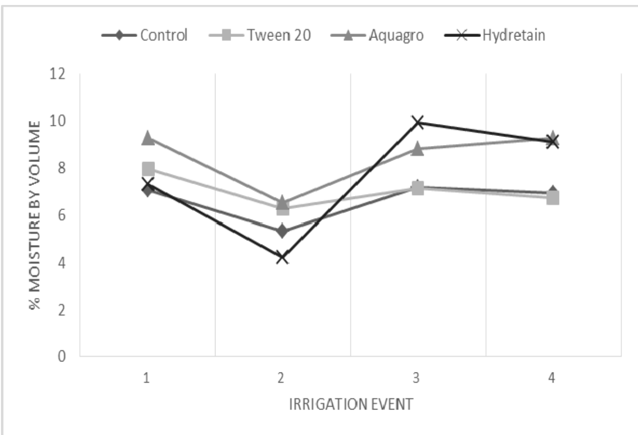

Figure 2. Evapotranspiration was measured as the time in between irrigations events which were 42 h apart.

Size index and dry weight

No differences were noted between treatments for both size index and dry weight (Table 2). This result is not altogether surprising because the products are not expected to be hormonal in nature. One exception is Tween 20 which was reported to influence synthesis of auxins and gibberellins in pea epicotyl segments (Stowe, 1958).

Table 2. Size index was measured by averaging the height + width at widest point + width perpendicular to widest point. Dry weight was measured after drying in oven at 77°C for 40 h.

Treatment		Size index			Dry weight (g)		
Product	Time[1]	Mean	Mean difference (± SD)	*P*	Mean	Mean difference (± SD)	*P*
Control	Control	17.52	-	-	1.86	-	-
Aqua-Gro L	Everytime	17.38	-0.14 ± 3.15	0.91	1.77	-0.09 ± 0.47	0.63
	First	16.95	-0.57 ± 3.16	0.634	1.76	-0.10 ± 0.47	0.58
	Last	16.52	-1.00 ± 3.16	0.41	1.69	-0.17 ± 0.47	0.34
Hydretain	Everytime	18.76	1.24 ± 3.16	0.30	1.96	0.10 ± 0.47	0.58
	First	18.76	0.33 ± 3.16	0.78	1.91	0.06 ± 0.47	0.75
	Last	18.76	-1.05 ± 3.16	0.38	1.76	-0.10 ± 0.47	0.58
Tween 20	Everytime	18.76	2.00 ± 3.16	0.0992	2.1	0.24 ± 0.47	0.179
	First	18.76	0.14 ± 3.15	0.9052	1.7	-0.16 ± 0.47	0.383
	Last	18.76	0.05 ± 3.15	0.9683	1.83	-0.03 ± 0.47	0.874

[1]The product was either applied only during the first irrigation event (First) (after the initial watering), applied at every irrigation event (Everytime), or only applied on the last irrigation event (Last) before the period of drought stress.

Drought soil moisture retention

Soil moisture content measured on a daily basis during the drought period of ten days was not different between treatments (Figure 3).

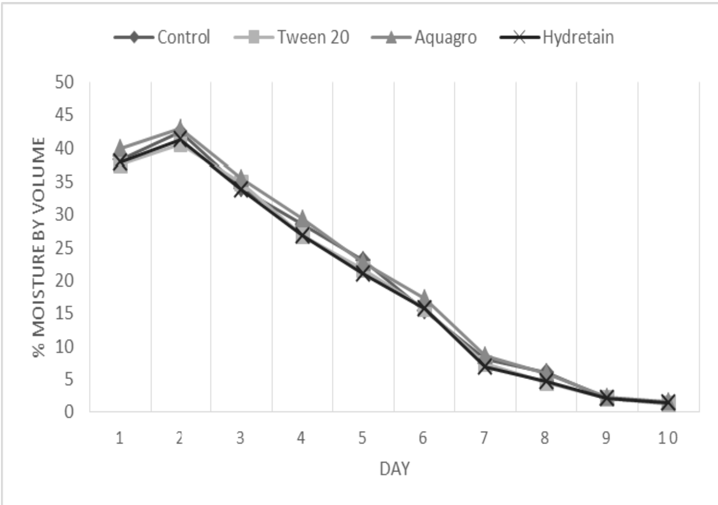

Figure 3. Soil moisture content (SMC) measured as % water by volume. Measurements taken at 7:00 daily for ten days. SMC was measured with a Delta T HH2 soil moisture sensor (Delta T Devices).

No significant differences

Measurements of soil moisture retention and evapotranspiration could be performed much more precisely in the future. Having measured these, especially ET with the soil moisture sensor, there may be error due to a lack of precision. In future studies, an IRGA photosynthesis machine will be utilized to measure leaf gas exchange. In addition, future studies will also include measurements of leaf water potential and photosystem II efficiency under drought conditions. The concentrations of product applied could also be increased to an extent and still be within label recommended rates which could make a difference in future results.

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All particles matter: the impact of characterizing horticultural substrates©

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INTRODUCTION

Knowledge of substrate particle size and shape is beneficial for reasons such as increasing product efficiency, ensuring specified standards, and maximizing plant growth. Classification of aggregate materials has long been analyzed on the basis of sieve analysis. Sieves work by separating aggregate materials by a particle's 2nd smallest dimension (Allen, 1997). The material is then expressed as a cumulative or differential distribution curve which reflects the percent mass of the material retained or passed through a sieve (Weiner, 2011). Despite its simplistic nature, this is a very crude and rudimentary method of characterizing materials. There are drawbacks to sieve analysis such as: reduced efficacy in worn screens, finite number of sieves, time consuming, data subjected to human error, and no capacity for shape parameters (Rauch et al., 2002; Vaezi et al., 2012).

Since the turn of the millennium, digital analysis has gained interest in the fields of biosystems and civil engineering. The applicability of this newer technology to determine size and shape distributions of aggregate materials has been well established in these fields (Rauch et al., 2002; Vaezi et al., 2012). Engineers have recognized the advantages of digital analysis to include attributes such as large repeatability, small sample sizes, non-destructive nature, and robustness of data.

There are numerous commercially available imaging devises/programs capable of distinguishing particle size and shape. The Computerize Particle Analyzer 2 (CPA-2) is one of three units introduced by W.S. Tyler's parent company, Haver & Boecker, for use in material gradation (Figure 1). Samples are placed into a feed funnel and gradually deposited onto a vibrating channel. The particles transverse the channel and are deposited onto a conveyor system. As every particle leaves the conveyor, it passes between the imaging device and a high intensity LED backlight. The camera utilizes line-scan technology which scans a line of 2,048 pixels 20,000 times per second. By merging successive line scans, the CPA-2 can discern the outline of each particle greater than 34 microns. Utilizing this equipment could give insight to the influence of particle size and shape of container substrate characteristics. However, in order to establish the validity of new testing technology, the results must compare favorably to traditional testing techniques.

The objective of this study is two-fold: evaluate the material limitations of sieve analysis with respect to particle length to width ratio (L:W) and time, and validate the use of the CPA-2 with traditional sieve analysis using capable materials and techniques.

MATERIALS AND METHODS

Sieve limitations

In order to evaluate material limitations of sieve analysis, particles with accurate dimensions were created using 2-, 3-, and 6-mm thick acrylic sheets and a laser cutter (Zing 24, Epilog Laser, Golden, Colorado). To isolate the effect of particle L:W, the width (w) of the particles were cut equal to the height (h) of the acrylic sheets (i.e., 2 mm w × 2 mm h). Only a particle's length (l) and width will be used as descriptive values from this point forward. Eight L:W ratios, ranging from 1:1 to 8:1, were cut in each width (2, 3, and 6 mm) so that the smallest particle evaluated was 2×2 mm and the largest was 6×48 mm. Particle widths were evaluated separately. For each width, 100 particles of each L:W ratio were mixed to represent a heterogeneous mixture of 800 particles. Each heterogeneous sample was

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dispersed onto the largest sieve of a stack containing 12 sieves. The sieve sizes used were 19, 16, 12.5, 9.5, 6.3, 5.6, 4.75, 4, 3.35, 2.8, 2.36, and 2 mm. The samples were agitated using a Ro-Tap (Model B, W.S. Tyler, Mentor, Ohio) then hand sorted and counted. To observe run time effect, samples were run for 1, 2, 3, 4, and 5 mins. Each sample at each time was replicated 3 times.

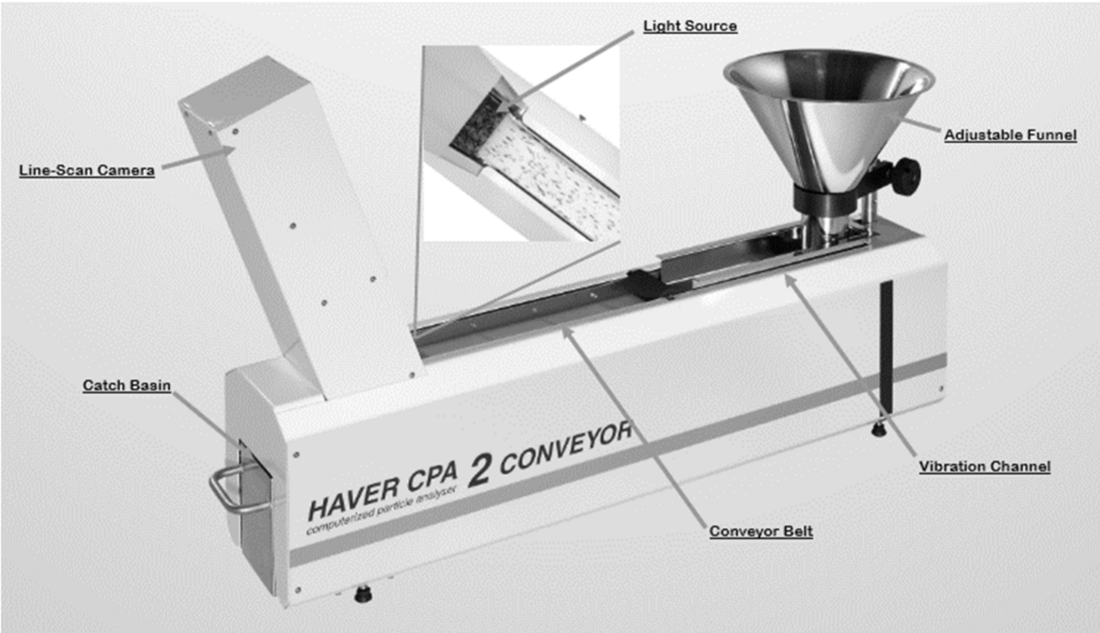

Figure 1. Tyler (Haver) computer particle analyzer 2 conveyor.

Number of particles falling within each sieve was modeled following a generalized linear model, assuming a multinomial distribution for the response (multinomial distribution with cumulative logit link). Fixed effects in the model were given by the particle L:W, runtime, and the interaction runtime by L:W. Repetitions within each time and L:W ratio were considered random effects.. All data were subjected to PROC GLIMMIX (SAS 9.4, SAS, Cary, North Carolina). All significances were at α=0.05.

CPA-2 validation

Sieve analysis is expressed in terms of percent mass retained while the CPA-2 values are weighted by number of particles and can be sorted by standard or custom size classes. The CPA-2 obtains particle size by applying image transformation algorithms for each particle. Volume of a particle can be calculated by the CPA-2 utilizing the equivalent sphere model. If one assumes all particles have the same density, then mass equals volume. Sand is a material with a fairly consistent particle density. Given the spherical nature of the material, it is also an ideal material for sieve analysis. Three different horticultural sands were evaluated, a course, medium, and fine textured sand. Since every particle is evaluated, sample sizes were reduced by half (50 g) for the CPA-2 compared to sieve analysis (100 g). The sieve sizes and size classes used were 4, 2.8, 2, 1.4, 1, 0.71, 0.6, 0.425, 0.25, 0.18, 0.125, and 0.063 mm. The sieve samples were agitated using the same Ro-Tap for 5 min.

To compare both gradation methods, a general linear model was fitted to percent retained measured through the Ro-Tap and CPA-2. Fixed effects were sieve size, gradation method, and their interaction. Repetitions within each method were considered a random effect. Simple effect analysis was used to compare both methods within each sieve size.

RESULTS AND DISCUSSION

Sieve limitations

Similar trends in the data were recorded for each particle width (2, 3, and 6 mm). Therefore, only the results from the 3 mm particles will be discussed. The distribution of particles of equal width and height were affected by L:W (p=<0.0001), time (p=<0.0001), and the interaction term L:W*time (p=0.0011). Summation curves of the 8 L:W ratios help visualize the influences of L:W and time across sieves sizes (Figure 2). As particle L:W increases, distribution across sieves also increases. No particles with an 8:1 L:W and only a single 7:1 L:W particle reached the targeted screen (2.8 mm). The more elongated the particle, the more time is required for that particle to properly orient itself to pass through a screen. Time affects varying L:W ratio particles differently. Time's effect increases as particle L:W increases. The squarer or rounder a particle is, the weaker the effect time has on the distribution of the particle.

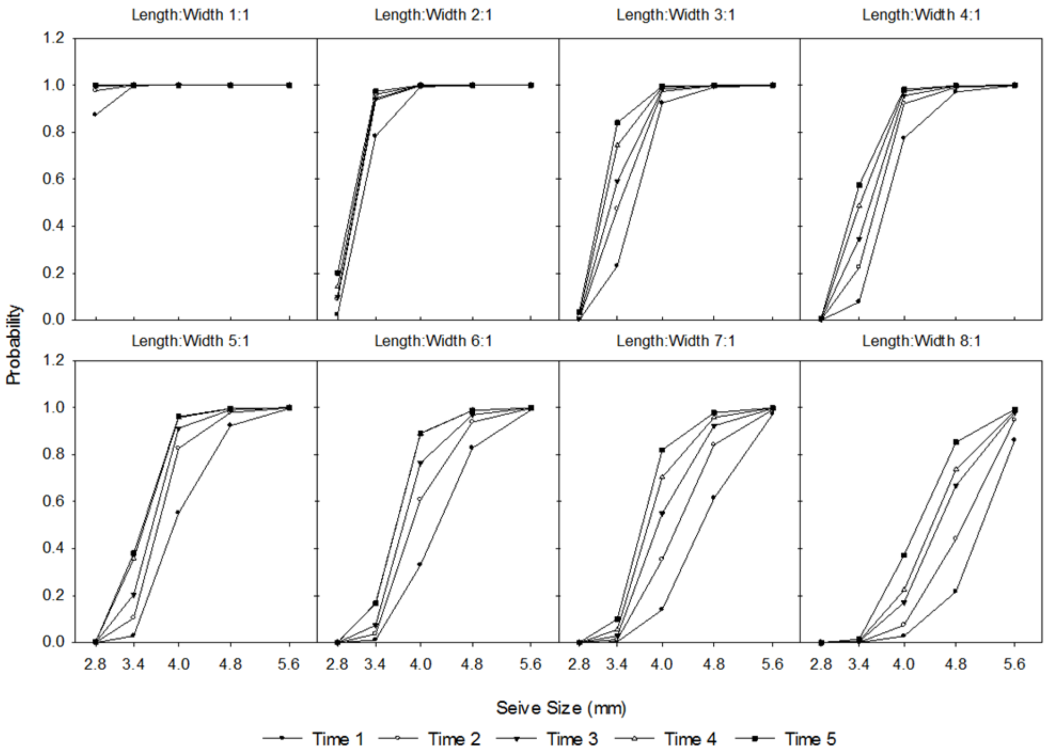

Figure 2. Predicted cumulative distribution of 3-mm particles by length: width ratio and time.

These results show three things concerning the retention of a particle on a sieve:

1) The width of the particle is the limiting dimension.
2) The length of the particle is the influential dimension.
3) Time is the variable that influences particle length effect.

The significance of these results, though simplistic in nature, directly impact horticultural substrate research. Many horticultural substrates are not spherical or cubic in nature and are not appropriate materials for sieve analysis. However, the limitations of sieve analysis are generally ignored without contemplating the implications on substrate research reproducibility. For example, seven of the eight L:W ratios were collected on the same sieve. In distribution analysis, the assumption is that all particles collected in a given sieve are the same or similar, but an 8:1 L:W particle will impart different characteristics to the substrate than a 2:1 L:W particle. In order to further substrate research, newer and more robust technology must be utilized to better characterize the diverse and dynamic materials used as substrates.

CPA-2 validation

Differences in distributions were observed between Ro-tap and CPA-2 in all three sand textures (Figures 3-5). One source of error could have occurred in the assumption of consistent particle density due to sand's varying mineral content. Other sources of error could be attributed to particle oscillation across the measuring line, improper equipment calibration, or poor transformational data into volumetric calculations. Volumetric calculations assume that particles have a consistent specific gravity. For example, two sheets of paper, side by side, have the same specific gravity and their volume will be calculated proportionately equal. However, a ream of paper and a sheet of paper with the same projected area but different specific gravities will be calculated disproportionately on the basis of their 2-D images. This is believed to be the primary source of error in the CPA-2's distributions. A larger, flat particle will have a calculated volume higher than its mass and skew the distributions toward larger sieve sizes.

Unlike traditional sieve analysis, singular calculations like volume are only a small computation in the large array of functions the CPA-2 uses to characterize particles. From container characteristics (air, water, and bulk density) imparted by particle size and shape, to the engineering processes that created them, this instrument has immediate implications into understanding particles' effect in container production. Once the unique features of substrates are discovered, the wealth of knowledge and information could lead to many solutions to decade-long questions.

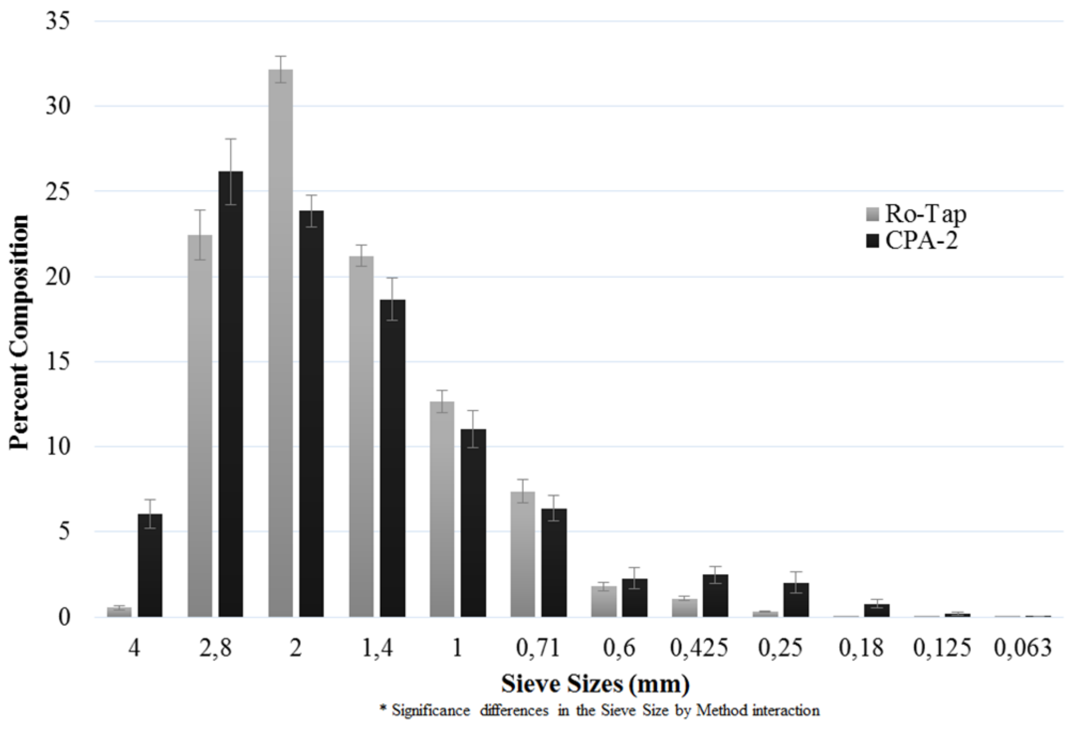

Figure 3. Differential distribution of coarse sand measured by Ro-Tap and CPA-2.

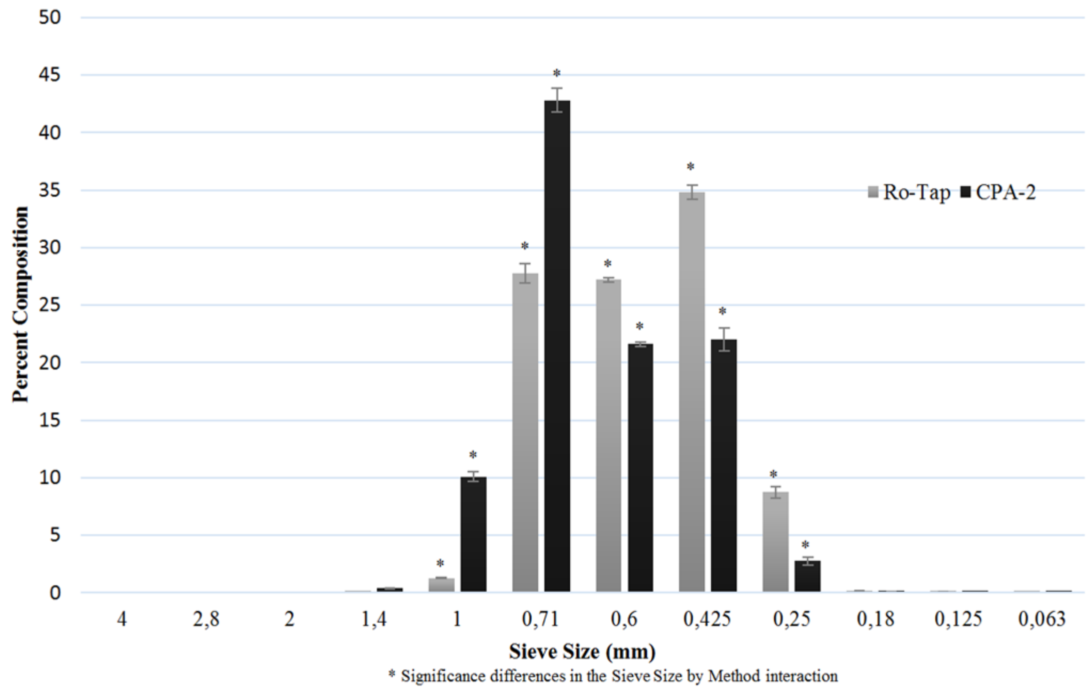

Figure 4. Differential distribution of medium sand measured by Ro-Tap and CPA-2.

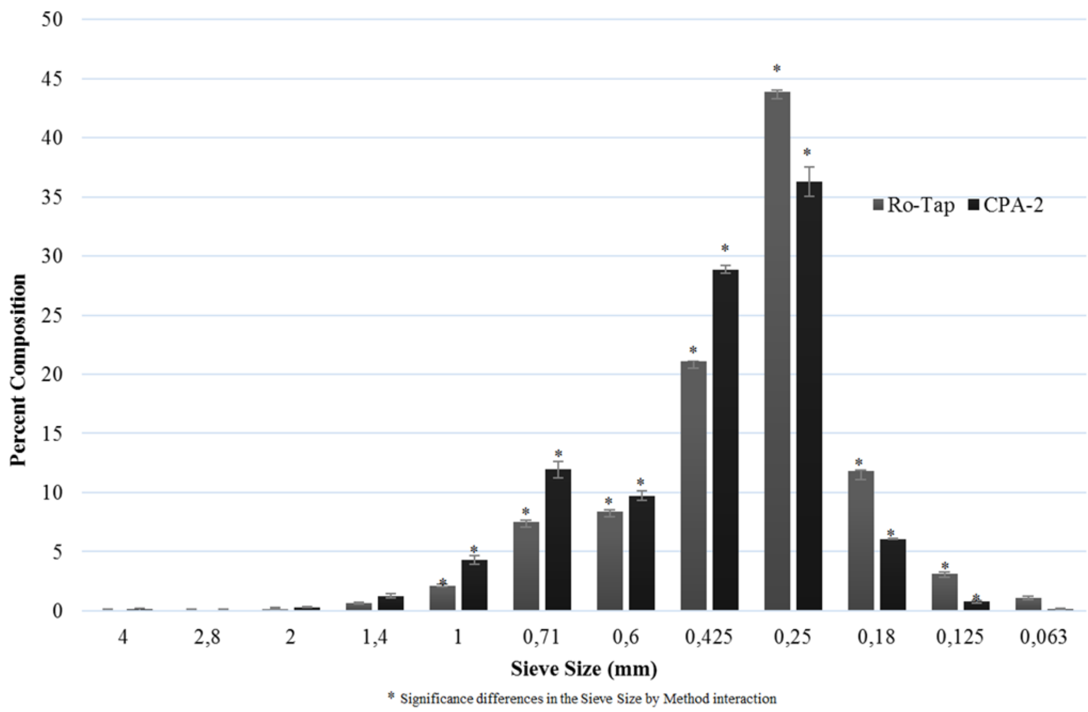

Figure 5. Differential distribution of fine sand measured by Ro-Tap and CPA-2.

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