Landscape

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A Review of 'Louisiana Select' Plants

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Index Words: Louisiana Select, Plant Promotions

Nature of Work: The 'Louisiana Select' plant promotion and recommendation program, sponsored by the LSU AgCenter and Louisiana Nursery and Landscape Association, originated in 1996 and was the second statewide plant promotion program in the country after the Texas CEMAP program (now known as Texas Superstar program). This program is intended to provide recommendations to Louisiana green industry professionals and home gardeners on outstanding plants worthy of increased landscape use. Typically, annual bedding plants, herbaceous perennials, trees and shrubs are considered.

Selection of plants is made by a committee consisting of LSU AgCenter faculty and board members of the Louisiana Nursery and Landscape Association. An attempt is made to send notice of selected plants 12-18 months ahead of promotion. News articles, primarily through the LSU AgCenter's mass media network, are the primary public outreach mechanism.

Results and Discussion: The 'Louisiana Select' plants for 2003 are 'Profusion Orange' zinnia and 'Profusion White' zinnia. These zinnias have been on the market since the late 1990s. The orange flowers of 'Profusion Orange' start out very bright and gradually fade with age. The bright white flowers of 'Profusion White' fade to creamy white. These plants are crosses between *Zinnia linearis* (*Z. angustifolia*) and *Zinnia elegans*. 'Profusion' zinnias reach 14-18 inches tall in the landscape and prefer a full sun, well-drained bed for best results. 'Profusion White' and 'Profusion Orange' are both All-America Selection winners.

'Goldsturm' rudbeckia produces bright-yellow, 3-4 inch flowers with a dark-brown to black eye. It is reliably perennial in Louisiana. Flowering occurs mid-late spring through fall in Louisiana. It reaches 3-4 feet tall in landscapes. Plant in full sun in the landscape for best flowering performance. 'Goldsturm' is tolerant of heat and drought and makes good cut flowers with long post-harvest qualities.

A plant to try as a companion to 'Goldsturm' rudbeckia would be 'Homestead Purple' verbena. This verbena produces deep rich purple flowers and blooms early. 'Homestead Purple' verbena maintains a ground cover growth habit. Plants come back year after year. Pruning back plants occasionally to force new stem and flower production is recommended. White flies and *Rhizoctonia* web blight are problems on verbena in Louisiana but are easily controlled if proper cultural practices are followed.

'New Gold' lantana is a Louisiana Select plant from 1998. Other lantanas promoted included 'Silver Mound', 'Dallas Red', 'Confetti' and 'Trailing Purple'.

'New Wonder' scaevola is a Louisiana Select plant and has outperformed other scaevolas in LSU AgCenter landscape trials. The common name of this plant is fan flower and they produce large, violet-blue fan-like flowers with bright yellow

centers on vigorous, compact flowering spikes. It performs best in full sun and is most recommended for container plantings. Plants can be trimmed occasionally to maintain season-long flowering. Plants have over-wintered in Baton Rouge (USDA hardiness zone 8B).

A warm season annual bedding plant for full sun is 'New Orleans Red' coleus. 'New Orleans Red' coleus, also known in the trade as 'Red Ruffle' and other names, provides dark red, almost black, foliage with an iridescent bright cherry center. This coleus has been one of the superior performers in LSU AgCenter landscape evaluations.

'Lady in Red' salvia is a former All-America Selections winner and reaches 18-24" under southern growing conditions. Flowers on this cultivar are an excellent red, almost fiery scarlet, and trumpet shaped. 'Lady in Red' is treated as an annual in many areas but can be grown as a perennial in the Gulf South.

Fall would be the best time to plant 'Foxy' foxglove. This foxglove is another former All-America Selection winner and reaches heights of 36-42". Although foxglove is commonly classified as a biennial or short-lived perennial, this cultivar is a reliable performer in Louisiana landscapes. Flower colors include carmine-red, creamy yellow, pink, and white with maroon.

A cool season annual bedding plant that has been featured as a Louisiana Select plant is 'Telstar' dianthus. This bedding plant reaches heights of 8-10" and bears clove-scented flowers that are 1 1/4" across and performs well from November through April in south Louisiana.

'Henry's Garnet' virginia willow and 'Watchet' azalea are shrubs chosen as Louisiana Select plants. 'Watchet' azalea is a repeat blooming variety. Moderate pink flowers about 3 1/2" in diameter lengthen floral displays in the fall and spring months and provide enhanced flowering when compared to other fall-flowering azaleas. 'Watchet' is a Robin Hill hybrid azalea. Other Robin Hill hybrids are promoted in the Louisiana Select program. 'Henry's Garnet' virginia willow is a graceful, deciduous, clump-forming native shrub, 3 to 8 feet in height with a variable spread that is usually wider than high. This plant tolerates Louisiana's wet and heavy soils but also performs well in drier sites. Plant virginia willow for the 4- to 5-inch long, fragrant, white flower racemes that appear in April and May against a background of dark green foliage. Foliage of the 'Henry's Garnet' virginia willow is especially handsome in fall. The leaves turn a brilliant deep red-purple and persist late into the season.

Bald cypress is Louisiana's state tree and a Louisiana Select plant. In addition, a native fruit tree, the mayhaw, has also been named a Louisiana Select tree selection. Red berries (excellent for jellies) are produced from mid-April through May.

Significance to Industry: The Louisiana Select program has provided a list of reliable plants for Louisiana's green industry professionals to promote to the gardening public. Sales have increased significantly for all the plants mentioned and wholesale production has benefited due to increased product mix and the introduction of new available species and varieties.

Butterfly Feeding Preferences Among Cultivars of *Lantana camara* in the Landscape, a Commonly Recommended Nectar Source

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Index words: Lepidoptera, 'New Gold', 'White Doves', 'Firewagon', 'Confetti', 'Hot Country', 'Radiation', 'Weeping Lavender', 'Irene', 'Cherry', and 'Carlos'

Nature of Work: Butterfly gardening has become a popular niche in horticulture. In response to popular demand many plants are marketed by the horticultural industry as butterfly attractants to tap into this growing market. Considerable knowledge exists regarding the types of plants that are important nectar sources including *Lantana camara* (L.). However, many cultivars of lantana are available exhibiting different flower colors and vegetative growth habits. Research has shown butterflies can be highly selective in their choice of nectar plants, based on many factors, including flower color, nectar guides, and nectar composition (1, 2, 3, 4). Additionally, previous research has shown that changes in corolla size and form during hybridization may disrupt or expand morphological matches between flower and insect, affecting nectar accessibility and changing the pollinator species composition (5). The objective of this study was to evaluate feeding preferences of native butterfly species among *L. camara* cultivars. Plant characteristics investigated in this study were flower color characteristics, including light reflectance in the visible spectrum, and morphology.

On June 18th, 2002, four single plant replications of each cultivar from 3.8 liter (#1) containers were planted in four blocks in the field plot for a total of 160 plants. Cultivars in the study included 'New Gold', 'Irene', 'White Doves', 'Carlos', 'Firewagon', 'Cherry', 'Weeping Lavender', 'Confetti', 'Hot Country', and 'Radiation'. Plants were drip irrigated for approximately eight hours once weekly. Soil testing identified the soil type in the research plot area as Marvyn sandy loam.

Butterfly visitation data was collected in August (8th and 22nd), September (12th), and October (11th) of 2002. Data collected for butterfly visitation included: 1) number of total visits to individual inflorescences, 2) species of the butterfly visitors observed, and 3) duration of each inflorescence visit by one randomly selected butterfly. Temperature, relative humidity, and light levels were recorded at the beginning and end of each data collection. Number of inflorescences for each plant was recorded during visitation data collections. Lightness, chroma, and percent reflectance in the visible spectrum of 400 to 700 nanometers (nm) of flowers were quantified using a Minolta Spectrophotometer CM-2002 A (Minolta Camera Co., Ltd., Ramsey, New Jersey) and inflorescence width, corolla width,

and corolla tube length were collected in November 2002 using one inflorescence from each of the sixteen single plant replications in the field study. White representing a value of 100 for lightness and black a value of 0 and chroma values quantifying the degree of color saturation. Additionally, the percentage of yellow flowers were calculated by dividing the number of yellow flowers per inflorescence by the total number of flowers. Mean separation was performed using Duncan's Multiple Range Test at the 5% level. Visitation data collected in August and September was statistically similar using ANOVA and the results combined for statistical analysis.

Results and Discussion: In August and September, total inflorescence visits were similar for 'New Gold' (2.9), 'White Doves' (2.4), 'Radiation' (2.2), 'Confetti' (1.8), and 'Firewagon' (1.7) while greater than the remaining cultivars (Table 1). Visitation was slightly different in October with an overall increase in number of visitors. 'Radiation' and 'New Gold' were again two of the most visited cultivars in October with 5.2 and 5.1 total inflorescence visits, respectively. However, less visitation to 'White Doves' and 'Firewagon' was observed. 'New Gold' and 'Radiation' total inflorescence visits were similar to 'Hot Country' (4.7), 'Confetti' (3.4), and 'Cherry' (3.2) and greater than the remaining cultivars. For August and September observations, total visit duration in seconds was similar with 'New Gold' (34), 'White Doves' (28), 'Radiation' (28), and 'Firewagon' (23) having the longest total visit duration and statistically similar. Total visit duration was similar between all cultivars in the October observation. Differences in the visitation data in October may be attributed to changes observed in the butterfly species distribution. The species recorded in August and September were consistent with Lepidoptera families of Hesperiidae and Nymphalidae equally dominating the species observed (Chart 1). For the October data collection, a shift in distribution occurred with Hesperiidae becoming the dominant species observed.

Correlations were found between butterfly visitation and flower characteristics including inflorescence number, lightness and chroma of flowers located in the outer and middle positions (Table 2), wavelengths in the visible spectrum of 400 to 700 nm of flowers in the outer, middle, and inner positions (data not shown), and percentage of yellow flowers or partially yellow flowers per inflorescence (Table 2). Correlation analysis confirmed trends observed with native butterfly visitation and duration of visits being consistently greater for 'New Gold' and 'Radiation'. Lightness values were consistently greater in 'New Gold' and 'White Doves' in outer, middle and inner flower locations and these cultivars being among those visited preferentially in August and September. Similarly, chroma values were greater for 'New Gold', 'Firewagon', and 'Radiation' which were preferentially visited in August and September. Additionally, cultivars with a greater percentage of entirely or partially yellow flowers such as 'New Gold', 'Radiation', and 'White Doves' were three of the most visited by native butterflies.

Significance to Industry: There have been few detailed studies conducted examining whether all cultivars or varieties of a certain plant species are equally effective for attracting butterflies. In these studies, visitation and visit duration of native butterfly species to two lantana cultivars 'New Gold' and 'Radiation' were consistently greater than visitation to the remaining cultivars in the tests. Statistical analysis revealed correlations between cultivar characteristics

investigated and the observed preferences. Therefore, hybridization of *Lantana camara* specifically for butterfly attraction should target flowers with higher lightness and chroma values and greater percentages of yellow flowers per inflorescence. Further studies on the flowering characteristics of *Lantana camara* cultivars evaluating nectar volume and nectar composition could provide information to the horticulture industry regarding additional traits that are effective for butterfly attraction and should be targeted for hybridization.

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Chart 1. Lepidoptera species distribution during data collections performed on 8/82002, 8/22/2002, 9/12/2002, and 10/11/2002.

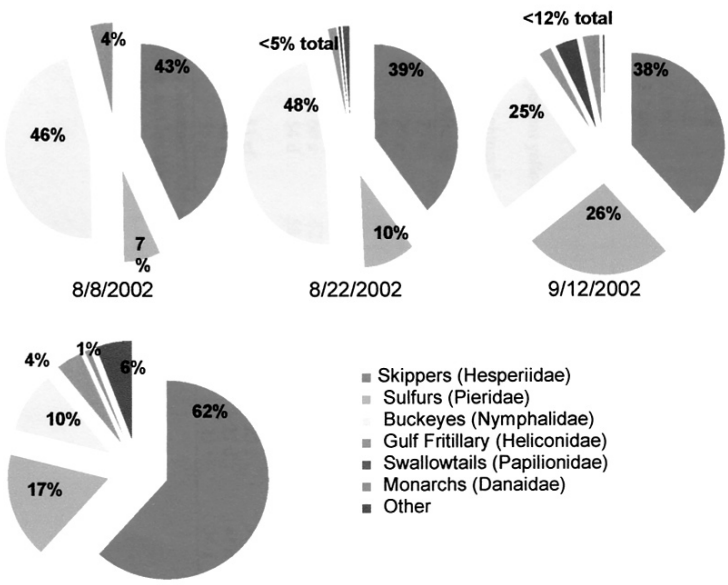

Table 1. Mean total inflorescence visits and total visit duration in seconds for native butterfly visitation of lantana cultivars for observations on 8/8/02, 8/22/02, 9/12/02, and 10/11/02.

Cultivar	Total inflorescence visits		Total visit duration (seconds)	
	8/8/02, 8/22/02 and 9/12/02 observations[z]	10/11/02 observations	8/8/02, 8/22/02 and 9/12/02 observations[z]	10/11/02 observations
New Gold	2.9 a[y]	5.1 a	34 a	31 a
White Doves	2.4 ab	2.6 bcd	28 a	15 a
Firewagon	1.7 abcd	2.3 cd	23 ab	29 a
Confetti	1.8 abc	3.4 abc	12 bc	26 a
Hot Country	1.4 bcde	4.7 ab	13 bc	21 a
Radiation	2.2 ab	5.2 a	28 a	26 a
Weeping Lavender	1.2 cde	1 d	13 bc	9 a
Irene	1 ef	2.6 bcd	15 bc	24 a
Cherry	0.9 def	3.2 abc	7 c	20 a
Carlos	0.4 f	0.8 c	4 c	10 a

[z]Results combined from observations performed on 8/8/02, 8/22/02, and 9/12/02.

[y]Means followed by different letters are significantly different according to Duncan's Multiple Range Test at the 5% level.

Table 2. Mean inflorescence number, lightness, chroma, and percent yellow flower per inflorescence for lantana cultivars collected in 11/ 02.

	Inflorescence number			Lightness[z]			Chroma[z]			Percent yellow flowers per inflorescence
	8.22.02	9.12.02	10.11.02	Outer[y]	Middle	Inner	Outer	Middle	Inner	
New Gold	160.3 a[x]	239 a	190 b	65 b	70 b	66 b	40 a	41 b	42 c	100.0 a
White Doves	146 ab	56 e	58 e	77 a	76 a	75 a	10 g	13 g	18 h	35.0 bc
Firewagon	54 e	41 ef	23 f	45 e	53 e	59 f	29 b	36 c	44 b	15.0 ef
Confetti	70 d	130 c	107 c	42 f	52 f	58 g	26 c	26 e	33 g	21.0 de
Hot Country	35 f	97 d	68 d	42 f	49 h	60 e	24 de	26 f	34 g	10.0 efg
Radiation	87 cd	138 c	199 a	46 d	60 c	62 d	29 b	42 a	47 a	46.0 b
Weeping Lavender	119 c	219 b	92 cd	53 c	54 d	58 fg	25 c	25 f	17 i	0.0 g
Irene	26 g	47 ef	61 d	42 g	53 ef	63 d	24 d	25 f	39 d	31.0 cd
Cherry	30 g	130 c	61 d	41 h	45 i	63 c	22 f	27 d	41 e	6.0 fg
Carlos	16 h	103 d	87 cd	43 g	51 g	60 e	23 e	25 f	36 f	20.0 e

[z]Lightness and chroma values quantified using the Minolta Spectrophotometer CM-2002.

[y]Flower characteristics were quantified for flowers in outer, middle, and inner locations on each inflorescence.

[x]Means followed by different letters are significantly different according to Duncan's Multiple Range Test at the 5% level.

Green Roofs – A New Market

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Index words: Garden roof, Sedum, succulents, vegetative roof

Nature of Work: Numerous benefits can be realized from green roofs. They provide insulation for buildings, thus saving on energy consumption (4, 8, 10), reduce the amount of runoff entering municipal stormwater management systems (7, 12), and increase the life span of a typical roof by protecting the various roof components from damaging UV rays, extreme temperatures, and rapid temperature fluctuations (5). In addition, green roofs improve the aesthetics of densely urbanized areas, provide habitat for a range of organisms from microbes to birds, and have the potential to reduce the Urban Heat Island Effect (10, 11).

Obtaining these benefits can sometimes be difficult. A rooftop is an extreme environment with strong and variable wind patterns and little or no protection from the sun's intense heat and ultraviolet radiation. Of the millions of plant species available, only a select few have been identified as appropriate for use in these harsh conditions (6, 9). Climatic conditions, especially the amount and distribution of rainfall and temperature extremes, will eliminate the use of certain species or will dictate the need for irrigation. Selection of plant material is crucial for success. In addition, substrate depth will influence the choice of plants that can be grown (2, 3). Deeper substrate depths will not only retain moisture longer, they are also less subject to fluctuations in temperature. However, a shallower and lighter substrate layer is often desirable because the building must be structurally strong enough to support the added weight of the substrate and vegetation.

Even though green roofs are relatively popular in Germany and the rest of Europe (1), the concept is just now being introduced in the United States. If we are to realize the benefits they provide, then we must develop a better understanding of what specific species will survive and prosper under harsh rooftop conditions. Several species of sedum commonly used in Germany did not survive cold winters in Quebec (1). What works in Germany is not necessarily what is best for Michigan or the rest of the U.S. because of our greater extremes in winter and summer temperatures. In addition, we must learn what substrate composition and depths can support plant life, yet still be light enough to be placed on a roof.

The green roof research program at MSU was initiated in collaboration with Ford Motor Company in an effort to advise them on the installation of a 450,000 square feet green roof that was recently installed on a new assembly plant in Dearborn. The objectives of our ongoing research are to evaluate plant species, propagation and establishment methods, substrates, water and nutrient requirements, and water quality and quantity of runoff. Numerous experiments are currently being conducted on 48 model scale roof platforms measuring 8 ft x 8 ft at MSU. The site is equipped with a weather station, thermocouples

measuring temperatures at various depths in the growing substrates, and electronic tipping buckets that record the volume and rate of stormwater runoff from the individual platforms. Measurements are taken every five minutes, 24 hours a day, and are recorded on a Campbell Scientific datalogger.

Results and Discussion: Over the past three years we have been conducting studies comparing nine species and cultivars of *Sedum* and 18 taxa of Michigan native plants: *Agastache foeniculum* (lavender hyssop), *Allium cernuum* (nodding wild onion), *Aster laevis* (smooth aster), *Coreopsis lanceolata* (lanceleaf coreopsis), *Fragaria virginiana* (wild strawberry), *Juncus effusus* (spikerush), *Koeleria macrantha* (junegrass), *Liatris aspera* (rough blazingstar), *Monarda fistulosa* (bergamot), *Monarda puntata* (horsemint), *Opuntia humifosa* (prickly pear), *Petalostemon purpureum* (purple prairie clover), *Potentilla anserina* (silver feather), *Rudbeckia hirta* (black-eyed Susan), *Schizachyrium scoparium* (little bluestem), *Solidago rigida* (stiff goldenrod), *Sporobolus heterolepis* (prairie dropseed), and *Tradescantia ohiensis* (spiderwort). The Michigan natives were planted as plugs and nine species of sedum were planted as either seed or plugs.

All nine species of *Sedum* significantly outperformed the native forbs and grasses in criteria such as rate of establishment, substrate coverage, drought tolerance, and plant mortality (9). This finding supports the concept that *Sedum* spp. can be used in a wide variety of conditions and will grow successfully – particularly in dry areas. Other studies support the suitability of low-growing Sedum spp. for use in green roofs due to their ability to survive in substrate layers as thin as 2-3 cm (0.8 – 1.2 in) because of their cold and drought tolerance (2, 3). Of the native species tested, *Coreopsis lanceolata*, *Tradescantia ohiensis*, and *Allium cernuum* are potential selections depending on the range of conditions present. However, if these native plants are to be grown successfully and maintain their aesthetic value, then irrigation must be available.

We also looked at the influence of five substrate compositions containing 60, 70, 80, 90, and 100% of heat-expanded slate (PermaTill®), four levels of controlled-release fertilizer (Nutricote 13-13-13 Type 180, Agrivert, Inc., Webster, Tex.), and two irrigation schedules on the establishment and growth. PermaTill® content and fertilizer level had little affect on plant mortality during either establishment or overwintering. PermaTill® content and irrigation schedule had minimal impact, but a lack of fertilizer significantly reduced the growth of the two Sedum spp. A lack of fertilizer had less affect on native plants, but these species were greatly affected by a lack of irrigation and to a lesser degree by PermaTill® content. These results suggest that a relatively low level of controlled-release fertilizer [50 $g \cdot m^{-2}$ (0.15 $oz \cdot ft^{-2}$)] and moderately high level of PermaTill® (approx. 80%) can be utilized in greenroof applications in Michigan (9).

Significance to Industry: Green roofs covered with vegetation offer many economic, environmental, aesthetic, and psychological benefits to mankind. In Germany, it is estimated 10% of all flat-roofed buildings are covered with vegetation, a number that is increasing as the German green roof industry continues to grow 10 to 15% per year. In Michigan and the rest of America the concept of green roofs is just now being introduced. A few installations exist in North America, the largest (10.6 acres) being the new assembly plant at the

Rouge facility of Ford Motor Co. in Dearborn, Mich. This one project resulted in over $200,000 in orders for plant material grown at Michigan nurseries. In the future, green roofs will likely become more common in this country. They represent an entirely new market for nursery stock and landscape installation and maintenance contractors and the potential market consists of all existing and future roofs in Michigan and the rest of the country. A market that it too large to ignore.

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Landscape Performance of Dianthus Cultivars – 2003

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Index Words: Dianthus, Landscape Performance

Nature of Work: The LSU Agricultural Center has been actively pursuing plant performance trials over the last five years. This has primarily concentrated on annual bedding plants. Dianthus is a widely popular annual herbaceous plant used extensively in Louisiana and the Gulf South for cool season plantings. The 'Telstar' series of dianthus have been named Louisiana Select plants. This trial evaluated the 'Ideal' and 'Floral Lace' series in addition to some new cultivars.

Dianthus varieties growing in jumbo cell packs were transplanted on October 24, 2002 into raised landscape beds at Burden Center in Baton Rouge, La. Bed material consisted of primarily slightly aged fine pine bark on top of an Olivier silt loam soil. Plants were planted on 12-inch centers and arranged in a randomized complete block by varieties with 24 plants per variety. Plants were located in full sun and were irrigated as needed to prevent stress throughout the evaluation period. StaGreen Nursery Special 12-6-6 was broadcast after planting at the rate of 2.5 pounds per 100 square feet. Osmocote 15-9-12 was broadcast after planting at the rate of 1.25 pounds per 100 square feet. Plants were not deadheaded during the evaluation period and insecticides, fungicides or herbicides were not applied to the area.

Visual quality ratings were taken January 15, February 1, February 15, March 1, March 15, April 11, and April 15, 2003. The rating was based on a scale from 1 to 5 with 1=worst, 5=best. Included in this evaluation were growth habit, foliage color/appeal, and flower quality. Ratings were discontinued mid-spring due to plant decline. Plants were rated April 17, 2003 for leaf spot caused by *Alternaria*. Disease ratings were based on a scale from 1 to 6 with 1=no disease and 6=76-100% of leaves with spots.

Results and Discussion: Visual quality ratings only revealed minor differences between varieties. Overall, the 'Ideal' series seemed to perform slightly better than the 'Floral Lace' series. 'Corona Cherry Magic', a recent All-America Selection winner, had above average performance. Also, 'Purple Bouquet' and 'Amazon Neon' had higher quality ratings throughout the evaluation period. *Alternaria* leaf spot was responsible for termination of the evaluation. This disease began appearing in early April and caused major plant decline by mid-April.

Significance to Industry: Conducting landscape trials to evaluate performance of annual bedding plant varieties provides useful information for greenhouse crop producers, retail garden center personnel, landscapers, and the gardening consumer. Dianthus studied here have potential for landscape use in Louisiana. In addition to 'Telstar', the 'Ideal' and 'Floral Lace' series should be recommended for Louisiana landscapes. Fungicide application may be needed to extend desirable performance into mid- and late spring. 'Corona Cherry Magic and 'Purple Bouquet' are above average performers.

Table 1. Visual quality ratings of dianthus cultivars.

Variety	Jan. 15	Feb. 1	Feb. 15	March 1	March 15	April 1	April 15
Festival Cherry Picotee	3.5	3.5	3.5	4.5	4.5	3.5	3.0
Festival Crimson Rose	3.0	3.0	3.5	4.0	4.0	3.5	3.0
Corona Cherry Magic	3.0	3.0	3.0	3.5	4.5	4.5	4.0
Valentine	2.5	2.0	3.0	3.0	3.5	3.5	3.0
Ideal White	3.5	3.5	3.5	4.0	4.0	3.5	3.5
Ideal Pink	3.5	3.5	3.5	4.5	4.5	4.0	3.0
Ideal Raspberry	3.0	3.5	3.5	4.0	4.0	3.0	2.0
Ideal Fuschia	3.5	3.5	3.5	4.0	4.0	3.0	3.5
Ideal Coral	2.5	3.0	3.5	4.0	4.0	4.0	3.5
Ideal Cherry	4.5	4.5	4.5	4.5	4.5	4.0	3.5
Ideal Blush	3.0	3.0	3.5	4.0	4.0	4.0	3.5
Ideal Rose	3.5	3.5	4.0	4.0	4.0	4.0	4.0
Ideal Violet	2.5	3.0	3.5	3.5	3.5	4.0	4.0
Ideal Violet Picotee	3.5	3.5	3.5	4.0	4.0	4.5	3.5
Ideal Cherry Picotee	3.5	3.5	3.5	4.0	4.0	4.0	4.0
Ideal Salmon	3.0	3.0	3.0	4.0	4.0	4.0	4.0
Ideal Carmine	3.5	3.5	3.5	4.0	4.0	4.0	4.0
Ideal Pearl	3.5	3.5	3.5	4.5	4.5	4.0	3.5
Ideal Crimson	4.0	4.0	4.5	4.5	4.5	4.0	3.5
Ideal Magical Mix	3.0	3.5	3.5	4.0	4.5	3.5	3.5
Ideal Mix	3.0	3.0	3.5	4.0	4.5	3.5	3.5
Ideal Sweetheart Mix	2.5	2.5	3.0	3.5	4.5	3.5	3.5
Floral Lace Violet Picotee	3.5	3.5	3.5	4.5	4.5	3.5	3.5
Floral Lace Violet	2.5	3.0	3.5	3.5	3.5	3.0	3.0
Floral Lace Cherry	3.5	3.5	3.5	4.5	4.5	3.0	3.5
Floral Lace Purple	3.0	3.0	3.5	4.0	4.5	3.5	4.0
Floral Lace Rose	3.5	4.0	3.5	4.0	4.5	3.0	3.5
Floral Lace Crimson	2.5	3.0	3.5	3.5	3.5	3.5	3.5
Floral Lace True Rose	3.0	3.5	3.5	4.0	4.0	3.0	3.0
Floral Lace Pink	4.0	3.5	3.5	4.5	4.5	3.5	4.0
Floral Lace Lilac	3.5	3.5	4.0	4.5	4.5	3.0	4.0
Floral Lace Picotee	3.5	3.5	4.0	4.0	4.0	3.5	3.5
Floral Lace Mix	3.0	3.5	4.0	4.0	4.0	3.5	4.0
Amazon Neon	4.0	3.5	3.5	4.0	3.5	4.0	4.5
Purple Bouquet	4.5	3.5	3.5	4.5	4.5	4.5	4.5
Cinderella	3.5	3.5	3.5	4.0	4.0	4.0	4.5

Note: Visual quality ratings based on a scale from 1 to 5 with 1=worst, 5=best. Included in this evaluation were growth habit, foliage color/appeal, and flower quality.

Table 2. Alternaria leaf spot ratings of dianthus cultivars.

Variety	Disease Rating
Festival Cherry Picotee	5.3
Festival Crimson Rose	5.7
Corona Cherry Magic	3.9
Valentine	5.2
Ideal White	3.7
Ideal Pink	5.4
Ideal Raspberry	6.0
Ideal Fuschia	6.0
Ideal Coral	5.2
Ideal Cherry	6.0
Ideal Blush	4.5
Ideal Rose	4.8
Ideal Violet	4.0
Ideal Violet Picotee	4.1
Ideal Cherry Picotee	3.2
Ideal Salmon	2.3
Ideal Carmine	5.8
Ideal Pearl	3.9
Ideal Crimson	6.0
Ideal Magical Mix	4.5
Ideal Mix	4.3
Ideal Sweetheart Mix	3.4
Floral Lace Violet Picotee	5.2
Floral Lace Violet	5.8
Floral Lace Cherry	6.0
Floral Lace Purple	4.5
Floral Lace Rose	6.0
Floral Lace Crimson	5.1
Floral Lace True Rose	5.2
Floral Lace Pink	3.6
Floral Lace Lilac	4.3
Floral Lace Picotee	3.7
Floral Lace Mix	3.6
Amazon Neon	2.0
Purple Bouquet	2.0
Cinderella	2.3

Note: Disease ratings based on a scale from 1 to 6 with 1=no spots, 6=76-100% of foliage with *Alternaria* leaf spot.

Landscape Performance of Viola and Panola Cultivars -2003

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Index Words: Landscape Performance, Violas, Panolas

Nature of Work: The LSU Agricultural Center has been actively pursuing landscape plant performance trials over the last five years. This has primarily concentrated on annual bedding plants. Violas and panolas are fast becoming an alternative to pansies. There has also been an increase in the number of cultivars and series of these plants in the last few years. This trial evaluated the 'Sorbet', 'Princess', 'Alpine', and 'Babyface' series of viola. In addition, panola varieties and several 'Baby Bingo' varieties were included.

Viola and panola varieties growing in jumbo cell packs were transplanted October 24, 2002 into raised landscape beds at Burden Center in Baton Rouge, La. Bed material consisted of primarily slightly aged fine pine bark on top of an Olivier silt loam soil. Plants were planted on 12-inch centers and arranged in a randomized complete block by varieties with 24 plants per variety. Plants were located in full sun and were irrigated as needed to prevent stress throughout the evaluation period. StaGreen Nursery Special 12-6-6 was broadcast after planting at the rate of 2.5 pounds per 100 square feet. Osmocote 15-9-12 was broadcast after planting at the rate of 1.25 pounds per 100 square feet. Plants were not deadheaded during the evaluation period and insecticides, fungicides or herbicides were not applied to the area.

Visual quality ratings were taken January 15, February 1, February 15, March 1, March 15, April 1, and April 15, 2003. The rating was based on a scale from 1 to 5 with 1=worst, 5=best. Included in this evaluation were growth habit, foliage color/appeal, and flower quality. Ratings were discontinued mid-spring. Plants were rated April 18, 2003 for *Botrytis* flower blight. Disease ratings were based on a scale from 1 to 6 with 1=no disease and 6=76-100% of leaves with blight.

Results and Discussion: Visual quality ratings did not reveal large differences in landscape performance between viola and panola varieties. It was noted, however, that panolas had a significantly more pronounced presence of *Botrytis* petal blight in the spring of 2003. Previous evaluations have shown panolas to be average to above average landscape performers when compared to many pansy and viola varieties.

Significance to Industry: Conducting landscape trials to evaluate performance of annual bedding plant varieties provides useful information for greenhouse crop producers, retail garden center personnel, landscapers, and the gardening consumer. Violas in this study were good performers as a cool-season bedding plant when compared to panolas. Panolas performed poorer than previously observed. Cool-season bedding plant trials will continue in 2003 and 2004.

Table 1. Visual quality ratings of violas and panolas.

Variety	Feb. 1	Feb. 15	March 1	March 15	April 1	April 15
Sorbet Purple Duet	3.0	3.5	4.0	4.0	4.0	4.0
Sorbet Black Delight	3.0	3.5	4.0	4.0	4.0	4.0
Sorbet Yellow Delight	3.0	3.5	4.0	4.0	4.0	3.5
Sorbet Beaconsfield	3.0	4.0	4.5	4.5	4.0	3.5
Sorbet Plum Velvet	3.0	3.5	4.0	4.0	4.0	3.5
Sorbet Antique Shade	3.0	3.5	4.0	3.5	3.0	3.0
Sorbet Blue Heaven Improved	3.5	4.0	4.0	4.5	4.0	3.5
Sorbet Coconut Improved	2.5	3.5	4.0	3.5	3.5	3.5
Sorbet Blackberry Cream	3.0	3.5	4.5	4.0	4.0	3.5
Sorbet Sunny Royale	3.0	3.5	4.5	4.0	4.0	3.0
Sorbet Blueberry Cream	3.0	4.0	4.0	4.0	4.0	3.5
Sorbet Mix	2.5	4.0	4.0	3.5	3.5	3.0
Sorbet Yesterday, Today, & Tomorrow	2.5	3.5	4.5	4.0	3.5	3.5
Sorbet Lemon Chiffon	3.0	4.0	4.5	3.0	3.5	3.0
Sorbet Orange Delight	2.5	3.5	4.0	3.0	4.0	3.0
Sorbet Orange Duet	2.5	4.0	4.0	3.5	4.0	3.0
Sorbet French Vanilla	2.5	4.0	4.5	3.5	3.5	3.5
Sorbet Coconut Duet	2.5	4.0	4.5	4.0	3.5	3.0
Sorbet Mix Blues	2.5	4.0	4.0	3.5	3.5	3.0
Sorbet Coconut Swirl	3.0	4.0	4.5	3.5	3.5	3.5
Sorbet Lemon Swirl	3.0	4.0	4.0	3.0	3.0	3.5
Sorbet Lavender Ice Improved	2.5	4.0	3.5	3.0	3.0	3.0
Sorbet Yellow Frost	2.5	3.5	3.5	3.5	3.0	3.0
Sorbet Black Duet	3.0	4.0	4.0	4.0	3.5	3.5
Baby Face Lavender	2.5	3.5	3.5	3.0	3.0	3.0
Baby Face Marina	2.5	3.5	3.5	3.0	3.5	3.0
Baby Face Yesterday, Today, and Tomorrow	3.0	3.5	3.5	4.0	4.0	3.0
Baby Face Ruby Gold	2.5	3.5	3.5	3.5	4.0	3.5
Baby Face White	2.0	3.0	3.0	3.0	3.5	3.0
Baby Bingo Yellow Clear	2.0	3.0	3.0	3.0	3.5	3.0
Baby Bingo Fire	2.5	3.0	3.5	3.0	3.5	3.5
Baby Bingo Beaconsfield	2.5	3.5	4.0	4.0	4.0	4.0
Princess yellow	2.5	3.5	4.0	3.0	3.5	3.5
Princess Cream	2.5	3.5	3.5	3.0	3.5	3.5
Princess Blue	2.5	3.5	3.5	3.5	4.0	3.5
Princess Lavender Yellow	2.0	3.5	3.5	3.5	3.5	3.0
Princess Purple Deep	2.5	3.5	3.5	3.5	4.0	3.0
Princess Mix	2.5	3.0	3.5	3.5	3.5	3.0
Princess Purple and Gold	2.5	3.5	4.0	4.0	4.0	3.5
Alpine Spring	3.0	3.5	4.0	4.0	4.0	3.5
Alpine Sun	2.5	3.5	4.0	3.5	4.0	3.5
Alpine Summer	3.0	3.5	4.0	3.5	4.0	3.5
Alpine Violet and White	2.5	3.0	4.0	3.5	4.5	3.0
Alpine Sky	2.5	3.5	4.0	3.5	4.0	3.5

	Panolas					
Royal Purple	2.5	3.5	3.5	3.0	3.0	2.5
Pink Shade	2.5	3.0	3.5	3.5	3.0	3.0
White	2.5	3.0	3.5	3.5	3.0	3.0
Purple Face	2.5	3.5	4.0	3.5	3.5	3.0
White Blotch	2.5	3.0	3.5	3.0	3.5	3.0
Red Blotch	2.5	3.0	3.5	3.0	3.5	3.0
Autumn Blue Mix	2.5	3.0	3.5	3.0	3.5	3.0
Deep Purple	2.5	3.0	3.5	3.0	3.5	3.5
Winter Blue Mix	2.5	3.5	4.0	3.0	3.5	3.0
Lavender Blotch	3.0	3.5	4.0	3.5	3.5	3.5
Yellow Blotch	3.0	3.5	3.5	3.0	3.5	3.5
Primrose	3.0	3.5	3.5	3.5	3.5	3.0
True Blue Improved	3.0	3.5	3.5	3.5	3.5	3.0
Blue Blotch Improved	3.0	3.5	4.0	4.0	3.5	4.0
Springtime Mix	2.5	3.5	3.5	3.0	3.5	3.5
Citrus Mix	2.5	3.5	3.5	3.0	3.0	3.0
Yellow Wink	3.0	3.5	3.5	3.5	3.5	3.5
Orange	2.5	3.5	3.5	3.5	3.5	3.0
Marina Shades	2.5	3.5	4.0	4.0	3.5	4.0
All Season Mix	2.5	3.5	3.0	3.0	3.0	3.0

Note: Visual quality ratings based on a scale from 1 to 5 with 1=worst, 5=best. Included in this evaluation were growth habit, foliage color/appeal, and flower quality.

Table 2. *Botrytis* flower blight ratings of violas and panolas.

Variety	Disease Rating
Sorbet Purple Duet	1.2
Sorbet Black Delight	2.0
Sorbet Yellow Delight	1.0
Sorbet Beaconsfield	4.1
Sorbet Plum Velvet	2.1
Sorbet Antique Shade	4.8
Sorbet Blue Heaven Improved	1.5
Sorbet Coconut Improved	2.8
Sorbet Blackberry Cream	2.7
Sorbet Sunny Royale	1.5
Sorbet Blueberry Cream	1.5
Sorbet Mix	1.5
Sorbet Yesterday, Today, & Tomorrow	2.5
Sorbet Lemon Chiffon	3.5
Sorbet Orange Delight	2.5
Sorbet Orange Duet	2.8
Sorbet French Vanilla	2.8
Sorbet Coconut Duet	1.5
Sorbet Mix Blues	2.7
Sorbet Coconut Swirl	4.7
Sorbet Lemon Swirl	4.2
Sorbet Lavender Ice Improved	4.0

Sorbet Yellow Frost	3.2
Sorbet Black Duet	2.3
Baby Face Lavender	3.5
Baby Face Marina	2.4
Baby Face Yesterday, Today, and Tomorrow	2.0
Baby Face Ruby Gold	1.0
Baby Face White	1.2
Baby Bingo Yellow Clear	4.0
Baby Bingo Fire	4.3
Baby Bingo Beaconsfield	2.8
Princess Yellow	4.4
Princess Cream	2.2
Princess Blue	1.2
Princess Lavender Yellow	1.9
Princess Purple Deep	1.2
Princess Mix	1.4
Princess Purple and Gold	1.1
Alpine Spring	1.1
Alpine Sun	2.5
Alpine Summer	2.3
Alpine Violet and White	2.2
Alpine Sky	1.2
Panolas	
Royal Purple	5.9
Pink Shade	5.5
White	4.5
Purple Face	6.0
White Blotch	5.6
Red Blotch	5.5
Autumn Blaze Mix	5.7
Deep Purple	5.3
Winter Blue Mix	5.7
Lavender Blotch	5.8
Yellow Blotch	5.8
Primrose	6.0
True Blue Improved	6.0
Blue Blotch Improved	6.0
Springtime Mix	6.0
Citrus Mix	5.2
Yellow Wink	5.1
Orange	4.5
Marina Shades	4.5
All Season Mix	4.9

Note: Disease ratings based on a scale from 1 to 6 with 1=no blight, 6=76-100% of flowers blighted due to *Boytritis*.

Long-term Evaluation of *Nandina domestica* Cultivars at the JC Raulston Arboretum

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Index Words: heavenly bamboo, *Nandina domestica*, cultivar evaluation

Nature of Work: *Nandina domestica* Thunb. has long been a standard evergreen shrub of the nursery trade in the southeastern U.S. as a result of its versatility in the landscape and ease of propagation. Although *Nandina* is a monotypic genus, the number of named cultivars speaks to the unusually high degree of genetic variability present. As is often the case, despite the large number of cultivars available, only a handful are grown on a large scale. Our long-term observations of the best cultivars in our *Nandina* collection are consistent with the predominance of these same cultivars in inventories of Southern nurseries. However, this evaluation has also shown that other, lesser-known cultivars deserve a second look, that further potential exists in cultivar development, and that some current information on some cultivars should be disputed.

While preferring moist, fertile soil, *Nandina* tolerates a wide range of growing conditions, from full sun to shade and moist to dry soil regimes. This concurs with the conclusion made by Dirr that *Nandina* is “possibly one of the most durable, broadleaf evergreens” (1). They are reliably cold hardy throughout the southeastern U.S., displaying little cold damage in the 2002-03 winter. Plants are propagated through stem cuttings, with division being an alternative for those cultivars that are rhizomatous. The foliage often emerges with a copper to purple flush changing to a dark to bluish green throughout the summer. Winter color often varies from clone to clone and is brilliant red in some cultivars. Flowers, produced in early summer, are borne on panicles ranging from 15 to 30 cm (6 to 12 in.), depending on cultivar. In fall, fruits ripen to a bright red; while some cultivars are selected for white to yellow fruit color.

Results and Discussion: Dr. J. C. Raulston, in his quest to trial not only new species of plants but also numerous cultivars for the rigors of the Southeast, assembled what is believed to be the best collection of *Nandina* cultivars in the United States. Housing over 35 cultivars and clones, many acquired over 15 years ago, this collection allows for an expansive evaluation of mature plant size, overall vigor, as well as an aesthetic evaluation. Plants in this collection have received minimal inputs in terms of irrigation, fertilization, and overall maintenance over their lifetime. The majority of the collection is located in one central location, thereby providing similar growing conditions for most cultivars.

The following are descriptions of many of the cultivars housed in the collections, including height and width data, as well as overall effect and growth characteristics as compared to other cultivars in the collection. Due to timing, this paper does not present data on fruit characteristics, winter foliage color, and

spring growth flush color. Many of these cultivars have been described in the horticultural literature as well as in Dr. Raulston's own observations of the plants (3). The descriptions reported within this evaluation are based on plants grown at the JC Raulston Arboretum over a period of time ranging from 7 years for those most recently planted to 17 years for the oldest cultivars. Table 1 presents growth and evaluative data on 25 cultivars within the collection.

Large Size Cultivars [150 cm (60 in.) or higher]

'Aurea' – Differing in age by 2 years from those plants in our collection labeled as 'Leucocarpa' this cultivar displays slightly greater vigor. Nomenclatural mysteries between 'Alba', 'Aurea', and 'Leucocarpa' remain unresolved.

'Compacta' – While this plant is slightly shorter in habit, and possesses a slightly less dense habit, as reported by Raulston (3), Dirr's (1) comments that this may be a catchall term for more restrained types seems to fit more so than distinguishing this as a cultivar. Hatch (2) presents this perhaps more correctly as Compacta Group, referring to the predominance of seed production of this “cultivar.”

'Leucocarpa' – As mentioned in the description for 'Aurea', these plants display slightly less vigor. That these plants originally were received under the name 'Alba' only adds to the confusion.

'Little Princess' – The only character possessed by this cultivar which is distinctive from the species is that it is slightly pink in bud but no more so than 'Moyer's Red'.

'Moyer's Red' – This cultivar is second only to 'Royal Princess' in the large-sized category for density of foliage from top to bottom. Raulston (3) refers to the flower color as being distinctly pink, possibly darker in cooler climates. Our observations are that the flowers are slightly pink in bud. However, even in the cool spring of 2003, this trait is not far removed from that of other cultivars.

'Royal Princess' – This is quite possibly the best of the large cultivars, displaying finer textured foliage and a rhizomatous habit, resulting in continuously renewed growth from the base of the plant, thus maintaining a dense planting from top to bottom. 'Royal Princess' and 'Harbour Dwarf' are only two cultivars of 35 within our collections that bear this rhizomatous characteristic.

'Southern Lace' – This is one of 2 seedlings in the collection, possibly resulting from a cross between a standard cultivar such as 'Compacta' or the like and one of the so-called “filamentosa” varieties. This seedling displays upright form and foliage, more closely resembling 'San Gabriel' than standard forms. This selection is a more graceful form than the majority of the large cultivars, possibly showing the potential of a new direction in *Nandina* breeding and selection.

'Towne and Country' – The plant under this name in the collection does not resemble Raulston's (3) or Hatch's (2) description of a compact plant resembling 'Harbour Dwarf'. Whether or not our specimen is truly 'Towne and Country' remains to be seen.

'Umpqua Chief' – Unlike Dirr, who feels that 'Umpqua Warrior is the largest in habit (1), our observations show 'Umpque Chief' to be the largest of any of the cultivars housed in the collection and largest of the “Umpqua” series both in panicle length and foliage. Our plant is also slightly larger than 'Umpqua Princess' and 'Umpqua Warrior' in overall height and width (1).

'Umpqua Princess' – This cultivar bears the smallest inflorescences of the "Umpqua" series and is similar in height and width to 'Umpqua Warrior'.
'Umpqua Warrior' – Smallest of the three Umpqua cultivars in habit refuting previous claims as being largest of the group in flower and size (1). Flower panicles are slightly smaller than 'Umpqua Chief'.
'Variegata' – This cultivar possesses an unstable / faint white variegation that quickly fades to green with high temperatures. Habit is similar to other large cultivars. Some seedlings from this plant have already demonstrated better variegation that the parent.

Medium Size Cultivars [75 – 150 cm (30 – 60 in.)]
'Chidori' – This cultivar is by far superior to 'San Gabriel' in both vigor and form. Hatch regards this as the most impressive of narrow-leaved cultivars, and justifiably so (3). We concur with Hatch's statement that this cultivar "should be grown by the hundreds of thousand for warm climates" (2).
'Firepower' – This clone is purported to be resistant to the virus that is responsible for the deformities that show up on 'Atropurpurea Nana' ('Nana', 'Nana Purpurea') (2). The plants in our collection show slightly less uniformity in growth than 'Okame' and 'Wood's Dwarf'.
'Gulf Stream' – This is by far the industry standard in terms of a midsize, compact cultivar. 'Gulf Stream' is slightly larger than 'Moon Bay' in both height and width. Mature height is slightly larger than previously reported (1, 2).
'Moon Bay' – As mentioned beforehand, 'Moon Bay' is slightly smaller than 'Gulf Stream' in both height and width. Also, some winter damage was noticed on the leaves of 'Moon Bay' in 2002/03 [minimum temperature of -14 °C (6 °F)] while 'Gulf Stream' had none.
'Nana' – Nomenclaturely speaking, this cultivar is said to be the same as 'Atropurpurea Nana'. However, the plant in our collection has about twice the vigor as a 'Nana Purpurea' (syn. 'Atropurpurea Nana') planted nearby. One possible explanation may be lack of the virus said to infect 'Atropurpurea Nana'.
'Okame' – This cultivar shares a close similarity to 'Wood's Dwarf' in overall vigor and growth habit, and is said to be virus-free giving it a distinct advantage over 'Atropurpurea Nana'.
'Pygmaea' – While some lump this name into synomony with 'Atropurpurea Nana' (2), both Raulston (3) and Dirr (1) recognize this as a distinct cultivar possessing foliage slightly reduced in size as well as a smaller growth habit as compared to the species (1, 3). The cultivar name 'Minima' is also mentioned as a possible synonym (1, 3). In our opinion, 'Pygmaea' is a better choice than 'Compacta' in terms of a medium sized *Nandina* for the landscape.
Raulston hybrid #2 – This is the second of two seedlings representing a possible cross between a standard type *Nandina domestica* and a *filamentosa* variety. Unfortunately, this seedling possesses extremely lax stems more so resembling a vine than a shrub, thereby rendering it unacceptable by our ratings. By our judging, this plant is more a curiosity than anything else.
Sunray™ ('Greray') – We agree with Hatch's statement that this cultivar does appear to be a very compact plant in regards to plant density. However, Sunray™ has reached a height of 114 cm (45 in.) at 9 years of age while 'Gulf Stream' stood at 91 cm (36 in.) and 'Moon Bay' at 69 cm (27 in.) at similar ages. This leads us to believe that Sunray™ does have the potential to become a larger plant than 'Gulf Stream' and 'Moon Bay' over time.

'Wood's Dwarf' – This cultivar is extremely similar to 'Okame' in overall growth and appearance. A true distinction between the two is hard to ascertain at this point.

Dwarf Cultivars [91 cm (30 in.) or smaller]

'Harbour Dwarf' – In the dwarf category, this is by far the most commonly offered *Nandina*. This cultivar spreads by its rhizomatous nature, a trait not present in the majority of *Nandina* cultivars. Due to this characteristic, 'Harbour Dwarf' is dense from top to bottom, while bearing typical foliage. Recently, a cultivar under the trademark name Harbour Belle™ has been introduced which is essentially 'Harbour Dwarf' with fall and winter color, which 'Harbour Dwarf' lacks.

'Nana Purpurea' – This cultivar is listed as synonymous with 'Atropurpurea Nana' and 'Nana' to some extent (2). The plant under this name in our collection is less vigorous and lacks any uniformity of growth, possibly due to virus infection.

'San Gabriel' – This is the only cut-leaf or *filamentosa* variety grown on any large scale. Based on our observations, as well as those of Hatch (2), 'Chidori' is definitely a better cultivar than 'San Gabriel'. Both vigor and density of this cultivar pales in comparison to that of 'Chidori'. Hatch (2) and Raulston (3) both note that 'San Gabriel' more than likely originated in Japan under the name 'Kurijuse'. The commonly cited synonym 'Ori Hime' for 'San Gabriel' is of uncertain placement in that our specimen of 'Ori Hime' bears no resemblance to 'San Gabriel'.

Significance to Industry: The cultivars mentioned above represent those planted in the collections at the JCRA to date. We continue to search out both new and lesser-known cultivars in order to make this collection as complete as possible. The goal of this paper is to present as inclusive a review as possible of long-term growth habits and aesthetics on those taxa currently growing at the JCRA. While newer cultivars such as Harbour Belle™ and Sienna Sunrise™ have been released recently, we feel that this study gives valuable information for both the industry and homeowner in both debunking some cultivar descriptions and offering better alternatives in other cases.

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Table 1. Growth and evaluative data on 25 taxa of *Nandina domestica* growing at the JC Raulston Arboretum (Raleigh, NC).

Cultivar[z]	Height cm (in.) Overall rating[x]	Width cm (in.) Plant Age	Plant Density[y]	
Large Size Cultivars				
[150 cm (60 in.) or higher]				
'Aurea'	229 (90) 17	160 (63)	4	4
'Compacta'	191 (75) 17	140 (55)	2	3
'Leucocarpa'	180 (71) 15	94 (37)	2	3
'Little Princess'	203 (80) 15	124 (49)	3	3
'Moyer's Red'	239)94) 17	147 (58)	5	4
'Royal Princess'	234 (92) 17	107 (42)	5	5
'Southern Lace'	185 (73) 10	142 (56)	4	4
'Towne and Country'	188 (74) 12	109 (43)	3	3
'Umpqua Chief'	257 (101) 17	208 (82)	3	4
'Umpqua Princess'	251 (99) 17	173 (68)	4	4
'Umpqua Warrior'	201 (79) 17	161 (63.5)	4	4
'Variegata'	244 (96) 15	119 (47)	4	4
Medium Size Cultivars				
[75 - 150 cm (30 - 60 in.) tall]				
Cultivar[z]	Height cm (in.) Overall Rating[x]	Width cm (in.) Plant Age	Plant Density[y]	
'Chidori'	86 (34) 7	137 (54)	5	5

'Firepower'	91 (36) 17	125 (49.5)	4	4
'Gulf Stream'	145 (57) 16	142 (56)	5	4
'Moon Bay'	107 (42) 15	127 (50)	4	3
'Nana'	91 (36) 17	102 (40)	4	3
'Okame'	91 (36) 17	145 (57)	4	4
'Pygmaea'	127 (50) 17	97 (38)	4	4
Raulston hybrid #2	107 (42) 10	188 (74)	2	2
Sunray™	114 (45) 9	130 (51)	5	5
'Wood's Dwarf'	107 (42) 17	127 (50)	4	4
<u>Dwarf Cultivars</u> [30 - 75 cm (12 - 30 in.) tall]				
'Harbour Dwarf'	51 (20) 17	135 (53)	5	5
'Nana Purpurea'	66 (26) 17	94 (37)	4	2
'San Gabriel'	43 (17) 17	112 (44)	5	4

[z]Cultivar names are as labeled as JC Raulston Arboretum. Some names may be shown in future work to be synonymous.

[y]A rating scale of 1 to 5 was used where 1 = 0-40%, 2 = 40-50%, 3 = 50-70%, 4 = 70-90%, and 5 = 90-100% coverage.

[x]Overall ratings refer to general landscape appearance. A rating scale of 1 to 5 was used where 1 = unacceptable, 2 = poor, 3 = substandard, 4 = acceptable, and 5 = outstanding.

New Broadleaf Evergreen Plants for Southern Nurseries

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Index Words: broadleaf evergreen, *Ceanothus*, *Craibiodendron*, *Distylium*, *Magnolia*, *Manglietia*, *Michelia*, *Myrcianthes*, *Myrica*, *Osmanthus*, *Pieris*, *Pittosporum*, *Podocarpus*, *Viburnum*, evergreen Araliaceae, evergreen Magnoliaceae

Nature of Work: Broadleaf evergreens form the backbone of most landscapes in the southeastern U.S. Ranging in diversity from the familiar camellias, azaleas, hollies, and gardenias to lesser known plants such as *Daphniphyllum macropodum* Miq. (courtesy-leaf) and *Illicium henryi* Diels (Chinese anise), broadleaf evergreen plants comprise an economically indispensable part of Southern nursery inventories. Ongoing work at the JC Raulston Arboretum (JCRA), USDA Cold Hardiness Zone 7b, continues to trial new and promising species and cultivars of broadleaf evergreen plants derived from collections throughout the U.S. and abroad in Japan and Europe. Of particular promise are the many newly introduced species of *Pittosporum* Banks ex. Gaertn, various Asian evergreen members of the Magnoliaceae, several new evergreen *Viburnum* L. taxa, new provenance-based taxa of *Pieris japonica* (Thunb.) D. Don ex G. Don, and a host of other species. These groups, and more, are currently under landscape evaluation for cold-hardiness, heat tolerance, sun/shade preferences, soil adaptability, insect and disease susceptibility, and all of the other factors that are typical to the Southern region.

Results and Discussion: Information is presented on 30 plants worthy of consideration for being grown by Southern nurseries. Many of these plants are poorly known in gardens, and have scant literature available on them.

Evergreen viburnums – Two botanical varieties of *Viburnum foetidum* Wall. are known in cultivation in the U.S.: *V. foetidum* Wall. var. *rectangulatum* (Graebn.) Rehder and *V. foetidum* Wall. var. *ceanothoides* (C.H. Wright) Hand.-Mazz. Although ultimate size may be large for these, their adaptability to shearing, and the glossy foliage, dark purple when emerging, set them apart from other broadleaf evergreens. Both produce medium-size cymes of white flowers which give rise to red fruits. (A plant circulating under the name *V. foetidum* var. *quadrangularis* is likely a misnomer of *V. foetidum* var. *rectangulatum*.) A third viburnum, introduced from the Sir Harold Hillier Gardens and Arboretum (Romsey, U.K.) is *V.* x*globosum* Coombes 'Jermyn's Globe' (4). This plant, a hybrid between the familiar *V. davidii* Franch. and the lesser known *V. calvum* Rehder, exhibits great foliage qualities, dense branching, and (thus far) better tolerance to poor drainage than does *V. davidii*. Lastly, *V. erubescens* Wall. is an evergreen to semi-evergreen shrub with small, thin leaves. Our plant forms a tight, dense, rounded shrub. In autumn to winter, the leaves turn a reddish-purple color, hence our common name of “blushing viburnum.”

Evergreen Araliaceae – Beyond the familiar *Fatsia japonica* (Thunb.) Decne. & Planchon, there are many, untested evergreen trees and shrubs of this family that merit attention. Thus far, we have been highly impressed at the JCRA with 2 species of false-ginseng, or *Metapanax* (formerly *Nothopanax*): *M. delavayi* Frodin ex J Wen & Frodin and *M. davidii* Frodin ex J Wen & Frodin. (1). Both of these evergreen shrubs combine the textural qualities of fatsia, due to their lobed, yet smaller, leaves, with superior cold hardiness. Thus far, we feel that these *Metapanax* are cold hardy to -18ºC (0ºF).

Dick Bir's *Ceanothus* trial – In 1999, the JCRA received a set of *Ceanothus* L. cultivars from a trial that Dick Bir (NCSU, Mountain Horticultural Crops Research and Extension Center, Fletcher, NC) was initiating. Unfortunately, none of the plants survived the climate of Fletcher, NC (USDA Zone 6). Of the 10 or so cultivars that were tested at the JCRA, we have had success with *C.* 'Victoria' and *C.* 'Ray Hartman', both being evergreen shrubs that produce brilliant, true blue flowers in late spring to early summer. These 2 cultivars have thrived since 1999, with partial defoliation only on 'Ray Hartman' this winter. Other cultivars, now dead, may have been lost due to siting them on poorly draining sites. These evergreen *Ceanothus* offer promise for Zone 7b and warmer areas, and should be re-investigated for their landscape potential on a larger scale.

Evergreen Magnoliaceae – Recently, there has been a large influx of new evergreen tree and shrub species belonging to the *Magnolia* family. At the JCRA, we have long grown and admired Yunnan wood-lotus, *Manglietia yunnanensis* Hu [or *Magnolia fordiana* (Oliv.) Hu], an outstanding evergreen flowering tree. [Recent molecular taxonomic studies now suggest that all genera in the Magnoliaceae (except for *Liriodendron* – tuliptree) should be merged into *Magnolia*, and as such, new, alternative names for these plants follow the traditionally known ones (3).] Other tree species of note include: a) *Michelia maudiae* Dunn [or *Magnolia maudiae* (Dunn) Figlar], with large, cream-white flowers in late winter; b) *Michelia martinii* (H. Lév.) Finet & Gagnep. ex H. Lév. (or *Magnolia martinii* H. Lév.), a stronger grower, albeit similar species to *Michelia maudiae*; c) *Michelia platypetala* Hand.-Mazz. [or *Magnolia maudiae* var. *platypetala* (Hand.-Mazz.) Sima], the most impressive (and, likely, cold hardy, too) of all our evergreen Magnoliaceae holdings, with rich, lustrous dark green foliage, covered in silky, golden hairs when young, and striking, ivory-white flowers in early spring; although we are not certain that our plant is correctly identified (it does not match photos of *Michelia platypetala* taken in China); d) *Michelia fulgens* Dandy / *Michelia foveolata* Merr. ex Dandy [or *Magnolia foveolata* (Merr. ex Dandy) Figlar], with long leaves ranging from 16-23 cm (6.5-9 in.) in length, but again, we are uncertain of this plant's identity since photos taken in China also do not match those of our specimen (stay tuned); and e) *Parakmeria lotungensis* (Chun & C.H. Tsoong) Y.W. Law (or *Magnolia lotungensis* Chun & C.H. Tsoong), the only species that has not yet flowered for us, but that bears evergreen foliage that emerges striking bronze- to reddish-pink in color. Lastly, the shrubby species *Michelia yunnanensis* Franch. ex Finet & Gagnep. (or *Magnolia dianica* Sima & Figlar) displays outstanding ornamental potential for its mass display of white flowers and lustrous, dark green leaves, backed with persistent golden hairs. Although none of these plants have the familiar fragrance of banana magnolia [*Michelia figo* (Lour.) Spreng.;

now called *Magnolia figo* (Lour.) DC], clearly, these plants have intrinsic value and market potential. Difficulties with accurate identification of existing taxa, and disagreements among taxonomists on this group will unfortunately hinder progress made in their swift introduction and deserved popularization in gardens.

Provenance-based *Pieris japonica* – Recently, we began work at the JCRA in assessing our *Pieris* collection for unique characteristics in light of changing taxonomic concepts (7). What was noticed immediately is the preponderance of species names – e.g., *P. polita* W.W. Sm. & Jeffrey, *P. japonica* var. *yakushimensis* Yamazaki, *P. japonica* var. *amamiana* [no authority found], *P. ryukyuensis* [no authority found], and *P. taiwanensis* Hayata – and garden-worthy characteristics associated with these names, all amid strongly varying taxonomic interpretations of this complex species (1, 4, 5, 6). Thus far, we have noted large variations in quality of fragrance (from putrid to sweet); foliage shape, size, and thickness; color of emerging foliage; flower and panicle size; plant vigor / heat tolerance; and observed differences in lacebug infestation (7). Using the taxonomic approach of Judd (6), we should lump all of these names into one entity – *P. japonica* in the broad sense.

Yet, more recent work by Japanese taxonomists segregates some of these variants into new varieties or species (5), which agrees with our observations of the significant morphological and field performance differences among our plants. In other words, reducing the plant we have named as *P. polita* (which represents those "*P. japonica*" native to eastern China) to *P. japonica* would result in our loss of knowledge of this plant's true origin. Since our specimen of *P. polita* has sweetly fragrant flowers, it would be unfortunate to have this lost as an unnamed clone. Furthermore, plants formerly known as *P. japonica* var. *yakushimensis* and *P. taiwanensis*, or those named in the trade as *P. japonica* var. *amamiana* and *P. ryukyuensis* (all representing more southerly provenances of this wide-ranging species) are known to prosper in Southern summers versus "typical" *P. japonica* from the northern end of this species' range. Use of Judd's taxonomy (6), wherein everything is lumped into the "variable" species *P. japonica*, results in the loss of this valuable "name" information that is seemingly directly tied to garden / landscape performance. Thus, at the JCRA, we have tentatively coined the usage of the following "group" names: *P. japonica* Amamiana Group, *P. j.* Polita Group, *P. j.* Ryukyuensis Group, and *P. j.* Taiwanensis Group.

In 1996, we also purchased a plant named "*Craibiodendron yunnanense* W.W. Sm." from Heronswood Nursery (Kingston, WA). In March, 2003, we keyed out this species as *P. japonica*, which since it represented Chinese germplasm, we now call *P. j.* Polita Group. Both this plant (which is circulating mistakenly in the trade as *C. yunnanensis* – an entirely different plant) and *P. j.* Amamiana Group (our clone at the JCRA) bear the largest flowers of any *Pieris* seen in cultivation in the southeastern U.S.

Zone 7 hardy *Pittosporums* – Of the approximately 150 species of *Pittosporum* that occur in the world (1), only *P. tobira* (Thunb.) W.T. Ait. is commonly grown in the southeastern U.S. (2). With so many species from which to choose, and with the huge industry importance of *P. tobira*, we at the JCRA have placed this genus as a high-priority one for new acquisitions. The following 5 Chinese species

represent the future of this genus, and all but one have been grown at the JCRA for at least the past 7 years: *P. heterophyllum* Franch., *P. parvilimbum* H.T. Chang & S.Z. Yan, *P. illicioides* Makino, *P. undulatifolium* H.T. Chang & S.Z. Yan, and *P. crispulum* Gagnep.

Pittosporum heterophyllum, which we call Chinese pittosporum, is a fine-textured species with small, narrow leaves measuring 4-6 cm (1.5-2.25 in.) long by 1-2 cm (0.5-0.75 in.) wide. Our plant, grown at the JCRA since 1988, has formed a dense shrub and has similar landscape qualities as wax myrtle (*Myrica cerifera* L.). In 2002, we acquired an exceptional, white-margined cultivar ('Variegatum') from Spinner's Nursery (Boldre, U.K.), which seems to hold tremendous promise. Another small-leaved species is, in part, “new” to us – *P. parvilimbum*. This plant has been grown at the JCRA since 1985, and until May, 2003 it was labeled incorrectly as *Phillyrea angustifolia* L. (a rarely seen member of the Oleaceae from Europe). This exceptional, low-growing evergreen shrub forms a dense, rounded mass, with leaves reaching only 2-5 cm (1-2 in.) long by 0.5-0.75 cm (0.2-0.3 in.) wide. Cold-hardiness is assured, since this species has been grown for nearly 20 years in Raleigh. Native both to China and Japan is *P. illicioides*, a variable species of which we have grown 3 clones strongly differing in leaf size and shape since 1996. The matte-green leaves stand in contrast to the aforementioned species, but are still attractive. Leaf dimensions on our clones range from 5-10 cm (2-4 in.) long by 0.75-3 cm (0.3-1.2 in.) wide. Perhaps the most attractive of all the species we grow at the JCRA is *P. undulatifolium*, wavy-leaf pittosporum, which we acquired in 1991. This species bears attractive, glossy foliage with undulating margins, the leaves measuring 6-11 cm (2.5-4.5 in.) long by 2-4 cm (1-1.5 in.) wide. Our plant was mislabeled until May, 2003 as *P. undulatum* Vent., a tender species native to Australia. We are just now starting to look at *P. crispulum*, appearing similar to *P. undulatifolium* with its wavy, albeit narrower, leaves. This plant was obtained from cuttings collected from the magnificent specimen [measuring at least 213 cm (84 in.) tall] growing at the Hillier Arboretum, U.K. in 2002 (4). Clearly, we feel, *Pittosporum* has a bright future in the Southeast.

Broadleaf evegreen plant medley – The final 6 plants represent an assortment of uncommon plants, some of which are starting to gain interest in the Southern nursery industry. Perhaps most recognizable would be *Myrica cerifera* var. *pumila* Michx. 'Willowleaf', a dwarf wax myrtle with very narrow leaves, ranging in size from 2.7-5 cm (1.1-2 in.) long by 0.4-0.8 cm (0.15-0.3 in.) wide, that originated at Woodlanders Nursery (Aiken, SC). Our specimen, planted in the fall of 2000, now reaches nearly 90 cm (36 in.) tall, bears striking textural qualities, and exhibited virtually no cold injury in the cold 2002-03 winter season. Another southeastern U.S. native evergreen shrub is *Myrcianthes fragrans* (Sw.) McVaugh, commonly called twinflower or Simpson's stopper, which we have grown since early 1998. Native to north-central Florida and southward, *M. fragrans* forms a dense shrub with small, white, powder-puff-like flowers that give rise to orange-red berry-like fruits. Thus far, *Myrcianthes* has proven itself to be much more cold-hardy than expected, which should not come too much as a surprise since its native range is similar to that of *Illicium parviflorum* Michx. ex Vent., which is known to be fully cold-hardy throughout Zone 7.

Several years ago, a distinctive, possibly dwarf, semi-arching form of *Distylium myricoides* Hemsl. was introduced by Piroche Plants (Pitt Meadows, B.C.) under the cultivar name 'Lucky Charm'. Several Southern nurseries currently sell this plant, although without the cultivar name for some unknown reason. At the JCRA, we have admired this plant for the past 3 years for its attractive blue-green leaves, set on the arching branches in planar fashion. No winter injury has yet been observed. Another Piroche Plants introduction is *Osmanthus suavis* King ex C.B. Clarke, or sawtooth tea-olive, which we obtained in 2002. This species bears small leaves, measuring 2-2.5 cm (0.8-1.0 in.) long by 0.8-1.3 cm (0.3-0.5 in.) wide, that bear reduced marginal spines that are not prickly to the touch, as is the case in other *Osmanthus* that are widely cultivated. Although we have yet to see this plant flower, the specific epithet “suavis,” meaning “sweet” or “pleasant,” certainly holds promise for this plant. In many regards, *O. suavis* resembles *O. delavayi* Franch., but is distinguished by its larger leaves and less sharply pointed marginal teeth (1). Although *O. delavayi* is found in cultivation, it is limited by its Zone 8a / 7b cold-hardiness range, which we feel that *O. suavis* will surpass.

Another group that we have studied here at the JCRA is the evergreen Lauraceae (bay family), of which we are most familiar with *Persea borbonia* (L.) Spreng., or redbay, due to its common presence in Coastal Plain forests. However, as *P. borbonia* is annually blemished by insect galls, we at the JCRA have been searching for a similar species that is not susceptible to this maligning problem. This search has led us to *P. podadenia* S.F. Blake, Mexican redbay. Our specimen, now reaching about 305 cm (120 in.) tall, and clothed with leaves from top to bottom, bears “crystal clear,” unblemished foliage. The leaves measure 7.0-8.6 cm (2.75-3.4 in.) long by 2.2-3.3 cm (0.9-1.3 in.) wide. As a plant that we have grown for at least 10 years, we have been completely surprised with its cold hardiness and medium-term adaptability to our climate.

Lastly, we present an unfamiliar species of a familiar genus to Southern nurseries: *Podocarpus lawrencei* Hook. f., commonly called mountain plum-pine. Growing as a dense, mounding shrub, *P. lawrencei* (formerly called *P. alpinus* R. Br. ex Hook. f.) looks unlike the commonly known *P. macrophyllus* (Thunb.) Sweet, which is known either as Japanese or Southern yew to most Southerners. *Podocarpus lawrencei* bears tiny, attractive, blue-green leaves, measuring only 1.0-1.5 cm (0.4-0.6 in.) long by 0.3-0.4 cm (0.1-0.2 in.) wide. Our 7 year-old specimen, reaching a height of only 76 cm (30 in.), attests to its compact form and utility in the landscape.

Significance to Industry: New plants continue to support growth in the nursery industry. The addition of the above-discussed plants to nursery inventories will only help to further industry growth as well as garden and landscape plant diversity throughout the Southeast.

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The Selection and Use of Southwest Plants in Southeast Gardens

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Nature of Work: The use of flora which is not usually associated with seasonal color beds is increasing in popularity. While large beds of marigolds, impatiens or pansies were acceptable in the 80's and 90's, they no longer can solve modern design needs. Color beds are typically changed a minimum of twice a year, in the spring (after the last frost) and in the fall. This has not changed, but what has changed is the selection and arrangement of plants in the beds. Woody plants and herbaceous perennials have been incorporated very successfully into seasonal beds. Plants being used with this design trend offer different characteristics from many of our usual southern flowering favorites. The overall size of the plant, bold foliage, and the architectural form of the plant are a few of the notable characteristics which add design value. Drought tolerance is another notable characteristic which many of the plants offer.

Results and Discussion: In addition to plant hardiness, the adoption of a plant by the southern landscape industry is largely dependant on its' showy blooms, spectacular berry display or particular season of color. This need has not diminished, but modern design concepts require plants to have strong architectural lines, great form, and / or bold, interesting, foliage patterns. Designers have started to use several of these plants for their 'tropical' look for seasonal interest in either large containers or color beds. The 'western' plants are becoming popular because of the increased architectural use of stucco, timbers, tile, boulders and stone in the south. Accent beds are changed at the end of the particular season. Hardy plants are incorporated into the landscape, while tender plants are overwintered in protected areas, or simply grown as annuals.

Aspidistra lurida 'ginga'	Speckled Cast Iron Plant
Alocasia 'Portodora'	Upright elephant ear
Agave sp.	Hardy Century Plant
Bougainvillea spectabilis	Brazil bougainvillea
Chamaerops humilis	Mediterranean fan palm
Colocasia sp.	Elephant Ear
Ensete maurlli	Red Abyssinian banana
Fatsia japonica	Fatsia
Hedychium coronarium	Common Ginger lily
Heliantus sp.	Sunflower
Iris ensata 'Varigata'	Stripped Japanese Iris
Musa sp.	Ornamental banana
Nolina nelsonii	Blue bear grass
Opuntia sp.	Prickly pear
Phormium tenax	New Zealand Flax
Rhapidophyllum hystrix	Needle palm
Rosmarinus officiallis	Rosemary

Sabal sp.	Hardy Palmetto palm
Trachycarpus fortunei	Windmill palm
Yucca filamentosa	Adam's needle yucca
Yucca gloriosa	Mound lily yucca

Significance to Industry: Designers use plants in the landscape for function and form. Plants not only are expected to solve problems, such as screening an unsightly view, or providing shade, but also to add interest and esthetics to a space. While many designers are satisfied with using the same 20-30 plants on routine projects, those trying to be creative and somewhat unique in style do not conform, especially with the growing popularity of 'western' architecture. This has resulted in the increased demand for plants with interesting architectural form, shape and size which typically are not associated with southern gardening.

Influence of Nitrogen Rate and Timing on Nitrate Leaching in a Simulated Landscape of Herbaceous Perennials

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Index Words: Lysimeter, Soil solution, Nitrate, Herbaceous perennial

Nature of Work: Nitrogen (N) is the fertilizer element required in the greatest quantity by most plants. Most of the N requirements in today's landscapes are met by the addition of synthetic fertilizers. The use of nitrogenous chemical fertilizers has benefited plant growth significantly, however, it has also contributed to the nitrate contamination of ground and surface water. This results mainly from N application in excess of plant N needs, and is a function of N rate applied and the timing of N application. Fertilizer N applied in excess of that needed to support optimum productivity accumulates in the soil and becomes increasingly vulnerable to a variety of losses such as leaching and denitrification. The synchronization of N supply with plant N demand is essential to improve N-use efficiency and reduce nitrate loss. By understanding the temporal patterns of herbaceous perennial N demand, the timeliness of fertilizer application may be improved and the efficiency of fertilizer N increased. Ideally, N should become available to a crop at a rate equal to its N requirement. Therefore, N fertilization practices and other management decisions that influence N availability should consider plant N demand and uptake patterns.

Current N rate recommendations for perennials range from 2 to 5 lbs • 1000 ft^{-2} with application timing recommendations ranging from dormancy to summer to fall (1, 4, 5, 6, 8). This is not unexpected as there is little information to provide accurate rate and timing recommendations. Information is needed to provide realistic and reasonable N recommendations. Industries that are not environmentally responsible will face tremendous public and legislative pressure. Therefore, the objectives of this study were to determine the effect of N rate and timing on: a) growth, flower number, and aesthetics of seven selected herbaceous perennials and b) nitrate loss.

Materials and Methods: The experiment was a 4 x 4 factorial in a randomized complete block design with four replications. Treatments included four rates of N (0, 1.5, 3.0, and 6.0 lbs • 1000 ft^{-2}) and four timings of application. Each N rate was divided equally into two applications and applied at the following times:

1) winter (January 15 and February 15)
2) spring (April 15 and May 15)
3) summer (June 15 and July 15)
4) fall (September 15 and October 15).

All N was applied as ammonium nitrate (34-0-0). Nitrogen application was initiated September 15, 2001. Prior to this study, no N has been applied to this site since 1998.

The study was conducted at the NCSU Horticulture Field Laboratory, Raleigh. Before planting, pH, phosphorus, and potassium of the Cecil clay loam were

adjusted according to the North Carolina Department of Agriculture soil report and 1 inch of milled pine bark (<0.5 in) were rototilled into the soil. Individual plots were 8 ft. x 11 ft. To maintain treatment integrity, a plastic barrier was installed to a depth of 24 inches between plots to keep roots and applied N within each plot. The following perennials (3 qt. containers) were planted in October 2000: *Canna* 'President', *Coreopsis verticillata* 'Moonbeam', *Echinacea purpurea* 'Magnus', *Iris siberica* 'Caesar's Brother', *Panicum virgatum* 'Shenandoah', *Sedum* 'Autumn Joy' and *Salvia* x *sylvestris* 'East Friesland'. Drip irrigation was installed for all plants. All plots received 2 inches of mulch (composted yard waste) after planting. Each plot was maintained as similarly to a well maintained landscape as possible.

Soil solution collection. Porous-cup lysimeters were installed to a depth of 15 inches in each plot in December 2001. Beginning January 2002, soil solution samples were collected approximately every two weeks. Samples were collected 48 hours after pulling a vacuum of 50 kPa in each lysimeter. Data were subjected to ANOVA with times of application separated with protected LSD, P=0.05. The rates of nitrogen application were subjected to regression analysis.

Results and Discussion: This manuscript will only focus on soil solution NO_3-N. By 17 days after application (April 15), NO_3-N concentration in the soil solution of the 6 lb application rate was significantly greater than all other rates (Fig. 1). The 6 lb rate remained significantly greater that all other rates until 142 days after fertilization (DAF). For all collection dates after fertilization (excluding 55 DAF) NO_3-N concentration in both 1.5 lbs and 3.0 lbs were significantly greater that 0 lbs until 101 DAF. The 1.5 lbs and 3.0 lbs rate were rarely significantly different from each other. All rates except 0 lb remained above the 10 mg • L^{-1} concentration from 9 until 113 days after fertilization. The U.S. EPA (2) has established a maximum contaminant level of 10 mg • L^{-1} nitrate in groundwater. Excessive nitrate levels in drinking water may potentially cause health hazards as well as promote increased algae growth in water bodies. The concentration of NO_3-N in the 0 lb treatment indicates N mineralization of soil organic matter and mulch, and atmospheric deposited N. Lloyd et al. (3) reported plant available N in the top 6 inches of soil averaged 27 mg • L^{-1} with 2 inches of composted yard waste and no applied N in a simulated landscape. Atmospheric deposited N can add up to 0.16 lb N • 1000 ft^{-2} • yr^{-1} (7). Due to collection time of our soil solutions, only winter and spring timings will be presented (Fig. 2). Three lbs of N applied during winter maintained similar levels of NO_3-N until 200 days after application, whereas N applied during spring began to decrease significantly by 90 days after application. This may be reflective of rapid N uptake during this time of year. From these early results, to minimize N losses landscapers will need to be concerned about the rate of N application and the timing in conjunction with the solubility of the fertilizer being applied.

Significance to Industry: These results suggest that current fertilizer recommendations for perennials may lead to excessive NO3-N leaching beyond the root zone of perennials one year after installation. In the 21st century fertility management without precise guidelines will probably not be tolerated.

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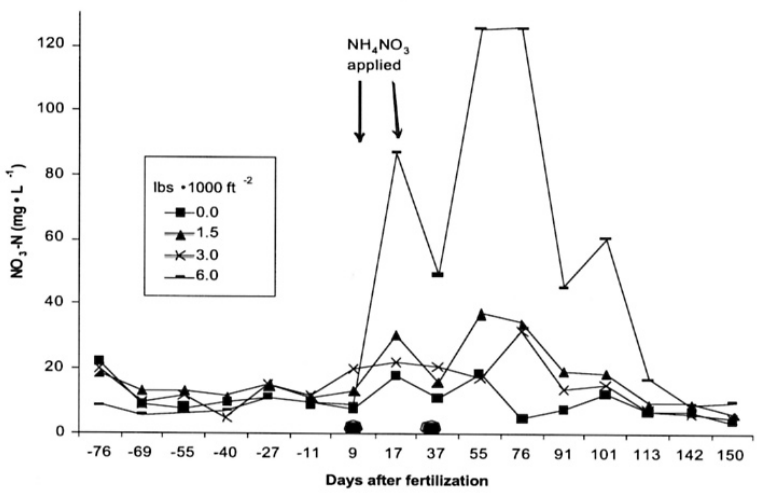

Figure 1. Effect of nitrogen rate applied in March and April on soil solution NO_3-N.

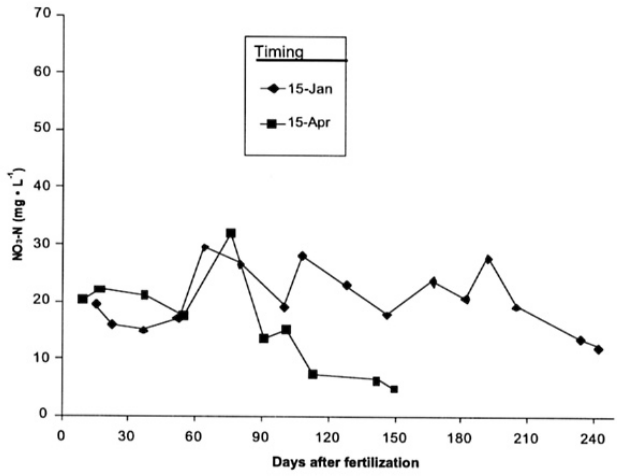

Figure 2. Effect of timing of 3 lbs N • 1000 ft^{-2} on soil solution NO_3-N.

Photosynthetic Response of *Acer rubrum* to Elevated Temperatures

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Index Words: *Acer rubrum* L., Heat stress, Gas exchange, Fluorescence, Rubisco activation

Nature of Work: Elevated temperature affects many physiological and developmental aspects of plants and is considered a major environmental factor in determining plant distribution (Berry and Björkman, 1980). Photosynthesis, in particular, is sensitive to heat and is a key participant in plant acclimation and tolerance mechanisms. Previous studies suggest that photosystem II chemistry is the photosynthetic process most susceptible to heat, due to antenna complex dissociation or conformational change and reduced activities of both the oxygen evolving complex and the photosynthetic carbon reduction (PCR) cycle (Lu and Zhang, 2000). However, photosystem II damage is often preceded by less-severe reversible alterations that occur at moderately elevated temperatures (35˚C/ 95˚F), such as ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) de-activation (Feller et al. 1998). It is not yet known how these processes interact to determine plant performance under elevated temperature. Therefore, the goal of this study was to determine the photosynthetic mechanisms responsible for increased plant performance under heat.

In this study we investigated the effects of heat on photosynthesis in *Acer rubrum* L. 'Florida Flame' and *Acer rubrum* L. 'Northwood', which are indigenous to Florida and Minnesota, respectively.

Plant Production. Rooted cuttings of *Acer rubrum* L. 'Florida Flame' and *Acer rubrum* L. 'Northwood' were transferred to 1 gal pots and fertilized with a modified half strength Hoaglands solution. Following 3 months of growth at Clemson University, the plants were acclimated to 30˚C/86˚F conditions for 3 weeks prior to any treatment or measurement.

Effect of heat on photosynthesis. Chlorophyll and photosynthesis were measured using a Ciras-1 gas analyzer with a modified leaf chamber that accepted the fiber optic cable from the OS-500 modulating fluorometer. Actinic light was provided by the gas exchange system and was set at 500 μmol m^{-2} s^{-1} PAR for most experiments.

Results and Discussion: Photosynthesis was inhibited by temperatures above 31˚C/87.8˚F in Northwood plants and above 37˚C/98.6˚F in Florida Flame plants (Figure 1). The temperature optimum for photosynthesis was higher for Florida Flame than Northwood. The temperature response curves were repeated 6 times with fairly consistent results. In some cases, however, Northwood inhibition did not occur until 33˚C/91.4˚F.

Photosynthesis of Florida Flame plants recovered rapidly when temperatures were reduced. In some cases there was not a clear distinction between treatment

induction and recovery phases (Figure 1). Conversely, Northwood plants rarely recovered 100% from high temperatures. Longer recovery times were not tested for either cultivar.

In order to determine the source of photosynthetic inhibition we monitored basal fluorescence (Fo'). A rise in Fo' is due to photosystem II damage or loss of trans-thylakoid energy gradient, while a decrease is indicative of photosystem I acceptor side limitation (Bilger et al. 1987). When an immediate heat stress was applied for 10 minutes, Fo' drastically increased for Northwood while Florida Flame was unresponsive (Figure 2). These results suggest photosystem I acceptor side limitation, possibly as a result of Rubisco de-activation. Similar findings were observed by Sharkey et al. (2000), which led the authors to propose that reversible decarbamylation of Rubisco at elevated temperatures is a protective mechanism for Rubisco and other photosynthetic processes.

Significance to Industry: The results obtained in this study clearly demonstrate that heat affects Northwood and Florida Flame photosynthetic processes differently. Characterization of these differences may reveal the photosynthetic mechanisms necessary for improved plant performance under elevated temperatures. Identification of such mechanisms could be used to develop a physiologically based evaluation tool for current and newly released cultivars.

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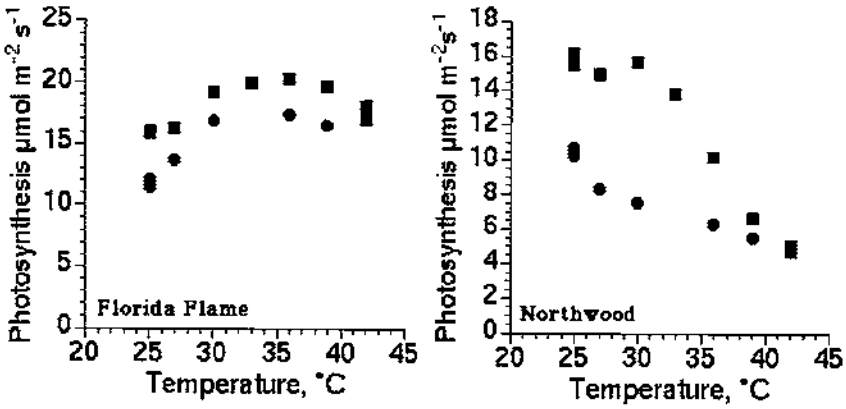
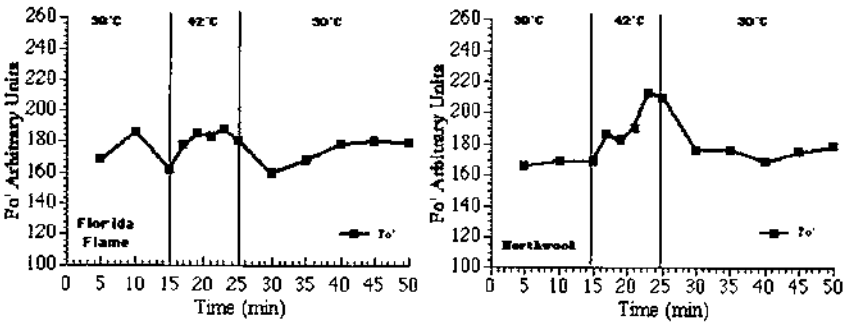


Figure 1. Temperature Response of photosynthesis of Florida Flame and Northwood. Carbon dioxide was 1000 ppm, oxygen was 2%, and light was 500 μmol m^{-2} s^{-1} PAR. Temperature was increased up to 44ºC (square) then decreased (circle).



Basal fluorescence before, during, and after a 10 minute heat stress. The parameter was measured in the dark immediately following a light period. Carbon dioxide was 1000 ppm, oxygen was 2%. and light was 500 μmol m^{-2} s^{-1} PAR. The heat stress was 42ºC for 10 minutes.

Evaluation of a Controlled-release Fertilizer on Leachate Quality and Growth of 'Bonanza' Daylily in the Landscape

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Index Words: ammonium, nitrate, nitrogen, lysimeter, application method, application rate, *Hemerocallis* x 'Bonanza'

Nature of Work: Various application methods and rates of controlled-release fertilizers (CRF) have been shown to affect the nutrient levels in leachate as well as plant growth of most container-grown plant species (1, 2, 3, 7). Although information exists regarding fertilizer use efficiency or nutrient losses in container systems utilizing CRFs, little information is available on nutrient losses in landscape settings. Lysimeters have been utilized in mock landscape situations to measure and collect leachate from a representative soil in order to determine total solute nutrient flow through the soil (6). The objective of this study was to evaluate the effects of CRF application methods and rates on leachate loss of ammonium nitrogen (NH_4+ - N) and nitrate nitrogen (NO_3- - N) using a field lysimeter and on growth and nutrient uptake of a herbaceous perennial in the landscape.

Uniform liners of *Hemerocallis* x 'Bonanza' (Bonanza daylily) were planted from 2.8 liter (#1) containers in May, 2000 into 0.89 m^2 (9.62 ft^2) shallow-pan free-drainage lysimeters (4). Lysimeters contained a native Marvyn sandy loam soil amended with 0.085 m^3 (3 ft^3) of amendment-grade pine bark. Five daylily liners were planted 1 ft (30.5 cm) on-center in each lysimeter. The CRF 14N-7.0P-11.1K (Polyon® NPK™ 14-14-14, 3-4 Month Nursery Fertilizer, Pursell Technologies Inc., Sylacauga, AL) was applied at three rates using three methods of application (3 x 3 factorial; 9 treatments). There were four replications of each treatment arranged as a randomized complete block design. Application rates of CRF were the manufacturer's recommended rate (1-X) of 48.93 g m^{-2} [1.0 pound (100 ft^2) $^{-1}$], half the recommended rate (½ -X) (24.47 g m^{-2}) [0.5 pound (100 ft^2) $^{-1}$], and twice the recommended rate (2-X) (97.86 g m^{-2}) [2.0 pounds (100 ft^2) $^{-1}$]. The application methods of the CRF were pre-plant incorporation (IA), dibble (DA), and topdress (TA) application.

Leachate aliquots and volumes were collected from lysimeter drainage basins following each weekly 1-in (2.5-cm) irrigation or each rainfall event that exceeded 1 in (2.5 cm). Irrigation and rain events were measured and recorded throughout the study. Leachate aliquots were analyzed for soluble salts, NH_4+ - N, and NO_3^- - N. In addition to leachate collection and analysis data, growth indices (GI) (1/3 (plant height + largest width + perpendicular width)) were determined every 30 days on all daylilies in the lysimeters. At termination of each year's experiment, daylilies were crown-pruned to determine total leaf dry weight and foliar nitrogen content (5). Treatment effects were determined using analyses of variance with SAS's general linear model procedure (SAS Institute, Cary, NC). Mean separation by Tukey's Studentized Range was performed at α=0.10.

Results and Discussion: Daylilies receiving the DA of CRF were largest, while IA treatments produced smaller plants each month regardless of CRF rate (Table 1). GI was similar during the first two months of the study; after that, the 2-X rate produced the largest plants, and plants receiving the ½-X rate were smallest. Monthly GI had no fertilizer rate by method of application interactions until November, the final observation date. On that date, daylilies receiving DA of CRF at the 2-X rate produced the largest plants (43.0 cm), while IA of CRF at the ½-X rate produced the smallest plants (36.7 cm). At termination, regardless of method of application, the CRF at the 2-X rate produced the greatest leaf dry weight (136.1 g), leaf N concentration (1.67%), and total leaf N content (2.28 g).

There was a CRF rate by method of application interaction for average leachate soluble salt values (Table 2). The CRF DA at the 2-X rate had the highest average soluble salt value for the growing season. Monthly NH_4+ - N values also reflected a fertilizer rate by method of application interaction with the 2-X rate IA and DA of the CRF producing the highest values. However, NO_3^- - N in leachate was affected by CRF application rate regardless of method of application such that levels from the 2-X rate (306.3 mg) and the 1-X rate (308.3 mg) were greater than the ½-X rate (229.1 mg).

Significance to Industry: Daylily plant growth is more encouraged through increased CRF in a sandy loam soil. Plant growth is also encouraged when the CRF is placed in close proximity to the root zone, i.e. through dibbling. In addition, increased CRF in this study produced nitrate levels that are equivalent to those produced at a manufacturer's recommended rate. For landscape professionals, caution should be taken in encouraging a 2-X rate of CRF for every landscape situation since fertilizer products, soils, and cultural factors could influence the environmental impact that the CRF makes.

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Table 1. Influence of Polyon 14-14-14 application method and rate on monthly growth indices (GI) of *Hemerocallis* x 'Bonanza' (Bonanza daylily) in the landscape.

	Monthly growth indices (cm)[z]				
	June	July	Aug.	Sept.	Oct.
Method					
Incorporated	21.0b[y]	33.7 b	42.3 b	45.6 b	45.5 b
Dibbled	25.2 a	36.1 a	44.6 a	47.7 a	47.4 a
Topdressed	21.2 b	34.3 b	43.0 b	46.6 ab	46.8 ab
Rate					
24.27 g m^{-2}	21.8 a	34.3 a	42.7 b	45.6 b	45.0 b
48.93 g m^{-2}	23.0 a	34.7 a	43.0 ab	46.2 b	45.7 b
97.86 g m^{-2}	22.5 a	35.2 a	44.3 a	48.1 a	49.0 a

[z](Plant height + largest width + perpendicular width)/3.

[y]Mean separation by Tukey's Studentized Range, P≤0.10.

Table 2. Leachate water quality as collected from lysimeters containing each fertilizer treatment and five *Hemerocallis* x 'Bonanza' plants.

Treatment[x]	Soluble salts[z]	NH_4^+ - N (mg)[y]
1	158.6 c[w]	14.3 a
2	174.1 bc	8.5 bc
3	166.5 bc	13.6 a
4	170.4 bc	8.9 bc
5	135.3 d	10.3 abc
6	191.4 a	10.9 abc
7	175.5 ab	12.7 ab
8	135.7 d	10.7 abc
9	172.0 bc	8.3 c

[z]YSI® Model 63 pH/SS Field meter was used to obtain soluble salt values as μmhos cm^{-1} at 25 degrees Celsius (102.6 degrees Fahrenheit) (YSI Incorporated, Yellow Springs, OH). Values represent seasonal averages.

[y]Ammonium nitrogen (NH_4^+ - N) expressed in milligrams. Values represent average accumulation for each month of the study.

[x]Treatments 1, 4, and 7 represent 24.47 g Polyon 14-14-14 m (0.5 lb $(100\ ft^2)^{-1}$); 2, 5, and 8 represent 48.93 g m^{-2} (1.0 lb $(100\ ft^2)^{-1}$); 3, 6, and 9 represent 97.86 g m^{-2} (2.0 lb $(100\ ft^2)^{-1}$). Treatments 1, 2, and 3 represent incorporation; 4, 5, and 6 represent dibble application; 7, 8, and 9 represent topdressing.

[w]Mean separation by Tukey's Studentized Range, $P \leq 0.10$.