

2007

Nursery Crops Field Day

Mountain Horticultural Crops Research Station
Fletcher, NC



NOTES

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Fletcher, NC

September 20, 2007

8:00 – 9:00 am	Registration at Mountain Horticultural Crops Research Station
9:00 – 9:30 am	Welcome and Opening Remarks <ul style="list-style-type: none">◆ Winston Hagler, Assistant Director, NC Agricultural Research Service, College of Agriculture and Life Sciences, NC State University◆ Richard Reich, Assistant Commissioner, North Carolina Department of Agriculture and Consumer Sciences◆ Julia Kornegay, Head, Department of Horticultural Science, NC State University◆ John Allen, President, North Carolina Nursery and Landscape Association; President Shiloh Nursery, Harmony, NC
9:30 am - Noon	Tour of Research
12:00 Noon – 1:00 pm	Lunch for participants pre-registered for the afternoon educational program. Sponsored by Carolina Farm Credit, Statesville, NC
1:00 pm – 5:00 pm	Nursery Crops Short Course

Field Day Sponsors

North Carolina State University

College of Agriculture and Life Sciences

- ◆ North Carolina Agricultural Research Service
- ◆ North Carolina Cooperative Extension

North Carolina Department of Agriculture and Consumer Services

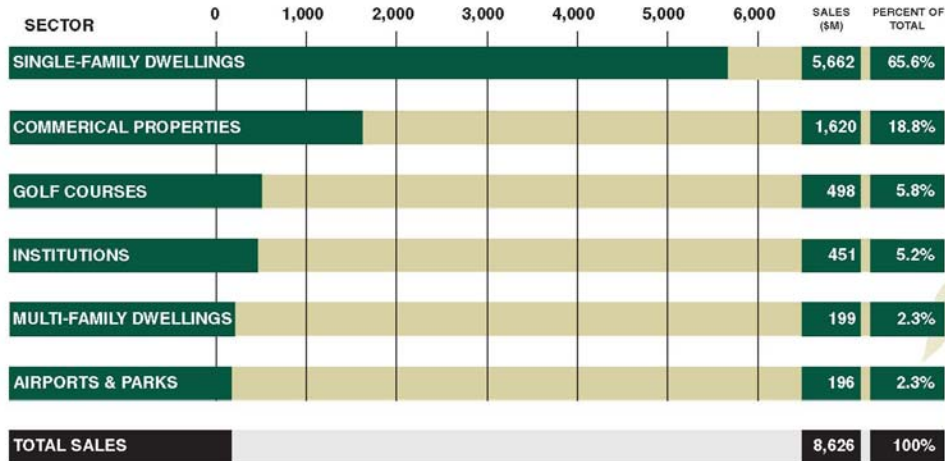
North Carolina Nursery and Landscape Association

Qualifies for 0.5 pesticide credits

NOTES

TOTAL ECONOMIC IMPACT

North Carolina's Green Industry 2005 total Economic Impact on the States Economy was more than \$8.6 billion.



There were more than 3.4 million single family dwellings on over 4.7 million acres of property.



TOTAL ECONOMIC IMPACT OF NORTH CAROLINA'S GREEN INDUSTRY:

\$ 8.6 BILLION

TOTAL EMPLOYMENT

Total Employment Impact for N.C. Green Industries was 124,790 employees in producing sectors in 2005.

Sector	Full-Time Employment	Part-Time Employment	Total Full and Part-Time Employment
	Total Effects	Total Effects	Total Effects
Nursery, Floriculture & Christmas Tree Growers	12,885	21,196	34,081
Sod Producers	776	484	1,260
Retail Garden Centers	4,632	4,261	8,893
Florists	3,546	4,226	7,772
Arborists, Landscapers & Lawncare	32,272	14,008	46,280
Landscape Architects	13,006	4,692	17,698
Irrigation Companies	6,014	2,792	8,806
Total	73,131	51,659	124,790



Arborists, Landscapers & Lawncare experts spent an average of \$149,298 on labor expense.



Total Employment Impact for N.C. Green Industries was 43,669 employees in consumer sectors in 2005.

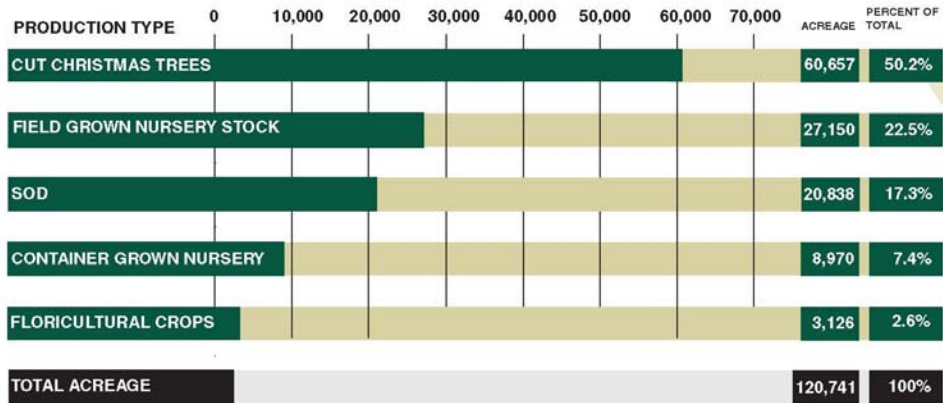
Sector	Full-Time Employment	Part-Time Employment	Total Full- and Part-Time Employment
	Total Effects	Total Effects	Total Effects
Golf Courses	8,057	5,366	13,423
Institutions	15,985	8,833	24,818
Airports and Parks	3,700	1,728	5,428
Total	27,742	15,927	43,669

TOTAL EMPLOYMENT IMPACT FOR NORTH CAROLINA'S GREEN INDUSTRY:

124,790 EMPLOYEES

TOTAL ACREAGE

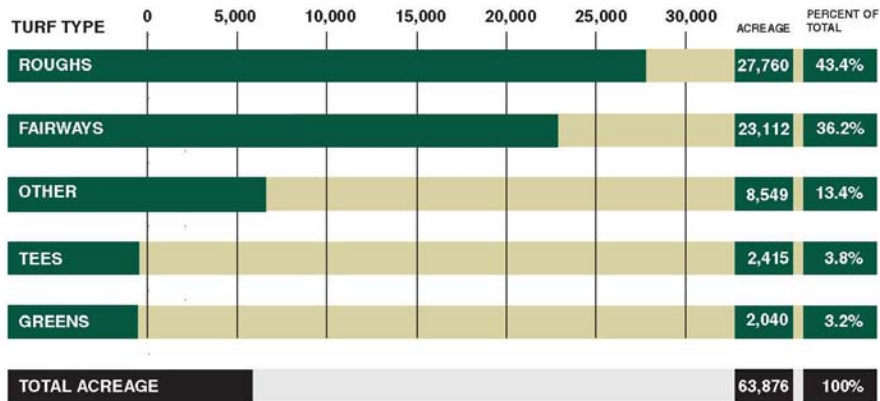
NORTH CAROLINA PRODUCTION ACREAGE IN 2005: 99,903 ACRES



Over 17.2 million rounds of golf were played on North Carolina's 605 golf courses in 2005.

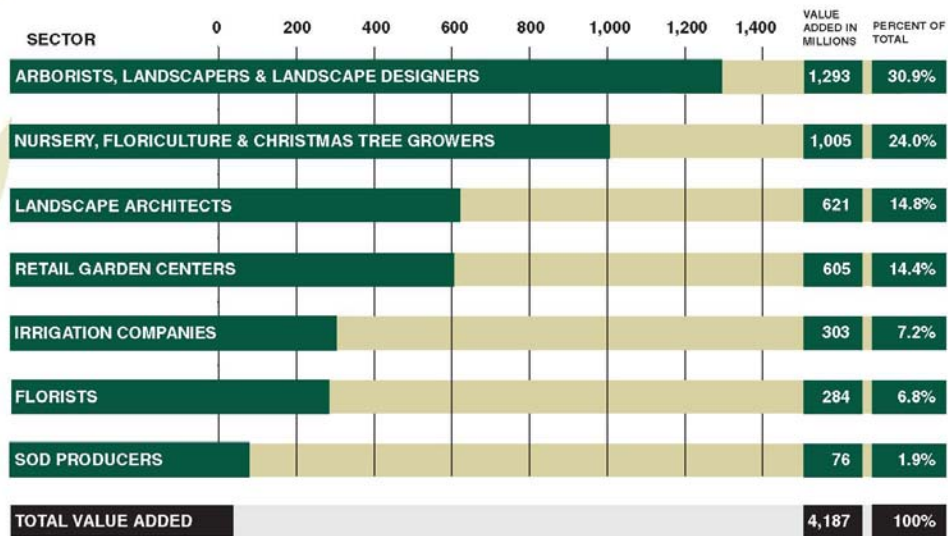


NORTH CAROLINA GOLF COURSE ACREAGE IN 2005: 63,876 ACRES



NORTH CAROLINA GREEN INDUSTRY

Total Value Added of Production in North Carolina was more than \$4.1 billion.



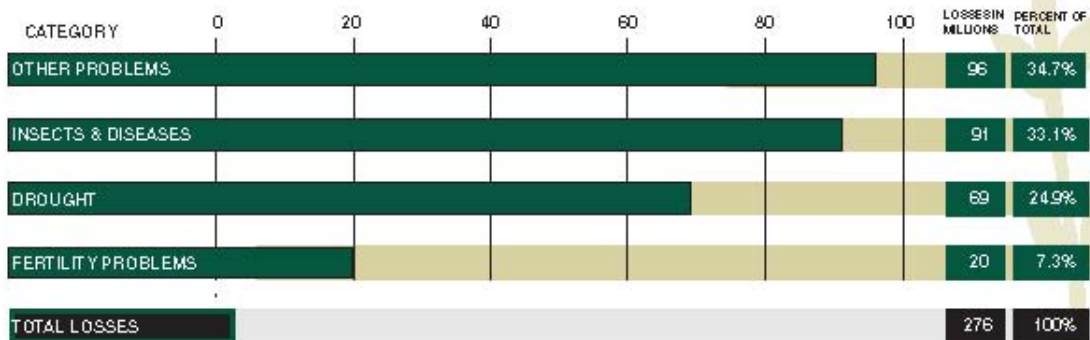
Plant sales at



4

NORTH CAROLINA GREEN INDUSTRY

Total Economic Losses are for both Producer and Consumer Sectors



Total Gross Sales by North Carolina Florists exceeded \$256.6 million in 2005.

Total Gross Sales by North Carolina Arborists, Landscapers, and Lawn Care Professionals was \$1.2 billion in 2005

Gross Sales by North Carolina Landscape Architects and Designers totaled \$574.2 million in 2005.

Over 2.9 million North Carolina homeowners spent an average of \$718 for green goods, equipment, and supplies in 2005.



Over 2,936 owners of commercial multi-family residences or apartment complexes spent an average of \$10,321 for green goods, equipment, and supplies in 2005.

MAP

Tour of Research

9:30 am – Noon

1. **Breeding New Disease Resistant Dogwoods.** Tom Ranney, Tom Eaker, Joel Mowrey, Nathan Lynch, and Brian Upchurch, Horticultural Science
2. **Developing Non-Invasive *Miscanthus* for Gardens and Biofuels.** Darren Touchell, Tom Ranney, and Jeremy Smith, Horticultural Science
3. **Propagating Native Azaleas.** Jeff Jones, Anthony LeBude, and Tom Ranney, Horticultural Science
4. **Screening *Franklinia*, *Gordonia*, and *Schima* for Resistance to *Phytophthora cinnamomi*.** Lis Meyer, Tom Ranney, Tom Eaker, and Kelly Ivors, Horticultural Science
×*Schimlinia floribunda* (Theaceae): A New Intergeneric Hybrid between *Franklinia alatamaha* and *Schima argentea*, Tom Ranney, T.A. Eaker, P.R. Fantz, and C.R. Parks
×*Gordlinia grandiflora* (Theaceae): An Intergeneric Hybrid between *Franklinia alatamaha* and *Gordonia lasianthus*, Tom Ranney, and P.R. Frantz
5. **Azalea and Rhododendron Trial Plants** (available to the first 150 participants). Tom Ranney, Jeff Jones, Joel Mowrey, and Anthony LeBude, Horticultural Science
6. **Breeding Azaleas and Rhododendrons.** Tom Ranney, Jeff Jones, Nathan Lynch, and Joel Mowrey, Horticultural Science
Ploidy Levels and Genome Sizes of Diverse Species, Hybrids, and Cultivars of Rhododendron. Jeff Jones, Tom Ranney, Nathan Lynch, and Stephen Krebs
7. **Clarifying Taxonomy and Nomenclature of *Fothergilla*.** Tom Ranney, Nathan Lynch, Paul Fantz, and Paul Cappiello, Horticultural Science
8. **Novel Applications for Plant Tissue Culture.** Darren Touchell, Tom Ranney, and Jeremy Smith, Horticultural Science
9. **Developing Non-Invasive Nursery Crops.** Tom Ranney, Darren Touchell, Tom Eaker, Joel Mowrey, Nathan Lynch, and Jeremy Smith, Horticultural Science
10. **Weed Control in Container-Grown Woody Ornamentals.** Joe Neal, Anthony V. LeBude, and Joe Conner, Horticultural Science
11. **Mixing It Up With Fluff Substrate Amendment.** Ted E. Bilderback.
12. **Improving Short-Term Drought Tolerance in Container Plants with the Growth Regulator ABA.** Anthony V. LeBude and Joe Conner, Horticultural Science
13. **Evaluating Various *Tsuga* (Hemlock) and *Ilex* (Holly) Species for Adaptability to Western North Carolina.** Anthony LeBude, Tom Ranney, Ray Head, and Bill Cannon, Horticultural Science



New "Carolina" dogwoods

By Dee Shore

Intern Irene Palmer, who works with with Dr. Tom Ranney to propagate disease-resistant dogwoods at the Mountain Horticultural Crops Research and Extension Center, here pollinates a dogwood flower.

that have ravaged native flowering dogwoods. Recent grants from the N.C. Association of Nurserymen and Golden LEAF, a nonprofit organization focused on economic develop-

ment, have allowed them to expand and accelerate these efforts.

Dogwood anthracnose has been particularly problematic over the past 15 years at mountain elevations of more than 3,000 feet, where the disease can wipe out entire stands of trees. And powdery mildew has taken a toll across the state, where it has resulted in deformed, dying and slow-growing dogwoods.

"The holy grail," says Ranney, "is to get resistance to these two diseases."

To that end, Ranney recently secured a \$40,000 grant to help enhance his work with flowering dogwoods.

He and his colleagues in the College of Agriculture and Life Sciences have since been scouring the state to find dogwood trees that seem naturally resistant to the diseases. That involves combing mountainsides with global-positioning system equipment in tow to find and keep track of trees that have survived where they shouldn't have.

The researchers then take samples of those trees and propagate them at the research station. With the help of Dr. Kelly Ivors from the Department of Plant Pathology, they then deliberately expose them to both dogwood anthracnose and powdery mildew to see if they are indeed resistant.

Those that prove to be robust can then be released to commercial nurseries for sale to those who want hardier

With its four-petaled flower heralding spring from North Carolina's coast to its forested mountains, the dogwood has come to be known – and treasured – as a symbol of rebirth and revitalization. And N.C. State University researchers are working to make sure it stays that way.

At the Mountain Horticultural Crops Research and Extension Center in Fletcher, Dr. Tom Ranney and his colleagues have spent the past five years working to breed hardier cultivars that withstand two diseases



2 | perspectives

trees for use in home and commercial landscapes, Ranney says. They also can form the basis for a breeding program to develop new types of dogwoods.

Ranney, a professor of horticultural science and a breeder of trees and other woody plants, is particularly interested in pursuing new hybrids that combine the best of North Carolina's flowering dogwoods and the kousa and evergreen dogwoods found in China. Over the past decade, a collection of more than 60 types of Asian dogwood cultivars has been acquired at the Fletcher research station.

With such breeding stock at his disposal, Ranney sees the potential for developing a series of "Carolina" dogwood varieties that not only are resistant to major diseases but also have unusual characteristics that gardeners and landscapers would find attractive — ones with weeping forms, evergreen foliage or different color flowers, for example.

But Ranney's goals go far deeper than his desire to develop interesting plants for the landscape. He is driven by a commitment to ensuring the continued growth of North Carolina's leading crop — not tobacco any more, but greenhouse and nursery plants.

In North Carolina, more than 1,800 nursery operations generate annual sales of more than \$845 million annually and employ some 63,000 people. The state ranks fourth in the nation in nursery crops production, behind only California, Florida and Texas.

Just one exceptional new nursery cultivar can generate wholesale sales of between \$1 million and \$2 million per year, Ranney says, and retail

sales and installation can potentially be twice that amount.

His earlier breeding projects include the development of the Venus sweetshrub, a flowering plant that is now widely grown by North Carolina nurseries, and Ranney has also helped patent and introduce the Summer Cascade and Shiloh Splash river birches.

With the "Carolina" dogwood series, Ranney expects that new introductions could begin as early as 2008. Through partnerships with the North Carolina Association of Nurserymen, North Carolina Cooperative Extension, the JC Raulston Arboretum at N.C. State and others, he intends to back the release of such trees with the grower education, promotion and marketing that are essential to commercial success.

"Each year, Americans buy 1.5 million dogwood trees," he says. "With each tree selling for about \$75, that translates into a \$112 million industry every year — before you even consider the value of landscaping and design services, fertilizers and so on.

"The potential for economic growth is huge."

The Cover

The N.C. Agricultural Research Service provides the science base for the College's land-grant programs. Here Joel Moorey, research technician at the Mountain Horticultural Research and Extension Center, uses GPS technology as he scouts for disease-resistant dogwoods. (Photo courtesy Dr. Tom Ranney)

Developing Non-Invasive *Miscanthus* for Gardens and Biofuels

Darren Touchell, Tom Ranney and Jeremy Smith

Horticultural Science, NC State University

What is *Miscanthus*?

Miscanthus is a perennial grass that is closely related to sugarcane (*Saccharum* spp.). It is native to Asia and comprises 14 species. Many cultivars have been developed for aesthetic traits and used extensively in the ornamental horticultural industry in the United States. In addition some interspecific hybrids produce abundant biomass and have significant potential as a bioenergy crop. *Miscanthus* can be used for heating, energy production or conversion into other fuel types such as ethanol.



M. x giganteus grown in Illinois
<http://genomics.energy.gov>

Table 1. Comparison between different bioenergy crops.

	Biomass (t/acre)	Ethanol g/acre	Input/Output*
Corn	4.5	300-475	1:1.4
Switchgrass	5-10	1000	1:4
Sugarcane	20-50	600-1200	1:8
Miscanthus	15-17	1500	1:5

* The number of units of energy produced for every 1 invested

Compiled from:

Today, Fourth Quarter 2006: 80-82

Sommerville (2007), Current Biology 17: 115-119

www.e2.org

www.cleanhouston.org/energy/features/ethanol2.htm

www.sciencedaily.com/releases/2007/02/070218140448.htm

What Species to Use for Biofuel

In Europe comprehensive studies have been conducted using *M. x giganteus*. It is a naturally occurring sterile triploid hybrid of *M. sacchariflorus* x *M. sinensis*. *M. x giganteus* is propagated from rhizomes, can grow up to 12 feet tall and is cold tolerant. Other hybrids need to be developed and tested for the US.

Miscanthus Compared to Other Biofuel Crops

Based in research from Europe and limited trials within the United States, *Miscanthus* may out-compete conventional energy crops (see Table 1.). *Miscanthus* yeilds up to 5 times more ethanol per acre than corn. Further, *Miscanthus* has an energy input/output ratio far greater than corn and only second to sugarcane.

Where to Grow *Miscanthus*

The Department of Energy geographical distribution of biomass crops shows *Miscanthus* grown in the Midwest and south-east. However, several attributes of *Miscanthus* may make it suitable biomass crop for the entire US.

- ♦ Cold hardy and can be grown over a larger range in the US compared to sugar cane.
- ♦ Requires low moisture and is therefore suitable for marginal areas.
- ♦ Associated with a nitrogen fixing bacteria and recycles nitrogen therefore reducing the requirement of nitrogenous fertilizers.
- ♦ Produces high quality of lignocellulistic material for energy production.



<http://genomics.energy.gov>

Ornamental Crops

M. sinensis is most common in the nursery industry. Currently, there are over 100 named varieties of *M. sinensis*, which are noted for their variegations, different foliage characteristics, compactness and inflorescence color. Vertical and horizontal leaf variegations are perhaps the most valued characteristics. It has become an important economical ornamental crop in North Carolina.

Invasiveness

Miscanthus produces large quantities of seed (over 100 seed per inflorescence) and has the potential of becoming invasive. In some areas of the United States, and particularly in Western North Carolina, *Miscanthus* has naturalized along roadside verges and disturbed areas raising environmental concerns. Development of non-invasive forms of *Miscanthus* is required for large scale biomass production.



Miscanthus naturalized along a roadside verge in Western North Carolina



Somatic embryogenesis in miscanthus

Developing Non-invasive Cultivars

We are currently attempting to develop non-invasive forms of *Miscanthus* that can be used as ornamental garden plants or as biomass crops. Our approach is to use a combination of conventional breeding methodologies with tissue culture procedures to produce seedless cultivars of *Miscanthus*. Interploid crosses between tetraploid and diploid plants results in triploid plants that produce little or no viable seed. Often seed from interploid crosses aborts before it matures. Therefore, techniques such as embryo rescue may be used to establish tissue culture from immature embryos prior to abortion.

When important lines are established in tissue culture, tissue culture procedures such as micropropagation and somatic embryogenesis can be employed to rapidly regenerate plants.

We are currently using this technology for the development of triploid forms of *Miscanthus* for the ornamental horticulture and biofuel industries.



Triploid *Miscanthus*

Propagating Native Azaleas

Jeff Jones, Anthony LeBude, and Tom Ranney

Horticultural Science, NC State University

The native, North American azaleas (*Rhododendron* spp.) have tremendous ornamental merit and can serve as outstanding landscape plants. Unfortunately, some of our native azaleas can be difficult to propagate from stem cuttings. Development of dependable and efficient propagation protocols would greatly expand the potential of these plants.

Cuttings from juvenile plants are typically easier to root from stem cuttings than are cuttings from older, mature plants. When plant material passes from the juvenile phase to the mature phase of growth, marked by flowering and slower growth, stem cuttings can become less competent to form adventitious roots with regularity. Juvenility can be restored or reinvigorated in plants through severe hedging. Optimizing hormone treatments and taking stem cutting at an optimal time of the year can further enhance success.

Mounding combines exclusion of light and layering with severe hedging to keep plants juvenile to promote adventitious roots. Stooling or mound layering promotes the formation of adventitious roots on stems of particular species by hedging and then covering (mounding) stems with a substrate to exclude light and provide an environment conducive for root formation. Plants are typically planted in the field and allowed to establish before they are hedged severely to within 15 cm of the ground. The proliferation of new stems are mounded/covered with up to 46cm of substrate depending on the height of shoot growth and general vigor of the plant material. Notching and girdling (excising a shallow, half inch wide ring of bark) of mounded stems may increase the percentage of stems forming roots, especially when a rooting hormone is added to the wounded areas at the appropriate time of year.

The objectives of this project are to develop and optimize protocols for cutting propagation of *R. flammeum* and *R. austrinum* by manipulating stock plant management techniques, rooting hormones, and timing of stem cutting collection.

These azaleas were successfully propagated by stem cuttings. The use of hormones had a significant effect on rooting with the best results occurring with 5000-7500 ppm K-IBA. Softwood cuttings had higher rooting percentages than semi-hardwood cuttings. Over-wintering of the cuttings can be problematic. Cuttings taken in the softwood growth stage allow sufficient time for rooting and a subsequent flush of growth, increasing over-wintering survival.

Mound layering was also quite successful. Two mounding times were compared (March and June) with both being effective in rooting (40-64%). Wounding and an IBA treatment were also conducted in the June mounding. The June mounding benefited from the application of IBA.

Acknowledgements

Funding for this research and development has been provided by Southeastern Chapter of the American Rhododendron Society.

Breeding and Evaluating *Franklinia*, *Gordonia*, *Schima* and their Hybrids

Lis Meyer, Tom Ranney, Tom Eaker, and Kelly Ivors

Horticultural Science and Plant Pathology, NC State University

Franklinia alatamaha is an ornamental shrub in the Theaceae native to the southeastern U.S that is extinct in the wild and exists only in cultivation. Although its large white blooms in fall, bright red fall foliage, and cold-hardiness make it a highly desirable ornamental, it rarely lasts for more than a few years in the landscape due to its susceptibility to *Phytophthora cinnamomi* Rands. Since *Franklinia* is a monotypic genus, genetic diversity is low within the species, limiting the possibilities for hybridization. However, Dr. Thomas Ranney has developed intergeneric hybrids between *Franklinia* and two closely related genera, *Gordonia* and *Schima*, at the N.C. State University Mountain Horticultural Crops Research Station. Two intergeneric hybrids, \times *Schimlinia floribunda* and \times *Gordlinia grandiflora*, have been developed in an effort to combine disease resistance and additional ornamental characteristics from *Schima* and *Gordonia* with those of *Franklinia*.

Current work with these intergeneric hybrids includes evaluating their resistance to *P. cinnamomi* and developing ways to propagate them and use them for further breeding. *Phytophthora* screening is being conducted on various \times *Schimlinia floribunda* and \times *Gordlinia grandiflora* hybrids, as well as on the parent species. Also, explants from these hybrids are being grown on a variety of media in order to discover how to best to produce them from tissue culture. Being able to effectively grow these new hybrids in tissue culture will provide an alternative and possibly quicker method of propagating large numbers of these plants.

Acknowledgements

Funding for this research and development has been provided by the Golden LEAF foundation, Horticultural Research Institute, and the NC Association of Nurserymen.

×***Gordlinia grandiflora* (Theaceae): An Intergeneric Hybrid between *Franklinia alatamaha* and *Gordonia lasianthus***

Ranney, T.G., and P.R. Frantz. 2006. HortScience 41(6):1386-1388.

Abstract

Franklinia alatamaha Bartr. ex Marshall represents a monotypic genus that was originally discovered in Georgia, USA, but is now considered extinct in the wild and is maintained only in cultivation. Although *Franklinia* is very ornamental, with showy flowers and crimson/maroon fall foliage color, it tends to be short lived when grown as a landscape tree and is known to be susceptible to a variety of root pathogens. *Gordonia lasianthus* (L.) Ellis is an evergreen tree native to the SE USA, typically growing in riparian habitats. *Gordonia lasianthus* has attractive foliage and large, white, showy flowers, but limited cold hardiness. Hybridization between *F. alatamaha* and *G. lasianthus* could potentially combine the cold hardiness of *F. alatamaha* with the evergreen foliage of *G. lasianthus* and broaden the genetic base for further breeding and improvement among these genera. Controlled crosses between *F. alatamaha* and *G. lasianthus* resulted in intergeneric hybrid progeny. A morphological comparison of parents and the progeny is presented. ×*Gordlinia grandiflora* Ranney and Fantz (mountain gordlinia) is proposed as the name for these hybrids and is validated with a Latin diagnosis.

×***Schimlinia floribunda* (Theaceae): A New Intergeneric Hybrid between *Franklinia alatamaha* and *Schima argentea***

Ranney, T.G., T.A. Eaker, P.R. Fantz, and C.R. Parks. 2003. HortScience 38(6):1198-1200.

Abstract

Franklinia alatamaha Bartr. ex Marshall represents a monotypic genus that was originally discovered in Georgia, USA, but is now considered extinct in the wild and is maintained only in cultivation. Although *Franklinia* is very ornamental, with showy flowers and crimson/maroon fall foliage color, it tends to be short lived when grown as a landscape tree and is known to be susceptible to a variety of root pathogens. *Schima argentea* Pritz is an evergreen tree that is native to Asia and is valued for its glossy foliage, late-summer flowers, and broad adaptability in mild climates. Hybridization between these genera could potentially combine the cold hardiness and desirable ornamental characteristics of *F. alatamaha* with the greater adaptability, utility, and genetic diversity of *S. argentea*. Controlled crosses between *F. alatamaha* and *S. argentea* resulted in new intergeneric hybrid progeny. A morphological comparison of parents and the progeny is presented. ×*Schimlinia floribunda* Ranney and Fantz (mountain schimlinia) is proposed as the name for these hybrids and is validated with a Latin diagnosis.

Azalea and Rhododendron Trial Plants

Tom Ranney, Jeff Jones, Joel Mowrey, and Anthony LeBude
Horticultural Science, NC State University

One of the challenges of any plant breeding program is the need to evaluate large numbers of seedlings to recover combinations of desirable characteristics. The potential for recovering plants with unique and desirable characteristics increases with the number of seedlings grown and evaluated. Because of practical limits in time and resources, we can't grow all the plants we would like, so we are offering new hybrid seedlings for cooperators to trial. These seedlings resulted from controlled pollinations that were completed to produce new hybrids with desirable ornamental characteristics. Seedlings were obtained from the following crosses:

1. *Rhododendron* 'Summer Lyric' (*R. prunifolium* × *R. arborescens*) [pollinated with either *R.* 'Millennium' (parantage) or *R.* 'August Beauty' (*R. prunifolium* × *R. arborescens*)] with the goal of deciduous azaleas with fragrant flowers, a range of flower colors, and summer bloom time.
2. *R.* 'Cheyenne' ('Jalisco' × Loderi Group) × *R.* 'Capistrano' ('Hindustan' × {[*catawbiense* × (*fortunei* ssp. *discolor* × Fabia Group)] × ('Russell Harmon' × 'Goldsworth Orange')}} × 'Golden Gala') with a goal of an improved yellow-flowered, elepidote, evergreen rhododendron with fragrant flowers.
3. *R.* 'Kimberly' (*williamsianum* × *fortunei* ssp. *fortunei*) × *R.* 'Nestuca' (*fortunei* ssp. *fortunei* × *degronianum* ssp. *yakushmanum*) with a goal of an evergreen, elepidote, rhododendron with a compact habit, good cold hardiness, and fragrant flowers.

In addition to these, a number of native azaleas will be available that were derived from propagation studies using new techniques.

Breeding Azaleas and Rhododendrons

Tom Ranney, Jeff Jones, Nathan Lynch, and Joel Mowrey
Horticultural Science, NC State University

The genus *Rhododendron* has tremendous diversity with over 900 species in 8 subgenera. *Rhododendrons* are widely distributed around the world and particularly prevalent in China, Japan, and the eastern United States. Foliage and flower characteristics can vary in shape, size, texture, color, fragrance, and timing. This diversity, along with a range of hardiness, growth habit, and adaptability make the potential for breeding *Rhododendron* especially exciting.

We are currently working on a range of breeding projects to develop new rhododendron and azaleas with better adaptability, disease resistance, fragrant flowers, and new flower colors – all of which contribute to greater commercial potential and improved products for producers and consumers. Specific projects include:

Developing cold-hardy evergreen rhododendrons with fragrant flowers

This goal is being accomplished by introgressing fragrance from deciduous azaleas with evergreen foliage from elepidote rhododendrons into new “azaleadendrons”.

New evergreen azaleas with fragrant flowers and new flower colors

In order to bring these traits together we are hybridizing deciduous azalea species (e.g., *R. austrinum*, *R. calendulaceum*) to combine fragrance and yellow flower color with desirable azalea cultivars that exhibit evergreen foliage and good cold hardiness.

Evergreen rhododendrons with improved stress tolerance and environmental adaptability

By utilizing species with better tolerances to environmental and biotic stresses (e.g., *R. hyperythrum*), new hybrids can be created that survive and thrive in harsh landscape sites.

Other projects are underway that study the basic genetics and reproductive biology of *Rhododendron* to provide fundamental information to advance plant breeding projects:

Ploidy Levels and Genome Sizes of Diverse Species, Hybrids, and Cultivars of *Rhododendron*

Jeff R. Jones, Thomas G. Ranney, Nathan P. Lynch, and Stephen L. Krebs

Horticultural Science, NC State University

(In press)

Significance to Industry

Polyploidy has been a central pathway in the evolution of plants and is an important consideration in plant breeding as it can influence fertility, crossability, plant vigor, and gene expression. In some cases, polyploid plants can also have desirable characteristics including thicker leaves and petals, enhanced vigor, and larger flowers that persist longer. This research provides an extensive survey of polyploidy in the genus *Rhododendron* L. and provides further insights into the genetics, evolution, and reproductive biology of rhododendron as well as serving as a valuable database for breeders.

Nature of Work

Many of the more than 800 *Rhododendron* species have been reported to be diploid with $2n = 2x = 26$. However, polyploidy occurs naturally in some rhododendron species, particularly within the *Pentanthera* and *Rhododendron* subgenera. Although some information has been published on polyploidy of *Rhododendron* species, there has been limited sampling and there is little data for specific clones or cultivars. The chromosomes in rhododendron are small and can be difficult to view and count. Determination of chromosome numbers by light microscopy is therefore not a practical method for establishing ploidy levels of large numbers of individual cultivars and clones. However, flow cytometry can provide a fast and accurate determination of nuclear DNA content (genome size) that is related directly to ploidy level among closely related taxa. Flow cytometry is also effective for detecting mixaploidy or cytochimeras. The objectives of this project were to determine the ploidy level and genome size of a diverse collection of species, hybrids, and cultivars of rhododendron using a combination of flow cytometry and traditional cytology. Holoploid, 2C DNA contents (i.e., DNA content of the entire non-replicated, chromosome complement irrespective of ploidy level) were determined via flow cytometry. Two hundred diverse species and cultivars were acquired from various sources that included taxa from the *Hymenantes* (Blume) K. Koch., *Rhododendron* L., *Tsutsusi* (Sweet) Pojarkova, and *Pentanthera* G. Don. subgenera. Stained nuclei from newly expanded leaf or petal tissue was analyzed using a flow cytometer (PA-I, Partec, Münster, Germany) to determine relative DNA content. Genome sizes were determined by comparing mean relative fluorescence of each sample with an internal standard, *Pisum sativum* L. 'Ctirad', with a known genome size of 9.09 pg and calculated as: 2C DNA content of sample = 9.09 pg \times (mean fluorescence value of sample / mean fluorescence value of standard). The relationship between ploidy levels and genome sizes was determined for plants with documented chromosome numbers. Mean 1Cx monoploid genome size (i.e., DNA content of the non-replicated base set of chromosomes with $x = 13$) was calculated as (2C genome size / ploidy level) to assess variability in base genome size. Data were subjected to analysis of variance and means separation using the Waller procedure. In situations where cytometric results were not consistent with published research, chromosomes were counted using standard cytology techniques.

Results and Discussion

Flow cytometry was an effective method for determining genome size and ploidy levels of rhododendron. Analysis of variance demonstrated significant effects of both subgenus and ploidy level on 2C genome size ($P < 0.05$). Genome sizes (2C) within ploidy level for a given subgenus had a narrow range providing clear distinction among ploidy levels (Table 1). Mean 1Cx monoploid genome size was conserved across ploidy levels within a subgenus (Table 1). As expected from past reports, all of the sampled species within the *Hymenantes* were diploid. However, many interspecific hybrids were polyploids. Hybridity has been shown to increase formation of unreduced gametes even when the parental species might not exhibit the same characteristic. Tetraploids arising from interspecific hybrids

included ‘Horizon Monarch’, ‘Lem’s Monarch’, ‘Point Defiance’, and ‘Gentle Giant’. ‘Vulcan’ tetraploid was found to be a 2x + 4x mixaploid that apparently arose from an asexual mitotic doubling event within a single histogenic layer. Several chemically induced tetraploids were found including ‘Everlasting Tetra’, *R. fortunei* Lindl. (NCSU 2005-175), ‘Super Nova’, and the mixaploid ‘Briggs Red Star’. Concordant with previous findings, polyploidy was common among species and their hybrid derivatives from subgenus *Rhododendron*. *Rhododendron augustinii* Hemsl. and its hybrids were found to be tetraploids, while *R. maddenii* Hook. f. clones were found to be hexaploids and octoploids. ‘Bumblegum’ and ‘Northern Starburst’ were both tetraploids developed from *in-vitro* colchicine treatments. Polyploidy was not common among the evergreen azaleas (subgenus *Tsutsusi*) with the exception of two chemically induced tetraploids. The majority of deciduous azaleas (subgenus *Pentanthera*) were found to be diploids as has been reported previously and *R. calendulaceum* (Michx.) Torr. was confirmed as a tetraploid. However, our results indicated that natural polyploidy is more prevalent among deciduous azalea species than previously thought. All of the *R. atlanticum* (Ashe) Rehder and *R. austrinum* (Small) Rehder accessions tested in this study were polyploids (mostly tetraploid and a few triploid), as were some of the *R. flammeum* (Michx.) Sarg. This is notable because in all earlier reports, only one instance of polyploidy (triploid) in these three North American species has been reported. Cytometric results in the present study were confirmed by chromosome counts on somatic cells from fifteen accessions of both *R. atlanticum* and *R. austrinum*, which showed that they were tetraploids, $2n = 4x = 52$ (Figs. 1 and 2). Many deciduous azalea cultivars were found to be polyploids including the tetraploids ‘Admiral Semmes’, ‘Gibraltar’, ‘Gold Dust’, ‘Lemon Lights’, ‘MaryDel’, ‘My Mary’, ‘Klondyke’, ‘Snowbird’, and the octoploid ‘Fragrant Star’.

Table 1. Summary of means and ranges for 2C, holoploid genome size (μg) and 1Cx monoploid genome size (μg) by sub-genus and ploidy level.

Sub-genus	Ploidy level				
	Diploid (2x)	Triploid (3x)	Tetraploid (4x)	Hexaploid (6x)	Octoploid (8x)
<i>Hymenanthes</i>	2C = 1.50 ± 0.01^1 A (1.41-1.64) 1Cx = 0.75 ± 0.01 A (0.71-0.82)	2C = 2.17 ± 0.05 B (2.06-2.22) 1Cx = 0.72 ± 0.02 A (0.69-0.74)	2C = 3.01 ± 0.04 C (2.89-3.37) 1Cx = 0.75 ± 0.01 A (0.72-0.84)	NA	NA
<i>Rhododendron</i>	2C = 1.65 ± 0.05 A (1.32-1.86) 1Cx = 0.83 ± 0.02 A (0.66-0.93)	2C = $2.01 \pm --$ B (NA) 1Cx = $0.67 \pm --$ B (NA)	2C = 3.06 ± 0.05 C (2.78-3.25) 1Cx = 0.77 ± 0.01 AB (0.70-0.81)	2C = 4.48 ± 0.04 D (4.39-4.61) 1Cx = 0.75 ± 0.01 AB (0.73-0.77)	2C = 5.70 ± 0.28 E (5.42-5.97) 1Cx = 0.72 ± 0.03 AB (0.68-0.75)
<i>Pentanthera</i>	2C = 1.63 ± 0.01 A (1.51-1.74) 1Cx = 0.81 ± 0.01 A (0.76-0.87)	2C = 2.48 ± 0.06 B (2.30-2.60) 1Cx = 0.83 ± 0.02 A (0.77-0.87)	2C = 3.24 ± 0.02 C (3.00-3.88) 1Cx = 0.81 ± 0.00 A (0.75-0.97)	NA	2C = $6.40 \pm .03$ D (6.32-6.46) 1Cx = 0.80 ± 0.00 A (0.79-0.81)
<i>Tsutsusi</i>	2C = 1.26 ± 0.01 A (1.22-1.30) 1Cx = 0.63 ± 0.01 A (0.61-0.65)	2C = 1.93 ± 0.03 B (1.88-1.98) 1Cx = 0.65 ± 0.01 AB (0.63-0.66)	2C = 2.68 ± 0.08 C (2.60-2.75) 1Cx = 0.67 ± 0.02 B (0.65-0.68)	NA	NA

¹Values represent means \pm SEM followed by (ranges) derived from the entire data set. Means followed by different letter, within a row, are significantly different, $P < 0.05$.

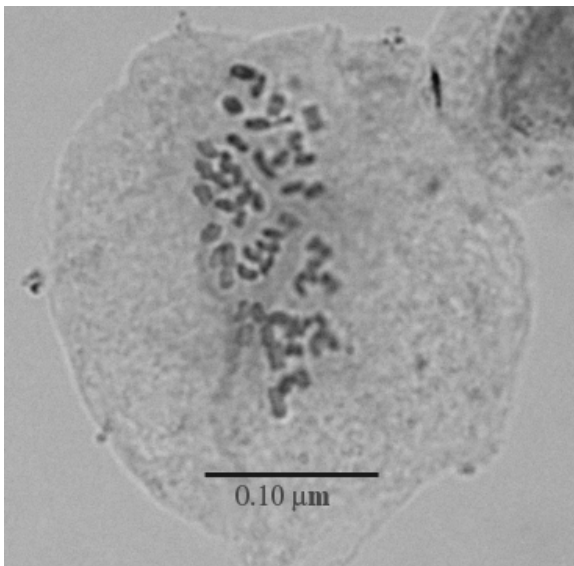


Figure 1. Photomicrograph of root tip cell of *R. atlanticum* (H2004-054-002) in prophase with $2n = 4x = 52$ somatic chromosomes.

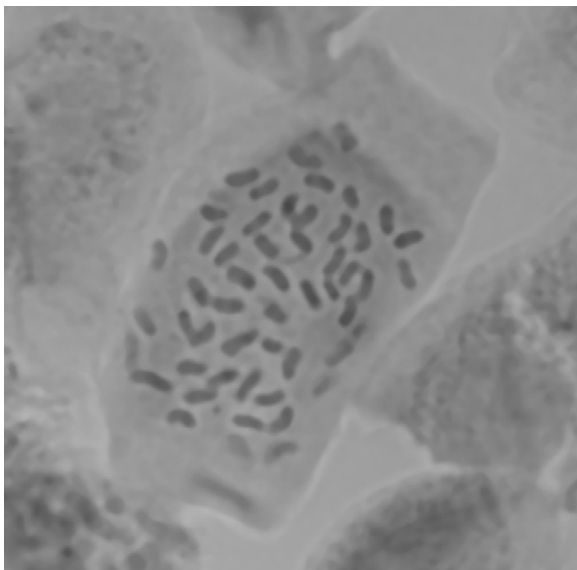


Figure 2. Photomicrograph of root tip cell of *R. austrinum* (2006-223) in prophase with $2n = 4x = 52$ somatic chromosomes.

ACKNOWLEDGEMENTS

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Clarifying Taxonomy and Nomenclature of *Fothergilla* (Hamamelidaceae) Cultivars and Hybrids

Ranney, T.G., N.P. Lynch, P.R. Frantz, and P. Cappiello. 2007. HortScience 42(3):470-473.

Summary

Significance to Industry

Fothergilla L. spp. (fothergilla or witch-alder; Hamamelidaceae R. Brown) are exceptional garden plants that display showy, white, fragrant flowers in a terminal spike that resembles a bottlebrush. Summer foliage color can be dark green to blue-green with fall foliage ranging from and including multi-colored combinations of yellow, orange, maroon, and scarlet. *Fothergilla* have few pest problems, they tolerate a broad range of climates (USDA hardiness zones 4-9), soil types, and shade. As a result, *Fothergilla* have become valuable nursery and garden plants.

Nature of Work

There are two species of *Fothergilla*, *F. gardenii* Murray and *F. major* Lodd which native to the Southeastern United States. *Fothergilla gardenii* is found in wet savannas and pocosins in the Coastal Plain of North Carolina, South Carolina, Georgia, Florida, and Alabama. This species is generally smaller in stature (3-10 dm) than *F. major*, and is distinguished sometimes by smaller leaves that are generally toothed only on the upper half and symmetric at the base. Cytology determined a chromosome number of $2n = 4x = 48$. In contrast, *F. major* is found on upland sites in the piedmont and mountains of North Carolina, South Carolina, Georgia, Alabama, Tennessee, and Arkansas. This species generally is larger in stature (7-65 dm) than *F. gardenii* and distinguished by larger leaves that generally are toothed from below the middle and conspicuously asymmetric at the base. Cytology determined a chromosome number of $2n = 6x = 72$. The ranges of these species do not naturally overlap; however, they have been cultivated together prompting speculation if they will hybridize. Hybrids between these species should have a chromosome number of $2n = 5x = 60$.

The objectives of this research were to verify the existence of hybrids between *F. gardenii* and *F. major*, and to clarify the proper taxa designations for clones of *Fothergilla* commonly grown in the nursery industry. A comparison of morphological characteristics was made among diverse clones representing both species and potential hybrids. Holoploid, 2C DNA contents (i.e., DNA content of the entire non-replicated, chromosome complement irrespective of ploidy level) were determined via flow cytometry. Chromosome counts were conducted on root tips collected in the morning from newly rooted stem cuttings of *Fothergilla* 'Mt. Airy'.

Results and Discussion

Cytological examination of 14 mitotic cells revealed that *Fothergilla* 'Mt. Airy' was a pentaploid with $2n = 5x = 60$ (Fig. 1), thereby confirming it is a hybrid between the tetraploid *F. gardenii* and hexaploid *F. major*. Flow cytometry was an effective method for determining genome size and ploidy levels of the species and their hybrids (Fig. 2). Genome sizes within species and hybrids had a narrow range providing clear distinction between the three taxonomic groups consistent with variations in ploidy levels.

Separating hybrids from parental species was particularly challenging when based strictly on morphology. Most ranges for morphological measurements of hybrids overlapped with one or the other parent. One exception was that the lamina width of *F. gardenii* was consistently narrower than either *F. major* or the hybrids. In general, hybrids tended to resemble *F. major* more closely, likely resulting from higher ploidy level and gene dose that was contributed from *F. major*. It was determined that the majority of cultivars represented in commerce were hybrids. *Fothergilla* \times *intermedia* Ranney and Fantz (hybrid fothergilla) is proposed as the name for these hybrids and is validated with a Latin diagnosis. To help clarify the taxonomy and nomenclature of *Fothergilla* spp., nothospecies *Fothergilla* \times *intermedia* Ranney and Fantz is proposed for the hybrid species name.

Based on this study, we further identified the cultivars ‘Appalachia’, ‘Bill’s True Dwarf’, ‘Blue Mist’, ‘Harold Epstein’, and ‘Jane Platt’ as *F. gardenii*. The cultivars ‘Arkansas Beauty’ and ‘KLMG’ Mystic Harbor™ were found to be *F. major*. The cultivars ‘Blue Shadow’, ‘Eastern Form’, ‘KLMtwo’ Beaver Creek®, one unnamed clone (YDG 2005-323-A), ‘KLMfifteen’ Red Monarch™, ‘KLMsixteen’ May Bouquet™, ‘Mt. Airy’, ‘Red Licorice’, ‘Sea Spray’, and ‘Windy City’ were hybrids, *Fothergilla* × *intermedia*.

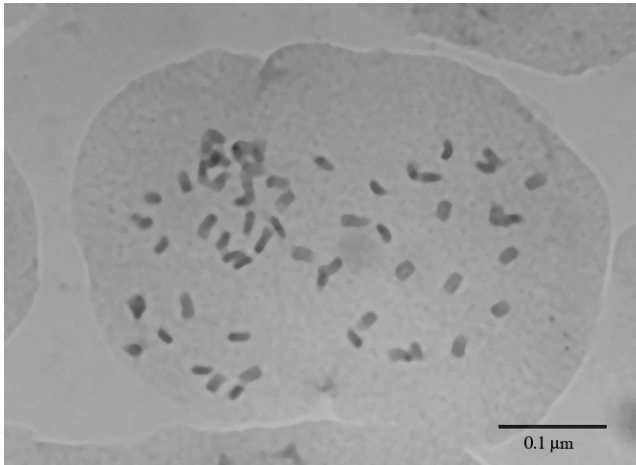


Fig. 1. Photomicrograph of root tip cell of *Fothergilla* × *intermedia* ‘Mt. Airy’ in prophase with 60 somatic chromosomes.

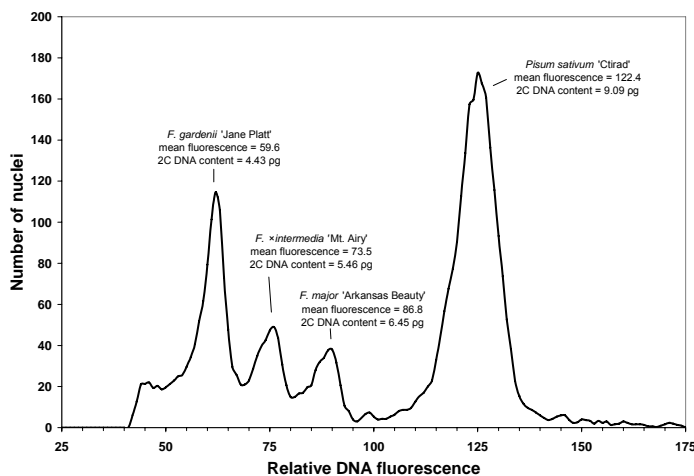


Fig. 2. Flow cytometry histogram of a combined sample containing nuclei from *Fothergilla gardenii* ‘Jane Platt’, *F. × intermedia* ‘Mt. Airy’, *F. major* ‘Arkansas Beauty’ and an internal standard, *Pisum sativum* ‘Ctirad’.

Novel Applications of Plant Tissue Culture

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Plant Tissue Culture – What and Why?

Plant tissue culture is the science (or Art!) that broadly refers to growing plant cells, tissues, organs, seeds or other plant parts in a sterile environment on a nutrient medium. Tissue culture has many applications, both in the production of plants as well as in research and development of new plant varieties. For many species, tissue culture provides a means for rapid propagation and commercial production compared to traditional propagation techniques, thereby reducing costs. Tissue culture was first used commercially in the 1920's for the production of orchids. Plant cultures in approved media are also easier and safer to transport and export, reducing risks of spreading disease.

Since the first commercial use over 80 years ago, tissue culture has progressed to be an important tool in horticultural science (please see <http://www.kitchenculturekit.com/historyTC.htm>). Tissue culture technology is now readily accessible and widely used in horticulture. Inexpensive tissue culture kits are even available for the home tissue culture hobbyist. In horticultural science, tissue culture provides many novel applications that assist with the development and screening of new cultivars.

At the Mountain Horticultural Crops Research and Extension Center tissue culture has become an integral part of the ornamental plant breeding program. Tissue culture has provided many novel approaches to help overcome barriers associated with conventional breeding and is a vital component of our program focused on developing non-invasive nursery crops. We use tissue culture as a means to facilitate plant selection, overcome seed dormancy problems, rescue aborting seeds, propagation and maintaining collections of important cultivars. Tissue culture has

Micropropagation

Micropropagation is also known as in vitro multiplication of plants is the basis of plant tissue culture. Small pieces of plant tissues and miniature shoots are cultured on nutrient media with plant hormones to derive plantlets that can be transferred to soil. Micropropagation techniques allows for rapid production of plants compared to conventional methods of vegetative propagation. For example, using micropropagation techniques, we can quadruple the number Miscanthus plantlets every 4 weeks. For Hypericum species, over 300 plantlets can be produced from a baby food jar in 8 weeks. Micropropagation procedures allows us to quickly multiply important cultivars to be used for field testing or in our breeding programs.



Embryo Rescue

Embryo or ovule culture techniques are used to rescue embryos from interplod crosses or wide crosses between different species within a genus. These embryos would fail to develop because the endosperm within the seed does not form normally. Embryos are usually small (< 2 mm) and required to be excised under a microscope. Embryos are usually cultured on media with high levels of amino acids to assist with development and growth. Embryo rescue techniques are being used successfully in developing non-invasive cultivars of *Miscanthus*. We have also rescued ovules from wide intergeneric crosses between *Diervilla* and *Weigela*.



Organogenesis/Somatic embryogenesis

Tissue culture is based on the principle of totipotency. Totipotency refers to the ability of a plant to regenerate from a single cell. Therefore with careful manipulation of nutrient media and plant hormones it is possible to regenerate entire shoots or embryos from a single cell. Using this technology we are often able to regenerate entire plants from leaves and other plant tissues.

In *Miscanthus*, somatic embryogenesis has provided a means for the rapid multiplication of important cultivars (see picture). Upto 300 plants can be obtained from only 1 g of starting tissue.



Somatic embryogenesis can also be used to establish plants from the endosperm. Endosperm is the part of the seed that provides nutrient to a germinating embryo. As endosperm is naturally triploid (i.e., contains 3 sets of chromosomes) the resulting plants are also triploid. Triploid plants produce little or no viable seed. For example seedless watermelon is triploid. This technology is being explored to help develop seedless forms of invasive species such as Barberry, *Miscanthus* and Winged Euonymus.

Developing Non-Invasive Nursery Crops

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Significance to Industry

Invasive species are an important issue for the nursery industry. The problem, briefly, is that some non-native landscape plants are weedy to the point of being invasive, i.e., causes or is likely to cause economic or environmental harm or harm to human health that outweighs any beneficial effects. It is often stated that invasive species represent a principal threat to biodiversity second only to that of habitat loss. It has also been estimated that approximately 85% of the invasive plant species in the United States were introduced for either ornamental or landscape use. Privets (*Ligustrum* spp.) are good examples – it is estimated that *L. sinense* alone has displaced the native shrub layer in 2.4 million acres throughout the Southern United States. However, privet is an important and valuable nursery crop with approximately 2.7 million new plants sold per year (<http://www.nass.usda.gov/census/census97/horticulture/table13.pdf>) at an estimated retail value of \$32 million dollars. Considering that many of these plants are economically, aesthetically, and environmentally important, development of seedless/noninvasive cultivars is an ideal solution whereby these valuable plants can be utilized without detriment.

Nature of Work

There are a number of approaches for developing seedless plants, but one of the most efficient and effective ways is to develop triploids - plants with an extra set of chromosomes. Although triploids typically grow and function normally, they have an inherent reproductive barrier in that the 3 sets of chromosomes cannot be divided evenly during meiosis yielding unequal segregation of the chromosomes (aneuploids) or complete meiotic failure. Triploids have been developed for many crops including seedless bananas (*Musa* spp.), watermelons (*Citrullus lanatus*), grapes (*Vitis* spp.) and althea (*Hibiscus syriacus*). Natural polyploids frequently occur in nature. Triploids can occur naturally or can be bred by hybridizing a tetraploid (4x) species or forms with a diploids (2x) to create seedless triploids (3x). Triploids are not always completely seedless. However, even in the unusual case when a triploid plant can produce seeds (e.g. apples), it happens infrequently, and seedlings generally have poor viability.

Results and Discussion

We are currently working on developing non-invasive triploids of the following: *Acer tartaricum* L. subsp. *ginnala* (Maxim.) Wesm. (amur maple), *Acer platanoides* L. (Norway maple), *Albizia julibrissin* Durazz. (silk-tree or mimosa), *Berberis* spp. (barberry), *Campsis tagliabuana* (Vis.) Rehd. (trumpet vine), *Cytissus scoparius* (L.) Link (Scot's broom), *Euonymus alatus* (Thunb.) Sieb. (burning bush), *Elaeagnus* L. spp. (elaeanthus), *Hedera helix* L. (English ivy), *Hypericum androsaemum* L. (tutsan St. Johnswort), *Koelerutaria paniculata* Laxm. (panicked goldenraintree), *Ligustrum* spp. (privet), *Miscanthus sinensis* Anderss. (maiden grass), *Pyrus calleryana* Decne. (callery pear) and *Ulmus parvifolia* Jacq. (lacebark elm). We have identified tetraploids of all of these species and have successfully developed triploids of *Pyrus*, *Hypericum*, *Ligustrum*, and *Campsis*. Because this approach involves controlled breeding, it also provides additional opportunities for plant improvement. In addition to breeding for seedlessness, we are simultaneously working on enhancing pest resistance, environmental adaptability, and further commercial potential of these crops. This project will ultimately provide new environmentally-friendly cultivars that will benefit the nursery industry, our environment, and consumers.

Acknowledgements

Funding for this research and development has been provided by: the USDA Floral and Nursery Research Initiative, the Horticultural Research Institute, NC Association of Nurserymen, the Landscape Plant Development Center, J. Frank Schmidt Family Foundation, and Spring Meadow Nursery.

Weed Control in Container-Grown Woody Ornamentals

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Herbicide efficacy is important when controlling weeds in containers. Despite good control of specific weeds with one preemergence herbicide, growers are encouraged to rotate herbicides because weeds may become resistant to a herbicides mode of action. Simply rotating to another herbicide, however, may not offer the same control, even if similar weeds are listed between labels.

Demonstrations of herbicide efficacy will be shown using the highest labeled rate of Snapshot 2.5TG (isoxaben + trifluralin) at 5.6 kg ai/ha (5.0 lbs ai/A), Scott's OH2 3G (pendimethalin + oxyfluorfen) at 3.4 kg ai/ha (3.0 lbs ai/A), Ronstar (oxadiazon) at 4.5 kg ai/ha (4.0 lbs ai/A), and Broadstar 0.25G (flumioxazin) at 0.42 kg ai/ha (0.38 lbs ai/A). Herbicides were applied to containers filled with composted pine bark using a handheld shaker jar. After application, approximately 40 seeds each of hairy willow weed (*Epilobium hirsutum*), bittercress (*Cardamine hirsuta*), hairy galinsoga (*Galinsoga ciliata*), spotted spurge (*Euphorbia maculata*), and common groundsel (*Senecio vulgaris*) were distributed in containers. Smaller seeds were mixed with sand then applied using a 0.5-teaspoon of the sand/seed mixture per gallon container. The effectiveness of the herbicides in controlling germination of these pernicious weeds will be evident.

Herbicide application to container grown plants should be made when the foliage is dry. Otherwise, foliar damage can result. The chemical can release on the wet foliage causing tip burn, necrosis, or severe stunting of foliage.

To demonstrate this point, we applied the same preemergence herbicides at the same rates to wet foliage or dry foliage of container grown plants of *Calycanthus ×raulstonii* 'Hartlage Wine', *Ligustrum* sp., and *Hydrangea* Endless Summer™.

Mixing It Up with Fluff® Substrate Amendment

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One name says it all!! Fluff® is a composted municipal waste (WastAway Corporation :<http://www.wastaway.com/> ; Bouldin and Lawson, McMinnville, TN). The concern over the availability of pine bark for container substrate is real. Bark has been a major component of nursery container substrate since the 1960s. In recent years, the continuous rise in energy prices, has created demand for bark as a clean fuel. The timber harvest in the US has slightly decreased since 1986. However, rapid growth in the nursery industry over the past two decades has resulted in increased demand. Therefore, the market share of bark for the nursery industry is projected to fall short of the demand. Investigating alternative components that can be used to extend bark supplies is the best solution requiring minimal changes in current nursery production practices.

Many studies have investigated the use of industrial and agriculture wastes as substitutes for pine bark. Some alternative substrate components show promise in that they are non-toxic to plants and can be successfully used to amend conventional substrates. However, regional availability and a limited supply of uniform and consistent quality reduce their widespread use.

At NC State, the Horticultural Substrates Laboratory has evaluated organic materials as additions to bark container potting media for 20 years. We test combinations of components for physical properties (air space, available water) and chemical properties (pH, EC, nutrient content) and their effects on plant growth. Upon hearing about another 'new' organic substrate for container-grown plants we were not particularly excited about composted residential household waste (Trademark Fluff®). On the surface the problems with such a material seemed endless. However, we agreed to run a small study examining the physical and chemical properties of the compost. We were wrong. Unlike most organic substrates including bark where the physical properties deteriorate over time, Fluff® combined with bark retained ideal physical properties over 19 weeks. Since Fluff® is a mixture of organic and inorganic materials this may help stabilize the material. In addition, Fluff® provided pH adjustment, calcium, magnesium, and micro-nutrients eliminating the need to amend the substrate with limestone or micro-nutrients.

The average American produces over 4 pounds of solid waste per day with the production of garbage estimated to increase by 5% per year. The use of recycled waste in container production would provide the nursery industry with a reproducible, consistent substrate amendment of unlimited supply. It is not incumbent on the nursery industry to solve the world's waste disposal problems. However, if recycled waste is a valuable substrate amendment then it becomes a win/win situation.

Fluff® when used as a bark amendment has the potential to replace a substrate component in ever increasing limited supply, stabilize physical properties of bark substrate, replace limestone and micro-nutrients additions, reduce irrigation volume, increase water use efficiency, and recycle a waste material. In addition, there would appear to be an unlimited and nationwide supply. The objective of this study will be to evaluate the physical, chemical, and growth effects of addition of Fluff® to ratios of pine bark.

Improving Short-Term Drought Tolerance of Container-Grown Ornamental Plants with the Growth Regulator ABA

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Department of Horticultural Science, North Carolina State University

Recent drought conditions and looming water restrictions have placed a great burden on growers producing plants in containers. One option for managing extended periods of drought during reduced water availability is to reduce the frequency of irrigation. Reducing irrigation during production, however, can decrease growth and be detrimental to the marketability of plants. The ability to increase the short-term drought tolerance of container-grown plants would allow growers to decrease the amount or frequency of irrigation while maintaining marketable plants. Therefore, we tested the effectiveness of various concentrations of abscisic acid (ABA) on short-term drought stress in container-grown ornamentals.

Hydrangea Endless Summer™, *Hydrangea* ‘Dooley’, and *Nandina* ‘Gulfstream’ were watered thoroughly 2-4 hours before treatment. Plants were grown under 35% shade cloth covered with opaque white polyethylene to exclude natural rainfall. Container plants were treated with a 150 ml solution per gallon container size of either 0 (water control), 125, 250, 500 or 1000 ppm S-ABA and were not irrigated for the remainder of the experiment. Each day at 10:00 a.m., plants were scored for the appearance of wilted or discolored foliage. If foliage was wilted or discolored, plants were designated as unmarketable.

Applications of increasing concentrations of S-ABA increased the number of days without wilting for all plants and therefore extended the days of marketability. The highest rates of S-ABA applied increased marketability by 3-4 days compared to the control. No phytotoxicity occurred on these three cultivars. The total length of time for all plants to become unmarketable was 12 days for *Hydrangea* and 30 days for *Nandina*. After the experiment ended with each species, all plants were rewatered and marketability was recorded the following day. For *hydrangea*, all plants treated with ABA returned to marketability, whereas the controls did not. For *Nandina* ‘Gulfstream’, plants did not regain marketable quality after rewatering in any treatment. Although short-term drought tolerance was increased in this species, *Nandina* has the ability to tolerate drought stress without ABA (control was marketable for 23 days). The delayed signs of wilting on the plant and its inability to recover after watering, however, may have masked the actual time it can withstand drought in containers.

Preliminary data provide support for further investigation on the use of S-ABA as an aid in increasing short-term drought tolerance in container-grown plants. Other possibilities include irrigating container plants with this compound prior to shipping, yet allowing plants to dry before loading. Shipping lighter plants may decrease freight costs. In large retail markets, where aftercare is often minimal, plants treated with this compound at nursery may be able to stay marketable longer in retail outlets. Of course more work is required to support these possibilities, and more species are needed to determine the efficacy of this product.

Evaluating Various *Tsuga* (hemlock) and *Ilex* (holly) Species for Adaptability to Western North Carolina

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Broadleaved and coniferous evergreens are a very important part of the nursery industry in NC and throughout the US. Hemlock wooly adelgid has destroyed many native hemlock populations. Asian hemlocks appear resistant to the adelgid, but there are some questions about the landscape adaptability of these species in western North Carolina. Various accessions of Chinese hemlock (*Tsuga chinensis*), Southern Japanese hemlock (*Tsuga sieboldii*), Northern Japanese hemlock (*Tsuga diversifolia*), Carolina hemlock (*Tsuga caroliniana*), and Eastern hemlock (*Tsuga canadensis*) will be planted in Winter/Spring 2008. Additionally, various cultivars or underutilized species of Hollies (*Ilex*) will be evaluated for landscape adaptability to Western NC. Factors include climate adaptability, foliage, flower, and fruit characteristics, and pest resistance or tolerance.

Cuttings of the plants to be evaluated were received from nurseries, private individuals, and Botanical Gardens and Arboretum from across the U.S. including Ray Head, Bill Cannon, Hefner's Nursery, Longwood Gardens, Arnold Arboretum, Keith Arboretum, J.C. Raulston Arboretum, Camellia Forest, Birmingham Botanical Garden, Holden Arboretum, Washington Park Arboretum, Morris Arboretum, Scott Arboretum of Swarthmore College, YewDell Botanical Gardens and the MHCREC. Following is the list of hollies to be included in the adaptability trial.

Genus	Seed parent or species	Variety or pollen parent	Cultivar
<i>Ilex</i>	x	<i>wandoensis</i>	
<i>Ilex</i>	<i>aquifolium</i>	<i>pernyi</i>	Red Beauty
<i>Ilex</i>	x	<i>koehneana</i>	Ajax – Male
<i>Ilex</i>	<i>burfordii</i>	<i>latifolia</i>	Anthony Brunner
<i>Ilex</i>	<i>Attenuate?</i>		Annie Armstrong
<i>Ilex</i>	<i>cornuta</i>	<i>latifolia</i>	Bessie Smith
<i>Ilex</i>	<i>burfordii</i>	<i>latifolia</i>	Bob Brunner – Male
<i>Ilex</i>	<i>ciliospinosa</i>	<i>sikkimensis</i>	Brilliant
<i>Ilex</i>	<i>aquifolium</i>	<i>aquifolium</i> x Nellie R Stevens	ButterCup
<i>Ilex</i>	<i>altaclarensis</i>	<i>camelliifolia</i>	Camelliaefolia
<i>Ilex</i>		<i>meservae</i>	Castle Spire
<i>Ilex</i>		<i>meservae</i>	Castle Wall
<i>Ilex</i>	<i>opaca</i>		Chief Paduke
<i>Ilex</i>	<i>opaca</i>		Clarendon's spreading
<i>Ilex</i>	<i>decidua</i>		council fire
<i>Ilex</i>	<i>opaca</i>		Dan Fenton – Female Rutgers
<i>Ilex</i>	<i>burfordii</i>	<i>latifolia</i>	Emily Brunner
<i>Ilex</i>	(<i>cornuta</i> <i>Burfordii</i> x <i>pernyi</i> <i>Red Delight</i>) x <i>latifolia</i>	OP Seed	Festive
<i>Ilex</i>	<i>burfordii</i>	<i>latifolia</i>	Ginny Brunner
<i>Ilex</i>	<i>glabra</i>	<i>nigra</i>	nigra
<i>Ilex</i>	<i>cornuta</i> x <i>pernyi</i>	<i>latifolia</i>	Hohman
<i>Ilex</i>	<i>aquifolium</i>	<i>cornuta</i>	Hollowell

Genus	Seed parent or species	Variety or pollen parent	Cultivar
<i>Ilex</i>	?	?	Honey Maid
<i>Ilex</i>	<i>cassine (myrtifolia)</i>	<i>opaca</i>	Hume #2
<i>Ilex</i>	<i>aquifolium</i>		J.C. van Tol
<i>Ilex</i>	x	<i>koehneana</i>	Kurly Koe
<i>Ilex</i>	<i>aquifolium</i>	<i>latifolia</i>	Lassie
<i>Ilex</i>	<i>opaca</i>		Longwood Gardens Gold
<i>Ilex</i>	<i>burfordii</i>	<i>pernyi</i>	Lydia Morris
<i>Ilex</i>	<i>pedunculosa</i>		Male
<i>Ilex</i>	<i>opaca</i>		Miss Helen
<i>Ilex</i>	<i>opaca</i>		Morgan Gold
<i>Ilex</i>	<i>cassine (myrtifolia)</i>	<i>opaca</i>	Nasa
<i>Ilex</i>	<i>pedunculosa</i>		NYBG form
<i>Ilex</i>	<i>(cornuta Burfordii x pernyi Red Delight) x latifolia</i>	OP Seed	Oakleaf
<i>Ilex</i>	<i>cornuta</i>	<i>latifolia</i>	Patrick Smith – Male
<i>Ilex</i>	<i>decidua</i>		Pochahontas
<i>Ilex</i>	<i>aquifolium</i>	<i>variegated</i>	Proud Mary
<i>Ilex</i>		<i>meservae</i>	Purple Frost
<i>Ilex</i>	<i>decidua</i>		Red Escort
<i>Ilex</i>	<i>aquifolium x cornuta (Nellie R Stevens)</i>	<i>cornuta</i>	River Queen
<i>Ilex</i>	<i>aquifolium</i>	<i>latifolia</i>	Ruby
<i>Ilex</i>	x	<i>koehneana</i>	San Jose
<i>Ilex</i>	<i>opaca</i>		Satyr Hill
<i>Ilex</i>	<i>integra</i>	<i>altaclerensis Hodginsii</i>	Sceptor
<i>Ilex</i>	<i>decidua</i>		Sentry
<i>Ilex</i>	<i>ciliospinosa</i>	<i>aquipernyi</i>	September Gem
<i>Ilex</i>	<i>vert.</i>		Southern gentleman
<i>Ilex</i>	<i>glabra</i>		Squat
<i>Ilex</i>	<i>vert.</i>		Sunset
<i>Ilex</i>	<i>cassine</i>		Tensaw
<i>Ilex</i>	?	?	Truffles Crinkleleaf
<i>Ilex</i>	<i>crenata</i>		Twiggy
<i>Ilex</i>	<i>aquifolium x cornuta (Nellie R Stevens)</i>	<i>latifolia</i>	Venus
<i>Ilex</i>	x	<i>koehneana</i>	Wirt L. Winn