2001

North Carolina State University
North Carolina Association of Nurserymen

Nursery

Short Course

February 8-9, 2001
Jane S. McKimmon Center
Raleigh, North Carolina

Sponsored by
North Carolina State University
North Carolina Agricultural Research Service
North Carolina Cooperative Extension
North Carolina Association of Nurserymen

NCSU NURSERY SHORT COURSE
February 7 & 8, 2001
McKimmon Center
Raleigh, N.C.

Registration	NCAN	8-9 a.m.

	Thursday Morning	9-12 a.m.
9:00 -9:10	Welcome and Opening Remarks- Eelco Tinga-President NCAN	
9:10-9:50	Growing Container Hydrangeas Successfully ? Richard E. Bir	
9:50-10:30	Can Manures Suppress Root Diseases in Potting Mixes? Dr. Mike Benson	
10:30-11:00.	BREAK	
11:00-11:30:	Controlled Screening for Fire Blight Resistance in Flowering Pears and Crabapples. Andrew Bell	
1130-12:00	What's Up With Ornamental Breeding in Buddleia, Stokesia, and Cercis. Dr. Dennis Werner	

Lunch	12- 1 p.m.

	Thursday Afternoon	1-5 p.m.
1:00-1:45	Cutting edge cultivars: Outstanding woodies. Tom Ranney	
1:45-2:30	Success with Ornamental Vegetables. James L. Gibson	
2:30-3:00	*BREAK*	
3:00-3:35	Rooting For You: Auxins And Adventitious Rooting- Frank Blazich	

3:35–4:35	*Don't Take Sides: Suggested Pairings of Woody and Herbaceous Plants for Contemporary Landscapes.*
	Bryce Lane and Robert Lyons
4:35	Any Questions???

Reception & Open House NCAN Office- 968 Trinity Road, Raleigh (919.816.9119)	5-6 p.m.

FEB 18

Registration	NCAN	8-9 a.m.

	Friday Morning 9-12 a.m.
9:00-9:35	Is that Your Final Answer? Taxonomy of Cultivated Liriopogons. Paul Fantz
9:35-10:15	Supply And Demand: Have The Rules Changed? -Kim Powell
10:15–10:45	BREAK
10:45-11:30	Got Cost Estimates? (What's It Costs To Grow Field Grown Trees And Shrubs?) Dr. Charles Safley
11:30-12:00	Irrigation Timing Is Everything With A Big Difference In Growth !! Stu Warren And Ted Bilderback

Lunch	12-1 p.m.

	Friday Afternoon 1-4:30 p.m.

1:00-1:45	It's Only Money: Economic Comparison Of Weed Control Options In Container Nurseries. Dr.Joe Neal
1:45-2:30	When Do You Pot Your Plants? Does It Make a Difference ? Stuart Warren and Ted Bilderback
2:30-3:00	Break
3:00:3:45	Are You Mixed Up About Container Mixes? Ted Bilderback
3:45	Any Questions??
4:00 Depart	

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*All telephone numbers are in area code 919 unless otherwise noted.

Growing Hydrangeas in Containers

Dick Bir
NC Cooperative Extension

Introduction: In North Carolina, two native species, *Hydrangea arborescens* and *quercifolia*, are commonly container grown with. In addition, at least two non-native species, *Hydrangea macropylla* (including varieties *macrophylla, normalis* and *serrata*) and *Hydrangea paniculata* are commonly grown in North Carolina. Excellent quality plants of the species and most cultivars of these four species can be grown within North Carolina if attention is paid to basic cultural practices. However, not all of these species grow well under the same conditions.

All cultural practices must be met, not just some, to grow the best quality plants. A day or two of carelessness may not kill the crop but it may reduce quality to the point where plants are unsalable.

Common names and a popular cultivar for these species are as follows: *Hydrangea arborescens* – Smooth or Wild Hydrangea, 'Annabelle'; *Hydrangea macrophylla* var *macrophylla* – Bigleaf, florist or French hydrangea (mopheads or hortensias), 'Nikko Blue'; *H. macrophylla* var *normalis* (lacecaps). 'Veitchii'; *H. macrophylla* var *serrata* – Mountain hydrangea. 'Preziosa'(var *serrata* has both mophead and lacecap flowers); *Hydrangea paniculata* – most often called "PeeGee's" but 'PG' is just one cultivar . . . var. *grandiflora* is 'PG'. 'Tardiva'; *Hydrangea quercifolia* – Oak leaf hydrangea. 'Alice' or 'Snow Queen.'

Light: *Hydrangea arborescens* and *paniculata* can grow well in full sun and may become leggy if grown in dense shade. However, both use large quanities of water when grown in full sun and should not be allowed to wilt. As a result, some growers produce these plants in light shade or in areas where plants will receive afternoon shade.

Hydrangea macrophylla and *quercifolia* should be grown under at least 30 % shade except in the coolest areas of NC. Most are grown under 50% or greater shade in the coastal plain and piedmont.

Water: Hydra, Greek for water (as well as a many headed monster slain by Hercules), are the first five letters of the species name. Hydrangeas need abundant supplies of available water in order to grow and develop properly. *Hydrangea arborescens* and *paniculata* need less water than *macrophylla* or *quercifolia* when grown under similar conditions. Although tolerant of moisture stress, both drought tolerant species will drop older leaves after bouts of moisture stress. Many cultivars of *Hydrangea macrophylla* and *quercifolia* will produce large, lush leaves in deep shade with abundant moisture and fertilizer. However, unless there is adequate air drainage, problems with powdery mildew, slugs and even grey mold may develop. If the potting medium is kept constantly saturated, root rot diseases are likely to develop. A key to growing good quality hydrangeas in containers is to keep the roots wet enough but not too wet.

Potting Mixes: Standard pine bark based potting mixes have performed well for hydrangeas across North Carolina. Sand and/or sphagnum peat and other amendments are added by individual growers in order to manage irrigation properly. Except where all pH management, calcium and magnesium needs are met through the irrigation water, dolomitic limestone is

generally added to the potting mix. Liming rates suitable for azaleas, camellias or rhododendrons are generally used for blue flowered *Hydrangea macrophylla* and all *quercifolia*. *Hydrangea arborescens*, *paniculata* and the pink flowered *macrophylla* are usually limed to a pH more suitable for other deciduous shrubs, i.e., around pH 6.5. However, both *arborescens* and *paniculata* are tolerant of acidic potting mixes. Chlorotic foliage can be expected in all of these hydrangea species if pH gets too high. Avoid excess liming of potting mixes and check irrigation water for pH, lime and salinity.

Fertilizers: Greenhouse and florist hydrangeas have been grown using completely soluble liquid fertilizers for years. However, the most commonly used fhydrangea cultural practices used in NC are overhead irrigation together with controlled release fertilizers (CRF) applied following potting or in the spring. The CRF should last throughout the growing season so choose a release pattern to fit the crop and the climate, i.e., 180 days in the mountains and 270 days or longer in the coastal plain and piedmont.

Rates of CRF application depend upon the size of the plant, irrigation techniques and the plant species/cultivar. Rarely are high rates of fertilization needed when growing any but the *macrophyllas*. *H. macrophyllas* will respond to the label high rate and tolerate even higher rates of fertilizer application but rates higher than those listed on the label are usually not economically beneficial.

If chlorosis becomes a problem with any species, check for causes. It is not uncommon to spray chelated iron solutions or use a fertilizer containing extra iron when growing hydrangeas in containers but lack of iron may not be the reason for the chlorosis. Treat symptoms but find causes.

Blue flowered *macrophylla* will not flower blue without available aluminum, iron and acidic potting mixes. Most often, spraying or irrigating with an aluminum sulfate solution can enhance the blue color of normally blue flowering cultivars that appear lavender or pink when grown in containers. Once planted into most NC soils, as soon as roots extend into the native soils the flower color will become the appropriate blue. Pink flowered *macrophylla* should have no aluminum or native soil available to the roots. In addition, potting mix pH should be maintained at pH 6.5-6.8.

Pests: The biggest problems with container grown hydrangeas involve too much or too little light and water. Next is over fertilization and growing plants so close together that inadequate air flow occurs.

Occasionally mites, caterpillars, grasshoppers, beetles and slugs are problems but rarely do they occur on container grown plants that are not too crowded, potbound, moisture stressed and/or sunscalded. Pest problems are usually easily managed by consulting the Ag Chemicals Manual if other cultural problems are kept under control.

Pruning: All of these shrubs grow rapidly in containers and may need to be encouraged to branch to fill the pot. Generally hedge clippers are the pruning tool used in commercial nurseries, i.e., liners are hedged. Large, full liners should be put in containers. Even then, a mid season pruning is often necessary to increase plant density. This is most frequently done right after the propagation crew has taken all the cuttings they need for next years crop. Please check with the propagator before pruning.

Flowering will occur on most of these plants when they get large enough. *Hydrangea arborescens* and *paniculata* will usually flower the season they are planted into 3 gallon pots and allowed a full season's growth. Despite the alleged fact that *Hydrangea macrophylla* and *quercifolia* form flower buds one year but do not flower until the next year, it is not uncommon to see flowers on plants of these species undergoing rapid growth in a container nursery under shade. These plants will revert to "normal" flowering patterns by the second year they are in the landscape.

Can Manures Suppress Root Diseases in Container Mixes?

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Farmers have used animal manures for centuries as an organic source of nutrients for crop production. Can manures suppress root diseases in container mixes? Several root diseases caused by *Rhizoctonia solani*, *Pythium* spp. and *Phytophthora cinnamomi* attack many important nursery crops in container production. Although pine bark-based container mixes are suppressive to these pathogens, disease can still develop when environment conditions exceed the capacity of the mix to suppress the pathogen. We have been evaluating animal manures in the last couple of years as amendments to container mixes to suppress root diseases. Development of value-added products based on manures generated by the expanding poultry and swine production in the state could be beneficial both to the animal and nursery industry. Our goal is to understand the microbial factors associated with suppressiveness of container mixes and learn how to manipulate these microorganisms for disease control.

Animal manures. This past year we conducted two different experiments to determine how suppressive container mixes amended with animal wastes were to *Pythium ultimum* and *P. cinnamomi*. Two types of animal manures were used: poultry compost consisting of composted waste and bird mortality (NCSU, Animal Waste Management Center), and swine waste collected from a lagoon and pelletized (BION Soil, BION, Inc. Smithfield, NC).

Cucumber bioassay. General suppression of the manures was tested in a cucumber bioassay with *Pythium*. The manures were amended to Fafard 4P peat-based container mix at rates of 4, 8, or 12% (v/v). The amended mix in 4" pots was planted with eight cucumber seeds, irrigated heavily to remove salts, then placed in a growth chamber with 16 hr of light/day at a constant temperature of 68 F. After 10 days, each pot was examined and the cucumbers rated for disease. Fafard mix without manure was used as a control.

Results of bioassay. Both swine waste and poultry compost incorporated into Fafard 4P were suppressive to Pythium root rot in two different runs of the experiment (Fig. 1). The best suppression of Pythium root rot was found at incorporation rates of 8 or 12%. However, disease was not suppressed completely as ratings of 2 meant that cucumber seedlings emerged but were stunted compared to seedlings in the controls.

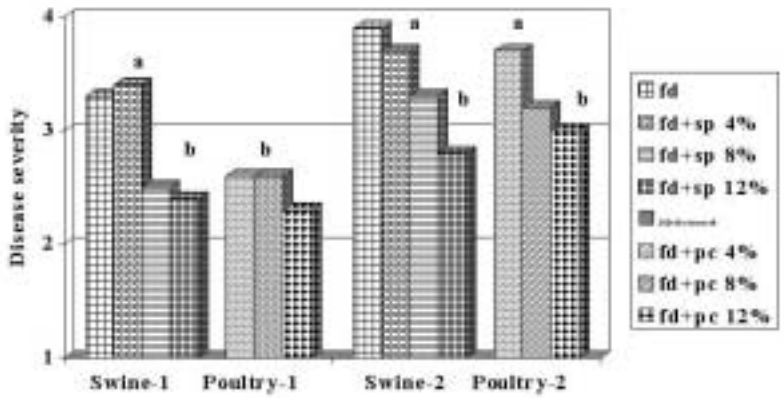

Fig. 1. Cucumber bioassay to detect suppression of Pythium root rot with either a swine pellet waste or poultry compost incorporated into Fafard 4P potting mix. Disease severity is 1=healthy, vigorous seedling, 2= seedling emerged but stunted, 3=emergence but seedling diseased and 4=dead, no emergence. Swine 1 and Swine 2 refer to experiments run in July and August, respectively.

Phytophthora root rot of azalea. The second experiment was conducted at the Horticultural Field Lab at NCSU with Hinodegiri azalea to test the suppression of manures for control of Phytophthora root rot. Azaleas were grown in pine bark mix amended with the manures at rates of 4, 8, or 16% (v/v). In early June, one half the plants in pots were inoculated with *P. cinnamomi*. Plants in control treatments without manures received 3.2 g N per pot of 16-5-10 Wilbro NPK fertilizer. No fertilizer was added to pots with manures. Pots placed under a shade cloth were irrigated daily by overhead sprinklers. Foliar symptoms of disease were rated regularly over the summer. The VTM 'pour through' method was used to determine soluble salts and pH levels in the pots during the season. In September, plant top weight was determined and the roots of each plant rated for extent of Phytophthora root rot where 1= healthy roots, 5 = roots completely rotten and plant dead.

Results of nursery test. Azaleas in mixes infested with *P. cinnamomi* developed symptoms of Phytophthora root rot on the foliage of azaleas beginning in July and progressing over the summer. Phytophthora root rot was not suppressed in any pine bark mix incorporated with the animal manures at rates of 4 to 16% compared to pine bark mix only (Fig. 2).

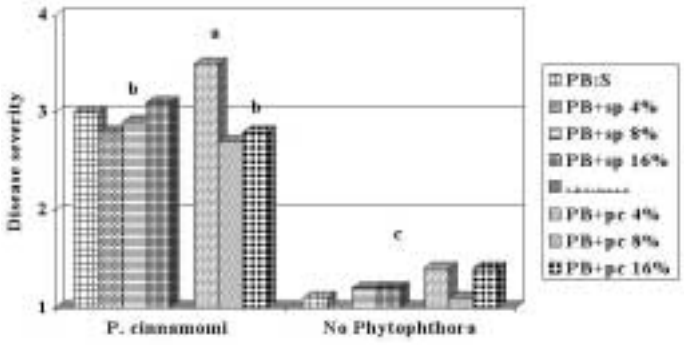

Fig. 2. Effect of swine waste and poultry compost at 4, 8, or 16% (v/v) in a pine bark mix on development of Phytophthora root rot of azalea in the presence and absence of *Phytophthora cinnamomi*. Disease severity scale: 1 = healthy, no root rot, 3= severe root rot

Plant top weights in all mixes infested with *P. cinnamomi* were much less than in comparable mixes without *P. cinnamomi* (Fig. 3). In the absence of *Phytophthora*, azaleas grown in the poultry compost mixes were generally smaller than those in the swine waste amended pine bark.

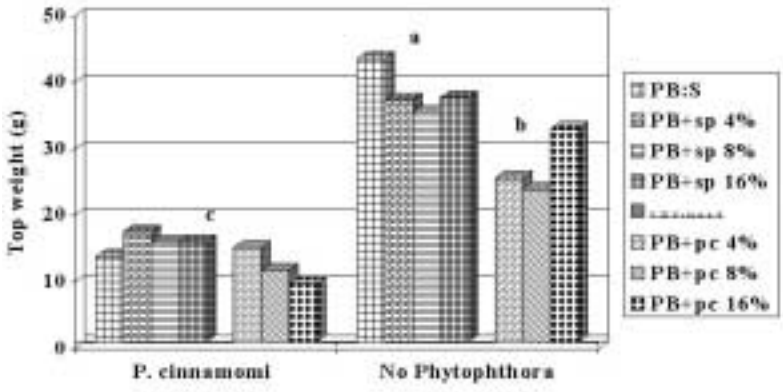

Fig. 3. Top weight of azaleas for plants grown in a pine bark mix amended with swine waste or poultry compost at 4, 8, or 16% (v/v) in the presence or absence of *Phytophthora cinnamomi*.

Effect of manures on soluble salts in azalea. Initially, soluble salts readings were highest in pine bark mix amended with the 16% rate of manure. However, EC values near 0.8 mmhos/cm dropped to less than 0.3 mmhos /cm in a couple of weeks.

Impact to nursery industry. Animal manure amendments were suppressive to Pythium but not Phytophthora root rot. In the absence of Phytophthora, azalea growth in 4% swine waste may be comparable to that in pine bark mix with inorganic fertilization.

Acknowledgements. The authors gratefully acknowledge the support of the USDA Southern Region IPM Program and the North Carolina Agricultural Research Service as well as the technical assistance of Kala Parker, Karen Parker, Candice Eckard and Billy Daughtry. We thank BION Inc., Smithfield, NC and the NCSU Animal Waster Management Center for samples of manures.

Fire Blight: A bacterial disease of Rosaceous plants

Andrew Bell
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I. Introduction

Fire blight, caused by the bacterium *Erwinia amylovora*, is one of the most significant diseases of plants in the rose family, particularly members in the subfamily Maloideae. Susceptible plants can be severely damaged and killed by fire blight in both nursery and landscape plantings. Although this disease originated in New York, it is especially problematic in both the Southeastern and Mid-western states where environmental conditions for the pathogen are favorable. Fire blight outbreaks result in significant economic losses each year, particularly in apple and pear orchards. Today, this devastating disease has a worldwide distribution with limited control measures available.

II. Symptoms

Blossom Blight

Blossom blight is usually the first symptom visible in the growing season. Flowers will first appear water soaked ("soggy") then will shrivel and turn dark brown or black in color. Some flowers may fall but typically they remain attached to the spur shoot. Bacterial ooze may also be produced and be visible on the flower stalk.

Shoot Blight

Shoot blight symptoms are easy to recognize and allow one to distinguish fire blight from other diseases of this group of plants. The most common symptom is necrotic young shoots that appear "scorched". It is this symptom that gives the disease its common name, fire blight. Young stems will curl at the tips revealing another classical symptom, "shepherd's crook".

Leaf Blight

Typically leaf blight results from secondary infection. The pathogen may enter directly through naturally openings in the leaf or through wounds caused by hail, strong winds, or insects. Necrotic areas may appear, however darkening of the midrib and petiole is very characteristic.

Fruit Blight

Like leaves, immature fruit can become infected through natural openings and small wounds. Sections of the fruit will initially appear water soaked and ultimately turn brown to black. Blighted fruits will typically remain on the plant and a milky to amber-colored ooze may appear on the fruit surface.

Limb and Trunk Blight

On more susceptible varieties, infection will spread into older limbs and the truck where cankers can develop. The cankers will appear as a sunken, darkened area with the bark peeling back. It is here in the cankers where the bacterial cells overwinter. As the temperature increases in the spring, bacterial cells become active and the sticky ooze begins to flow out of the cankers attracting insect vectors.

III. Disease Development

Fire blight outbreaks are based on the interaction between the host plant and the pathogen but is mediated by the environment. Primary inoculum source, the presence of insect vectors, plant nutrition, soil conditions, host plant resistance, and pathogen virulence are important factors affecting disease development. Warm, humid weather conditions with sufficient rainfall are ideal for fire blight outbreaks. These conditions are common in the eastern U. S. where fire blight can be problematic. Cultural practices, selection of resistant varieties, and chemical applications are important to the management and control of this disease. Furthermore, it is essential to monitor the plant growth stage and weather as these factors play a crucial role in the timing of chemical applications.

IV. Control

Cultural Practices

-Remove overwintering cankers to reduce inoculum source, sanitize pruners after each cut to prevent the spread of the disease.

-Select an appropriate site or maintain soil pH level above 5.5, plants grown at lower pH levels are more susceptible

-Avoid excessive fertilization, succulent tissue is more susceptible

Chemical Application

Copper Compounds (Bordeaux Mixture)

Dissolve 8 grams of crystalline copper sulfate in 100 gallons of water, then add 8 grams of hydrated lime. The mixture should be constantly agitated during application. Copper compounds are applied during the dormant season up to ½ inch green up in the spring. They can be very toxic to foliage; do not apply copper compounds after bud break. Copper compounds are less effective in controlling fire blight than bactericides but are still widely used. Other formulations have been used- consult the extension service for additional information.

Bactericides

Streptomycin (Agri-Strep, Agrimycin) is the most effective bactericide available for the control of fire blight. It needs to be applied to open flowers to control blossom blight. Bactericides can be applied throughout the growing season to control bacterial reproduction.

***Spray schedules and application rates are crucial, consult labeling for application rates and your local extension service for recommendations.**

Resistant Varieties

Cultivar selection is crucial, including rootstock. Generally species of pears are more susceptible to fire blight than are species of apples and crabapples. However, many of the cultivated varieties of apples are highly susceptible. Recent research conducted at N C State University has documented more reliable fire blight resistance information for flowering pears and crabapples.

Although many taxa of flowering pears and crabapples are susceptible to fire blight, there is considerable variation in resistance to this disease providing opportunities for the selection and development of superior plants. Research on fire blight resistance among flowering pears and crabapples has been limited and has primarily been based on observations of natural infection. Because the incidence of fire blight can be sporadic and vary from region-to-region and year-to-year, observations and results from field surveys can be inconsistent and highly variable. Plants that initially appear to be resistant may later be found to be susceptible when conditions are favorable. Controlled inoculations of actively growing shoots with *E. amylovora* can provide an effective and consistent means for evaluating fire blight resistance. *For the complete publication of this research, please refer to the following web site:
http://fletcher.ces.state.nc.us/programs/nursery/metria/metria11/bell/fireblight.htm

Pyrus taxa	% lesion length
950104[y]	1[z]
P. ussuriensis 'Prairie Gem'	3
P. betulifolia 'Dancer'	16
P. regelii	22
93-70-2[y] (*calleryana* 'Chanticleer' x	22
elaeagrifolia)	31
P. calleryana 'Chanticleer'	32
93-61-1[y] (*amygdaliformis* x *calleryana*	38
'Chanticleer')	42
91-42-1[y] (*amygdaliformis* x *regelii*)	44
911014[y]	46
93-15-1[y] (*elaeagrifolia* x *ussuriensis*)	50
P. calleryana 'Fauriei'	62
P. calleryana 'Bradford'	63
P. calleryana 'Whitehouse'	65
91-53-1[y] (*callyerana* 'Chanticleer' x	69
betulifolia)	81
P. calleryana 'Aristocrat'	87
P. calleryana 'Red Spire'	89
93-17-3[y] (*elaeagrifolia* x *amygdaliformis*)	91
93-2-2[y] ((*calleryana* x *fauriei*) x *nivalis*)	92
P. fauriei 'Korean Sun'	94
P. elaeagrifolia 'Turkish Mist'	95
911010[y]	97
93-32-4[y] (*salicifolia* 'Pendula' x *ussuriensis*)	98
P. pyrifolia	100
P. nivalis 808	
93-8-5[y] (*fauriei* x *salicifolia* 'Pendula')	
P. salicifolia 'Pendula'	

[y] hybrid Pyrus taxa

[z] % of total shoot length infected 40 days following inoculation

Malus taxa	Strain:	273	273	2002A	4001A
	Year:	1999	2000	2000	2000
sieboldii 'Calocarpa'		0[z]	1	24	28
'David'		0	1	1	6
'Adirondack'		0	2	9	36
'Sentinel'		1	4	86	79
'Adams'		1	1	12	16
'Pink Princess'		2	15	44	47
'Sutyzam' (Sugar Tyme™)		3	1	41	35
'White Cloud'		4	NA	NA	NA
'Centurion'		4	10	24	17
baccata 'Jackii'		4	14	46	56
'Radiant'		6	13	10	19
'Molten Lava'		6	19	53	56
'Pink Satin'		6	17	22	69
'Camzam' (Camelot™)		7	16	73	69
'Ormiston Roy'		7	4	47	56
'Prairifire'		7	43	93	79
'Indian Summer'		8	1	22	27
floribunda		9	16	18	46
'Robinson'		9	9	27	26
'Narragansett'		10	15	52	65
'Dolgo'		10	27	51	35
sargentii		10	48	83	59
'Liset'		11	10	76	78
'Jewelberry'		11	22	55	78
'Purple Prince'		11	52	91	98
'Strawberry Parfait'		11	21	48	74
'Callaway'		12	22	35	35
'Candy Mint'		13	60	85	86
'Glen Mills'		14	19	94	93
'Silver Drift'		14	0	79	100
'Snow Drift'		14	75	100	100
'Canary'		17	33	33	38
'Hargozam' (Harvest Gold™)		18	21	81	83
'Louisa'		19	10	23	27
'Prairie Maid'		22	91	100	88
'Red Splendor'		23	19	63	54
'Doubloons'		28	35	57	64
'Baskatong'		32	75	95	90
'Professor Sprenger'		33	12	38	85
'Branzam' (Brandywine™)		39	51	78	63
'Mary Potter'		40	40	100	96
'White Angel'		41	44	90	70
'Mazam' (Madonna™)		50	66	100	97
hupehensis		55	56	98	99
'Donald Wyman'		61	60	93	97
'Silver Moon'		61*	84*	99*	100*
'Schmidtcutleaf' (Golden Raindrops™)		91*	100*	100*	100*
tschonoskii		100*	100*	100*	100*
'Sinai Fire'		100*	94*	100*	100*

[z] Controlled Inoculations: % of total shoot length infected.

* Lesion extended into prior years growth on some branches.

Plant Breeding Efforts in *Stokesia*, *Cercis* and *Buddleia* at North Carolina State University

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INTRODUCTION

Breeding and genetic studies of various herbaceous perennial and woody ornamentals have been initiated by the author at North Carolina State University. In addition to development of new ornamental cultivars, the research program will also focus on other related objectives including studies of reproductive biology, genetic diversity, propagation, and inheritance of important traits in these genera.

Stokesia

Stokesia laevis (Hill) E. Greene, Stokes Aster, is a herbaceous perennial native to the southeastern United States. Its range is quite restricted, with scattered populations found primarily in Mississippi, Alabama, Florida, Louisiana, and Georgia. Historically, Stokes Aster has enjoyed moderate popularity in the perennials industry. Renewed interest in this plant has been fueled by the discovery in central Georgia of a population of Stokes Aster demonstrating unique architecture. This population, now lost due to agricultural use of the site, was discovered in Colquitt County, GA, near the town of Omega by Ron Dieterman of the Atlanta Botanical Garden. Plants in this population showed tall, upright flowering scape architecture, unlike the shorter, non-upright scapes typical of the species. Selections from this population have given rise to the cultivar 'Omega Skyrocket'. 'Omega Skyrocket' has lavender-blue flower color typical of the species. Our initial breeding objectives have focused on incorporating the novel upright scape architecture into a broader range of flower colors. Accordingly, we have hybridized 'Omega Skyrocket' with cultivars 'Alba', 'Mary Gregory', 'Peachy', and 'Purple Parasols', demonstrating white, yellow, violet, and deep violet flower color, respectively. Preliminary hybridization experiments suggested that Stokes Aster is sexually self-incompatible, simplifying the hybridization process and eliminating the need for emasculation (removal of male sexual flower parts on the intended female parent). First generation hybrid plants (F_1 progeny) in all crosses demonstrate both violet-blue flower color and upright growth architecture characteristic of 'Omega Skyrocket', suggesting genetic dominance of these characters. Progeny within each of these three F_1 families have been intercrossed by planting in isolated field locations, or by establishing potted plants in screened cages, and introducing bumblebees and honeybees as pollinators. Large amounts of F_2 seed have been obtained and have been germinated. F_2 populations, which will show genetic segregation for the various traits of interest, will be field planted in the summer of 2000. Individuals showing the desired combinations of traits will be selected and further tested in comparative performance trials. To date, we have recovered various interesting progeny that have potential as commercial cultivars. These will be discussed.

Cercis

The high number of interesting genetic variants in *Cercis canadensis* offers a number of exciting breeding opportunities. Traits of interest include red leaf color ('Forest Pansy'), leaf variegation ('Silver Cloud'), double flowers ('Flame'), white flowers ('Alba'), pink flowers

(‘Withers Pink Charm’), violet-red flowers (‘Appalachian Red’), weeping growth habit (‘Traveller’ and ‘Covey’), purple fruit color (some accessions of *Cercis canadensis* var. *mexicana*), and glossy foliage (*Cercis canadensis* var. *texensis*). We have made hybridizations in numerous combinations between these taxa. Initial hybridization attempts suggest that controlled crosses in *Cercis* are difficult, as fruit set was poor. Because the pollination biology of *Cercis* is unknown, we resorted to emasculation when making crosses, which may result in flower injury and a decrease in fruit set. However, we were successful in obtaining F_1 seed from numerous combinations in 1999. ‘Traveler’, a weeping cultivar of considerable breeding interest, is particularly difficult to use in hybridization. Two years of effort suggest that it is highly male and female sterile, and will produce little or no fruit. We have grown F1 trees in pots under luxuriant growing conditions in year 2000. The different F1 families have been established in isolation blocks at the Sandhills Research Station in Jackson Springs, NC for production of genetically pure F2 seed. Additionally, hybridizations in 2001 will be conducted using potted trees placed in screened cages in which insect pollinators will be introduced. Such a strategy should result in greatly improved seed set and hasten breeding progress.

We have grown out open-pollinated progeny (seed collected from a specific cultivar, hence the female parent is known, but with no knowledge of the male parent) of various cultivars. Of particular interest are the progeny grown from seed collected from the variegated ‘Silver Cloud’. Of 520 daughter plants, only two individuals showed the variegated character of ‘Silver Cloud’. This demonstration of sexual transmission of the variegated trait from ‘Silver Cloud’ to its offspring suggests that the variegated character present in this clone is not caused by chimerism. Because of our lack of knowledge of the pollination biology of *Cercis*, and consequently our inability to infer whether these offspring are a result of self or cross pollination, no conclusions can be made regarding the inheritance of this trait at this time.

Buddleia

The high amount of genetic variability present in *Buddleia* affords considerable opportunity to develop new and novel taxa through controlled breeding. Initial efforts in our *Buddleia* breeding have focused on compactness, silver-gray leaf color, flower color, and branched-panicle (inflorescence) architecture. Considerable effort has been made hybridizing the yellow-flowered *Buddleia* ‘Honeycomb’ with various cultivars with the objective of developing yellow-flowered taxa demonstrating more compact growth, greater flower production, silver-gray foliage color, and improved panicle architecture. The branched-panicle character presently found only in *B. davidii* cultivar ‘Dartmoor’ behaves as a recessive trait in controlled hybridizations with cultivars demonstrating normal (non-branched) panicle architecture. We have recovered one interesting white-flowered seedling in hybridizations of ‘Dartmoor’ with ‘Nanho Alba’. Efforts have also been initiated in hybridization of the unique compact cultivar ‘White Ball’ with other color forms in order to develop a series of compact forms demonstrating different colors.

The potential for interspecific hybridization in *Buddleia* appears great. Numerous clones already in the commercial trade represent interspecific hybrids, and our initial breeding efforts suggest that controlled hybridization of *B. davidii* Franch. with *B. lindleyana* Fortune, *B. fallowiana* Balf., and *B. salvifolia* (L.) Lam. are possible. At this time, progeny from hybridization of *B. lindleyana* with *B. davidii* ‘Nanho Purple’ appear promising.

Cutting Edge Cultivars: Outstanding Woodies

Thomas G. Ranney
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Mountain Horticultural Crops Research & Ext. Center
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The crops we work with are constantly changing. New cultivars and unfamiliar species are continually being introduced. People around the world are working diligently to select, evaluate, and develop new and better plants with greater ornamental merit, novel traits, and greater resistance to diseases, insects, and environmental stresses. Considering the diverse genetic base we are working with, the possibilities are endless.

This presentation will provide a look at a diversity of woody plants with an emphasis on species and cultivars from around the world that have commercial potential, superior pest resistance, stress tolerance, and ornamental merit. Results from plant evaluation programs and an update on certain plant breeding projects at the Mountain Horticultural Crops Research Station will be given.

Slide List
Cutting Edge Cultivars - Outstanding Woodies
2001 NC State Nursery Short Course
Dr. Thomas G. Ranney, Professor, North Carolina State University

1. Mountains of Western North Carolina
2. Mountain Horticultural Crops Research Station
3. Tom Eaker, Research Specialist

Selected Breeding Projects

4. *Pyrus calleryana* (callery pear)
5. *Pyrus regelii* (regelii pear)
6. *Pyrus koehnei* (koehnei evergreen pear)
7. *Pyrus elaeagrifolia* 'Turkish Mist'
8. *Pyrus betulifolia* x *P. calleryana* (new hybrid pear)
9. *Stewartia ovata* var. *grandiflora* (mountain stewartia)
10. *Stewartia malacodendron* (silky stewartia)
11. *Stewartia sinensis* (Chinese stewartia)
12. *Stewartia rostrata* (beaked stewartia)
13. *Stewartia pseudocamellia* (Japanese stewartia)
14. *Stewartia ptero-petiolata* (one of the evergreen stewartias)
15. *Calacanthus floridus* (common sweetshrub)
16. *Sinocalycanthus chinensis* (Chinese sweetshrub)
17. *X Sinocalycalycanthus raulstonii* 'Hartlage Wine' (proposed name)
18. *Sinocalycanthus chinensis* x *Calycanthus occidentalis*
19. Tetraploid *Calycanthus* hybrid
20. *Hypericum calycinum* (St. Johnswort) - tetraploid
21. *Hypericum androsaemum* 'Albury Purple'
22. *Hypericum androsaemum* 'Gladis Brabazon'

23. *Hypericum reductum*
24. New hybrids: *H. galioides* ‘Brodie’ x *H. kalmianum*
25. *Betula utilis* var. *jacquemontii* ‘Grayswood Ghost’ (Himalayan birch)
26. *Betula nigra* Heritage and Dura-Heat (river birch)
27. New hybrids: *Betula nigra* x *B. utilis* var. *jacquemontii*

Other New Plants

28. *Cornus kousa* ‘Greensleeves’. Others: ‘Temple Jewel’, ‘Blue Shadow’, ‘Cherokee’
29. *Cornus florida* ‘Cherokee Brave’. Flowering dogwood. UT has also introduced ‘Jean’s Appalachian Snow’, ‘Karen’s Appalachian Blush, and ‘Kay’s Appalachian Mist’ all with good mildew resistance. ‘Appalachian Spring’ has resistance to dogwood anthracnose.
30. Dr. August Kehr
31. *Magnolia sieboldii* ‘Colossus’ (Siebold magnolia)
32. *Magnolia* ‘Daybreak’ (hybrid magnolia)
33. *Chionanthus virginicus* ‘Emerald Knight’ (fringetree)
34. *Prunus* ‘Corinthian Mauve’. (ornamental peaches) Also ‘Corinthian White’, ‘Corinthian Pink’, and ‘Corinthian Rose’
35. *Cornus mas* ‘Spring Glow’ (corneliancherry dogwood)
36. *Illicium mexicanum* ‘Aztec Fire’ (Mexican anise-tree)
37. *Illicium x* ‘Woodland Ruby’. For high light areas, *I. parviflorum* ‘Forest Green’ is good.
38. *Chaenomeles speciosa* ‘Dragons Blood’ (flowering quince)
39. Mt. Hood, OR
40. Keith Warren, Director of Product Development, J. Frank Schmidt & Son Nursery
41. *Ulmus parvifolia* Allee. (lace-bark elm) Resurgence of Elms, see: (http://fletcher.ces.state.nc.us/programs/nursery/metria/metria11/warren/elm.htm)
42. *Ulmus americana* ‘Valley Forge’ and ‘New Harmony’ (American elm)
43. *Ulmus* x ‘Accolade’ (hybrid elm)
44. Conifers - Buchholz and Buchhoz Nursery
45. *Pinus koraiensis* ‘Tabuliformis’ (Korean pine)
46. *Cedrus deodara* ‘Silver Mist’ (deodar cedar), Stanley and Sons Nursery
47. *Metasequoia glyptostroboides* ‘Jack Frost’ (dawn redwood).
48. *Taxodium distichum* ‘Cascade Falls’ (baldcypress)
49. *Calocedrus decurrens* - (California incensecedar) New cultivars include: ‘Maupin Glow’, ‘Pioneer Sentry’, etc.
50. *Platycladus orientalis* ‘Sunlight’ (*Thuja orientalis*) (oriental arborvitae)
51. *Ginkgo biloba.* (ginkgo) Many cultivars now available*:* ‘Chase Manhattan’, ‘Jade Butterflies’, ‘Saratoga’, ‘Tubiformis’, etc.
52. *Ginkgo biloba* ‘Chi Chi’
53. *Hamamelis x intermedia* ‘Arnold Promise’ grafted on *Parrotia persica*
54. *Liriodendron tulipifera* ‘Ardis Dwarf’ (tulip tree)
55. *Fothergilla sp.* - new blue form (fothergilla)
56. *Acer macrophyllum* ‘Kimballiae’ (bigleaf maple)
57. *Magnolia* ‘Wada’s Memory’ (hybrid magnolia)
58. *Cotinus coggygria* Golden Spirit (smoke tree)
59. *Gymnocladus dioicus* ‘Variegata’ (Kentucky coffeetree)
60. Japan
61. Mt. Fuji
62. Mr. Akira Shibamichi with weeping *Stewartia pseudocamellia* (Japanese stewartia)

63. Mr. Chikara Ishii with weeping *Camellia japonica* (Japanese camellia)
64. Weeping *Albizia julibrissin* (mimosa)
65. Y. Hirose and M. Yokoi. 1998. Variegated Plants in Color. Varie Nine Ltd., Iwakuni, Japan
66. *Callicarpa kochiana* 'Kochi Splash'(beautyberry) variegated
67. *Disanthus cercidifolius* 'Golden Crown' (disanthus) - variegated
68. *Daphniphyllum spp.* (daphniphyllum) - variegated
69. *Wisteria floribunda* (Japanese wisteria) - albino
70. Mr. Brian Upchurch with *Albizia julibrissin* 'Summer Chocolate' (mimosa)
71. *Illicium anisatum* 'Red Leaf' (Japanese anise tree)
72. *Prunus zippeliana* (zippeliana cherry)
73. *Myrica rubra* (an evergreen bayberry with red fruit)
74. *Chimonanthus praecox* 'Mangetsu'(fragrant wintersweet)
75. Japanese nursery
76. Driving range
77. Garage
78. Dwarf *Loropetalum chinense* var. *rubrum* (dwarf, red, loropetalum)
79. Dwarf *Cotinus coggygria* (smoke tree)

Zelkova serrata 'Mushashino' (zelkova)

Success with Ornamental Vegetables

James L. Gibson and Brian E. Whipker
Department of Horticultural Science
North Carolina State University

Vegetables are plants cultivated for edible purposes, but can be classified as ornamentals when produced for landscape use. Ornamental vegetables are excellent items for growers to produce during the summer and fall. Several studies and cultivar trials have been conducted at NC State, and below is a summary of the findings.

Sometimes pesticides (insecticides, fungicides or plant growth regulators) are applied to prevent blemishes and establish proportionality with the pot. ***If growers apply pesticides (PGRs, insecticides, or fungicides), then consumers need to be advised not to eat the treated plants. This requires that the plant be clearly marked "for use only as an ornamental". Also wholesale growers need to provide retailers with a history of pesticides applied to the crop.***

Mustards and Kales

Several mustard cultivars, which have been traditionally used in oriental stir-fry dishes, and kales, which have been used as fodder for cattle, have outstanding foliar and cold hardiness traits that make them ideal "winter annuals". Other leafy vegetables like Swiss chard and lettuce can be used as bedding or container plants. Listed in Table 1 are eleven ornamental vegetables trialed at the Horticultural Science Field Lab in Raleigh, NC. (For cultivar information and a detailed description of ornamental vegetable production techniques, visit *www.ces.ncsu.edu/depts/hort/floriculture/crop/crop_veggies.htm*).

Mustard Cultivar Descriptions

The 'Giant Red' mustard or 'Red Giant' has been one of the most popular ornamental vegetables used by landscapers in the Southeast. This vigorous growing plant has white midribs with bronze foliage. The plant does well in protected areas away from winter winds. As temperatures increase in the spring, the fleshy leaves expand rapidly, making the plant attractive with spring pansies and bulbs. 'Red Giant' grown in mass has a striking display, and when used as a specimen, this sprawling plant represents a focal point in the winter garden.

The cultivar 'Osaka Purple' has a similar leaf color to 'Red Giant', but differentiates itself with 1-inch wide midveins and lobed leaf margins. Unfortunately 'Osaka Purple' bolts early and rapidly in the growing season, but growers can pinch the flower stalks from the crown without affecting plant form.

The potherb mustard 'Mizuna' or 'Kyona' is a finely textured plant with bright green leaves arising from a fleshy tan crown. 'Mizuna's' mounded growth habit makes it an excellent plant to be used in mass or as a specimen plant. Early fall is the optimal planting time for 'Mizuna' due to dieback from freezing temperatures.

Flat Pak-Choi or 'Tatsoi' makes an excellent border plant in pansy displays. 'Tatsoi' may reach 6 to 8 inches in height, and with its flat, dark green foliage, the plant in mass creates a dense mat. Because 'Tatsoi' has a low growth habit, growers should not apply PGRs. If growers desire to have more pronounced white petioles, lower nitrogen rates of 125 to 150 ppm are recommended.

Another type of Pac Choi called ‘Joi Choi’ has bright white petioles with large fan-like leaves. The rapid growth rate of ‘Joi Choi’ allows growers to market plants 2 to 3 weeks after transplanting, thus avoiding the use of plant growth regulators. ‘Joi Choi’ is extremely cold tolerant and was rated the best winter Brassica in the 1999 NCSU Winter Trial Report.

Production

Mustards can be produced quickly with a constant liquid fertility program of 200 ppm N. The substrate should be moist at all times because mustards can quickly dry out due to fibrous root systems. As with kale production, growers should communicate with the public if pesticides were applied. The heights of the above mentioned mustard cultivars were effectively controlled with Sumagic rates between 6 and 15 ppm, or B-Nine at 2500 ppm sprayed twice or a single application at 5,000 ppm.

Kale Cultivar Descriptions

‘Red Bor’ is a curly leaf kale with a tall growth habit and an outstanding ability to proliferate in the cold. 'Red Bor’ also "colors up" 2 to 4 weeks earlier than any of the curly ornamental kale cultivars. Planted in a mass or used just as a specimen in the garden, the purplish-red foliage of 'Red Bor' will provide any dormant shrub or perennial garden with vibrant color.

‘Winterbor’ is very similar to ‘Red Bor’ in terms of foliage characteristics and cold tolerance, but has olive green leaves. Both ‘Winterbor’ and ‘Red Bor’ performed extremely well during the cold periods experienced in late December 2000 and early January 2001.

‘Red Russian’ is a tall growing, cold tolerant kale, which has silvery blue-green colored foliage with wavy leaf margins and reddish-pink colored stems and midribs. An interesting characteristic about this kale cultivar is its late bolting response, which still makes it attractive in early spring when accompanied by flowering bulbs and pansies. ‘Red Russian’ develops a mild reddish tinge on the foliage when temperatures drop below 45ºF.

The kale cultivar ‘Lacinato’ or Italian kale is a unique plant with narrow strap-like leaves which possess a bumpy and crumpled texture. The blue-green foliage and white midribs of this tall kale are very attractive in the early winter, but as temperatures drop below 20ºF, the outer foliage may develop necrosis due to cold damage.

Production

The production of these kale cultivars is relatively simple. Because coloration occurs much earlier than ornamental kale, plants can be marketed 8 weeks after sowing. Ornamental cabbage and kale usually begin to color 10 to 12 weeks after sowing and exposure to temperatures 55ºF or lower. Fertilize the kale on a continual basis until sales with a soluble fertilizer (150 to 200 ppm N) that has a high percentage (>70%) of nitrate-nitrogen. Two foliar sprays of B-Nine at 2,500 ppm 2 weeks apart are recommended for height control.

Other Vegetables

The All America Selections winner ‘Bright Lights’ Swiss chard is not only a plant ideal for the cool season garden, but it also performs well during the heat of the summer. This widely used cultivar has red, purplish-red, yellow, or white petioles and stems and robust foliage with crumpled leaves. ‘Ruby Red’ or Rhubarb chard is very similar to ‘Bright Lights’ in terms of

growth habit, but only expresses red or purplish-red stems. Both cultivars do well in containers and can survive low temperatures.

Growers should plant 2 to 3 plugs per gallon pot or mum pan to achieve multiple colored clumps of Swiss chard. Seeds can be direct sown in cell packs and fertility levels should remain at 200 ppm N until sales. The application of B-Nine to 'Bright Lights' Swiss chard resulted in only minimal height control. Research this past fall, using high concentrations of Sumagic at 30 and 60 ppm on Swiss chard, resulted in little control of plant height, therefore it is not economically feasible to apply plant growth retardants to chard-type plants.

Table 1. Suggested ornamental vegetable cultivars and seed sources.

Crop	Cultivar	Common Name	Botanical Name	Hardiness*	Seed Source**
Kale	Red Bor F1	Red Bor Kale	**Brassica oleracea**	++++	S
	Red Russian	Ragged Jack	*Brassica napus* var. *pabularia*	++++	J, S
	Winterbor	Green Kale	**Brassica oleracea**	++++	J, S
	Lacinato	Italian Kale	*Brassica oleracea*	+++	S
Mustard	Red Giant	Red Mustard	*Brassica juncea* var. *rugosa*	++	S, AT
	Mizuna/ Kyona	Potherb Mustard	*Brassica rapa* var. *nipposinica*	+	J, S, AT
	Tatsoi	Flat Pak Choi	*Brassica rapa* var. *rosularis*	+	J, S, AT
	Southern Giant	Mustard Greens	**Brassica juncea**	+	J, S
	Osaka Purple	Red Mustard	*Brassica juncea*	++	CG
Swiss chard	Bright Lights	Swiss Chard	*Beta vulgars*	++	J, S, B, N, P
	Ruby Red	Rhubarb Chard	*Beta vulgars*	++	P

* Hardiness in Raleigh, NC- "+": very sensitive; "++" : moderately sensitive; "+++": slightly sensitive; "++++" : not sensitive

** Seed Sources:

AT = American Takii, 301 Natividad Rd., Salinas, CA 93906; Ph: (831) 443-4901; Fax: (831) 443-3976
B = Ball Seed, 622 Town Road, West Chicago, IL 60185; Ph: (800) 879-2255; Fax: (800) 234-0370
CG = The Cook's Garden, PO Box 535, Londonderry, VT 05148; Ph: (800) 457-9703; Fax: (800) 457-9705
FG = Fred C. Gloeckner 600 Mamaroneck Ave. Harrison, NY 10528; Ph: (914) 698-2300; Fax: (914) 698-0848
J = Johnny' Seeds, 1 Foss Hill Rd. RR 1 Box 2580, Albion, ME 04910; Ph: (207) 437-4301; Fax: (800) 437-4290
N = Novartis Seeds, 5300 S. Katrine Avenue, Downers Grove, IL 60515; Ph: (800) 323-7253; Fax: (800) 327-9736
P = Park Seed, 1 Parkton Avenue, Greenwood, SC 29647; Ph: (800) 845-3369; Fax: (800) 275-9941
S = Shepherd's Garden Seeds, 30 Irene St., Torrington, CT, 06790; Ph: (860) 482-3638; Fax: (860) 482-0532

Ornamental Cabbage and Kale

Don't forget to include ornamental cabbage and kale into your fall production program! Twenty six cultivars of ornamental cabbage and kale were trialed in 8 inch mum pans at the Horticultural Science Field Lab in Raleigh, NC. Located at *www.ces.ncsu.edu/depts/hort/floriculture/crop/crop_kale.htm* are the results of the trial with linked images to the cultivars. Listed in Table 2 are six out of the 26 ornamental cabbage and kale cultivars that performed exceptionally well in the landscape during the fall of 1998 and 1999 at the NCSU Trial Gardens. Publications addressing chemical plant growth regulation, nutrition strategies, and pinching of ornamental cabbage and kale can also be found at *www.ces.ncsu.edu/depts/hort/floriculture/crop/crop_kale.htm*.

For addition information about ornamental cabbage and kale, see NCSU Horticulture Information Leaflet No. 507: Success with Ornamental Cabbage and Kale.

Table 2. Ornamental cabbage and kale cultivar descriptions and seed sources.

Cultivar	**Plant Type***	**Description**	**Seed Source****
Osaka Pink	OC	Blue-green foliage; pale fuchsia to a deep fuchsia center color; upright growth habit	B, FG, N
Rose Bouquet	OC	Wavy margins; purplish-green foliage; deep pink to magenta center; less aggressive growth habit than 'Osaka' series cultivars	B
Peacock White	ONK	Medium green foliage; deeply grooved leaves; pronounced textured center diffuses pigment; faint blush accent in milky white center; tall growth habit	B, FG, N, P
Flamingo Plumes	ONK	Notched leaf margins; deep magenta pigmentation on purplish foliage; open, textured center diffuses color; slow to develop color; excellent specimen plant in the landscape; vigorous growth habit	FG
Kamone White	OCK	Dark green foliage; milky white, expansive center color; semi-creamy center; rated the best curly kale by NC State researchers	B
Chidori Red	OCK	Fringed leaved kale with purple foliage; extremely curly leaf margins; deep magenta center color; mounded shape	B, FG

* OC = Ornamental cabbage, ONK = Ornamental notched kale, OCK = Ornamental curly kale
** Refer to Table 1 for seed sources.

Thanks to Ingram McCall, Todd Cavins, Paul Lineberger, and Bradley Holland for their technical support and Fafard and Scotts for their generous donation of root substrate and fertilizer. Appreciation also expressed to Dr. Bob Lyons for providing landscape space for cultivar evaluation.

Rooting for You: Auxins and Adventitious Rooting

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Use of auxins to stimulate adventitious rooting of stem cuttings is a powerful tool used to propagate many nursery species. When used properly these compounds will 1) increase the percentage of cuttings which form roots, 2) hasten root initiation, 3) increase the number and quality of roots produced per cutting, and 4) increase the uniformity of rooting.

There are many auxins that can be used to stimulate adventitious rooting but the two that are used most often commercially are indolebutyric acid (IBA) and naphthaleneacetic acid (NAA). In fact, both these auxins, either alone or in combination, are the active ingredients in most commercial rooting formulations although IBA is more effective for a wider range of species.

Commercial rooting products are generally available in two major formulations/preparations. The first of which consists of one or more auxins dispersed in a talcum powder carrier (e.g., Hormodin, Hormo-Root, Rootone, etc.) and the second consisting of one or more auxins dissolved in a solvent (e.g., C-mone, Dip'N Grow, Wood's Rooting Compound, etc.). The rooting powders are available in a range of concentrations (strengths) whereas the solutions are concentrated and often require dilution prior to use depending on the species or cultivar you wish to propagate. Instead of purchasing commercial powder or liquid formulations, one may obtain the pure form of particular auxins and actually prepare a rooting powder or solution of one or more auxins. However, this can be somewhat difficult which is why the commercial preparations are so widely used.

Individuals will often ask which formulation (powder or solution) is most effective for rooting cuttings of various species. Although both formulations have advantages and disadvantages and can provide satisfactory results if used properly, the solutions are generally more effective for various reasons. The powders are best used on stem cuttings of herbaceous (nonwoody) plants (e.g., coleus, chrysanthemum, and geranium), woody species which are not difficult to root (e.g., boxwood, Japanese holly, and forsythia), and softwood cuttings of woody species which are relatively easy to root (e.g., Atlantic white cedar and 'Green Giant' arborvitae). However, for difficult-to-root woody species, the solutions are much more effective. The following slides will illustrate the benefits of treating stem cuttings of various species with auxins in addition to comparing the effectiveness of rooting powders versus auxin solutions.

Don't Take Sides: Suggested Pairings Of Woody And Herbaceous Plants For Contemporary Landscapes

Bryce H. Lane and Robert E. Lyons
NCSU Horticultural Science and JC Raulston Arboretum

I. Combinations in Reality (alternating trays, slides in order of presentation)

Picea pungens 'Glauca Globosa' & Liatris 'Kobold'
Chamaecyparis pisifera 'Filifera Aurea' & Narcissus hybrids
Acer palmatum 'Crimson Queen' & Geranium 'Johnsons Blue'
Cornus controversa 'Variegata' & Aquilegia canadensis
Mahonia bealei & Impatiens walleriana
Cotinus coggygria 'Velvet Cloak' & Allium giganteum
Picea pungens 'Glauca Globosa' & Hylotelphium x spectabile 'Autumn Joy'
Wisteria floribunda & Lupinus polyphyllus
Juniperus 'Mother Lode' & Pennisetum alopecuroides 'Hameln'
Spirea bumalda 'Anthony Waterer' & Hosta
Ilex verticillata & Hypericum calycinum
Hamamelis x intermedia & Narcissus 'February Gold'

II. Suggested Combinations (in seasonal arrangement)

Bryce's Tray	Bob's Tray
Daphniphyllum macropodum	Brassica 'Flamingo Plumes'
Prunus persica 'NCSU Double Red'	Anemone blanda
Fothergilla gardenii	Aquilegia canadensis
Itea virginica	Tiarella 'Pink Bouquet'
Clethra alnifolia	Pachysandra procumbens
Berberis thunbergii 'Rose Glow'	Heuchera 'Plum Puddin'
Hydrangea quercifolia	Polygonatum odoratum thunbergii 'Var.'
Acer palmatum 'Waterfall'	Begonia sutherlandii
Callicarpa japonica	Colchicum autumnale
Heptacodium miconioides	Hibiscus moscheutos
Poncirus trifoliata	Solanum quitoense
Itea virginica	Centaurea gymnocarpa 'Colchester White'

III. Outrageous & Impossible Combinations We'd Like to See !!

Bryce's Tray	Bob's Tray
Cornus florida 'Rubra'	Mandevilla x amoena 'Alice du Pont'

Lagerstroemia faurei 'Fantasy'	Viridiflora class tulips
Cornus mas 'Spring Glow'	Petunia 'Purple Wave'
Cornus kousa	Crocus (white cultivar)
Prunus mume 'Pendula'	Begonia (semperflorens-cultorum hybrid)

Is That Your Final Answer? Taxonomy of Cultivated Liriopogons

Paul R. Fantz
Department of Horticultural Science

Liriopogons (lilyturfs, Aztec grasses, mondo grass, monkey grasses) are important landscape plants used for foundations, ground covers, edging, rock gardens, and as woody understory plants, erosion control, and lawn substitutes. They are effective in combination with woody plants, perennials and water. Landscapers utilize numerous cultivar selections for their ornamental flowers, fruits or for the texture and color of the leaves which come in hues of green, purplish-black, or variegated patterns of green and gold, cream or white stripes. Liriopogons are prized for their adaptability, low maintenance, moderate drought resistance, durability, evergreen foliage and lack of serious pest/disease problems.

Can you correctly identify your liriopogon stock? Is that your final answer? A taxonomic study of cultivated liriopogons in the United States during the past decade demonstrated serious identification and nomenclature problems with these plants.

Genera. Many individuals are questioning if liriopogons (*Liriope, Ophiopogon*) represent one or two genera. They observed that standard characters of segregation break down and note that these genera are difficult to distinguish. What is being sold in the green industry? There are 4 genera, including two weedy imposters.

Species. Most nurserymen and landscapers cite 4-5 species in the trade: *L. muscari, L. spicata, O. japonicus, O. planiscapus* and occasionally *O. jaburan*. Also, these names are being used for several distinct species not recognized by trade professionals. How many species are involved? There are at least 6 species of *Liriope* and 9 species of *Ophiopogon* -- triple the number of recognized species. Therefore, your final answer as to species identification may be right only about 1/3 of the time.

Nomenclatural Problems. Several species require examination of type (original) plant material from Chinese herbaria to ascertain correct scientific names. Written inquiries produced NO response in each of the last three years.

Current Research Status. Data is being incorporated into manuscripts for *HortScience* that will include an inventory of taxa, quantitative morphological descriptions, identification aids, and a key with multiple characters per couplet to segregate taxa. Preliminary manuscripts will address morphology, identification of genera, species of *Liriope*, and species of *Ophiopogon*. Current

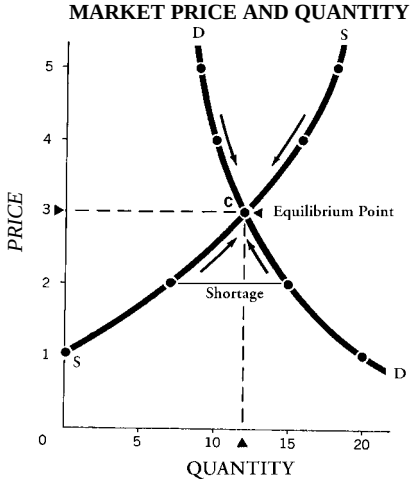
limitations include unanswered questions due to lack of response from China and lack of financial support for obtaining a biological illustrator and payment of publication charges.

Supply and Demand
Have the Rules Changed?

M.A. Powell
N.C. State University

The greenhouse and nursery industry has increased at a tremendous rate over the last 20 years, not only in North Carolina, but all across the southeastern US. The statistics are rather confusing and contradictory when trying to access the size and value of the industry.There is a significance difference between the estimates of the US. Dept. of Agriculture, NC Dept. of Agriculture and the Cooperative Extension Service.

HOW SUPPLY AND DEMAND DETERMINE MARKET PRICE AND QUANTITY



Regardless of the size and value of the industry, the principle of supply and demand has not changed. It applies to our nursery and greenhouse crops, just as it applies to corn, hogs or widgets. A downward sloping demand curve relates quantity to price, the upward sloping supply curve relates price to the quantity produced, and the equilibrium price, the only price that can last, is the price at which the amount willingly supplied and the amount willingly demanded are equal. The long term equilibrium price must be at the intersection of supply and demand curves.

The basic questions remains the same--what to produce? How much to produce? And who to sell it to? These are the same questions that were asked by agri-businessmen over the last 30 years. (Looking back over this period, we know that demand would be at an all time high, especially during periods of a strong national and state economy, and supply could not equal the demand for greenhouse and nursery crops). Is now a good time to start a nursery? One might question the logic in this if you look at the current economic statistics. Consumer spending is down, investors have lost more than $1.5 trillion on stocks in the last year, and the 'R' word (recession) is being used regularly by television economists. All of these factors could have a direct impact on landscape contracting, as housing starts and commercial and industrial growth is down ie. less plants needed for landscaping. Disposible income and consumer spending is down, that means less plants being sold at the retail garden center. When the quantity demanded is low and the quantity supplied is high, there is a surplus. What typically happens when there is a surplus in a commodity? The price comes down, resulting in lower profit margins for the grower. Can you afford to lower your price?

If one decides to start a nursery in today's economy, a firm commitment should be made in the following areas.
* Do your homework. Get the technical and horticulture information to be able to produce a quality product. Attend educational meetings, join local, state and national associations and develop a library of technical publications. Become familiar with the internet educational resources. This also includes being prepared to meet local, state and national environmental standards for your nursery. Visit other growers, take nursery tours with trade associations, and

get to know the local horticulture extension agent.

* Target a market destination. A growing technique and a target market (i.e.: containers, propagation, field grown, pot-n-pot, etc.) should be determined in the early planning stages. Field grown plants will be marketed to the landscape industry, while container materials can be sold to retailers or landscape professionals. Propagated materials will be produced for other growers. There are many factors that will impact your decision on what to grow and how to grow it. One of the most important ones is the site and natural resources (water) available on that site.

* Set long-term goals. Have a plan that allows for slow economic growth periods. Be able to 'weather the storm'. For example, if you have a crop of one gallon containers that do not sell, be prepared to shift them up, and find a market for the larger size at a later date. Don't position yourself for bankruptcy in the short run. The time period between planting a crop and selling that crop could be years. Have a strategic plan.... along with your dream.

* Be flexible. Many growers begin a nursery growing a particular crop one way, but have to change to adapt to changes in landscape and consumer trends. The smart grower is familiar with the current supply and demand situations of all nursery products. By visiting nurseries, reviewing current price lists, talking with landscape architects and garden designers, one can find specialty plants in high demand -low supply. Current examples for landscape professionals would be large container shade and ornamental trees. Landscape installation is a 12-month process. 25 years ago landscape professionals did very little planting out of the 'digging season' or especially in mid-summer. Times have changed. Most nurseries now offer summer digging, and others are getting into shifting 2-3" caliper trees into large containers for summer sales. Specialty plants might include single stem crape myrtles, or espaliered large shrubs such as camellias or loropetalums. I also think 'tree -form' evergreen shrubs also have potential. Who has tree -form yaupon hollies, burford hollies, camellias, or ligustrurn in the 6'-8 range available?

* Have a pro-active marketing plan. Growing the crop comes naturally to most farmers; marketing does not. Develop a price list and brochure. Attend and exhibit at trade show; advertise in trade publications and make personal visits. If you are not capable of this, and will not hire a sales representative or broker, then failure is eminent. If buyers don't know your nursery exists, and that you have quality plants available, then essentially they are worthless.

* Develop a unique marketing plan or strategy. "Packaging" is a concept that retailers appreciate. Examples of current successful programs include "Garden Rich" TM , Royal Monarch Collection, Autumn Ac'cents or Rubies in Flight. These are specially labelled plants that home gardeners can select at the garden center. Instead of buying only one or two individual plants, this concept promotes the idea of buying the whole collection of plants for a theme garden. Package information includes lots of horticulture tips for home gardeners.

* A large re-wholesale nursery is implementing the “Partners” program. The professional landscaper gets 1 point for every $100 that is spent. A catalog showing various prizes, from a pocket knife to tickets to the superbowl, encourages the landscaper to become a partner. (Someone told me about the green stamp days of the 50's-60's. Sounds like a similar concept).

Got Cost Estimates?
(What's It Costs to Grow Field Grown Trees and Shrubs?)

Charles Safley
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As the nursery industry grows, there is an increased demand for cost of production information for potential growers to make more informed decisions about entering the industry or for experienced growers to expand their current operation. The objective of this study was to develop enterprise budgets to estimate the costs associated with growing and harvesting five-acre plantings of Pin Oak, Bradford Pear, and Ilex Fosters. The data and cost models for this study were developed with the assistance of several North Carolina growers.

The total cost of growing and harvesting Pin Oaks was estimated to be $127,212 over a five-year production period, Table 1. This was an average expense of $37.97 per tree for the 3,350 marketable trees, however the actual cost per tree ranged from $34.96 to $38.21 depending on the size and year when the tree was harvested, Table 2. Overall, the loss rate for Pin Oaks was 16.25%, 650 of 4,000 trees. The total cost to grow and harvest 3,800 marketable Bradford Pears was estimated to be $107,396 over a four-year production cycle, for an average cost of $28.26 per tree, Table 3. The average cost per tree ranged from $26.74 to $29.99 per tree, Table 4, and the aggregate loss rate was 5%. Ilex Foster production cycle took seven years to grow 5,675 marketable plants and cost an estimated $111,750, or an average of $19.29 per tree with an overall loss rate of 3.47%, Table 5. However, the actual cost per plant ranged from $15.11 to $26.59 depending on the market size and when the tree was harvested, Table 6.

Table 1. Estimated Annual Cost for Pin Oak, Five Acre Planting

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Land Preparation	$ 3,626	0	0	0	0
Planting Trees	$64,929	0	0	0	0
Maintenance	$10,426	$4,031	$3,904	$ 3,614	$ 43
Harvest					
2 ½ - 3" Trees	0	0	$7,393	$19,660	$4,370
3 - 3 ½" Trees	0	0	0	0	$5,216
Trees Planted & Sold	4,000	0	692	1840	818
Loss Rate	10%	5%	1%	1%	1%

Table 2. Estimated Cumulative Cost per Harvested Pin Oak

	NUMBER OF TREES	COST PER TREE
Year 3: 2 ½ - 3"	692	$ 34.96
Year 4: 2 ½ - 3"	1,840	$ 36.31
Year 5:		
2 ½ - 3"	409	$ 36.36
3 – 3 ½"	409	$ 38.43

Table 3. Estimated Annual Cost for Bradford Pear, Five Acre Planting

	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Land Preparation	$ 3,626	0	0	0
Planting Trees	$42,249	0	0	0
Maintenance	$10,427	$4,556	$ 4,534	$ 214
Harvest:				
Spring: 2 ½ - 3” Trees	0	0	$20,306	$6,092
Fall: 2 ½ - 3” Trees	0	0	$ 8,123	0
Spring: 3 – 3 ½” Trees	0	0	0	$7,269
Trees Planted & Sold	4,000	0	2,660	1,140
Loss Rate	4%	1%	0%	0%

Table 4. Estimated Cumulative Cost per Harvested Bradford Pear Tree

	NUMBER OF TREES	COST PER TREE
Year 3		
Spring (2 ½ - 3”)	1,900	$26.74
Fall (2 ½ - 3”)	760	$27.74
Year 4		
Spring (2 ½ - 3”)	570	$27.93
Spring (3 - 2 ½ ”)	570	$29.99

Table 5. Estimated Annual Cost for Ilex Foster, Five Acres Planting

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7
Land Preparation	$ 3,626	0	0	0	0	0	0
Planting	9,349	0	0	0	0	0	0
Maintenance	2,933	$5,142	$5,142	$5,142	$ 5,142	$ 4,327	$2,793
Harvest							
22” B&B	0	0	0	0	$12,508	$12,508	$9,317
28” B&B	0	0	0	0	$12,295	$12,295	$9,231
Trees Planted & Sold	6,200	0	0	0	2,066	2,066	1,543
Loss Rate	2%	1%	0.5%	0%	0%	0%	0%

Table 6. Estimated Cost per Harvested Ilex Foster

	NUMBER OF TREES	COST PER TREE
Year 5:		
22” Ball	1,380	$15.11
28” Ball	686	$23.97
Year 6:		
22” Ball	1,380	$16.22
28” Ball	686	$25.08
Year 7:		
22” Ball	1,236	$17.73
28” Ball	617	$26.59

While the primary focus of this study was to estimate the costs associated with growing and harvesting trees, growers incur additional overhead costs that should be included when pricing their plants. Unfortunately, many growers ignore or overlook these additional costs, which were estimated to range from 17.8% to 21.4% of a nursery’s annual net sales, Table 7.

Table 7. Overhead Costs as a Percentage of Net Annual Sales

CATEGORY	LOW	HIGH
Advertising	2.84 %	3.58 %
Bad Checks	1.00 %	2.00 %
Maintenance and Utilities	2.17 %	2.25 %
Property Taxes	0.24 %	0.41 %
Rent	1.98 %	3.07 %
Other Operating Costs	9.54 %	10.05 %
Total	17.77 %	21.36 %

The information derived should provide a basis for decision making for those evaluating the profitability of establishing a new nursery or expanding production. A shortcoming of this analysis is that markets were assumed to be present and available as the plants were harvested. If this situation is not the case, the actual cost per plant will increase as the number of plants that the grower cannot sell increases. The actual cost per tree will also increase if the actual loss rates are greater than the estimated rates used in this study. Since every nursery situation is different, it is highly recommended that each grower estimate their individual costs-of-production based on their own production cycles and growing techniques. Growers who wish to receive more detailed production budgets for these three crops to help them in this process, should contact the author at:

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Irrigation Timing: Does It Make a Difference?

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Introduction

Much research has focused on increasing irrigation efficiency by improving method of application and reducing irrigation volume. Previous research has shown that cyclic irrigation can reduce water loss by 25% to 35%. In addition, leaching fractions of 0.15 to 0.25 have maximized plant growth. However, even with these improvements, substantial volumes of water are still lost from the container during irrigation. Growers need additional techniques for irrigation efficiency to continue to improve. Ideally, these new techniques could be carried out with minimum changes to their current production systems. One technique may be irrigation scheduling.

Irrigation scheduling is the process of determining when to irrigate and how much to apply. The goal of irrigation scheduling is to control the water status of the crop to achieve a targeted level of plant performance. Since the commercial value of woody landscape plants is generally based on size and aesthetics, most growers are currently focused on maximizing plant growth. Irrigation scheduling has received considerable attention in field crop production. However, until 1999 no one had examined the impact of irrigation scheduling, i.e., time of irrigation application with container-grown nursery crops.

In 1999, irrigation was applied in equal parts at the following times:

A. 3:00 A.M., 5:00 A.M., and 7:00 A.M.
B. 5:00 A.M., 12:00 P.M., and 7 P.M.
C. 5:00 A.M., 12:00 P.M., and 3 P.M.
D. 12:00 P.M., 3:00 P. M., and 7:00 P.M.

Plant growth increased 57% when irrigation was applied in the P.M. (treatment D) compared to early morning irrigation (Treatment A). The smallest plants were produced when irrigation was applied in the early A.M. (Treatment A). This was surprising since many growers traditionally irrigate predawn to reduce water lost to evaporation and to minimize interfering with workers. However, a single study is not enough evidence to recommend changing irrigation scheduling, so the study was repeated in 2000.

In 2000, irrigation was applied at:

A. 2:00 A.M., 4:00 A.M., and 6:00 A.M.
B. 6:00 A.M. 9:00 A.M., and 12:00 P.M.
C. 12:00 P.M., 3:00 P.M., and 6:00 P.M.
D. 6:00 A.M., 12:00 P.M. and 6 P.M.

Results

Plant growth was increased 69% when irrigation was applied in the PM (Treatment C) compared to predawn irrigation (Treatment A). Watering throughout the day (Treatment D) increased growth 51% compared to predawn whereas, watering in the morning increased growth 34% compared to predawn. Why? We speculated that it could be due to reduced container temperature and/or increased late day photosynthesis. Container temperatures were measured continuously throughout the experiment. We are still working with the data. However, there were big differences in photosynthesis. Compared to plants irrigated at predawn, plants watered in the PM had much higher levels of photosynthesis throughout the day resulting in larger plants.

Its Only Money!
An Economic Comparison of Weed Control Options

Joseph C. Neal
Department of Horticultural Science

Weeds compete with nursery crops for water, nutrients and light and if not controlled can reduce not only the growth, but also the marketability of your nursery crops. In the continual battle with weeds container nursery crop producers typically make four or more herbicide applications per year. The costs of these treatments range from about $50 to $260 per acre per treatment. Some of the average prices for common nursery herbicides are provided in Table 1.

Table 1. Nursery herbicide costs in dollars per acre per application and costs per 3-gallon pot (spaced) per year (4 applications per year).

Herbicide	Price per acre	Price per pot per year
OH2	$182.00	$0.05
Regalkade G @ 0.75	$92.00	$0.03
Regalkade G @ 1.5	$185.00	$0.05
Regal OO	$178.00	$0.05
Snapshot TG	$260.00	$0.08
Treflan	$49.00	$0.01

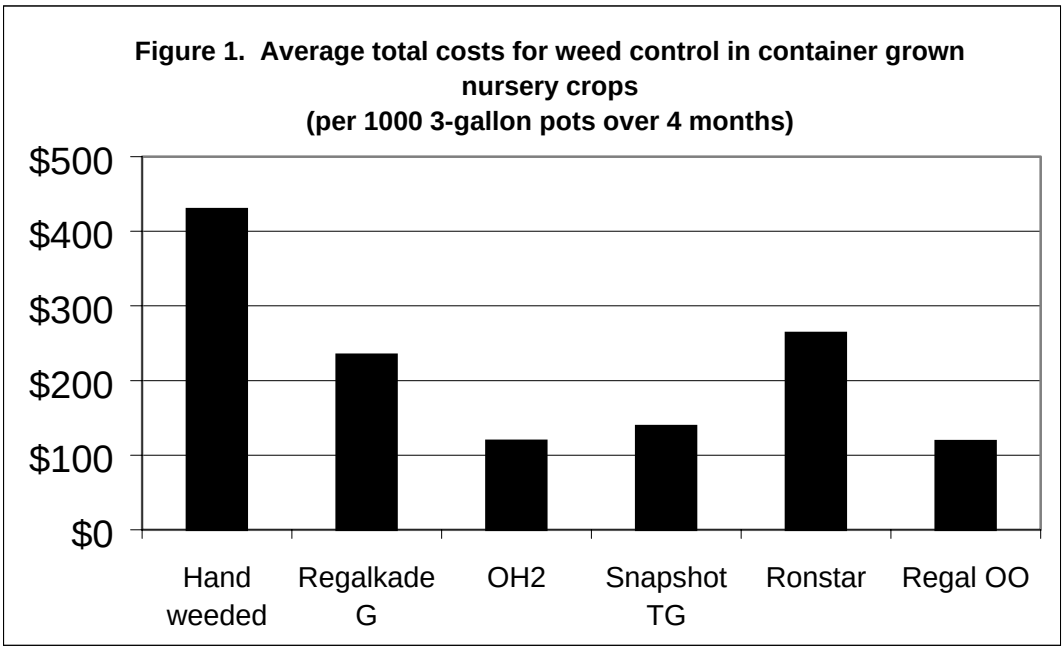
With four applications per year that means nurseries may spend $1040 or more per acre per year just for herbicides. And, these treatments will not control all weeds; some supplemental hand weeding will be required. Just how much does weed control really cost? And, how do our alternatives compare?

In 1982 Dr. Walter Skroch (Professor Emeritus, NCSU) and I conducted an experiment to look at how much herbicides and hand weeding cost. In that trial we found that it would cost about $34 per year to hand weed 1000 one-gallon pots but the total weeding costs could be reduced to about $4 if an effective herbicide were used. Furthermore, we found that using a fairly in-effective herbicide was still cost effective – for example: Treflan did not control weeds nearly as well but it did reduce the amount of time spent hand weeding, thus reducing the total weeding costs to about $14 per 1000 pots. The message was clear – herbicides are cost effective alternatives for weed control; and, more effective herbicides (even though they may be more expensive) are less expensive to use because they significantly reduce the amount of time hand weeding.

In 1998 and 1999 (with the generous help of several NC nurseries and Extension Agents) I attempted to update this information under more “real world” conditions by conducting large-plot trials on nursery sites. Nursery managers applied the herbicides; we measured the time it took the nursery workers to weed each treatment; and we weighed the amount of weeds removed from each block. We estimated the total weeding costs using average herbicide costs provided by local vendors, labor costs (including benefits) of $14.75/hr (provided by local nurseries), and

estimated time it takes to apply herbicides. Since the number of pots at each nursery differed, all data were converted to costs per 1000 3-gallon pots.

The results were quite surprising in many respects. Total weed control costs differed among nurseries. If the nursery relied solely upon hand weeding costs per 1000 3-gallon pots ranged from a high of $1300 (with heavy weed pressure) to as little as $35 (with light weed pressure). On average, total weed control costs will reflect the efficacy of the herbicides. Herbicides that provide good control of the weeds at a particular nursery, will reduce total weed control costs by reducing the amount of time spent hand weeding. On average, it cost $0.42 per pot to control weeds by hand weeding alone compared to $0.17 per pot when herbicides are used. When a truly effective herbicide is used the weed control cost can be as little as $0.02 per pot.



There are, however, crops that are quite sensitive to herbicides. Many growers avoid herbicide applications to hydrangeas and dwarf burning bush. We have looked at the use of mulching materials for such species. Pelleted newspaper (PennMulch), pelleted wool by-product (Wulpak), and copper coated fabric disks (Geodisk) have provided weed control comparable to some herbicide treatments. These products may add as much as $0.25 per pot. However, if weed control is reduced comparable to herbicides then the final weed control cost for such products will be between $0.30 and $0.42 per pot – slightly less than the cost of hand-weeding alone. Add to this the fact that your employees can be doing something more profitable (and enjoyable) than hand weeding.

When Do You Pot Your Plants? Does It Make a Difference?

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Introduction

Fertility programs for container-grown nursery stock are typically based on controlled-release fertilizers (CRFs). While CRFs offer some advantages compared to liquid feeding, there are problems associated with use of CRFs, i.e., nutrient release from CRF may not match plant nutrient demand. Since most CRFs increase rate of release with increasing temperature, relatively high rates of nutrient release may occur at the beginning of the growing season when recently potted plants are small and their nutrient demands are low. In addition, at this time woody plants are inefficient in absorbing released nutrients due to a very limited root system.

Most woody plants exhibit cyclical patterns of top and root growth. However, container-grown plants may produce fewer roots during the growing season due to high container temperatures. Since container temperatures can be > 108 F for many hours each day during the summer, root growth in container-grown plants in the south may be predominant in spring and late summer/early fall. Therefore, potting plants in late summer to fall when growth of roots may be high and CRF release rate is reduced due to lower temperatures, may increase nutrient uptake and growth.

Another approach to increasing CRF efficiency may be to split the fertilizer into two applications. Others have suggested using split applications to improve fertilizer longevity and subsequent nutrient availability.

Applying fertilizer other than during spring/early summer raises concern as to the effect of late season fertilization on susceptibility to winter injury. The supposition that high fertility levels, especially nitrogen, induces plants to continue growth late into the fall and delays natural maturity development is well entrenched. This delayed maturity is believed to predispose plants to greater risk of winter injury. However, much research has suggested that concerns with lack of cold acclimation due to fall fertilization are unfounded.

With the growth of the landscape industry, containerized plant material is in demand throughout the year. Traditional spring potting at many nurseries has been replaced with potting throughout the year. More information is needed on how time of potting affects woody plant growth together with differing rates of fertilization and subsequent cold acclimation. Therefore, the objective of this study was to determine the effect of potting date and rates of fertilization on plant growth, substrate EC and pH, and winter injury.

Two species, *Ilex crenata* >Compacta= and *Viburnum awabuki* >Chindo=, were potted into gallon containers (8 pine bark : 1 sand) in July 1998, September 1998, October 1998, March 1999, and May 1999. Each container was fertilized with either Wilbro/Polyon 15-4-9 or Scotts 23-4-8, Southern formulation with one of four rates of fertilization at potting: 0.5X (X = manufacturers recommended rate per gallon container, Wilbro/Polyon X = 0.95 oz, Scotts X =

0.78 oz) with surface application of remaining half six months after potting date, 1X, 1.5X and 2X.

One year after potting, both species were harvested. Plant quality (visual assessment) was rated before harvest. Substrate solution was collected from containers via the pour-through nutrient extraction method every 30 days after potting until harvest.

Results

Plants potted in Sept. and Oct. outperformed plants potted in March regardless of species and rates of fertilization. No plants were injured by cold temperatures regardless of potting date or rate of fertilization throughout the study period. Holly and viburnum were smaller when fertilized with 0.5/0.5X compared to all other rates of fertilization. Plants potted in July, September, and October had highest EC values in March, whereas plants potted in March and May had highest EC values in August. EC values increased with increasing rates of fertilization. Substrate pH decreased with increasing rates of fertilization, but pH was not affected by potting date.

Significance to the Nursery Industry

A grower wants to produce a high quality plant throughout the year. Information concerning accurate fertilizer rates and their interaction with potting date can aid in achieving this goal. High fertilizer rates are a concern in the fall. However, our data suggested that concerns over winter injury for plants potted with typical rates of fertilization are unfounded regardless of time of potting. Furthermore, based on our data growers should apply the full rate of fertilizer at potting regardless of time of potting. Plants potted in the fall outperformed all other potting times. Therefore, growers may want to incorporate more fall potting in lieu of traditional spring potting whenever possible.

Mixed Up About Container Mixes?

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Managing Potting Supplies

How organic potting components are stored and managed can have great effects on the chemical and physical properties of the container mix. Organic potting materials such as pine bark, hardwood bark, rice hulls, leaf and yard waste composts, animal waste composts and sphagnum peatmoss require moistening and turning if they are stored or maintained as bulk inventories. Organic potting materials, even after they have been composted and stabilized, require moistening and turning if they have been undisturbed for more than 3 to 4 weeks. Organic components dry out, particularly if they heat up and lose moisture through steam.

Also, moistening potting components before blending with other components creates much more desirable physical properties compared to mixing dry components. For example, if dry sphagnum peat moss is mixed with dry pine bark, prior to adding water, the mix will have low aeration and water may actually puddle on the surface of the substrate. If the components are moistened prior to mixing, the sphagnum peat moss becomes spongy and well hydrated and the pine bark holds additional available moisture; when the components are blended the spongy peatmoss holds the aeration and the particles do not collapse together or fit as tightly. Aeration of pre-moisten components will be higher than components mixed dry.

Chemical characteristics of potting substrates are also affected by storing and inventorying practices. The more unstable an organic potting component is, the more it needs to be turned and moistened. Essentially, good composting practices need to be followed on unstabilized components, turning inventory windrows and keeping the height of the windrows below a maximum of 10 feet. Windrows can be turned daily, weekly or by monitoring temperatures and turning inventories when temperatures reach 140° to 160° F. Unstable potting components should be turned and re-moistened until they no longer heat beyond 140° F.

Pine bark is utilized by the nursery industry as a green/fresh or aged/composted product. Wood splinters and cambium contained in green /fresh pine bark enhance rapid decomposition, heat and moisture loss in inventories. Excessive heat can char bark particles, creating charcoal characteristics and altering chemical and physical characteristics of the bark. Aged or composted pine bark supplies have reached a more stable state, however unless conditions were managed during the aging process, problems may be present. However, both products require management including turning and re-wetting. Green/fresh pine bark supplies will rapidly develop dry bands and anaerobic pockets. Dry bands 24 to 30 inches from the top of the pile are frequently accompanied by a grey mycelium seen as clumps when the pile is disturbed. This band creates a impervious layer above the interior of the pile. The impervious layer deprives microbial decomposers of oxygen. When oxygen is depleted, the microbial flora changes to anaerobic organisms which generate acetic acid and in the presence of moisture in the middle of the pile, extracts many salts, including potassium. The result is that anaerobic pockets may have pH as low as 2.3, EC levels as high as 2.5 mmhos/cm and potassium concentration as high as 200 ppm. If plants are potted in pine bark with these characteristics, plants will die or be stunted. The key is to turn inventories of pine bark at the nursery and inspect supplies when they are delivered. Look for gray mycelial clumps and test for pH and EC. Samples can be

collected for testing by filling small containers, pouring distilled water over the pot. Wait approximately 20 minutes for equilibration and then pour water over the surface again and collect the leachate that drains from the pot. Check the pH and EC. If pH is less than 3.8 or EC higher than 0.5 mmhos, consider not potting in the inventory immediately. Place sprinklers or a soaker hose over the pile, wet the inventory, turn it 2 to 3 times over the next month and check the pH and EC again.

Mixing Up Potting Mixes

There are no one size fits all recipes for growing containerized ornamental plants. However, not all nursery crops thrive under the same cultural practices related to irrigation frequency, nutritional regimes or potting mixes. The predominant potting components in nurseries in most of the eastern U.S. are pine bark, sand and sphagnum peat moss. Some alternative materials that are being used include shredded coconut husks (coir), composted yard wastes and animal wastes, composted cotton gin wastes, composted hardwood bark, mushroom compost, municipal compost, rice hulls, peanut hulls, and pecan shells. The stability and chemical and physical characteristics may limit the volume of alternative materials that can be used in a potting substrate. Unstablized organic components decompose rapidly, leaving a full container, 3/4 full in a few weeks. Composted materials often lack the large coarse particles necessary for adequate aeration and can not be used in volumes greater than 50% for most container substrates. Animal wastes characteristically have high electrical conductivity (soluble salts) and nutrient levels, therefore are usually limited to 10 to 30% volume in potting substrates. Potting mixes containing compost components will generally have higher pH levels ranging from 6.0 to 6.5 in contrast to pine bark or sphagnum peat moss substrates which even with dolomitic limestone addition frequently range 5.0 to 6.2. The higher pH is generally not a problem for growing most nursery crops but, since composts have a "liming effect" dolomitic limestone should not be added to compost containing potting mixes and usually, no minor element packages are required.

Physical properties of substrates

Physical properties for container potting substrates include, particle size distribution, total porosity, air space, water holding capacity (container capacity), available water capacity and unavailable water content and bulk density. There are no distinct physical property standards for container substrates, however, normal ranges for nursery containers substrates after irrigation and drainage are easiest to manage within the normal ranges shown at the bottom in Table 1. A balance between aeration and moisture content are necessary for optimum growing conditions. Fewer problems related to over-watering during production would be expected with potting mixes that have at least 15% air space in test samples. A perched or saturated water table is created at the bottom of the container. In a container, air space increases as height increases above the bottom of the container. Air space also increases as water is lost.

Blending components yields physical (and chemical) characteristics that are intermediate between characteristics of the components. For example, addition of sand to pine bark tends to increase moisture retention and available water content but reduces air space and total porosity (Table 1). The greatest liability is that air space may be reduced too much, requiring careful irrigation management to avoid waterlogging and anoxia of roots. Growers in the Southeastern

U.S. frequently add sand to pine bark, but may think that the only reason is to increase the weight of the container, to reduce blowing over of containers in growing beds. Another less obvious reason to add fine particle components such as sand is that the infiltration rate of irrigation water is slowed down as it moves through the container profile rather than channeling rapidly to the bottom of the container. This promotes wetting of the substrate. However, too much sand can increase weight too much, creating handling and shipping difficulties.

When greatly different particle sizes of potting materials such as fresh pine bark and sand are combined, considerable component shrinkage occurs. In this case one cubic yard plus one cubic yard is not equal to two cubic yards. The shrinkage may yield a volume of 1.5 cubic feet. In this situation a great increase in bulk density, which is the solid composition of the substrate, would be expected. Particles less than 0.5 mm in pine bark create many of the pores that hold water. Fresh pine bark has very few particles less than 0.5 mm so growers add other components to replace the fines for better moisture retention (Tables 1 & 2). Moisture holding characteristics for organic components are different from soils, since water is held within particles and fibers as well as between particles as in soils. Moisture held within chambers in pine bark particles and inside fibers of sphagnum peat moss are available and explored by plant roots.

Irrigation and fertility must be closely managed to optimize air, water and nutrient characteristics of the substrate to avoid excessive leaching or salt build up or too wet or dry conditions in containers.

Particle size considerations for potting substrates

The age and handling prior to use as a potting component affect the physical and chemical characteristics of pine bark. Loblolly pine is the predominant species of pine used for pine bark potting substrates over much of the Eastern U.S. This pine bark is generally considered to be non-phytotoxic and can be used without aging or composting. Aging produces a more stable material and allows break down of larger particles, degradation of wood, cambium and complex compounds associated with the turpentine like smell of fresh pine bark. Aged pine bark is sometimes referred to as composted bark, although in the strictest sense, unless pine bark is amended with a nitrogen source, moistened and turned regularly as described as composting procedures for leaf yard wastes and animal wastes, true composting may not fully occur. Stability of an organic material is frequently based upon it s carbon to nitrogen ratio. For most organic potting components the ratio should be at least 30 : 1 (C : N), however, even composted pine bark may not have this low of a C/N ratio since most of the pine bark is lignin and not cellulose.

Stability and particle sizes of potting components and how two or more components fit in the mix is important and creates the physical properties discussed in Table 1. Stable components are necessary since rapid decomposition will also continually change the physical properties, decreasing air space and increasing moisture retention. Nitrogen applied for plant growth may also be used during decomposition, resulting in reduced growth of container plants. Particle size distributions of potting substrates can be measured. Results generally compliment physical property data, but can be used to diagnosis potential aeration and water retention difficulties if used for crop production (Table 2).

Table 1. Physical properties of selected substrates.[z]

Substrate[y]	Total Porosity	Air Space	Container Capacity	Available Water	Unavailable Water	Bulk Density (g/cc)
			(% Volume)			
Fresh Pine Bark	86	42	44	13	31	0.19
Aged Pine Bark	82	31	51	21	30	0.19
Fresh PB +Sand	81	31	50	19	31	0.34
Aged PB + Sand	82	27	55	24	31	0.36
9PB:1P	79	15	63	39	34	0.19
9PB:1Soil	74	15	59	33	26	0.31
3PB 3/8” 2P:2RH	87	16	72	48	24	0.19
Normal Ranges	50.0-85.0	10.0-30.0	45.0-65.0 (% volume)	23.0-35.0	23.0-35.0	0.19-0.52.0 (g/cc)

[z]All analyses performed using standard soil sampling cylinders (7.6 cm ID, 7.6 cm h)
Air Space and Container Capacity affected by height of container.

Table 2. Particle size distribution of selected nursery container substrates.[z]

Sieve no.	Opening (mm)	Substrate[y]						
		Fresh Pine Bark	Aged Pine Bark	8 Fresh PB + 1 Sand	8Aged PB +Sand	9 PB 1 Peat Moss	9PB 1Soil	3PB 3/8” 2P:2RH
0.25	6.3	9.0	13.3	5.0	6.1	7.9	6.1	5.8
10	2.0	47.3	36.2	28.7	26.4	34.6	30.7	29.5
25	0.7	25.7	23.2	34.3	30.5	28.4	30.0	28.7
		82.0%	72.7%	68.0%	63.1%	70.9%	66.8%	64.0%
35	0.50	6.8	7.3	14.3	14.5	8.6	11.1	15.5
60	0.25	7.6	10.0	14.3	14.5	12.1	14.4	14.4
140	0.11	2.8	2.8	0.6	2.3	2.5	1.2	1.3
		18.0%	27.3%	32.0%	37.0%	29.1%	33.2%	36.0%

[z]Suggested ranges for fine particles < 0.5mm in size (% weight) is 20% to 30% for pine bark fines and < 50% for multiple component blended potting substrates.

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