SECTION 2
CONTAINER-GROWN PLANT PRODUCTION

Dr. Richard C. Beeson
Section Chairman and Moderator

The Effects of Container Drainage Hole Size on Plant Growth of Ageratum

Donna C. Fare and W. Edgar Davis
Tennessee

Nature of Work: Reduction of container leachate, irrigation effluent, coupled with water use efficiency are water quality concerns in the nursery industry. Several researchers have reported benefits from altering or changing irrigation methods to reduce container leachate and irrigation effluent for minimal environmental impact (Tilt, 1994; Kaplan, 1992; Green, 1989; and Whitesides, 1989). This research explores the potential to improve water quality at container nurseries through redesign of the growing container and subsequent effects to plant growth.

One gallon containers were modified by altering the number and size of the drainage holes. Eight container modifications were evaluated: 1) containers with 1, 3, or 5 drainage holes with 3/4" diameters , 2) containers with 1, 3, or 5 drainage holes with 3/8" diameters , and 3) containers with 1, 3, or 5 drainage holes with 3/16" diameters. Containers with 5 - 3/4" diameter drainage holes were used to represent the industry standard.

Ageratum houstonianum 'Blue Puffs' were grown in a 6 pinebark: 1 peat (v:v) medium amended per cubic yard with 5 lbs dolomitic limestone and 1.5 lbs Micromax. Plants were topped dressed with 1 TBL/container of Nursery Special 12-6-6 (Parker Fertilizer Co., Sylacauga, Al). Initially plants were hand watered to saturation, then placed in greenhouse where subsequent irrigation was applied with a Chapin drip irrigation system. Irrigation was applied when an individual container's medium decreased to 80% of container capacity; a gravimetric method was used to determine daily water requirements. Plants were placed in randomized block design of 3 replications with 4 plants per experimental unit and grown for 30 days. Leachate volume was collected about 1 h after watering on days 1, 3, 5, 10, 20, and 30 then analyzed for electrical conductivity (soluble salts), pH, $N0_3$-N and NH_4-N levels (only volume data reported). At termination, growth indices (GI=[(height + widthl + width2)/3]), shoot and root dry weight was determined.

Results and Discussion: Shoot growth was greater with plants grown in containers with fewer and smaller drainage holes than the industry standard container with 5 - 3/4" holes (Fig 1.). The authors believe this is the result of the container medium retaining water for a longer period of time during the day. Gravimetric weights recorded 1 h after irrigation indicated that containers with fewer and smaller drainage holes had higher water retention, but by the following morning container mass was similar among all modified containers. Data from shoot and root dry weights had similar trends as the shoot growth indices.

Container leachate volume was reduced in all modified containers with fewer and smaller drainage holes compared to the industry standard with 5 - 3/4" holes (Fig 2.).

Regardless of drainage hole size, containers with 5 drainage holes had the greatest volume of leachate. As the drainage hole size decreased, the volume of leachate decreased. For example, containers with 1, 3, or 5 - 3/8" drainage holes had 22%, 19% or 7%, respectively, less container leachate volume than the industry standard. Containers with 1, 3, or 5 - 3/16" drainage holes had 42%, 32%, or 25%, respectively, less container leachate than the industry standard.

Significance to Industry: These data indicate that modified containers may be another alternative to improving water quality in container nurseries. Leachate volumes were reduced from containers with fewer and smaller drainage holes than containers currently used in nursery production. Ageratum plant growth was improved in the modified containers. Currently, research with modified containers is being evaluated with woody ornamentals grown under overhead irrigation.

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Fig 1. Effects of Modified Drainage Holes on Growth of Ageratum

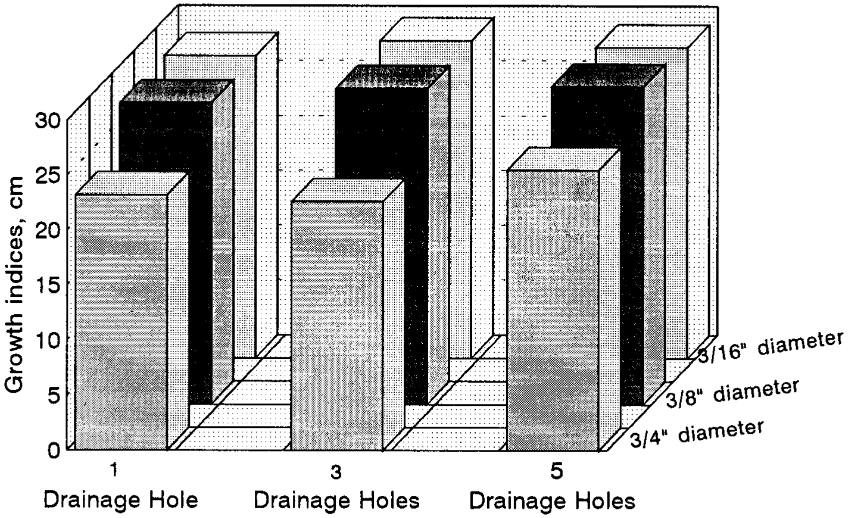
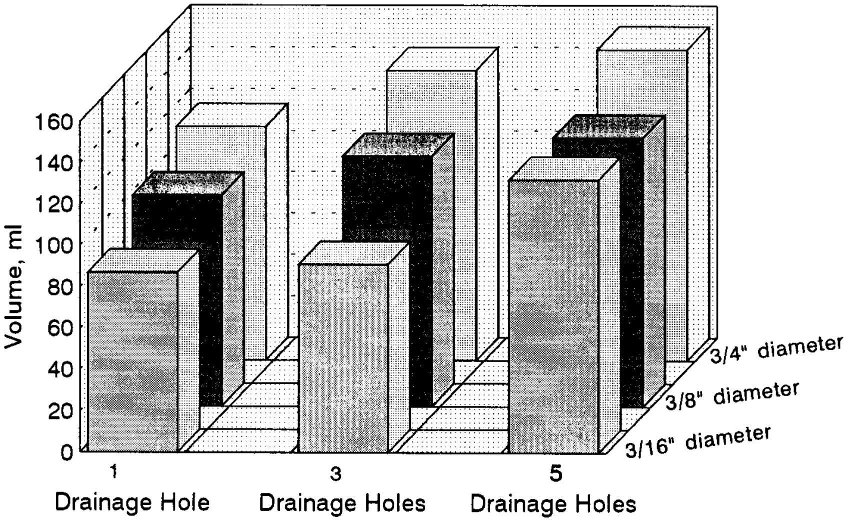


Fig 2. Effects of Modified Drainage Holes on Volume of Leachate



Chemical Root Pruning of Container-Grown Trees using Trifluralin and Copper Impregnated Fabric

Steven E. Newman and Jesse R. Quarrels
Mississippi

Nature of Work: Seedling trees grown in containers often have several root disorders that contribute to the total health of the plant and landscape establishment. Circling roots can lead to a weakened tree long after transplant. Many different pot configurations and chemical treatments have been introduced to eliminate root circling in a pot as well as stimulating fibrous branching (2). These include open bottomed pots, ribbed pots, “stair-stepped” pots (3), pots with longitudinal slits, and copper carbonate paints (1). Each of these pots or treatments stimulates fibrous branching by disrupting the apical dominance of the apical meristem of the root. These pots and treatments do control root growth, but pot modifications are cost prohibitive and chemical applications may not be easily adaptable to mechanization (3).

Root control is not a concern unique to nursery growers. The protection of buried waste and physical structures from tree root encroachment stimulated the development of a long-term root control product (2). This product uses a unique slow release technology that releases trifluralin herbicide from a polyethylene bead fastened to a non-woven polypropylene fabric. The trifluralin is released and forms a chemical barrier. Trifluralin is a mitotic poison and any root tip that comes into contact the herbicide is killed without any of the herbicide being translocated within the plant. This in turn disrupts the apical dominance of the root system stimulating fibrous branching of the remaining roots. BioBarrier disks or fabric disks treated with a root pruning compound such as Spinout placed into the bottom of a pot may be a convenient and effective means for controlling root circling in a pot and/or preventing root escape from the drainage holes. This may be even more important to nursery growers using pot-in-pot container systems.

Disks of BioBarrier, polypropylene fabric (Typar) dipped in trifluralin, fabric dipped in Spinout and allowed to dry, fabric dipped in copper carbonate blended with latex paint, fabric dipped in copper sulfate blended with paint, fabric dipped in latex paint, and plain fabric were cut and placed into the bottom of #3 polyethylene pots along with an untreated control. The copper carbonate and copper sulfate rates yielded the same concentration of copper as Spinout. Two week old seedlings of *Cercis canadensis,* Eastern redbud, and *Quercus obtusa,* diamondleaf oak were transplanted into #3 polyethylene pots in June 1992 with pine bark amended with 5 lb/yd3 dolomitic limestone and 1 lb/yd^3 Micromax. The plants were grown in a shade house with daily overhead irrigation during the 1992 growing season and in full sun with overhead irrigation during the 1993 growing season. Height and caliper were measured after the onset of dormancy in the fall of 1993. The roots were rated, 14 for the degree of root circling and close proximity to the bottom of the pot, where 1=no roots within 1 inch of disk, 2=root just touching disk, 3=roots protruding through disk or around edge of disk, and 4= roots in mass or circling under disk.

Results and Discussion: Stem caliper and plant height of *Quercus* was not affected by any of the root control treatments (Table 1). None of the root control treatments were different from the control for stem caliper and plant height of *Cercis,* however, plants treated with copper carbonate as well as the BioBarrier and trifluralin treatments tended to be larger (Table 1). *Cercis* plants treated with Spinout disks were the smallest.

Quercus plants treated with BioBarrier or trifluralin had the lowest root rating, where those treated with copper sulfate had the greatest rating (Table 1). This indicates that trifluralin more prevented root growth near the bottom of the pot than did the copper treatments. *Cercis* plants treated with BioBarrier, trifluralin, and Spinout had the lowest root rating compared to the other treatments (Table 1). As with *Quercus,* trifluralin treatments, whether a straight dip or slow release, provided the most root control.

Significance to Industry: Using a polypropylene fabric treated with a root control chemical or BioBarrier placed into the bottom of a nursery container can prevent some root circling and prevent root escapes from the bottom of the pot. This procedure may be especially useful for those growers using the pot-in-pot production system, reducing harvesting problems as well as nutritional and disease problems associated with native soil.

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Table 1. Caliper, height, and root rating of *Quercus obtusa* and *Cercis canadensis* seedlings grown in polyethylene pots (#3) with polypropylene fabric disks treated with root control chemicals and placed in the bottom of the containers.

Treatment	Caliper (mm)	Height (m)	Root Rating
	Quercus obtusa		
BioBarrier®	16.0 a[z]	1.26 a	1.20 d
Trifluralin	16.1 a	1.30a	0.36 e
Spinout®	17.1 a	1.17 a	2.33 b
Copper Carbonate	16.0 a	1.30 a	2.17 bc
Copper Sulfate	17.6 a	1.25 a	3.00 a
Polypropylene Fabric	16.4 a	1.15 a	1.75 c
Fabric with Paint	16.6 a	1.12 a	2.00 bc
Control	16.2 a	1.19 a	2.00 bc
	Cercis canadensis		
BioBarrier®	17.6 a	1.67 a	0.20 c
Trifluralin	17.8 ab	1.56 ab	0.30 c
Spinout®	15.4 c	1.34 b	0.00 c
Copper Carbonate	18.3 a	1.54 ab	1.60 b
Copper Sulfate	17.0 abc	1.43 b	1.57 b
Typar Fabric	17.1 abc	1.52 ab	2.00 b
Typar with Paint	15.8 bc	1.40 b	2.90 a
Control	16.8 abc	1.53 ab	1.70 b

[z] Means followed by different letters within columns were different as determined by Duncan's Multiple Range Test (a<0.05).

Container Production System Comparison for Pine, Oak and Palm

Tom Yeager, Claudia Larsen, Roger Newton, and J. C. Tort
Florida

Nature of Work: Container tree production has many advantages compared to growing trees in native soil; however, container trees frequently blow over. Placing containers in ground would reduce blow over. A single container placed in ground requires cutting roots protruding the container at harvest. To minimize escaping roots, one container could be placed inside another container (1, 2) or a plastic sleeve could be placed on container in the ground (4). The purpose of this study was to evaluate growth of trees in different container production systems.

Three gallon Pinus elliottii (Slash Pine), Quercus virqiniana (Live Oak), and Washingtonia robusta (Washington Palm) were planted on 23 Nov. 1990 at Sun City Tree Farm, Bunker Hill, Florida (north Manatee Co.) utilizing one of the following production systems: 1) black 25 gallon round container (23 inch diameter, 17 inch depth) placed in ground so that approximately 2 inches of container rim was above ground surface, 2) black 25 gallon round container placed inside 4 mil black plastic sleeve with 4 drain holes (Clark Container, Inc., Lyles, Tenn.) in ground with approximately 2 inches of container rim and sleeve above ground surface, 3) black 25 gallon round container placed inside same size container in ground with approximately 2 inches of container rim above ground surface, 4) black 25 gallon round container resting on ground (no ground cover), and 5) direct planting into native soil (Duette sand) without a container. Trees were planted 10 feet between rows and 5 feet within rows with 15 replicate trees for each of the 3 species grouped by treatment. A brick (3.5 x 5.5 x 11. 5 in) was placed flat between the bottom of the two containers for the container in container system and a cinder block (7 x 7 x 14 in) was placed flat below the bottom of the plastic sleeve. The container substrate was pine bark, Florida peat, and sand (2.6 : 2.6 : 1.0 by volume) amended with Micromax at 1.5 lb/cubic yard and limestone to adjust pH to 6.0. All trees were fertilized every 3 months. Each pine tree was fertilized with 4 oz of Milorganite 6-2-0 (Milorganite Division-MMSD, Milwaukee, Wis.), each oak with Lykes 15-5-10 (Lykes Agri-Sales, Eaton Park, Fla.) the first year then Gator Brand 16-6-12 (Howard Fertilizer Co., Inc., Orlando, Fla.), both at 2 oz per inch of caliper. Each palm was fertilized with 6 oz of Lykes 10-5-10 the first year then 10 oz per tree (except Oct. - Feb.). Fertilizers were surface-applied inside containers or applied within 18-inch diameter circle around trunk for trees grown in native soil. Each plant received 5 gal of irrigation water as needed from Chapin spray stakes (Chapin Watermatics Inc., Watertown, N.Y.). Tree height was measured on 13 Mar. 1991, 20 Dec. 1991 and 11 June 1993. Oaks and pines were measured to tallest stem tip; the first measurement for palms was to tip of crown and subsequent measurements were to tip of highest leaf. On 11 June 1993, substrate temperature of one plant for each treatment was measured at 1300 HR EDST. Temperature was recorded on the southwest side of containers 2 inches inside the container wall and 4 inches below the medium surface, and in a similar position for trees planted in native soil. On 14 July, two people tried to lift each container to determined which containers were harvestable or removable.

Results and Discussion: Tree heights for pines and oaks were not different due to production system (Table 1). Palms grown in containers on ground were taller in Dec. 1991 than palms grown in other production systems except for single container in ground. This same trend was evident in June 1993, with palms grown in containers on ground being the tallest. This could have been due to the subtropical habitat of Washington palm, thereby requiring or tolerating higher root-zone temperatures than other trees used in this study. Temperatures recorded 11 June 1993 were 31C in container on ground; and 28, 25, 28, and 26C for container in ground, container in sleeve, container in container, and in native soil, respectively. On 11 June, pines grown in native soil were exhibiting a general foliar chlorosis that could have been due to inadequate soil potassium levels as revealed by a soil test. Pines grown in containers on ground also exhibited a slight foliar chlorosis.

All pine and palm trees grown in a container placed in ground or on ground were not removable after 2.5 years. All oaks for these two treatments, except for one tree in a container in ground, were not removable. All palms grown with the sleeve or container in container system, and pines grown with sleeve system were not removable. Two oaks grown with containers in sleeves were removable while eight oaks and six pines grown with container in container system were removable 2.5 years after planting. This indicated that the container in container system was most successful in limiting roots from escaping to native soil. However, some trees of all species were not removable from the container in container system and thus presumed to be rooted into native soil. Several methods (3) have been evaluated to minimize roots escaping the container in container production system.

Significance to Industry: Slash pines, live oaks and Washington palms were grown with different container production systems. Heights of pines and oaks were not different after 2.5 years, while palms were tallest when grown in containers on ground. The number of plants that could be lifted by human force after 2.5 years varied with species and container system. No palms were removable while about one half the pines and oaks were removable when grown in ground in a container in container system. Nursery operators should consider methods to minimize roots escaping container in container production systems.

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Table 1. Height (inches) of Pinus elliotti, Quercus virginiana, and Washingtonia robusta planted 23 Nov. 1990 utilizing various container production systems.

	Pine			Oak			Palm		
	Mar 91	Dec 91	Jun 93	Mar 91	Dec 91	Jun 93	Mar 91	Dec 91	Jun 93
Container in ground	39 ±5	76 ±9	132 ±9	71 ±6	106 ±9	134 ±9	21 ±3	48 ±5	86 ±8
Container in sleeve in ground	35 ±7	73 ±8	127 ±8	70 ±8	105 ±10	121 ±9	19 ±2	44 ±2	75 ±13
Container in cont. in ground	36 ±7	72 ±10	128 ±14	67 ±6	108 ±6	121 ±16	20 ±3	45 ±3	88 ±11
Container on ground	38 ±4	81 ±10	127 ±15	71 ±8	108 ±9	131 ±9	22 ±3	52 ±3	109 ±7
Planted in ground (no container)	35 ±4	69 ±10	113 ±16	65 ±8	98 ±11	142 ±18	21 ±3	44 ±2	90 ±5

Mean of 15 plants ± standard deviation.

Physical Analysis of Fresh and Aged Rice Hulls Used as a Peat Moss Substitute in Greenhouse Media

Shelly D. Dueitt* and Steven E. Newman
Mississippi

Nature of Work: Components of a container growth medium vary among growers. Media amendments include pine bark, peat moss, perlite, and vermiculite. Availability and fluctuating cost of peat moss have generated interest in alternative media components. Kenaf fibre core, composted sewer sludge, and pecan shells are media alternatives. Rice hulls, a by-product of the rice milling process, may have potential as a substitute for sphagnum peat moss in a peat-based soil-less media for greenhouse container crops. The pH ranged from 6.0 to 7.0 in both aged and fresh rice hulls initially. After plant harvest, the pH ranged from 7.0 to 7.8 in both rice hull media. The objective of this study was to determine the physical analysis of fresh and aged rice hulls used as a peat moss substitute in greenhouse media.

Seedlings of *Tagetes erecta,* Gold Coin Series Marigold, and *Limonium suworowii,* Suworowii Statice were transplanted into 12 cm azalea pots with one of the six media listed in Table 1. The media was incorporated with Micromax minor trace elements 0.5 kg/m^3 (Grace/Sierra, Fogelsville, PA) and limestone 5 kg/m^3. Physical analysis was obtained from initial media before planting and media after plants were harvested. Percent pore space and water holding capacity was measured. The experimental design consisted of three replicates of 10 plants per treatment in a randomized complete block.

Results and Discussion: The addition of rice hulls did not modify the pore space (Table 2). The pore space was reduced slightly over the duration of the study. The amount of pore space in a medium must be significant enough to hold air and water necessary for plant growth. The addition of aged rice hulls reduced the air space in the media initially, but these differences were not observed in the media post-test evaluation (Table 3). Media containing fresh rice hulls, initially, had greater air space compared to media containing aged rice hulls. This observation was reversed after the conclusion of the study. This was most likely due to media shrinkage during the growth period. The addition of aged rice hulls did not change the water holding capacity of the media compared to the control; whereas, media containing fresh rice hulls had less water holding capacity than the control media (Table 4). At the conclusion of the study, the fresh rice hull media held more water than the aged.

[1] Appreciation is expressed to Mr. Nolan Branton of Greenville, MS for the contribution of rice hulls for this study.

Significance to the Industry: Pore space for both the aged and fresh rice hull media was significant enough to have good water holding capacity. Rice hulls, both fresh and aged, can be used successfully as a sphagnum peat moss substitute for short term selected cut flowers. It is an inexpensive alternative media component compared to peat moss.

Table 1. Components of media treatments.

Media[Z]	(By volume)
V:RH:PM	5:5:0
V:RH:PM	5:4:1
V:RH:PM	5:3:2
V:RH:PM	5:2:3
V:RH:PM	5:1:4
V:RH:PM	

[Z] V = Vermiculite, RH = Rice Hulls, PM = Peat Moss

Table 2. Percent pore space, pre-test and post-test, found in various rates of aged and fresh rice hulls and/or sphagnum peat moss in a sphagnum peat-based media.

		Level	
	Rate (%)	Aged	Fresh
		- - - - - - - - - - % - - - - - - - - -	
Pre-test	0	59.67 a[z]	62.16 a
	10	57.16 a	57.83 a
	20	56.50 b	59.67 a
	30	57.33 a	58.83 a
	40	53.17 a	55.67 a
	50	55.17 b	58.83 a
Linear		NS	NS
Quadratic		NS	NS
Cubic		NS	NS
LSDY (Rate 5.019) (Level 2.897)			
Post-test	0	50.00 b	53.17 a
	10	50.00 a	50.83 a
	20	50.00 a	50.00 a
	30	50.00 a	50.00 a
	40	50.00 a	50.00 a
	50	50.00 a	50.00 a
Linear		NS	***
Quadratic		NS	****
Cubic		NS	****
LSD[Y] (Rate 0.506) (Level 0.292)			

[Z] Mean separation within rows by LSD, P=0.05; means in rows followed by the same letter are not significantly different.

[Y] LSD a=0.05)

NS Not Significant

*** Significant at the 0.001 level.

**** Significant at the 0.0001 level.

Table 3. Percent air space, pre-test and post-test, in various rates of aged and fresh rice hulls and/or sphagnum peat moss in a sphagnum peat-based media.

		Level	
	Rate (%)	Aged	Fresh
		- - - - - - - - - - % - - - - - - - - -	
Pre-test	0	7.33 a[z]	7.83 a
	10	5.67 a	5.67 a
	20	5.25 b	6.00 a
	30	1.90 b	6.42 a
	40	4.00 b	8.08 a
	50	5.00 b	9.17 a
Linear		NS	NS
Quadratic		*	NS
Cubic		*	NS
LSD[Y] (Rate 4.509) (Level 2.603)			
Post-test	0	6.33 a	3.17 b
	10	6.34 a	2.67 b
	20	5.17 a	5.34 a
	30	8.17 a	4.50 b
	40	6.00 a	3/50 b
	50	8.33 a	6.00 b
Linear		NS	NS
Quadratic		NS	NS
Cubic		NS	NS
LSD[Y] (Rate 4.201) (Level 2.425)			

[Z] Mean separation within rows by LSD, P=0.05; means in rows followed by the same letter are not significantly different.

[Y] LSD (a=0.05)

NS Not Significant

* Significant at the 0.05 level.

Table 4. Water holding capacity, pre-test and post-test, in various rates of aged and fresh rice hulls and/or sphagnum peat moss in a sphagnum peat-based media.

		Level	
	Rate (%)	Aged	Fresh
		- - - - - - - - - - % - - - - - - - - -	
Pre-test	0	52.33a[z]	54.33 a
	10	51.50 a	52.00 a
	20	51.25 b	53.67 a
	30	55.43 a	52.42 b
	40	49.17 a	47.58 a
	50	50.17 a	49.67 a
Linear		NS	*
Quadratic		NS	NS
Cubic		NS	NS
LSD[Y] (Rate 3.752) (Level 2.166)			
Post-test	0	43.67 b	50.00 a
	10	43.67 b	48.17 a
	20	44.83 a	44.67 a
	30	41.83 b	45.50 a
	40	44.00 b	46.50 a
	50	41.67 b	44.00 a
Linear		NS	**
Quadratic		NS	**
Cubic		NS	**
LSD[Y] (Rate 4.182) (Level 2.414)			

[Z] Mean separation within rows by LSD, P=0.05; means in rows followed by the same letter are not significantly different.

[Y] LSD (a=0.05)

NS Not Significant

* Significant at the 0.05 level.

** Significant at the 0.01 level.

Use of Cocoa Bean Shell Mulch as a Media Amendment for Potted Chrysanthemums

Kenneth C. Sanderson
Alabama

Nature of Work: Rising costs, reduced supplies, and environmental concerns have prompted a 20 year search for sphagnum peat alternatives. Barks of various kinds have often been used as media substitutes for peat (3). Other crop residues, such as melaleuca bark, cotton burrs, kenaf, sewage sludge, rice chaff, and coconut husks, have also been considered as peat alternatives (2).

Waste shell from the extraction of chocolate from cocoa beans has been used for over 30 years as a mulch for roses and a soil amendment for flower beds at Hershey Gardens, Hershey, PA (1). Cocoa bean shell mulch (CBSM) slowly decomposes and contains approximately 2.5% nitrogen, 1.0% phosphate and 3.0% potash (1). Analysis of CBSM by the Auburn University Soil Testing Laboratory revealed it to be exceedingly high in specific conductance, soluble salts, phosphorous, potassium and magnesium; but low in pH, nitrogen and calcium (Table 1). Nitrogen's reading was probably inaccurate due to the dark color imparted by the sample. Little information exists on the use of CBSM as an organic potting media amendment, although Neal mentions its use (2). This research was conducted to determine if CBSM could be substituted for sphagnum peat moss (SPM) in container media. Five media were formulated using sphagnum peat moss (SPM), and/or cocoa bean shell mulch (CBSM provided by Mulch Cocoa Distributing, Inc., Nashville, TN). Each media was amended with dolomitic limestone (4 oz., or 112g per ft^3). A standard commercial medium, Fafard No. 2 (SPM, vermiculite and perlite; Fafard Springfield, MA), was provided for comparison with the five formulated media (Table 2). Rooted cuttings of 'Dare' chrysanthemum, Dendranthema x grandiflora (Ramat.) Kitamura (Chrysanthemum x morifolium), were planted four per 6 in. (15 cm) pot on October 21, 1991. Plants were grown in a glasshouse at 62°F (17°C) with the day length supplemented from 10 PM to 2 AM using incandescent light until October 28. Plants were pinched to increase branching when new growth was 1-1 1/2 inches (2.5 - 3.75 cm) and the roots reached the bottom of the pot. Natural short days provided photoperiods for flowering. Peters Peatlite Special 20-19-18 (The Scotts Company, Marysville, OH) was applied to the media every two weeks at the rate of 2 lbs. per 100 gal. (2.4g per liter). When buds were 1/4-inch (0.6 cm) in diameter, the center bud on a shoot was removed to influence flower formation and fertilization was stopped. Data on plant height, canopy area, flower number, rating and flowering date were recorded when one-third of the flowers were open. Plants were rated for quality on an index of one (very poor) to five (excellent). All data were subjected to an analysis of variance. Mean comparisons were made by Duncan's multiple range test. Peat-amended media were contrasted with CBSM media.

Results and Discussion: A harmless mold appeared on the surface of CBSM media during the first few weeks after planting. Appearance of this mold has been noted when

CBSM is used as a mulch (1). It disappeared as the experiment progressed. Following pinching, new growth on plants growing in CBSM-amended media exhibited chlorosis. Analysis of the CBSM media revealed a pH of 7.8. To correct the pH of the CBSM media, the plants were irrigated with water containing 0.6oz. H_2SO_4 per 100 gal. (.05 ml per liter). A single application of NH_4NO_3 at the rate of 21.8 oz. per 100 gal (6.4g per liter) was also made to all plants on November 16. While it was quite possible that the high phosphorous content and high soluble salts of CBSM may have contributed to the chlorosis, subsequent experiments using half as much or no limestone did not exhibit chlorosis. Significant differences in all the growth parameters except flowering date (data not shown) were observed (Table 2). Growth parameters for plants in SPM amended media were significant better than for plants in CBSM amended media. Fafard grown plants were the tallest and differed in height from plants grown in the other media. Peat-amended media produced taller plants than cocoa bean shell amended media. Plant canopy area was greatest in plants grown in Fafard media. Plants in peat-amended media had significantly greater plant canopy areas than plants in CBSM media. The most flowers per pot were produced by plants grown in 2 SPM:1 PB:1 VL:1 PL and Fafard. Peat-amend media produced larger plant canopy areas than CBSM-amended media. Plants rating showed that Fafard and peat-amended media produced the highest plant ratings. Plants grown in 1 CBSM:1 VL were rated 1.5 and probably were unsalable.

Significance to Industry: Cocoa bean shell mulch was not an acceptable substitute for Sphagnum peat moss in chrysanthemum media when it comprised more than 20% (by volume) of the media. Sphagnum peat moss-amended media and the peat-based commercial media, Fafard No.2, generally produced better growth than cocoa bean shell mulch media. Cocoa bean shell mulch's high phosphorous and potassium merit its consideration as a fertilizer.

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Table 1. Analysis of cacao mulch: pH, soluble salts, conductance, N, P, K and Ca.

Analysis	Reading	Interpretation
pH	4.7 acid	
Soluble Salts	5320.0 ppm	Very high
Conductance	7.6 mmhos/cm	Very high
Nitrates	26.8 ppm[Z]	Low
Phosphorous	574.0 ppm	Very high
Potassium	2850.0 ppm	Very high
Calcium	620 ppm	Low
Magnesium	321.0 ppm	Low

[Z] Reading may be inaccurate due to color of sample.

Table 2. Comparison of the growth of 'Dare' potted chrysanthemums grown in sphagnum peat moss (SPM) -amended and cocoa bean shell mulch (CBSM) amended media.

Media[Z]	Plant height (cm)	Plant canopy area (cm^2)[y]	Flowers per pot	Plant rating[x]
2 SPM:1 PB:1 VL:1 PL	31 b[w]	1302 ab	60 a	5.0 a
2 CBSM:1 PB:1 VL:PL	22 d	993 c	39 c	3.0 c
1 SPM:1 VL	31 b	1128 abc	47 bc	5.0 a
2 SPM:1 CBSM:1 VL:1 PL	27 c	1096 bc	46 bc	3.8 bc
1 CBSM:1 VL	20 d	926 c	25 d	1.5 d
Fafard No. 2	34 a	1364 a	51 ab	4.5 a
Significant contrasts				
CBSM vs SPM media	**	**	**	**

[Z] Media by volume. SPM = sphagnum peat moss, PB = pinebark, VL = vermiculite, PL = perlite, CBSM - cocoa bean shell mulch.

[y] Plant canopy area = diameter at top of plant in two directions multiplied.

[x] Rating index. 1 = very poor, unsalable; 2 = poor. salable; 3 = average, salable; 4 = good, salable; 5 = excellent, salable.

[w] Means followed by the same letter(s) are not significantly different according to Duncan's multiple range test, 5% level.

[v] Significance. ** = 1% level, ns = not significant.

Broiler Litter Compost Affects Growth of Annual and Perennial Plants

Virginia V. Allen, Bridget K. Behe, David G. Himelrick
Alabama

Nature of Work: Disposal of organic waste products, such as broiler litter, have become more challenging in light of increased scrutiny of ground and surface water supplies. Since poultry manure contains organic nitrogen, it can be composted and partially substitute for commercial fertilizers in plant production (1). The objective of this study was to determine the effects on growth of two annual (pepper and impatiens) and two perennial (salvia and coreopsis) plant species grown in four media amended with broiler litter compost (BLC).

Media were developed to resemble a commercially available peat-lite mix by blending BLC, peat moss, and perlite. Resulting media were, by volume (BLC:peat:perlite) 1:3:4, 2:2:4, 3:1:4, and 4:0:4. Plants grown in these media were compared to plants grown in a commercially prepared peat-lite medium, Fafard #2 (Buffalo Co., Greenville, SC).

Plugs each of *Impatiens wallerana* 'Accent Lilac', *Capsicum fruitescens* 'Bonnie Bell', *Salvia farinacea* 'Victoria', and *Coreopsis grandiflora* 'Early Sunrise' were transplanted on February 15, 1994, into four-inch square pots. Eight plants per treatment were arranged in a randomized complete block design. Transplants were place in a polyethylene-covered greenhouse and grown for six weeks using standard cultural practices. Plants were fertilized with 27 oz. per 100 gallons of water of 20-10-20 Prosol at each irrigation. Plants were irrigated as needed.

Table 1 shows that the only difference in height for *Impatiens wallerana* 'Accent Lilac'occurred in the medium which contained 25% BLC (2:2:4). Growth index for impatiens was affected by both the 2:2:1 and 4:0:4 media, reducing the size of the plants when compared to plants grown in Fafard #2. The addition of any amount of BLC significantly reduced the fresh weight and dry weight of impatiens. Impatiens were smaller when grown in media containing broiler litter compost.

Table 2 shows similar results for *Capsicum fruitescens* 'Bonnie Bell'. Pepper height was reduced when more than 12.5% BLC was added to the medium. Growth index of pepper was significantly smaller when compared to the Fafard medium. Also, fresh weight and dry weight in each treatment were considerately lower in comparison to peppers grown in Fafard #2. Peppers and impatiens reacted negatively to the addition of BLC, even at small amounts.

Table 3 shows that the heights of *Salvia farinacea* 'Victoria', a perennial, was affected minimally by the addition of BLC to the medium. One growth index was significantly different from the Fafard treatment, the medium containing the most BLC. Fresh and dry weights were not significantly affected by the use of BLC in the medium. It appears that *Salvia farinacea* can be successfully grown in media containing up to 50% BLC.

Coreopsis grandiflora 'Early Sunrise' was not affected by the addition of BLC to the medium. No height, growth indices, fresh or dry weights were significantly different in comparison to Fafard #2. Thus, *Coreopsis grandiflora* 'Early Sunrise'and *Salvia farinacea* 'Victoria'can be grown successfully in media containing up to 50% BLC.

Significance to the Industry: From the information gained in this study, BLC can be used in the production of some perennial plants, and perhaps some annual plants. Attention should be given to the ratio of BLC:peat:perlite when formulating a potential medium. Growth appeared to be more similar to plants grown in the commercial medium when lower amounts of BLC were used, particularly with the 1:3:4 ratio. Other annual and perennial plant species should be tested prior to production in media containing BLC.

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Table 1. Effects on growth of Impatiens wallerana 'Accent Lilac' in media containing broiler litter compost when compared to a commercial medium (Fafard #2)[1].

Medium[2]	Height[3]	Growth Index[4]	Fresh Wt.[5]	Dry Wt.[5]
1 : 3 : 4	11.1	21.1	43.9*	2.8*
2 : 2 : 4	5.1*	9.3*	8.7*	0.6*
3 : 1 : 4	9.2	22.7	40.8*	2.8*
4 : 0 : 4	8.6	14.1*	15.4*	1.1*
Fafard #2	11.8	25.4	73.8	4.7

[1] Significant at p=0.05 using Dunnett's test.
[2] Medium contains broiler litter:peat:perlite by volume.
[3] Height and width measurements in centimeters.
[4] Growth index = [(height + width1 + width2)/3], in cm.
[5] Weight in grams.

Table 2. Effects on growth of Caspicum fruitescens 'Bonnie Bell' in media containing broiler litter compost when compared to a commercial medium (Fafard #2)[1].

Medium[2]	Height[3]	Growth Index[4]	Fresh Wt.[5]	Dry Wt.[5]
1 : 3 : 4	20.8	25.9*	22.2*	3.5*
2 : 2 : 4	13.2*	18.5*	9.9*	1.4*
3 : 1 : 4	17.1*	22.4*	12.5*	1.9*
4 : 0 : 4	15.7*	20.6*	12.9*	2.0*
Fafard #2	23.3	29.9	31.5	4.8

[1] Significant at p=0.05 using Dunnett's test.
[2] Medium contains broiler litter:peat:perlite by volume.
[3] Height and width measurements in centimeters.
[4] Growth index = [(height + width1 + width2)/3], in cm.
[5] Weight in grams.

Table 3. Effects on growth of Salvia farinacea 'Victoria' in media containing broiler litter compost when compared to a commercial medium (Fafard #2)[1].

Medium[2]	Height[3]	Growth Index[4]	Fresh Wt.[5]	Dry Wt.[5]
1 : 3 : 4	8.5	14.2	5.8	0.7
2 : 2 : 4	9.3	14.7	6.6	1.0
3 : 1 : 4	16.0	19.7	10.4	1.6
4 : 0 : 4	11.8	14.8*	11.1	1.8
Fafard #2	14.1	20.3	17.9	2.8

[1] Significant at p=0.05 using Dunnett's test.
[2] Medium contains broiler litter:peat:perlite by volume.
[3] Height and width measurements in centimeters.
[4] Growth index = [(height + width1 + width2)/3], in cm.
[5] Weight in grams.

Effectiveness of Several N-Source Products for Container Grown Plants

Kevin Tucker and Don Wagner
South Carolina

Nature of Work: Previous studies have demonstrated the need for further investigations into the efficiency of nitrogen utilization (1,2,3,4). The objective of this investigation was to determine the effectiveness of some recently developed N-source products, and combinations thereof. Forty-five one-year-old azalea liners (*Mrs. G.G. Gerbing*) were potted in standard nursery gallon containers using 60% pine bark, 30% Canadian peat and 10% coarse sand, amended with plastic coated sulfate of potash (0-0-40) @ 2 lb/cu yd potash, the micronutrient Perk [Vigoro product]@ 2 lb/cu yd, dolomite @ 6 lb/cu yd and gypsum @ 2.5 lb/cu yd.

Treatments were as follows:

1. 20 UF [urea formaldehyde]/80 IBDU [isobutylidene diurea] (32.9% N)@ 7.6 lb/cu yd (2.5 lb N)
2. 40 UF/60 IBDU (34.3% N)@ 7.3 lb/cu yd (2.5 lb N)
3. 50 MAGAMP [magnesium ammonium phosphate]/50 IBDU (21-22-0-6.5 Mg)@ 7.5 lb/cu yd + 1049 gm Escote 400 (40-0-0) [2.5lb N + 1.65 lb phosphate]
4. 40 MAGAMP/60 IBDU (23-17-0-5.2 Mg)@ 7.5 lb/cu yd + 879 gm Escote 400 (40-0-0) + 472gms dical phos (0-36-0) [2.5 lb N + 1.65 lb phosphate]
5. 20 MAGAMP/80 IBDU (27-8-0-2.6 Mg)@ 7.5 lb/cu yd + 539 gm Escote 400 (40-0-0) + 1323gm dical phos (0-36-0) [2.5 lb N + 1.65 lb phosphate]
6. IBNS [IBDU/methylene urea, experimental Vigoro product](32-0-0)@ 7.8 lb/cu yd (2.5 lb N)
7. V-Cote 8% coated urea [urea with water-based experimental coating, Vigoro experimental product]@ 6.1 lb/cu yd (2.5 lb N)
8. V-Cote 42-0-0 bagged [urea with water-based experimental coating, Vigoro experimental product]@ 6.0 lb/cu yd (2.5 lb N)
9. Osmocote 17-7-12@ 14.7 lb/cu yd

The design was a randomized complete block with 5 replications.

Data collected was as follows:

1. Growth index (Ht + [Width 1 + Width 2] / 2). (Table 1).
2. Top dry weights and visual root score (1-9, 9 best). (Table 2).
3. Analysis of leachate for $NO3^-$ (mg/L) 14, 28, 60, 120 and 180 days after treatment (DAT) (Table 3).

Results and Discussion: Analysis of the growth index ratings (GI) for the treatments indicated that all treatments were the same as the control (treatment 9) at the termination of the experiment (Table 1). Top dry weights (Dry WT) were greatest in treatments

3,4,8&9 (Table 2). Visual root ratings (RR) at the termination of the study (180 DAT) showed that all treatments were the same (Table 2).

Leachate analysis for total NO_3^- demonstrated that the Osmocote was the highest at all sampling periods through 60 DAT(Table 3). Leachate NO_3^- levels in the other treatments were considerably less until 120 DAT. All treatments seemed to run out of NO_3^- by experiment termination (180 DAT). Generally, it appears that the NO_3^- in the Osmocote products was more available (leachable) early on, and was used up by 120 DAT.

Significance to Industry:

Generally speaking, the plants in most treatments looked good and were consumer acceptable by the termination of the experiment. Therefore, even though there were some differences in NO_3^- levels throughout the experiment, the resulting plant growth didn't reflect these differences adversely. Osmocote NO_3^- was more available early on and that might be a concern, but the final plant products did not seem affected. Treatment 2 (40 UF/60 IBDU and treatment 6 (IBNS) demonstrated the least amount of leachate NO_3^- losses in the study.

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Table 1. Growth indices (GI) at periodic intervals during the experiment.
*Means seperation by column using Fisher's Protected LSD.
**Means of five replication.

TRT	GI O DAT	GI 14 DAT	GI 28 DAT	GI 60 DAT	GI 120 DAT	GI 180 DAT
1	14.05**	18.65	26.0	43.6	93.4	104.9
2	16.35	21.55	31.2	49.35	113.2	123.8
3	14.5	20.55	28.0	44.25	110.0	123.5
4	12.65	17.75	26.3	41.85	105.6	111.8
5	13.4	19.3	27.4	44.5	98.4	114.3
6	17.35	23.5	30.25	50.9	102.3	109.0
7	15.7	21.05	28.25	44.1	105.6	114.6
8	14.7	20.5	26.8	46.25	103.4	116.1
9	13.05	18.55	25.1	45.25	102.0	116.1
LSD (0.05)*	3.08	4.56	5.24	5.77	10.35	12.54

Table 3. Leachate NO_3- levels at periodic intervals during the experiment.
*Means seperation by columns using Fisher's Protected LSD.
**Means of five replciations.

TRT	NO_3- O DAT	NO_3- 14 DAT	NO_3- 28 DAT	NO_3- 60 DAT	NO_3- 120 DAT	NO_3- 180 DAT
1	1.68**	2.50	14.59	48.31	15.72	4.67
2	1.60	2.22	15.47	53.75	16.25	4.68
3	2.05	3.27	14.09	51.24	15.08	4.64
4	2.59	3.36	13.82	47.30	15.82	4.65
5	2.25	2.63	17.60	61.51	16.04	4.29
6	1.15	1.94	14.60	23.82	11.91	5.58
7	2.38	7.25	22.16	45.21	13.51	4.86
8	2.11	14.65	41.52	72.33	9.29	4.66
9	2.99	78.02	97.21	91.79	11.38	1.99
LSD (0.05)*	1.16	6.83	10.5	18.3	6.2	3.02

Table 2. Dry weights and root ratings (1-9, with 9 best) at determination of experiment.
*Means seperation by column using Fisher's Protected LSD.
**Means of five replications.

TRT	DRY WT (g)	RR 180 DAT
1	23.42**	6.9
2	35.52	7.6
3	38.02	6.7
4	36.3	6.9
5	34.36	7.3
6	31.94	8.0
7	28.08	7.6
8	46.3	7.0
9	44.48	8.0
LSD (0.05)*	10.06	1.32

Water Drained from Soilless Substrate Perched Water as an Indicator of Substrate N Availability

Alex X. Niemiera
Virginia

Nature of Work: The pour-through (PT) method of substrate solution extraction for soilless substrates has been shown to be an effective method for monitoring the nutritional status of container substrates of woody plants (Yeager et al., 1983) and poinsettia (Wright et al., 1990). Furthermore, correlations between PT leachate N, P, K concentrations and application concentrations showed that the PT method was as effective in extracting nutrients from a pine bark substrate as the SME (saturated media extract) method (Yeager et al., 1983). Since at least part of the water retained by the perched water table, a zone of saturation at bottom of container following irrigation, is displaced during the PT procedure, the nutrient content of water in the table may be similar to nutrient values obtained via the PT. In lieu of the PT method, some nurserymen are extracting substrate solutions by tilting relatively large containers. If the perched water displacement (PWD) yields a solution whose N concentration is similar to values for a PT-yielded solution, then the PWD method would be an improvement of the PT method, since PWD requires less effort and time than the PT. The objective of this study was to determine if N concentrations of the substrate solution extracted by the PWD method were the same as solution N concentrations obtained by the PT method.

Tagetes erecta L. 'Inca Gold' seedlings were transplanted into 12 and 20 liter (3 and 5 gal) plastic containers. For each container size, substrate solution extraction methods, PT and PWD, were in factorial combination with two with two fertilization methods, WSF or CRF, and two substrate types, pine bark or Sunshine Mix #1 (Sun Gro, Warwick, N.Y.). Bark had a bulk density of 0.19 g•cm^{-3}, air space, total porosity, and container capacity of 20.3%, 84.8%, and 63.5%, respectively. Sunshine Mix #1 was composed of 3 sphagnum peat moss: 1 vermiculite (by volume); bulk density, air space and container capacity was 0.11 g•cm^{-3}, 18%, and 60%, respectively. Substrate solution testing method treatments were conducted 72 days after transplanting. In the PT method for each container size, 200 and 125 ml (6.8 and 4.2 oz, respectively) tap water were applied uniformly to the bark and peat mix surface, respectively, and leachate was collected for 10 min. In the PWD method, containers were tilted at a 45 degree angle (relative to bench surface) and leachate was collected. Containers (both sizes) with bark were tilted for 15 sec and with the peat mix for 3 min. The amount of water to add in the PT method to leach≈75 ml (2.5 oz), and the tilting time duration to leach ≈75 ml was determined in preliminary experiments. Both solution extraction methods were conducted one h after irrigation. Leachate was analyzed for NO_{3}-N and NH_{4}-N using ion-selective electrodes. Fertilization of plants, either by a WSF or a CRF, in all treatments commenced at the time of transplanting. For the WSF treatment, plants in the 12 and 20 liter containers received 1.5 and 3.0 liters (1.6 and 3.2 qt) of nutrient solution (beaker-applied), respectively, two to three times per week. Nitrogen, P, and K concentrations of the WSF were 200, 20, and 75 mg•liter^{-1}. For the CRF

treatment, 12 and 20 liter containers received surface applications of 80 or 140 g (2.8 and 4.9 oz) of Osmocote 13N-5.7P-10.8K (8 to 9 month release), respectively. The frequency and volume of irrigation (tap water) for the CRF treatments were the same as for the respective container sizes in the WSF treatments. For each container size, there were four single plant replications per extraction method x substrate type x fertilization method treatment combination; plants were arranged in a randomized complete block design. Data were subjected to ANOVA analysis.
For both container sizes, PT and PWD solution N (NO3-N and NH4-N) concentrations were the same for each fertilization method x substrate type combination (Table 1). Thus, in terms of the extracted solution N concentration, the PWD method was as reliable as the PT. As a modification of the bulk solution displacement method, the PT method displaces at least part of the perched water. Due to the relatively porous nature of soilless substrates, much of the applied water in the PT procedure most likely percolates through macropores until reaching and displacing the perched water. Since the PT is conducted shortly after irrigation, micropores would be water-filled and water flow would occur through macropores (Spomer, 1990). This is expected since the rate of saturated flow is related to pore size and geometry (Spomer, 1990). Tilting the container, as in the PWD method, also displaces perched water. The fact that solution nutrient concentrations from the PT method were found to be highly correlated with nutrient application concentrations and similar to values from the SME method (Yeager et al., 1983), implies that the nutrients in the perched water are in equilibrium with the bulk solution.

Compared to the PT method, the PWD method required much less time and effort to collect 75 ml of leachate from pine bark, the predominate substrate in eastern United States nurseries. Since extracted substrate solution N concentrations were the same for both extraction methods for treatments within the 12 and 20 liter containers, we expect that the PWD would be a reliable substrate solution extraction method for container sizes > 20 liters.

Significance to Industry: Periodic extraction of the substrate solution of container-grown plants and subsequent nutrient solution analysis allows growers to adjust fertilizer regimes so that plants as supplied with an adequate but not excessive amount of fertilizer. This research demonstrated that the N concentration of substrate solution extracted by tilting the container was the same as for the pour-through method. Thus, this tilting method reduces the amount of effort and time in substrate solution extraction.

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Table 1. Substrate solution N concentrations for 12 and 20 liter containers as influenced by two substrate solution extraction methods for two substrate types and two fertilizer methods.

Container size (liter)	Substrate Solutinn extraction method	Fertilizer	Leachate N conc. (mg•liter $^{-1}$)	
			$NO_{3-}N$	$NH_{4-}N$
		Pine Bark		
12	PT	WSF	132	13
	PWD		126	14
	Significance		NS	NS
	PT	CRF	480	88
	PWD		639	118
	Significance		NS	NS
		Peat Mix		
	PT	WSF	136	9
	PWD		142	10
	Significance		NS	NS
	PT	CRF	483	133
	PWD		456	93
	Significance		NS	NS
		Pine Bark		
	PT	WSF	116	15
	PWD		124	15
	Significance		NS	NS
	PT	CRF	396	146
	PWD		480	126
	Significance		NS	NS
		Peat Mix		
	PT	WSF	115	16
	PWD		138	17
	Significance		NS	NS
	PT	CRF	494	146
	PWD		646	126
	Significance		NS	NS

^{NS} Nonsignificant at P=0.05.

Nitrogen Nutrition of Containerized *Cryptomeria japonica* 'Elegans Aurea'

Laura G. Jull, Stuart L. Warren, and Frank A. Blazich
North Carolina

Nature of Work: Japanese Cedar *[Cryptomeria japonica (L.* f.) D. Don], a coniferous evergreen indigenous to Japan and southern China is a widely used timber species in the Orient. There are many cultivars of Japanese cedar (cryptomeria) with smaller cultivars being more desirable than others for residential landscaping. One such cultivar is 'Elegans Aurea'. It has soft, feathery, bright green foliage normally reaching a height of 3-5 m (9-15 ft) in most landscapes but can grow taller. 'Elegans Aurea' cryptomeria has a yellow-green fall color that persists throughout the winter before becoming green in the spring .

Nitrogen is the mineral nutrient that promotes the greatest top (aerial tissue) growth in conifers (6). Growth is asymptotic with increasing substrate N with the optimal N concentration often dependent upon the reported growth measurements. Henry et al. (3) reported 230 mg NAiter maximized top growth of eastern redcedar *(Juniperus virginiana* L.*)* in a pine bark substrate while root growth was maximized at 105 mg NAiter. Ingestad (5), working with Scotch pine *(Pinus sylvestris* L.*),* found that nutrient solutions containing 50 and 5 mg NAiter were optimal for top and root growth, respectively. In contrast, Ingestad (4) reported a nutrient solution with 50 mg NAiter produced maximum top and root growth of Norway spruce *[Picea abies (L.)* Karst.]. For most conifers in containerized culture, 100 to 150 mg NAiter appears optimal (6). However, little is known about the N requirements of Japanese cedar. Tsutsumi (8) demonstrated in a hydroponic experiment that ammonium nitrate was the best N source for Japanese cedar; however, no N rate recommendations were given. Therefore, the objective of this study was to determine the influence of N fertilization on growth and mineral nutrient status of 'Elegans Aurea' cryptomeria.

On Feb. 12, 1993, uniform, rooted single-stem cuttings of 'Elegans Aurea' cryptomeria with a mean height of 22 cm and stem diameter mean of 4.4 mm were potted in 3.8 liter (#1) black plastic containers in arcillite, a calcined montmorillonite and illite clay. Arcillite was selected as the substrate because it allows recovery of intact root systems at harvest.

Plants were grown in a greenhouse under natural photoperiod and irradiance (8:00 AM to 5:00 PM) with day/night temperatures of 24 + 4°C (75 ± 7°F) /16 + 4°C (60 ± 7°F). From 11 :00 PM to 2:00 AM daily, plants received a night interruption from incandescent bulbs.

The experiment, a randomized complete block design with 9 single plant replications, consisted of five concentrations of N (0, 25, 50, 100, or 200 mg N/liter) supplied as ammonium nitrate. Three weeks after potting, fertilization was initiated with one liter of nutrient solution applied to each plant on Monday, Wednesday, and Friday. Before application, the nutrient solution was adjusted to pH 6.0 using 1 N NaOH. Tap water containing 0.10, 0.0, 0.5, 4.0, 20.0 and 2.0 mg/liter NO_3, NH_4, P, K, Ca, and Mg, respectively, with a pH of 7.0 was applied on remaining days.

At treatment initiation, plant height and stem diameter measurements were taken from the surface of the substrate. After 14 weeks, plant heights and stem diameters were measured, roots were washed free of arcillite and each plant separated into tops (stems and needles) and roots. All tissue was dried at 70°C (158°F) for 72 hr. Before drying, total root length and root area of four replications per treatment were measured utilizing a Monochrome Agvision System 286 Image Analyzer (Decagon Devices, Inc., Pullman, Wash.).

Data were subjected to regression analyses. The analyses showed significance for most measurements only if the nontreated control (0 mg N/liter) was included in the analyses. Therefore, the nontreated control was excluded from the regression analyses and a linear contrast was utilized to test for differences between a pooled N treatment effect and nontreated control.

Results and Discussion: Top dry weight was not affected by N rate suggesting that 25 mgAiter was adequate for maximizing growth (Table 1). This is similar to data reported for Douglas fir *[Pseudotsuga menziesii* (Mirb.) Franco] (9), sitka spruce *[Picea sitchensis* (Bong.) Carr.] (9), Formosa pine *(Pinus taiwanensis* Hayata) (2), and Taiwan Douglas fir *(Pseudotsuga wilsoniana* Hayata) (2) as the optimum N concentration ranged between 25 and 50 mg/liter. However, this is a low N concentration compared to many woody landscape species where 100 to 300 mg N/liter were required to maximize growth (7). Nitrogen fertilization increased top dry weight by 149% compared to the nontreated controls (0 mg N/liter) (11.7 to 4.7 9, respectively). Plants not receiving N (0 mg N/liter) exhibited symptoms characteristic of N deficiency, (e.g., chlorosis and stunting).

Similarly, root dry weight was not affected by N rate (Table 1). This is in contrast to previous reports where increasing N concentration reduced root dry weight (1). Nitrogen increased root dry weight 20% compared to the nontreated controls (2.1 to 1.8 g, respectively). Root response to N is usually reduced compared to top response. Even though root dry weight was not affected by N, root area and total root length decreased linearly with increasing N rate (Table 1). Chiang et al. (2) working with Formosa pine and Taiwan Douglas fir also reported that total root length decreased with increasing N concentration. Even though total root length was reduced by increasing N rate, it had no apparent affect on top growth. However, root length may be important when transplanting into the landscape because the plant is dependent upon existing roots for water and nutrient absorption. Higher N rates during production may produce a lower quality plant since total root length and area are reduced.

Significance to Industry: Recent introduction of various cultivars of Japanese cedar *[Cryptomeria japonica* (L. f.) D. Don] has stimulated interest in the commercial potential of this attractive evergreen tree and also created a need for production information.

One popular cultivar, 'Elegans Aurea' can be used in the landscape or as a containerized Christmas tree. Maximum overall top and root growth of containerized 'Elegans Aurea' cryptomeria was realized by applying a solution containing 25 mg NAiter three times weekly. Higher rates of N significantly decreased root area and total root length.

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Table 1. Effect of nitroqen rate on various qrowth measurements of 'Eleqans Aurea' crvPtomeria.

Nitrogen rate (mq N/liter)	Top dry wt. (g)	Root dry wt. (g)	Root area (cm^2)	Total root length (CM)
0	4.7	1.79	112.7	1123.9
25	12.1	2.25	163.6	1438.8
50	11.9	2.19	153.9	1295.1
100	11.7	2.18	114.7	857.4
200	11.2	1.94	101.5	776.4
Significance[z]				
Linear	NS	NS	**	**
Quadratic	NS	NS	NS	NS
N rate vs. control[y]	***	**	NS	NS

[z] NS, **, *** Nonsignificant or significant at $P \leq 0.01$ or $P \leq 0.001$, respectively. Zero rate not included in the regression analysis.

[Y] Linear contrast. N rate = pooled nitrogen treatment. Control = 0 mg N/liter.

Influence of Container Size and Spacing on First-Year Field Performance of *Pinus taeda*

David B. South, Janusz B. Zwolinski and John B. McRae
Alabama

Nature of Work: In northern states, conifer seedlings are often produced in greenhouses. To increase greenhouse utilization, many growers use small containers and attempt to produce a plantable seedling in every cavity. These practices can result in the production of small, spindly seedlings that may not survive or grow well when outplanted. However, in the southern United States, greenhouses are not a requirement and their use often just adds to the cost of production. When grown outside, space is not as limiting and growers may choose to grow seedlings in larger containers. Even so, more potting media and land is required when growing seedlings in larger container.

Selection of an appropriate container size and density is important since field performance (Barnett 1980) and costs are affected. In some cases, a larger cell may not necessarily mean better field growth. For example, Barnett and Brissette (1986) reported that pine seedlings grown in a 88 cm^3 cell at a density of 1,657/m^2 did not grow as well as those grown in a 67 cm^3 cell at 312/m^2 . Apparently in this case, spacing was more important than cell volume. Therefore, the objective of this study was to determine if an interaction exist between cell volume and spacing.

Seeds of loblolly pine were sown into containers on April 21, 1992 at the International Forest Seed Company (IFSCO) Nursery at Odenville, Alabama. Three types of containers were used: IFSCO-67; IFSCO-40; Ray Leach Super Cell (respective cell densities were 881/m^2, 526/m^2 , 526/m^2 and cell volumes were 50, 93, 164 cm^3). Three spacings were used for each container type. Seedlings were grown with each cell filled (FULL), or with alternating rows filled (HALF), or with alternating rows filled and alternating cells empty (QUARTER). Seedlings were fertilized according to operational standards. However, in October, half of the seedlings were given seven extra applications of nitrogen (200 ppm N). In late October, samples of seedlings were analyzed for root-collar diameter, stem height, lateral root length, shoot dry mass, and root dry mass. On October 27, seedlings were outplanted on two sites at Union Springs, Alabama. Site #1 had heavy grass competition while site #2 was a cut-over area that had been burned and disked. Survival and heights of seedlings were recorded in December of 1993.

Results and Discussion: At lifting, seedlings were 5 months old. Although seedling morphology varied, an average seedling was less than 1 g and had a root-collar diameter of less than 2.8 mm (table 1). Both container volume and spacing affected seedling morphology. Due to the smaller rooting volume, the IFSCO-67 containers produced the smallest seedlings. However, there was a volume by spacing interaction for both diameter and height.

Survival and growth was lower on site 1 which had high levels of grass competition. Overall, survival on site 1 was 48% while on site 2 it was 75%. No chemical weed control was applied at either site.

On site #1, there were no treatment effects for survival. Probabilities for a greater F values were 0.53, 0.70 and 0.42 for container volume, spacing, and extra fertilization. Average height after 1 year was only 24.6 cm and groundline diameters averaged 4.3 mm. This indicates little height growth during the first year. As a result, there were no treatment effects for height or diameter (P>F>0.10).

On site #2, nursery treatments affected field performance. Although extra fertilization did not affect survival (P>F = 0.67), container type did affect survival (P>F = 0.01). The Super Cell had 83% survival compared to 72% for the IFSCO-67 and 71% for the IFSCO-40. This could be explained by a longer taproot for the Super cell (20 cm) as compared to the other containers (8.5 cm).

Heights averaged 31.2 cm and ground-line diameters averaged 5.1 mm for site #2. Cell size affected both heights (P>F=0.04) and diameters (P>F=0.001). Both height and diameter were greater for seedlings grown in the Super Cells. Seedlings grown in the IFSCO-67 trays had the least growth. The extra fertilization in October did not affect first year heights or diameters.

Significance to Industry: The initial survival and growth of pine seedlings is an important concern for both the public as well as growers. Container grown seedlings are often selected when performance of bare-root seedlings is less than desired. To remain competitive with less expensive bare-root stock, growers must keep production costs to a minimum while producing seedlings that outperform bare-root stock. These data suggest that with regards to 5-month-old container seedlings, wide spacing between cells does not improve early field performance of loblolly pine.

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Table 1. Effect of container size, spacing, and additional nitrogen fertilizer on seedling morphology of 5-month old seedlings.

Container	Spacing	Fertilizer	RCD	Length		Dry mass	
				stem	root	root	shoot
			mm	- - - - cm - - - -		- - - - mg - - - -	
IFSCO-40	full	operational	2.0	19.6	14.7	292	471
	half	operational	2.3	20.7	15.2	378	581
	quarter	operational	2.0	18.4	15.0	257	437
	full	additional N	2.0	21.0	15.3	246	467
	half	additional N	1.9	18.3	15.1	254	448
	quarter	additional N	1.8	15.8	16.6	190	317
IFSCO-67	full	operational	2.2	22.6	17.1	360	555
	half	operational	2.4	20.0	20.9	347	534
	quarter	operational	2.2	19.8	16.2	451	562
	full	additional N	2.1	22.6	19.2	350	560
	half	additional N	2.3	21.3	16.8	498	587
	quarter	additional N	2.1	18.5	14.9	379	483
Super Cell	full	operational	2.7	22.1	22.3	736	840
	half	operational	2.4	20.1	23.2	431	575
	quarter	operational	2.3	20.2	22.1	513	527
	full	additional N	2.2	17.9	22.9	361	406
	half	additional N	2.1	17.6	23.1	352	391
	quarter	additional N	2.2	18.3	23.7	349	439

Table 2. Effect of container size, spacing, and additional fertilizer on first-year field performance of Pinus taeda on site #2.

Container	Spacing	Fertilizer	Survival	Height	Diameter
			- - % - -	- - cm - -	- - mm - -
IFSCO-67	full	operational	80	30.3	4.7
	half	operational	75	30.2	4.6
	quarter	operational	54	28.7	4.7
	full	additional N	72	30.3	4.8
	half	additional N	89	30.6	4.8
	quarter	additional N	61	27.1	4.3
IFSCO -40	full	operational	69	32.5	5.3
	half	operational	76	30.3	4.9
	quarter	operational	69	32.8	5.4
	full	additional N	61	31.7	5.1
	half	additional N	72	30.2	4.9
	quarter	additional N	76	30.7	4.9
Super cell	full	operational	89	35.8	5.9
	half	operational	69	31.4	4.8
	quarter	operational	89	30.5	5.3
	full	additional N	78	36.9	6.0
	half	additional N	86	32.0	5.4
	quarter	additional N	89	30.8	5.4

Use of Biobarrier for Control of Rooting-Out in Pot-In-Pot Production Systems

John M. Ruter
Georgia

Nature of Work: Production of trees and shrubs in containers offers a number of production and marketing advantages over field-grown plants. One problem associated with production of container-grown plants is exposure of root systems to extreme temperatures. Roots are not as hardy as above-ground plant parts thus extreme temperatures limit production of plants produced in containers. Root systems of plants growing in the soil are insulated and thus are not exposed to large fluctuations in root-zone temperatures, which commonly occur in container-grown plants.

The pot-in-pot (PIP) production system was designed by Lancaster Farms to address some of the problems associated with the production of container-grown trees (1). With the PIP system, a holder or socket pot is permanently placed in the ground. A container-grown plant is then placed inside the holder pot during the production cycle. Root systems are protected from extreme temperatures and problems with plants blowing over are reduced when the PIP system is used. Production system had no effect on shoot growth but increased root dry weight of two species produced PIP (2).

A shortcoming of the PIP system has been the growth of roots out of the planted container, through the holder pot and into the surrounding soil (1,2). Biobarrier is a permeable geotextile fabric with trifluralin (Treflan) impregnated nodules bonded to the fabric which is used to control root growth. The purpose of this study was to evaluate the effectiveness of Biobarrier on preventing rooting-out problems with ‘Acoma’ crape myrtle produced PIP.

The experiment was conducted at the University of Georgia Coastal Plain Experiment Station in Tifton. Uniform liners of *Lagerstroemia indica x fauriei* ‘Acoma’ were potted in #7 containers in March 1992. Potting medium consisted of pine bark and sand (6:1 by vol) amended with Micromax (1.5 lb/yd^3) and dolomitic limestone (5.0 lb/yd^3). Plants were topdressed with Osmocote 18-6-12 at 5.3 oz per container in March and 2.6 oz in August, 1992. Holder pots (#7) were placed in the ground with 1 in at the top of the container remaining above grade. Containers planted with ‘Acoma’ crape myrtle were placed in holder pots for the duration of the study. Plants were irrigated daily using low volume spot spitters at the rate of 1.0 gal per container.

The experiment was a completely randomized design with seven single plant replicates. Treatments were a control or a piece of Biobarrier (18 in by 18 in) placed between the planted container and the holder pot with the beads facing the planted container.

Data taken at termination of the study in October 1992 included plant height, growth index [(height + width1 + width2 (perpendicular to width1))/3], shoot dry weight, root dry weight inside the planted container, and root dry weight outside the planted container but within the holder pot. Data were analyzed using SAS with mean separations by LSD.

Results and Discussion: Control plants were taller (21 in) than plants grown with Biobarrier (17 in). Treatment had no effect on the growth indices of either treatment. Shoot dry weights of plants grown with the Biobarrier treatment were reduced 33% compared to control plants.

Root dry weight inside the planted container was not influenced by treatment. Root dry weight between the planted container and the holder pot was influenced by treatment. For the control, 7.1% of the combined root dry weight (root dry weight inside the planted container + root dry weight between the planted container and the holder pot) was found outside of the planted container but within the holder pot. In contrast, only 0.2% of the combined root dry weight was outside the planted container for the Biobarrier treatment. Compared to the control, the Biobarrier treatment reduced combined biomass (shoot dry weight + combined root dry weight) by 23%.

At harvest, control containers had to be removed with assistance of a tractor-mounted boom lift. Roots as large as 0.8 in. in diameter grew out holes in the holder pot into the surrounding soil. With the Biobarrier treatment, most containers had a large mass of white roots at the bottom of the planted container with only a few small roots growing out into the airspace between the planted container and the holder pot. When a very tight seal occurred between the planted container and the holder pot, roots at the bottom of the planted container were dead. Root damage inside the planted container when a tight seal occurred was probably due to higher concentrations of trifluralin herbicide vapors being trapped in the airspace between the planted container and the holder pot.

Significance to Industry: Biobarrier effectively eliminated the rooting-out problem with 'Acoma' crape myrtle. However, a the rate used (234 nodules/pot), a reduction in plant growth was noted. Preliminary research indicates that 32 nodules/pot may work on some species grown in #15 containers (Harold Harned, personal communication). Research is currently under way to evaluate different concentrations of Biobarrier on different plant species and container sizes. Pre-cut pieces of Biobarrier (32 nodules) for use in PIP production systems should be available from Reemay, Inc. (Old Hickory, TN) in the near future.

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Supraoptimal Root-Zone Temperature Influences Medium Solution Composition

Ronald F. Walden and Robert D. Wright
Virginia

Nature of Work: When an ammoniacal N source is applied to a pine bark medium, the predominant form of N in the medium solution is largely determined by the rate of nitrification (biological conversion of NH_4^+ to NO_3^-) which is influenced by several environmental factors, including medium temperature and pH (1). Medium temperatures in containers exposed to direct solar radiation can exceed 104°F for up to 6 hours/ day (5). In pine bark, continuous exposure to 104°F inhibited nitrification (7). Chemical inhibition of nitrification in a pine bark medium lowered the level of Mn in several species of woody plants (6). Other researchers have found similar effects on the Mn concentration in plants grown with fertilizer regimes high in NH_4-N (3,4). Heat-induced inhibition of nitrification may increase the ratio of NH_4-N:NO_3-N in the medium solution of nursery containers. Reduced concentrations of Mn have often been observed in the chlorotic tissue of apparently heat-stressed plants in Virginia (8), especially when urea ammonium nitrate (UAN) was the principle N source. The objective of this research was to determine the effect of supraoptimal root-zone temperature on the medium solution composition and Mn content of *Ilex crenata* grown in a pine bark medium supplied with UAN.

Unlimed pine bark and pine bark amended with 10 lbs dolomitic limestone/yd^3 was irrigated biweekly with a solution containing 100 ppm N as $(NH_4)_2SO_4$ in order to stimulate nitrification. After 10 weeks, rooted cuttings of *I. crenata* Thunb. 'Helleri' were grown in this media in a heated greenhouse in 1-qt containers at two root-zone temperature regimes (unheated or heated to 104°F for 6 hours/day) and three weekly N application rates (200, 400, or 600 ppm N as UAN). Nitrogen treatment solutions also contained 20 ppm P, 50 ppm K, and micronutrients (4). Medium solution extracts (VTEM) were obtained after the initial fertilizer treatment application and every 2 weeks thereafter. Medium solution pH and the concentrations of NH_4-N and NO_3-N were determined for all extraction dates. Medium solution Mn concentrations were determined on days 40 and 80. After 12 weeks, plants were harvested for determination of shoot and root dry weights and the Mn content of the shoots.

Results and Discussion: Shoot and root growth of *I. crenata* was decreased by root-zone heating and by limestone addition. There were no influences of N application rate on growth. In unlimed media, pH increased from the initial extraction date to a maximum on day 40 and declined thereafter, but remained higher in the heated media. The increase in pH was greatest at the highest N application rate and likely due to hydrolysis of applied urea to ammonium (1). In limed media, pH gradually declined but remained higher in the heated medium regardless of limestone addition. The rate of pH decline in limed media was greatest at the highest N application rate.

The influence of root-zone temperature and limestone addition on concentrations of NH_4-N and NO_3-N was similar over all levels of nitrogen application. Limestone addition resulted in a lower medium solution ratio of NH_4-N:NO_3-N, whether heated or unheated. After day 40, the ratio of NH_4-N:NO_3-N was higher for the heated/unlimed treatment than for the unheated/unlimed treatment.

Root-zone temperature had no influence on the concentration of Mn in the medium solution extracted on day 40 but did influence Mn concentration by day 80, primarily through its effect on medium solution pH. The pH of the medium solution and medium solution Mn concentration were negatively correlated on day 80. High medium solution pH and low Mn concentrations were generally associated with heated treatments. Final shoot tissue Mn concentrations were negatively correlated with medium solution pH.

In this experiment, heating of the container medium to 40C for 6 hour/day proved sufficient to increase the medium solution NH_4-N:NO_3-N ratio in unlimed media, presumably by inhibiting nitrification. The NH_4:NO_3 ratio in limed media was lower than that in unlimed media, regardless of root-zone temperature treatment. That is, limestone addition to a pine bark medium promoted nitrification, even at supraoptimal medium temperature. Results also suggest that when N is supplied as urea, medium temperature can influence plant absorption of Mn through its direct effect on nitrification and subsequent effect on medium solution pH. The increase in pH due to urea hydrolysis or limestone addition was counteracted to a lesser extent in the heated medium by the acidity generated by nitrification or plant absorption of NH_4-N than were corresponding pH increases in the unheated medium. Higher medium pH resulted in lower medium solution Mn concentrations and, subsequently, lower tissue levels of Mn, when the medium was heated. These effects could account for the lower Mn levels observed in apparently heat-stressed container-grown nursery plants fertilized with N sources which contain significant amounts of urea-N. Additionally, higher ratios of NH_4-N:NO_3-N in a container medium where high root-zone temperature has decreased nitrification may further reduce plant absorption of Mn.

Significance to Industry: Use of fertilizers with an N source containing no urea and no more than 50% NH_4-N for production of container grown woody plants in Southern nurseries may reduce the incidence of chlorosis due to Mn deficiency or ammonium toxicity induced by high root-zone temperature.

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Substrate Temperatures in Above and Below-Ground Containers in a Pot-in-Pot System

Al Hight and Ted E. Bilderback
North Carolina

Nature of Work: Since the 1980's some nurserymen have investigated "pot-in-pot" as a method of tree and shrub production. Advantages include avoiding the thermal heat loading of above-ground containers, eliminating blow-over and utilizing the system as an overwintering technique. Root control and up-front costs are disadvantages.

Exposure of plant root systems to temperature extremes has posed problems for container nursery growers. Root-zone temperatures above 40° C (104° F) have caused root loss and reduced growth (1,2,3). Conversely, roots are the least cold hardy of all plant tissue systems (4). Nursery growers have traditionally relied upon winter protection houses covered with white copolymer film to avoid loss of plant material due to low temperatures.

This experiment was conducted to quantify temperatures in the substrate of above and below-ground containers and in Lerio's Keeper-Uppers to evaluate the pot-in-pot system's ability to moderate high temperatures and provide winter protection. The randomized split-split plot design study with four blocks was hosted by Worthington Farms in Pitt County, North Carolina.

Temperature differentials were recorded via a Campbell Scientific 21X micrologger and thermocouple sensors placed in Acer rubrum 'Red Sunset' trees (J. Frank Schmidt and Sons, Boring, OR) treated with Spin-Out™ (Griffin Corporation, Valdosta, GA) and growing in Hyponex 90% pine bark:10% sand. Six above-ground and six below-ground containers were utilized. One-half of the containers from each group received three irrigation cycles 30 minutes apart that totaled 75% of the one-time "traditional" irrigation. Thermocouple wires were placed in the east and west sides of the containers approximately one inch from the outside edge and six inches below the surface. Thermocouple sensors were also included in the east and west sides of the air space and the bark substrate of containers placed in Lerio's Keeper-Uppers to evaluate their ability to reduce thermal heat loading and provide winter protection. Ambient air temperature was recorded via a thermocouple sensor placed in a shaded box situated in the growing block of trees. Daily maximum and minimum temperatures were evaluated from three time periods: Low Temperature (January); Moderate Temperature (April); and High Temperature (July).

Results and Discussion: During the Low Temperature Period in January when minimum ambient air temperatures of - 6.4° C (20.5° F) were recorded, minimum temperatures in below-ground containers never dropped below 0° C (32° F). The lowest temperature recorded for below-ground containers was 0.2° C (32.4° F) (Fig. 1). Temperatures as low as - 2.8° C (27° F) were recorded in above-ground containers during this same period (data not shown). Minimum temperatures in containers placed in Lerio's Keeper-Uppers fell slightly below 0° C (32° F) but the minimum temperature was much higher than the above-ground containers (data not shown).

Maximum temperatures recorded during the Low Temperature Period in below-ground containers and those placed in Lerio's Keeper-Uppers were at or below maximum ambient temperature. However, there was considerable fluctuation in above-ground containers. Temperatures in the east side of the above-ground containers rose from -1.7° C (28.9° F) to 21.9° C (71.4° F). During the Moderate Temperature Period in April no temperatures below 0° C (32° F) or above 40° C (104° F) were recorded in any of the containers. Maximum temperatures in the below-ground containers remained at or below maximum recorded ambient air temperature while minimums were 4 to 5° C (7 to 9° F) higher than minimum ambient air temperature. Maximum temperatures in the above-ground containers were 4 to 10° C (7 to 18° F) higher than maximum recorded ambient temperature and minimum temperatures were 3 to 4° C (5 to 7° F) higher than minimum recorded ambient temperature. Maximum temperatures recorded in containers placed in Lerio's Keeper-Uppers followed a pattern similar to the above-ground containers where maximum temperatures were 4 to 5° C (7 to 9° F) higher than ambient. Minimum temperatures followed ambient temperature fairly closely with the Keeper-Upper minimums generally slightly lower than above-ground containers.

During the High Temperature Period in July the maximum ambient temperature recorded was 43.1° C (109.6° F). The maximum temperature recorded in the below-ground containers was 36.5° C (97.7° F) (Fig. 2). In the above-ground containers maximum temperatures exceeded 40° C (104° F) each day during the period ranging 1 to 6° C (2 to 11° F) higher than maximum ambient temperature (Fig. 3). Maximum temperatures recorded in Lerio's Keeper-Uppers were similar to those for the above-ground containers. Because of the black color and the angle of the side walls air temperatures as high as 50.5° C (122.9° F) were recorded between the side walls and the growing container.

Significance to the Industry: Based on these data the pot-in-pot system for growing trees and shrubs in below-ground containers does reduce thermal heat loading enough to avoid root-damaging temperatures above 40° C (104° F). Healthier and more vigorous root systems impose less stress on the plant allowing for more uniform growth and fewer pest problems; especially on heat-sensitive species such as Prunus laurocerasus 'Otto Luyken'. (personal observation)

Minimum temperatures six inches below the surface of the bark substrate remained slightly above freezing indicating adequate winter protection. From visual observations about one inch at the top of the substrate froze but this did not affect the survivability of the plants.

Plants growing in containers placed in Lerio's Keeper-Uppers were subjected to high summer temperatures similar to those in above-ground containers indicating no reduction of thermal heat loading. Changes in the design of the Keeper-Upper (color, ventilation for improved air exchange, side wall angle, etc.) could alter these results. During the winter the Keeper-Uppers did provide significant buffering of low temperature indicating the potential for use as an overwintering structure.

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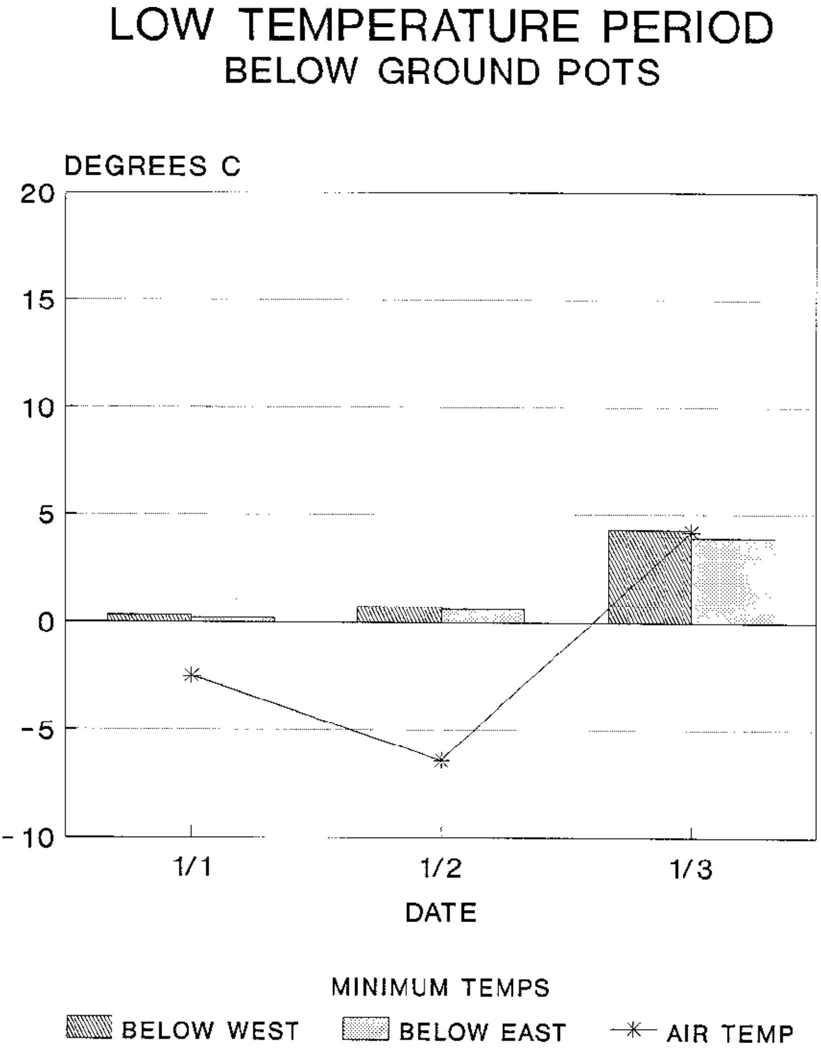
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FIGURE 1.

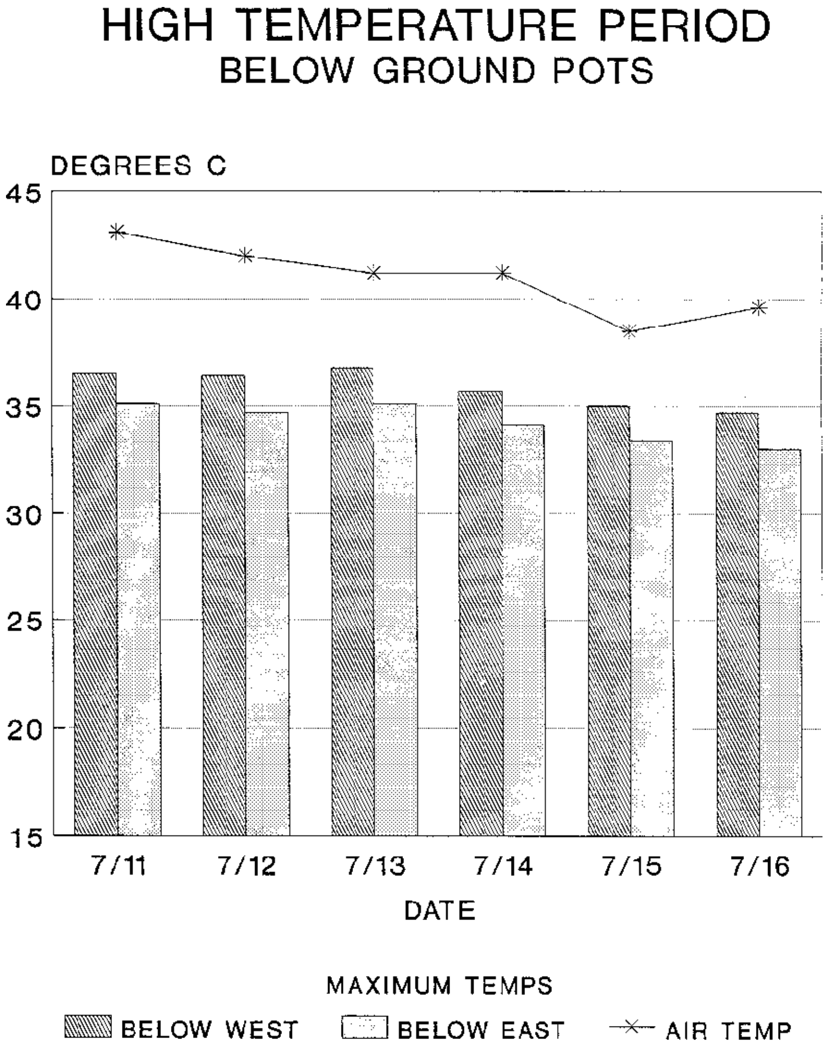
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FIGURE 2.

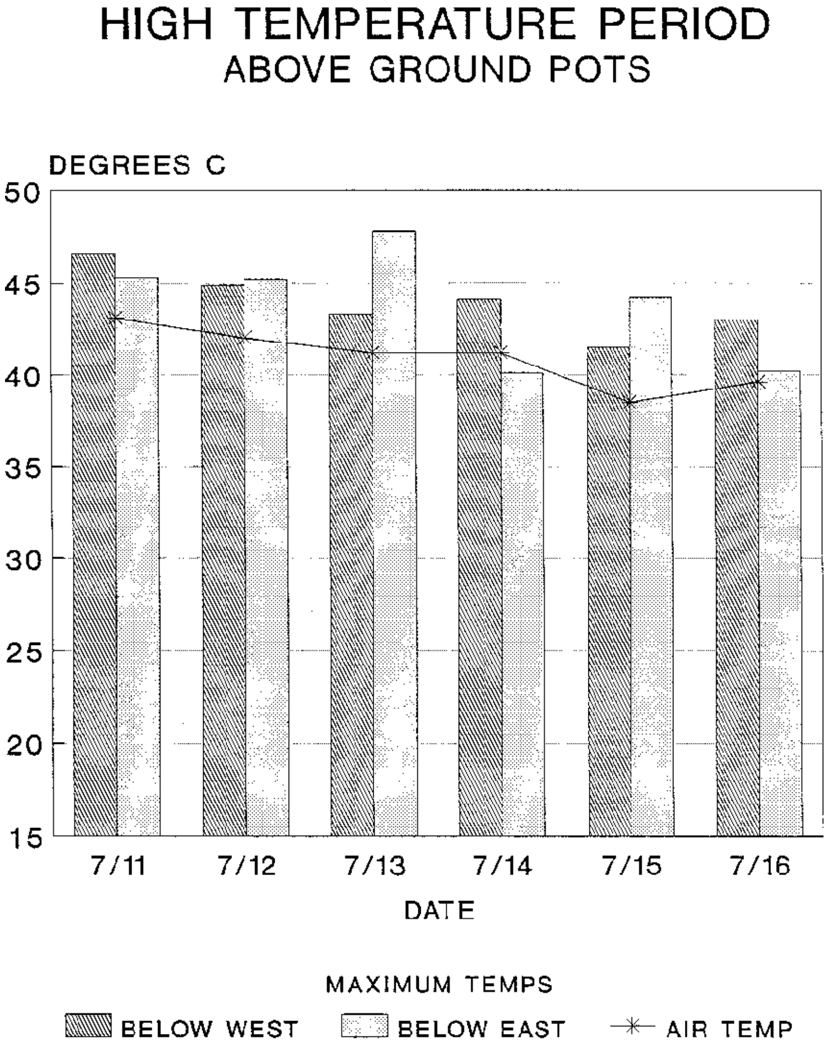
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FIGURE 3.

Initial Growth of Seedlings of Rosebay Rhododendron as Influenced by Day/Night Temperatures

Mark C. Starrett, Frank A. Blazich, and Stuart L. Warren
North Carolina

Nature of Work: Rosebay rhododendron *(Rhododendron maximum* L.) is a well known, native evergreen rhododendron in the eastern United States. The size, texture (3) and late bloom period of this plant make it highly desirable as a woodland shrub. Rosebay rhododendron is well suited for low-light conditions, and flourishes in shaded areas where other plant species of similar habit do not grow well. Salable plants of rosebay rhododendron often consist of wild-collected material (1). To reduce exploitation of native populations and to improve current cultural practices for producing the species, further research is needed on the influence of temperature on growth. Therefore, the objective of this study was to examine the effects of selected day/night temperatures on initial vegetative growth of seedlings of rosebay rhododendron under long-day conditions.

Seedlings were propagated from open-pollinated seed of rosebay rhododendron, collected in Polk Co., Tenn. Seedlings were grown for 2 years in a community flat containing a pinebark medium. Following growth in the flat, seedlings were transplanted individually into l-liter (l.1 qt), black plastic pots containing arcillite [Turface (AIMCOR, Deerfield, Ill.)] and grown in a greenhouse. Two months after transplant, seedlings were transferred to the Southeastern Plant Environment Laboratory (Phytotron) and placed in controlled environment A-chambers (2). The study was a 4 x 4 factorial in a completely randomized design using nine single plant replications per temperature treatment. The two main factors were day temperatures of 18°, 22°, 26°, or 30°C (64°, 72°, 79°, or 86°F) in factorial combination with nights of 14°, 18°, 22°, or 26°C (57°, 64°, 72°, or 79°F). Day temperatures were maintained for 9 h each day and coincided with the daily high irradiance period. Plants were moved between chambers at 8:00 a.m. and 5:00 p.m. daily to maintain appropriate day/night temperatures. During the 9-h high irradiance period, chambers used a combination of cool-white fluorescent and incandescent lamps. Only incandescent lamps (low irradiance) were used to interrupt the dark periods between 11 :00 p.m. and 2:00 a.m. resulting in long-day conditions. Initially, plants were fertilized twice weekly with the standard Phytotron nutrient solution (2). Beginning on week 3, fertilization was increased to three times weekly. Plants were watered with deionized water on the remaining days. After 14 weeks, the study was terminated and the plants separated into leaves, stems, and roots, which were dried at 70°C (158°F) for 72 h. Before drying, total leaf area was measured using a LI-COR LI-3100 leaf area meter (LICOR, Lincoln, Neb.). Dry weight data were utilized to calculate total plant dry weight (sum of leaf, stem, and root dry weight), leaf weight ratio (leaf dry weight: total plant dry weight), root weight ratio (root dry weight: total plant dry weight) and leaf area. Data were subjected to general linear modeling procedures and regression analysis.

Results and Discussion: Dry matter production was influenced by both day and night temperatures (Figs. 1 and 2). Total plant dry weight was lowest at days of 18°C (64°F) and increased to a maximum at 26°C (79°F) (Fig. 1). A similar response occurred for top, leaf, root and stem dry weights (Fig. 1). Nights of 22°C (72°F) maximized total plant, top, leaf, and stem dry weight (Fig. 2).

Leaf area (data not presented) was greatest at nights of 18°C (64°F). Leaf weight ratio (Fig.3) was consistently higher than root weight ratio across night temperatures. This indicates a preferential distribution of dry matter to the leaves during initial seedling growth. As nights increased from 14°C (57°F) to 22°C (72°F), leaf dry weight increased at the expense of roots. Malek et al. (4), noted a similar response in flame azalea *[Rhododendron calendulaceum* (Michx.) Torr.] where gains in leaf weight ratio were accompanied by a decrease in the root weight ratio.

Significance to Industry: Data indicate that optimal seedling growth of rosebay rhododendron can be achieved by utilizing a day/night cycle of 26/22°C (79/72°F) with long day conditions.

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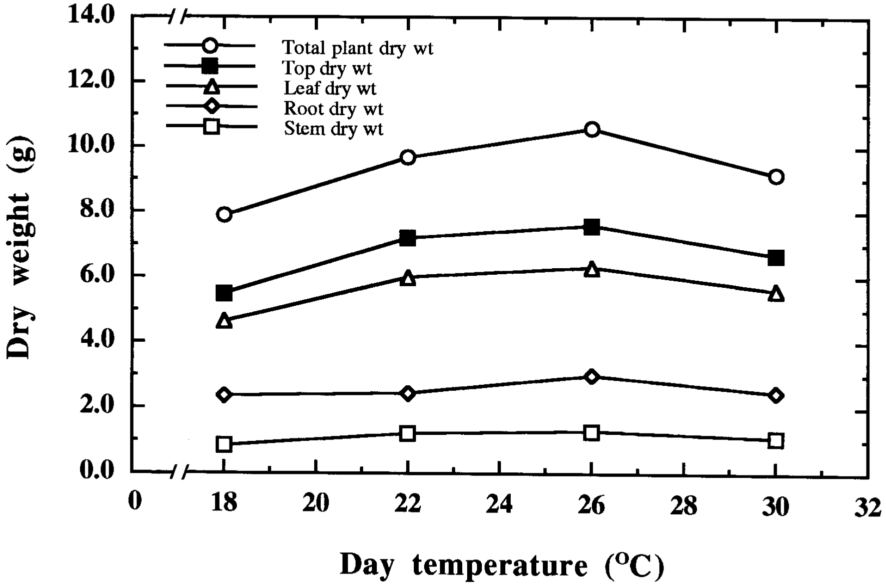

Fig. 1 Effects of selected day temperatures on dry weight during initial growth of seedlings of rosebay rhododendron. Each symbol is the mean of nine observations.

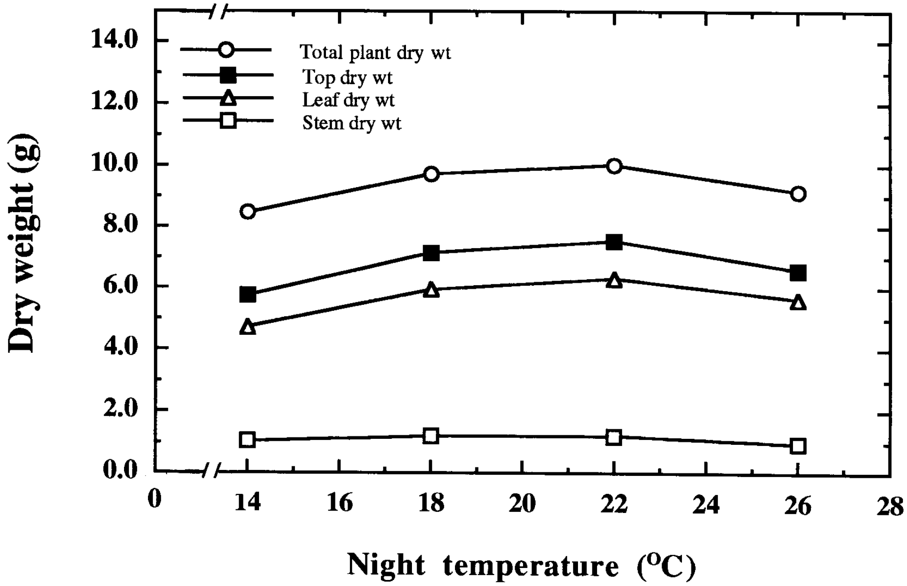

Fig. 2 Effects of selected night temperatures on dry weight during initial growth of seedlings of rosebay rhododendron. Each symbol is the mean of nine observations.

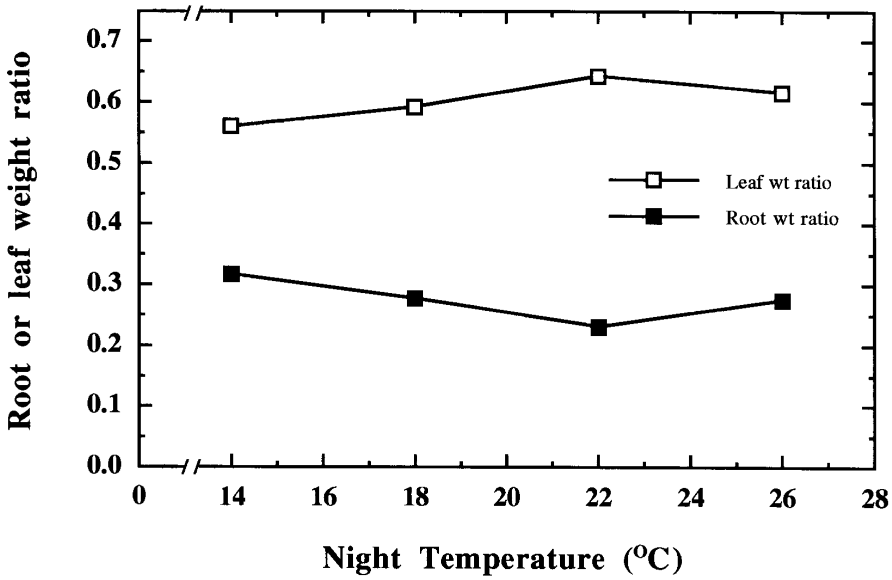

Fig. 3 Effects of selected night temperatures (averaged over all day temperatures) on root or leaf weight ratio during initial growth of seedlings of rosebay rhododendron. Each symbol is the mean of 36 observations

Pruning, Flower and Fruit Removal on the Growth of Magnolia ‘Little Gem’

Adolph J. Laiche, Jr.
Mississippi

Nature of Work: Southern magnolias, *Magnolia grandiflora,* are evergreen trees with large leaves and flowers that can be produced as field-grown balled and burlapped plants or as container plants. The *Magnolia grandiflora* cultivar, ‘Little Gem’ has smaller leaves, flowers and fruit; flowers profusely at an early age, and flowers through the summer until October and November, (1 and 2). Several growers of ‘Little Gem’ suspect that flower bud removal would result in increased growth. The objective of this study was to determine the effects of pruning to remove vegetative shoots, flower buds or fruit on the growth of Magnolia ‘Little Gem’.

Treatments were: 1) not pruned, trees flower and fruit normally; 2) terminal growth bud removed when stem of each flush was 6 inches long; 3) flower buds removed as soon as visible and; 4) fruit removed after flower petal fall. Trees were examined weekly to perform these pruning treatments. An experimental unit consisted of one container plant per treatment. Treatments were replicated 10 times and arranged in a randomized complete block design.

Trees of ‘Little Gem’ in 3 quart containers that averaged 15 inches in height, 0.26 inches in caliper, and 2 to 3 branches per tree were planted in 25 gallon containers on 19 February 1992. The growth medium was 100% pine bark. A mixture of amendments equivalent to 2 lb of dolomitic limestone, 0. 5 lb each of Micromax and 0-20-0 and 1 lb of Stagreen 20-5-10 per cubic yard and control release Osmocote 17-7-12 equivalent to 12 lb per cubic yard were surface applied and incorporated 2 - 3 inches into the growth medium on 20 February 1992.

On 29 March 1993, a mixture of amendments equivalent to 3 lb of dolomitic limestone, 1 lb of 0-20-0 and 1/2 lb of Micromax per cubic yard and control release Osmocote 17-7-12 equivalent to 8 lb per cubic yard were surface applied. The amendment mixture was reapplied at the spring rate and the Osmocote 17-7-12 was reapplied at 1/2 the spring rate on 3 August 1993. The trees were grown in full sun and irrigated with two Aqua-turrent microsprinklers per container as required.

Tree height, width, caliper and number of branches were recorded in November of 1992 and 1993, with shoot fresh weight and root ratings recorded in November 1993. Tree height was measured from the rim of the container. Tree width and trunk caliper were measured in two directions perpendicular to each other and averaged. Trunk caliper was measured 6" above the rim of the container. Number of shoots consisted of all terminal branches with at least one expanded leaf. Trunks were severed at the surface of the growth medium to obtain shoot fresh weight. Roots were rated from 10 (excellent) to o (very poor).

Results and Discussion: Removing flower buds as soon as visible resulted in tallest trees with more branches per tree after both the 1992 and 1993 growing seasons. In 1992, tree width was improved by removing flower buds, but in 1993 widths of trees not pruned and those with flower buds or cones removed were similar (Table 1). Removing flower buds resulted in increased caliper and higher shoot fresh weight after two growing seasons (Table 1).

Slightly poorer root systems were obtained with trees from which cones were removed after petal fall. Tree height, caliper, number of branches and shoot fresh weight after two growing seasons were similar on trees that were not pruned and trees on which vegetative buds and cones were removed (Table 1).

Significance to Industry: Removing flower buds as soon as visible was beneficial, resulting in more vegetative growth of *Magnolia grandiflora* 'Little Gem'. Growers may find flower bud removal a cost effective practice to improve the growth of *Magnolia grandiflora.*

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Table 1. Effects of selected pruning practices on the growth of Magnolia grandiflora ‘Litttlle Gem'. Gem’

Treatment[1]	Height 1992	Height 1993	Width 1992	Width 1993	Number of Caliper 1992	Number of Caliper 1993	Shoot Fresh branches 1992	Shoot Fresh branches 1993	Root weight 1993	rating[2] 1993
	ft		ft		in				(lb)	
Check(not pruned)	3.61c	6.06b	2.44b	3.96a	0.89	1.65b	42.lb	180.8b	13.38b	8.80a
Vegetative buds	3.68cb	6.32b	2.05c	3.66b	0.88	1.58b	41.5b	180.3b	12.65b	9.00a
Flower buds	4.27a	6.83a	2.75a	4.14a	0.95	1.77a	55.6a	205.4a	16.23a	9.20a
Cones	3.94b	6.2lb	2.49b	3.96a	0.93	1.58b	37.6b	173.6b	12.94b	8.10b
F test	**	*	**	*	NS	**	**	*	**	**
LSD	0.28	0.47	0.23	0.27	-	0.09	8.8	22.0	1.41	0.67

1 - Vegetative buds removed when growth flush was 6 inches long; flower buds removed when visible; cones or fruit removed at flower petal l fall..

2 - Root rating - 10-excellent, O=very pooroor.

3 - Means within columns not followed by the same letter differ at the 5% level.level.

Evaluation of Spring and Summer Slow Release Fertilizer Application Rates

Adolph J. Laiche, Jr.
Mississippi

Nature of Work: Information is needed to determine time and rate of slow release fertilizer application to optimize growth and fertilizer use efficiency. In 1974 Osmocote 18-6-12 fertilizer applied at 10 lb/yd^3 in April with a supplemental surface application of 3.3 lb/yd^3 in August resulted in larger and higher quality plants than an April application only. Plant size was similar and quality only slightly increased using higher supplemental rates (2). *Ilex crenata* 'Helleri' fertilized with Osmocote 18-6-12 in March, plus a supplemental application in June or July were larger by October than plants that received no supplemental application or an application in August or September (5). For azaleas fertilized with several slow release fertilizers at 4 rates, growth medium electrical conductivities began to drop sharply 90 days after treatment regardless of fertilizer product or rate (1). In another test with 'Coral Bells' azalea using different slow release fertilizers nutrient levels were not maintained through the production season, indicating mid-season fertilization may be necessary to promote maximum growth (3).

Slow release 24-4-16 manufactured by Purcell Industries, Sylacauga, AL has a 12 month expected release rate. The objective was to evaluate 4 rates of 24-4-16 incorporated in a growth medium in the spring and 3 rates of 24-4-16 surface applied in mid-summer. Spring rates incorporated on 21 April 1992 were 8.3, 12.5, 16.7 and 25 lbs/cubic yard (2, 3, 4 and 6 lbs N/cubic yard, respectively). Rates applied in mid-summer on 3 August 1992 were 0.0, 6.3 and 12.5 lbs/cubic yard (0.0, 1.5 and 3.0 lbs N/cubic yard, respectively). Treatments were arranged in a randomized complete block design with 14 single container plant replicates.

Liners of *Ilex crenata* Compacta' in 3 inch pots were planted in 3 quart containers on 21 April 1992. In addition to the incorporated spring rates of slow release fertilizer, the growth medium of 4 pine bark:1 sand (v/v) was amended with 4 lb dolomitic limestone and 1 lb Micromax per cubic yard. All plants were grown in full sun and irrigated with an overhead system.

Growth data consisted of plant height, averaged width in two directions perpendicular to each other and foliage color (5=excellent-dark green and l=very poor-very light green). Six replications of treatments were sacrificed on 13 October 1992 to obtain shoot fresh weights and root ratings (lo=excellent and l=very poor). The remaining 8 replications were sacrificed on 22 March 1993. Leachates were taken from each treatment with 6 replicates on 1 June, 2 August, and 5 October 1992 and on 14 January and 22 March 1993 to obtain electrical conductivity levels (4).

In mid-March minimum temperatures ranged from 21° to 29°F with about 6 inches of snow recorded at the site. Plants held for spring evaluation were covered with a white polyethylene cover with the only cold damage observed being a slight foliar burn to leaves in contact with the cover.

Results and Discussion: Growth data taken in October 1993 and March 1994 of spring and summer fertilizer applications were generally similar. Therefore, only results obtained on 22 March 1993 are given (Table 1). Plant height increased as spring fertilizer rate increased only with plants not receiving August fertilization. Plant width and foliage color ratings increased significantly from August fertilization. Shoot fresh weight increased linearly from August, but not April fertilizer application. Spring fertilization at 2 and 3 lb of N/yd^3 with subsequent mid-summer fertilization at 3 lb of N/yd^3 resulted in shoot fresh weight equal to or greater than higher spring rates of 4 lb/yd^3 of N plus 3 lb of N/yd^3 in mid-summer and the still higher spring rate of 6 lb of N plus 1.5 or 3.0 lb of N applied in mid-summer. Data of plant height, width and foliage color, in general, also exhibited a similar trend. Root balls of all plants were excellent regardless of fertilizer treatment, (data not shown). Results of this study show the importance of mid summer fertilization.

Soluble salt levels prior to August fertilization increased with higher fertilizer rates as indicated by leachate electrical conductivity measured in June and August (Table 2). Electrical conductivity of growth media increased linearly in October as both April and August fertilizer rates increased. Electrical conductivity ranged from 0.03 to 0.23 in October. Electrical conductivity decreased with time from initiation of this study (April 1992) to its termination (March 1993, Table 2). Electrical conductivity measured 14 January and 22 March 1993 were less than 0.1 for all treatments (data not shown).

Significance to the Industry: Results of this study indicate the importance of mid-summer fertilization. Even with the 12 month slow release 24-4-16, supplemental fertilization was necessary to maintain vigorous growth of plants canned in early spring throughout the growing season. More efficient fertilizer usage was obtained by applying 24-4-16 at rates which supply 2 to 3 lb of N in the spring plus 3 lb of N in mid summer versus comparable rates applied only in the spring.

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Table 1. Effects of nitrogen (N) rate from slow release fertilizer Purcell 24-4-16 incorporated in April and surface applied in August on the growth of *Ilex crenata* 'Compacta'.

Lbs of N	Lbs of N incorporated			
surface applied	2	3	4	6
		Height (cm)		
0.0	30.7g[1]	32.7fg	34.9efg	38.7cde
1.5	38.6cde	37.Odef	36.7def	37.9cde
3.0	48.4a	40.9bcd	42.6bc	43.6ab
		Width (cm)		
0.0	38.5f	41.3ef	45.lbcde	43.2de
1.5	42.4ef	44.6cde	44.7bcde	46.8abcd
3.0	50.3a	49.4a	48.7ab	48.3abc
		Foliage color[2]		
0.0	2.0d	I.9d	2.6c	2.8c
1.5	3.6b	3.9ab	3.9ab	3.9ab
3.0	4.lab	4.3a	4.3a	4.lab
		Fresh weight (grams)		
0.0	135.5g	154.0fg	179.5ef	203.3de
1.5	202.4e	196.3e	229.5cd	232.5bc
3.0	280.5a	257.9ab	246.9bc	242.6bc

1 - Means not followed by the same letter are significantly different according to the LSD (0.05).
2 - Foliage color; 5=excellent, very dark green leaves, l=very poor, light green leaves.

Table 2. Effects of nitrogen (N) rate from slow release fertilizer Purcell 24-4-16 incorporated in April and surface applied in August on the growth medium electrical conductivity (mmhos/cm) of *Ilex crenata* 'Compacta'.

Lbs of N	Lbs of N incorporated			
surface applied	2	3	4	6
		June 1, 1992		
0	.35c[1]	.65b	1.02a	1.16a
		August 2, 1992		
0	.lld	.15c	.19b	.27a
		October 5, 1992		
0	.03d	.04d	.04d	.06d
1.5	.07cd	.07cd	.07cd	.11bcd
3.0	.09cd	15bc	.19ab	.23a

1 - Means not followed by the same letter are significantly different according to the LSD (0.05).

Evaluation of Kenaf Fiber Core as a Component of Container-Plant Growth Media

Adolph J. Laiche, Jr., Steve E. Newman
Mississippi

Nature of Work: Kenaf *(Hibiscus cannabinus* L.) is an annual fiber crop that can be used to manufacture newsprint, as forage for livestock and as poultry litter (4). The bark or outer fiber possesses characteristics favorable for high grade paper used in bibles, cigarettes and fine writing paper. The core, which makes up 60 - 70% of a plant, can be used as an animal bedding and as an oil absorbent (2). Production and use of kenaf fiber will result in availability of a very large quantity of fiber core byproduct, which will require development of market outlets.

Kenaf fiber core could be a satisfactory or superior substitute for currently used growth medium components. The objective of this study was to evaluate growth of woody landscape plants produced with kenaf fiber core or pine bark as the primary organic component in a media. Short-term composting of milled fresh kenaf fiber core was accomplished in 45 gallon containers with drainage holes. Kenaf in the containers was stored outdoors under ambient temperatures. One half lb of N as ammonium nitrate was applied to the kenaf in each container on 1 March, 1 April and 1 May 1992. After each nitrogen application and as required, the kenaf was irrigated to maintain a moist condition. Kenaf not composted was stored dry and only moistened for use five days prior to initiation of this study. Fresh pine bark used in this study was composted for 3 months outdoors under ambient temperatures.

On 27 May 1992, *Ilex crenata* ‘Cherokee’ in 3-inch pots were planted in 1.6 gallon containers in growth media with organic components of pine bark or kenaf fiber core either uncomposted or composted. All organic components were mixed with sand in a 5:1 ratio (v/v). Dolomitic limestone rates of 0, 2, 4, and 8 lb/cubic yard were incorporated in the growth media. In addition, Osmocote 17-7-12 at 15 lb along with MicroMax and 0-20lb each per cubic yard were incorporated in each growth medium. A randomized complete block design was used with treatments of 3 growth media and 4 rates of dolomitic limestone in a factorial arrangement. Treatments were replicated seven times with one container plant as an experimental unit. Data analysis from initiation to 14 October 1992 was from seven replications for plant height and width and growth medium depth, six replications for media pH and electrical conductivity using the Virginia Tech Extraction Method (3) and four replications for shoot fresh weight and root ratings. The study continued with the remaining three replications of treatments to obtain similar data taken on March 23, 1993 when the experiment was terminated.

Results and Discussion: Tallest plants were obtained with composted kenaf at 0 lb/yd3 dolomitic lime. At 2 and 4 lb/yd^3 of dolomitic lime, plants were similar with all 3 organic components, while at 8 lb/yd^3 plant height was significantly less in uncomposted kenaf. In general, composting kenaf fiber core was beneficial. Plants grown in composted kenaf were slightly larger, weighed more, and had slightly better root systems than plants grown in uncomposted kenaf. Plants grown in composted kenaf were generally similar in size and weight to plants grown in pine bark. Visual ratings of root systems of plants grown in pine bark were slightly better than those grown in composted kenaf. Poorest root systems were obtained with uncomposted kenaf.

A quadratic effect was obtained with several variables due to dolomitic lime rate. Taller plants and more growth were obtained as indicated by height in March and fresh weight in both October and March at the 2 and 4 lb/yd3 dolomitic limestone rates. Root ratings in March decreased as dolomitic lime rates increased.

Growth medium depth from the rim of the container increased as dolomitic lime rate increased with uncomposted and composted kenaf, but not with pine bark in October. The increased medium depths were due to shrinkage of the organic components from decomposition and settling (1). A greater increase in growth medium depth was obtained with uncomposted kenaf compared to composted kenaf. The smallest increase in growth medium depth was obtained with pine bark. The increase in medium depth from the rim of the container or sinking of the growth medium in the containers indicated less stability of kenaf fiber core.

In June pH increased with pine bark from 3.8 to 4.9 as dolomitic lime rate increased. The pH with uncomposted kenaf and composted kenaf ranged from 5.6 to 5.8 and 5.2 to 5.3, respectively, regardless of lime rate. In August media leachate pH ranged from 4.6 to 5.1 with slight significant differences among treatments obtained. The media pH for all treatments in October 1992, and January and March 1993, were similar and decreased compared to pH levels in June and August. The pH in March 1993 ranged from 4.1 to 4.3. Soluble salt levels for all treatments, reflected by electrical conductivity measurements in June and August were generally within suggested guide lines for woody ornamentals. Electrical conductivity declined in October and remained low in January and March 1993.

Significance to the Industry: Results of this preliminary experiment using kenaf fiber core indicate that it can be used as a growth medium component to produce woody landscape plants in containers. However additional research with kenaf fiber core is needed on a wide assortment of cultivars of woody ornamental plants to determine its reliability for use in growth media for the nursery industry.

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Efficacy of a Fall Fertilization Program

Gary R. Bachman and Ted Whitwell
South Carolina

Nature of Work: Slow release fertilizers are used by nurseries to maintain adequate levels of nutrition for plants during the year. During the spring and fall, these slow release fertilizers are supplemented with broadcast applications of granular quick release fertilizers to help the plants achieve maximum growth. The importance of adequate plant nutrition in the fall has been reported (Bir et al., 1992; Walden and Epelman, 1992). Broadcast applications of fertilizers or pesticides result in considerable losses due to granules falling between spaced containers, termed nontarget loss. Nontarget loss of granular herbicide from 2.8L (#1) containers spaced container to container, 20 cm (8 in) or 30 cm (12 in) on center was 23, 51 and 80%, respectively (Gilliam et al., 1992). Nontarget losses were similar with both dense and open canopy plants and empty containers (Gilliam et al., 1992).

Nontarget fertilizer loss increases the potential for high concentrations of nitrates in water runoff. Ten ppm nitrate has been set as the maximum threshold for water leaving a nursery. In a six-state container nursery survey of runoff water, most samples were below 10 ppm nitrate but some individual samples were in excess of the drinking water standard (Yeager et al., 1993). Excess nutrients from nontarget losses also provide nutrition to weeds growing in and around nursery beds. Large amounts of fertilizer missing the containers may not be economical. The objectives of this study were to determine fertilization rates, non-target fertilizer losses and plant growth of a fall fertilization program at a large container nursery.

The first part of this study consisted of determining the area of each container size•spacing combination within the nursery. A single fertilizer rate was applied to the individual growing bed data to determine theoretical nontarget losses for each container size•spacing combination up to 3 gallon.

Two container sizes, trade 1 gallon (2.8 l) and 3 gallon, with spacing consisting of cantight for both and square spacing of 1 and 2 ft centers, respectively, accounted for over 67% of the production area. Polyethylene plastic sheets (2 ft x 3 ft) were placed underneath empty containers of each container size•spacing. No containers were placed on 2 plastic sheets in order to measure the broadcast application rate and serve as a control. Granular 14-7-7 fertilizer was broadcast over these empty containers. After application, empty containers were removed and fertilizer remaining on the plastic sheets was collected and weighed. Fertilizer on the empty sheets was collected, weighted and averaged to obtain the application rate. The amount of fertilizer collected around the empty containers was divided by the application rate to determine the nontarget loss of fertilizer. This procedure was repeated three times for each container size•spacing combination. Actual nontarget loss was compared to theoretical calculations.

The second part of the study involved growing different species with alternative fall fertilization treatments. Species included *Pyracantha* x 'Red Mound', *Euonymus fortunei* 'Manhattan', and *Spiraea* x 'Little Princess'. All plants were liners planted in 2.8L containers for a minimum of 8 weeks and were pruned uniformly before treatment applications. Treatments consisted of 7.5 g/container 14-7-7 Special Blend granular, 10g /container 5-10-15 granular, 16g/container MgO, and soluble 20-20-20 with chelated micronutrients at 200 ppm N (16 oz/container) to simulate fertilizer injected into the irrigation water (applied 6, 13, and 20 OCT 93). An unfertilized treatment was included as a control. All treatments were topdressed with the exception of the soluble 20-20-20 which was drenched. There were 5 replications in a RCBD with each treatment topdressed with 7.5 g/container 14-7-7 granular on 15 Feb 94. Dry weight of the above ground biomass and tissue for analysis were sampled on 16 Dec 93 and 5 Apr 94.

Results and Discussion: Broadcast application of fertilizer over the empty containers resulted in nontarget losses of 22.1 and 87.5% for the cantight and spaced one gallon containers, similar to the results that Gilliam reported. Losses for the three gallon containers were 32 and 82.6% for cantight and spaced on 2 ft centers. Total area for the growing beds of the four container size•spacing combinations was calculated (Table 1) and the potential nontarget application loss of fertilizer was determined for each container size•spacing combination. Total nontarget loss was 59.3% of the total fertilizer broadcast and resulted in 48,777 lbs of 14-7-7 granular fertilizer missing the containers and reaching the ground.

All tissue nutrient levels, except Mg in the spring, were similar within each species regardless of fall treatment. When nitrogen was applied in the fall, regardless of formulation, dry weight increased iin the fall only for Spiraea, but for all species by spring. With *Euonymus,* MgO also increased spring dry weight. Fall applied granular 14-7-7 produced higher spring dry weights compared to the soluble 20-20-20 only with Spiraea. Pyracantha and Euonymus had similar spring dry weights among nitrogen treatments.

Significance to the Industry: Fertilizing container-grown landscape plants in the fall enhances initial growth in the spring. However, broadcasting granular fertilizers on container-grown landscape plants is an inefficient method of applying fertilizer. Nurseries using irrigation with fertilizer injectors have another option for applying nutrients during the fall growth period. Since growth was comparable labor savings could be realized from applying soluble fertilizers rather than granular.

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Table 1. Total potential nontarget loss of fertilizer broadcast over 4 container size•spacing combinations at Carolina Nurseries.

Total Area (Sq. ft.)	1,645,620
Total container Area (sq. ft.)	670,075
Average Application Rate (lb/sq. ft.)	0.05 (22.7g)
Total Fertilizer Applied (lb)	82,281
Percent Area Missed	59.3
Nontarget Fertilizer Loss (lb)	48,777

Table 2. Dry weights and tissue analysis of landscape plants fertilized with alternative fall fertilization.

Pyracantha	16 Dec 94					5 Apr 94				
	Wt (g)	N	P	K	Mg	Wt (g)	N	P	K	Mg
14-7-7	28.5	1.72	0.15	1.53	0.15	45.4	2.37	0.27	1.52	0.18
5-10-15	29.0	1.85	0.25	1.48	0.14	48.9	2.28	0.26	1.49	0.14
MgO	25.5	1.59	0.14	1.47	0.22	38.6	2.44	0.29	1.55	0.25
20-20-20	38.1	1.72	0.17	1.31	0.16	50.4	2.45	0.27	1.47	0.18
Control	27.0	1.56	0.15	1.58	0.17	34.9	2.38	0.27	1.55	0.19
LSD (0.05)	6.9	.20	.02	.14	.03	10.1	.36	.05	.22	.04
Euonymus	Wt (g)	N	P	K	Mg	Wt (g)	N	P	K	Mg
14-7-7	64.2	1.69	0.19	1.17	0.21	79.7	2.45	0.29	1.26	0.20
5-10-15	55.4	2.07	0.30	1.47	0.22	77.9	2.75	0.27	1.18	0.19
MgO	46.3	1.73	0.21	1.30	0.20	76.5	2.87	0.27	1.30	0.24
20-20-20	66.6	1.77	0.20	1.31	0.19	72.3	2.61	0.30	1.48	0.18
Control	53.5	1.68	0.18	1.26	0.18	59.6	2.63	0.28	1.43	0.19
LSD (0.05)	26.9	0.38	0.03	0.32	0.09	16.7	0.96	0.06	0.35	0.06
Spirea	Wt (g)	N	P	K	Mg	Wt (g)	N	P	K	Mg
14-7-7	9.8	1.71	0.31	0.84	0.26	17.5	4.11	0.57	1.84	0.37
5-10-15	8.6	1.72	0.52	1.42	0.21	10.5	4.14	0.60	1.91	0.38
MgO	4.8	1.13	0.55	0.99	0.40	7.6	4.49	0.63	2.11	0.52
20-20-20	8.6	3.96	0.38	0.99	0.27	13.2	3.44	0.51	1.87	0.36
Control	5.2	1.05	0.51	1.07	0.31	6.3	4.5	0.64	1.97	0.39
LSD	1.3	1.1	0.14	0.27	0.08	3.77	1.17	0.12	0.23	.09

Growth Response of Sourwood as Influenced by Temperature, Photoperiod, and Media

Frank A. Blazich, Stuart L. Warren, and Mack Thetford
North Carolina

Nature of Work: A preliminary study was conducted at the Southeastern Plant Environment Laboratory (Phytotron) to investigate the effects of temperature, photoperiod, and media on growth of sourwood *[Oxydendrum arboreum* (L.) DC.].

Uniform seedlings in 1 liter (1.1 qt.) containers were placed in controlled-environment A-chambers maintained at 9/15 hr day/night temperatures of 22°/18°C (72°/64°F), 26°/22°C (79°/72°F), or 30°/26°C (86°/79°F) under both short day or long day conditions (1). Long days were obtained by interruption of the 15 hr dark period from 11:00 p.m. to 2:00 a.m. with light from incandescent bulbs. For each temperature-photoperiod treatment (six plants per treatment), half the seedlings were grown in a pine bark medium [<13 mm (0.5 in)] and the other half in Turface, a calcined clay. Plants were fertilized three times weekly with the standard Phytotron nutrient solution (1). On remaining days plants were watered with deionized water. The study was terminated after 12 weeks and top dry weight [dried at 70°C (150°F) for 48 hr] determined.

Results and Discussion: There were no statistically significant interactions among temperatures, photoperiods, and media. For each temperature, plants grown under long days had significantly greater ($P = 0.05$) top dry weight than plants grown under short days. Media had a similar influence on top dry weight with plants grown in pine bark having significantly greater ($P = 0.05$) top dry weight. Greatest top dry weights were realized for plants grown at 26°/22°C (79°/72°F) or 30°/26°C (86°/79°F).

Significance to Industry: Data indicate that commercial production of seedlings of sourwood may be accelerated by utilizing a pine bark medium and a day/night cycle of 26°/22°C (79°/72°F) or 30°/26°C (86°/79°F) with long day conditions.

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Comparison of Three Controlled-Release Fertilizers in Production of New Verbena Cultivars

Allen D. Owings, Peggy Reed, and Traci Compton
Louisiana

Nature of Work: Perennial verbenas (*Verbena* x *hybrida*) are increasing in popularity among home gardeners and landscapers. Six new perennial verbena cultivars are commercially available in 1994. These plants produce large, showy flowers, typical of annual verbenas, on vigorous perennial plants. New cultivars include 'Texas Appleblossom' (hot pink flowers changing to shades of white and pink), 'Homestead' (dark purple flowers with blue overtones), 'Fiesta' (magenta flowers striped with purple, changing to shades of lavender pink), 'Morning Sunrise' (coral pink flowers changing to light pink), 'Summer Blaze' (red flowers), and 'Abbeville' (lavender flowers). Perennial verbenas are recommended through USDA hardiness zone 8.

A completely randomized experiment was initiated March 30, 1994 when 1206 cell pack liners of 'Texas Appleblossom', 'Homestead', 'Fiesta', 'Morning Sunrise', 'Summer Blaze', and 'Abbeville' perennial verbenas were transplanted to trade gallon (1 liner/pot) nursery containers. The medium was pine bark with incorporated amendments of 8 lbs/yd^3 dolomite and 1.5 lbs/yd^3 Micromax. The following fertilizers were topdressed at 1 tsp/pot: Sta-Green Nursery Special 12-6-6, Osmocote 14-14-14, and Nutralene 12-5-9. A control (no fertilizer) treatment was also included. Each treatment was replicated four times. Plants were maintained on a limestone bed canyard in full sun and received overhead sprinkler irrigation.

Visual quality ratings and plant spread were determined June 20, 1994. Visual quality ratings were based on a scale from 1 to 5, where 1=dead, 3=average, salable, and 5=best. Plant spread was expressed as a linear measurement of the greatest shoot width.

Results and Discussion: Comparison of the three controlled-release fertilizers indicated no significant difference in visual quality ratings of 'Texas Appleblossom', 'Homestead', 'Fiesta', 'Abbeville', and 'Morning Sunrise' (Table 1). 'Summer Blaze' verbenas had a higher quality rating when fertilized with Osmocote 14-14-14 when compared to Sta-Green Nursery Special 12-6-6. Plants receiving no fertilizer had unacceptable quality ratings.

Spread of 'Texas Appleblossom', 'Summer Blaze', 'Abbeville', and 'Morning Sunrise' perennial verbenas was affected by fertilizer source (Table 1). Osmocote 14-14-14 produced the greatest spread on 'Texas Appleblossom', 'Summer Blaze', and 'Morning Sunrise', while Sta-Green Nursery Special 12-6-6 produced a significantly greater spread on 'Abbeville' verbenas when compared to Osmocote 14-14-14 and Nutralene 12-5-9. Sta-Green Nursery Special 12-6-6 and Nutralene 12-5-9 were comparable to Osmocote 14-14-14 in some instances in production of 'Texas Appleblossom', 'Summer

Blaze', and 'Morning Sunrise'. Spread of 'Homestead' and 'Fiesta' perennial verbenas was not affected by fertilizer source.

Significance to Industry: Salable trade gallon perennial verbenas are produced in three months. Sta-Green Nursery Special 12-6-6, Osmocote 14-14-14, and Nutralene 12-5-9 (3-4 month controlled-release fertilizers) can be used to produce perennial verbenas. These data indicate that Osmocote 14-14-14 and Sta-Green Nursery Special 12-6-6 performed best in this study; however, Nutralene 12-5-9 or other fertilizers may produce comparable results in some production situations.

Table 1. Evaluation of three controlled-release fertilizers in the container production of new verbena cultivars.

Fertilizer	Quality Rating[1]	Spread (cm)[2]
	'Texas Appleblossom'	
Sta-Green Nursery Special 12-6-6	3.1 a	38.8 ab
Osmocote 14-14-14	3.3 a	45.0 a
Nutralene 12-5-9	3.0 a	33.8 b
Control	2.4 b	14.3 c
	'Homestead'	
Sta-Green Nursery Special 12-6-6	3.0 a	59.8 a
Osmocote 14-14-14	3.6 a	62.0 a
Nutralene 12-5-9	3.1 a	55.5 a
Control	1.9 b	30.0 b
	'Summer Blaze'	
Sta-Green Nursery Special 12-6-6	2.8 b	46.3 ab
Osmocote 14-14-14	3.1 a	47.8 a
Nutralene 12-5-9	3.0 ab	32.8 bc
Control	2.4 c	26.5 c
	'Fiesta'	
Sta-Green Nursery Special 12-6-6	3.1 a	41.3 a
Osmocote 14-14-14	3.1 a	40.8 a
Nutralene 12-5-9	3.1 a	35.5 a
Control	2.4 b	19.8 b
	'Abbeville'	
Sta-Green Nursery Special 12-6-6	3.0 a	61.0 a
Osmocote 14-14-14	3.1 a	51.5 b
Nutralene 12-5-9	3.1 a	37.5 c
Control	2.5 b	21.3 d
	'Morning Sunrise'	
Sta-Green Nursery Special 12-6-6	3.1 a	40.0 ab
Osmocote 14-14-14	3.6 a	46.5 a
Nutralene 12-5-9	3.3 a	31.0 b
Control	2.1 b	17.5 c

Means were averaged over four replications and are separated within cultivars by Duncans multiple range test at alpha=0.05.

[1] Quality ratings based on a scale from 1 to 5 where 1=dead, 3=average, salable, and 5=best.

[2] Spread is expressed as a measurement of greatest shoot width.

Evaluation of Fertilization Practices in Container Production of Mayhaws

Allen D. Owings and Edward W. Bush
Louisiana

Nature of Work: Container production of mayhaw (*Crataegus opaca*) trees has increased significantly in Louisiana over the past several years. This has been primarily attributable to an increased interest in establishing commercial mayhaw orchards. Homeowners and landscapers are also interested in mayhaw as an ornamental plant. Nurserymen producing mayhaw trees in containers are in need of fertilization and lime recommendations that will result in optimum plant growth, while decreasing production time.

A 4 (Osmocote® 18-6-12 rate) x 2 (Micromax® rate) x 4 (dolomitic lime rate) factorial experiment was initiated April 5, 1993 to determine the influence of incorporated application of these nutrient sources on growth of mayhaw seedlings in full-gallon nursery containers filled with pine bark. Each treatment in the completely randomized experiment was replicated 6 times. Uniform liners were obtained from the Louisiana Department of Agriculture and Forestry seedling nursery in Columbia, LA. Osmocote® 18-6-12 application rates were 0, 6, 12, and 18 lbs/yd^3, Micromax® application rates were 0 and 1.5 lbs/yd^3, and dolomitic lime application rates were 0, 5, 10, and 15 lbs/yd^3. Plants were maintained on a limestone canyard in full sun and received overhead sprinkler irrigation.

Visual quality ratings, shoot height, and shoot fresh weight were determined October 11, 1993. Quality ratings were based on a scale from 1 to 9 where 1=dead, 5=salable, 9=best. Height was measured from the medium level to the tallest shoot apex.

Results and Discussion: The addition of Osmocote® 18-6-12, Micromax®, and dolomite increased visual quality ratings, shoot height, and shoot fresh weight of mayhaws (Table 1). Generally, applications of Osmocote® at 12-18 lbs/yd^3 in combination with dolomite at 10-15 lbs/yd^3, and Micromax® yielded plants with significantly higher visual quality ratings, greater shoot height, and greater shoot fresh weight. Dolomite application did not increase growth to the same degree as Osmocote® and Micromax®; however, the increased shoot height and shoot fresh weight in response to dolomite was significant. Plants in the 0 lbs Osmocote®/yd^3 treatments were unsalable because of low visual quality ratings.

Significance to Industry: Osmocote®, Micromax®, and dolomite improved growth of mayhaws growing in full-gallon nursery containers. An Osmocote® 18-6-12 application rate of 12-18 lbs/yd^3 along with recommended application rates of Micromax® (1.5 lbs/yd^3), and dolomite additions of 5-15 lbs/yd^3 will produce salable mayhaws within 6-9 months after potting. It is possible that other fertilizer sources would produce comparable plants .

Table 1. Evaluation of Osmocote® 18-6-12, Micromax®, and dolomitic lime incorporated application rates on growth and visual quality of mayhaws in full-gallon containers.

Application Rate (lbs/yd^3)			Quality	Ht.[2]	Shoot Fresh Wt.
Osmocote®	Micromax®	Dolomite	Rating[1]	(cm)	(grams)
0	0	0	2.3	30.0	4.5
		5	2.2	28.3	3.5
		10	2.3	33.3	5.5
		15	2.3	30.0	4.3
0	1.5	0	2.5	30.0	5.0
		5	2.3	31.7	5.0
		10	3.2	40.0	14.0
		15	2.0	26.7	4.0
6	0	0	5.3	58.3	37.0
		5	5.5	63.3	46.8
		10	2.8	33.3	11.8
		15	2.2	23.3	5.5
6	1.5	0	6.0	63.3	53.7
		5	4.8	71.7	56.8
		10	6.7	65.0	77.3
		15	5.7	48.3	46.3
12	0	0	5.7	70.0	52.5
		5	5.8	58.3	56.2
		10	6.2	61.7	52.3
		15	2.8	31.7	16.8
12	1.5	0	6.2	61.7	62.0
		5	6.5	73.3	64.8
		10	6.7	65.0	77.3
		15	6.8	68.3	85.7
18	0	0	4.7	48.3	34.7
		5	6.2	51.7	50.5
		10	4.0	43.3	21.2
		15	2.7	36.7	11.3
18	1.5	0	5.3	48.3	36.0
		5	5.2	51.7	49.3
		10	5.8	75.0	80.2
		15	7.2	83.3	77.0
LSD (alpha=0.05)			1.5	18.7	22.7

[1] Quality ratings based on a scale from 1 to 9 where 1=dead, 5=salable, 9=best.

[2] Height measured from medium level to tallest shoot apex.

Purple Coneflower Production as Influenced by Incorporated Rates of Osmocote and Dolomite

Allen D. Owings and Peggy Reed
Louisiana

Nature of Work: Container production of flowering perennials continues to increase in the southeastern United States. One plant widely grown for use in Louisiana is purple coneflower (*Echinacea purpurea*). Typically, this plant can be produced for year-round marketing to retail garden centers and landscape contractors.

A 3 (dolomitic lime rate) x 4 (Osmocote 14-14-14 rate) factorial experiment was initiated May 11, 1993 to determine the influence of incorporated application of these nutrient sources on vegetative growth and flowering of purple coneflower produced in full-gallon nursery containers filled with pine bark amended with 1.5 lbs/yd^3 Micromax. Each treatment in the completely randomized experiment was replicated six times. Dolomitic lime application rates were 0, 5, and 10 lbs/yd^3, while Osmocote 14-14-14 application rates were 0, 6, 9, and 12 lbs/yd^3. Plants were maintained on a limestone bed canyard under approximately 30% shade and received overhead sprinkler irrigation.

Visual quality ratings, plant height, and flower number were determined August 10, 1993, three months after experiment initiation. Visual quality ratings were based on a scale from 1 to 5 where 1=dead, 3=average, salable, and 5=best. Plant height was measured from the growing medium surface to the tallest plant part.

Results and Discussion: Purple coneflowers growing in the 9 and 12 lbs/yd^3 Osmocote 14-14-14 application rates had significantly greater quality ratings than plants growing in the lower rates (Table 1). Low, medium, and high recommended application rates for Osmocote 14-14-14 are 6, 9, and 12 lbs/yd^3, respectively. Increasing rates of dolomite from 0 to 10 lbs/yd^3 reduced quality at the 6 lbs/yd^3 Osmocote 14-14-14 rate, however, this trend was not observed at the 0, 9, and 12 lbs/yd^3 Osmocote 14-14-14 rate.

When considering plant height, applications of 6-12 lbs/yd^3 Osmocote 14-14-14, regardless of dolomite application, produced the taller plants (Table 1). Flower production was greatest when plants received 9-12 lbs/yd^3 Osmocote 14-14-14 (Table 1). Flower numbers due to dolomite rate were variable.

Significance to Industry: Salable, high quality purple coneflowers can be produced using Osmocote 14-14-14 at incorporated application rates of 6-12 lbs/yd^3. Dolomitic lime additions, generally, did not improve overall plant performance. Other controlled-release fertilizers or nutrient sources could yield similar results.

Table 1. Evaluation of Osmocote 14-14-14 and dolomitic lime incorporated application rates on growth of purple coneflower.

Application Rate (lbs/yd^3)		Quality	Ht.[2]	Flower
Osmocote	Dolomite	Rating[1]	(cm)	Number
0	0	2.3 c	15.3 cde	0.5 c
	5	2.2 c	20.7 bcde	0.7 bc
	10	2.0 c	13.7 e	1.0 bc
6	0	4.8 a	29.2 abcde	4.3 bc
	5	3.8 ab	27.8 abcde	2.2 bc
	10	3.0 bc	32.3 abcd	2.3 bc
9	0	4.7 a	43.5 a	3.2 bc
	5	4.3 a	46.2 a	8.5 a
	10	4.2 a	37.2 ab	3.6 bc
12	0	4.3 a	34.7 abc	4.7 ab
	5	4.7 a	30.7 abcde	3.7 bc
	10	4.3 a	44.0 a	8.5 a

Means were averaged over six replications and are separated by Duncans multiple range test at alpha=0.05.

[1] Quality ratings based on a scale from 1 to 5 where 1=dead, 3=average, salable, and 5=best.

[2] Height measured from medium surface to the tallest plant part.

Evaluation of Growing Media Composed of Sewage Sludge

Don Wagner and Kevin Tucker
South Carolina

Nature of Work: Composted sewage sludge has previously been recognized as a potentially valuable component for container grown horticultural crops (1,2,3,4). On May 11, 1993, azalea liners *(Mrs. G.G. Gerbing)* were potted in nursery gallon plastic containers filled with growing media treatments of 100% pine bark (PB), 75% PB + 25% sludge (S), 50% PB + 50% S, 25% PB + 75% S, and 100% S. These five media treatments were replicated six times in a randomized complete block design. Osmocote (18-6-12) fertilizer at the suggested rate of one tablespoonful per container was applied.

A second experiment, involving Foster holly liners (growing in 1 qt. plastic containers), was established using the same media as developed for the azaleas with the exception that the hollies were potted in two gallon plastic containers. Osmocote was applied at the recommended rate for two gallon containers . Visual plant ratings (19, with 9 best) were made every two weeks starting on June 11 until the termination of the study on October 4, 1993. A rating of 7.0 or greater was considered consumer acceptable. At termination, plant tops were harvested and prepared for dry weight determinations. Roots were observed and visual evaluations (1-9, with 9 best) were also made at the end of the study. Media pH was determined at the beginning and end of the experiment. It was within an acceptable range for the two test plants.

Results and Discussion: Interpretation of the results through statistical analysis led to these conclusions. Visual ratings (VR) indicated that the azalea plants, grown in 50% PB:50% S media, were best at the first visual rating of the study, but the other treatments caught up two weeks later (Tablel). The trend was for the quality of azalea plants to drop off in the 100% S medium from July through the termination of the experiment. All other media treatments were alike for the duration of the investigation. Root development in the pine bark medium did appear superior in the tests, although the 75PB:25S and 50PB:5OS media were evaluated as being consumer acceptable score of RR=7 or greater (Table 1). Dry weight (g) determinations supported this to the extent that the 50PB:5OS medium produced plants also of the highest grade (Table 1). A parallel study with holly yielded similar results to the azalea work. Visual ratings (VR) indicated that quality went up as the growing season progressed through the first part of July, then dropped off, particularly in the sludge medium (Table 2). Root visual ratings (RR) supported these findings. Plants developed the most roots in the bark medium followed by the 75PB:25S and 50PB:5OS combinations. Pure sludge was again the poorest root growing medium for holly.

Significance to Industry: In summary the poorer growth in the pure sludge and higher S:PB combinations, for both the azalea and holly, was due to the breakdown and compaction of the organic material as has been reported in previous studies. This created a moisture-saturated root environment, limiting the oxygen availability for strong root growth. Since pine bark tends to decompose very slowly as compared to sawdust or other wood products used as bulking agents these problems were not evident in the pine bark mix. Again, some component that will create and retain the qualities of improved drainage and air-filled pore space, throughout the growing season, is needed to improve the sludge medium. It is possible that a greater proportion (greater than 25%) of one or more of the components such as bark could bring about the improved physical conditions that are needed in the sludge. Combining pine bark at a volume of 25% or greater will allow the medium to produce long-term (one growing season) woody plant material of excellent quality, acceptable to the consumer.

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Table 1. Data analyzed for sludge experiment using azalea as the test plant. VR= top visual rating, RR= root visual rating and DRY WT= dry weight. Ratings, 1-9, with 9 best and 7 or greater=consumer acceptable. *Means separation by rows using Fisher's Protected LSD. **Means of six replications.

	PINE BARK	75:25 PB-SL	50:50 PB-SL	25:75 PB:SL	SLUDGE	LSD (0.05)*
VR 6/11	7.3**	7.0	7.8	7.3	7.3	0.4
VR 6/25	7.3	7.3	7.5	7.4	7.2	0.4
VR 7/9	7.3	7.5	7.4	7.4	6.8	0.6
VR 7/23	7.8	7.7	7.4	7.4	6.8	0.6
VR 8/6	7.9	7.6	7.5	7.6	6.6	0.8
VR 8/20	7.9	7.6	7.6	7.8	6.4	0.8
VR 9/3	7.9	7.7	7.4	7.6	6.4	0.8
VR 9/17	8.0	7.7	7.7	7.6	6.4	1.0
VR 10/4	7.8	7.6	7.7	7.6	6.3	0.9
RR 10/4	8.5	6.9	7.0	4.7	1.6	0.9
DRY WT	41.9	37.3	46.5	39.4	27.7	10.4

Table 2. Data analyzed for sludge experiment using holly as the test plant. VR= top visual rating, RR= root visual rating and DRY WT= dry weight. Ratings, 1-9, with 9 best and 7 or greater=consumer acceptable. *Means separation by rows using Fisher s Protected LSD. **Means of six replications.

	PINE BARK	75:25 PB-SL	50:50 PB-SL	25:75 PB-SL	SLUDGE	LSD (0.05)*
VR 6/11	7.0**	7.1	6.9	7.3	7.1	0.5
VR 6/25	7.3	7.1	7.0	7.3	7.3	0 5
VR 7/9	7.5	7.3	7.3	7.3	6.9	0.4
VR 7/23	7.9	7.6	7.7	7.6	7.0	0.5
VR 8/6	7.9	7.7	7.9	7.6	7.0	0.8
VR 8/20	7.9	7.8	7.8	7.8	6.8	1.0
VR 9/3	7.8	7.9	7.9	7.9	6.8	0.8
VR 9/17	7.7	7.4	7.8	7.8	7.0	0.8
VR 10/4	7.7	7.3	7.8	7.8	7.1	0.8
RR 10/4	8.6	7.1	6.4	4.7	2.1	0.8
DRY WT	91	85.4	90.1	92.6	91.9	21.8

Container Production of Hostas in Middle Tennessee

R.J. Sauve, C.J. Catanzaro and J.-T. Ling
Tennessee

Nature of Work: Hostas are shade-loving herbaceous perennials. They have many characteristics that very few hardy perennials can equal. During the last decade, the popularity of hostas has increased proportionally with the multitude of new cultivars that have been developed. More information is needed to improve the efficiency of hosta production in containers.

The objective of this study was to determine the effect of container size on two cultivars of hostas, 'Gold Standard' and 'Golden Tiara'. The experiment, a randomized complete block design, was replicated twice with 10 single-plant replicates. The treatments included 5 sizes of containers: 1) 1-quart, 2) 3-quart, nursery gallon (6" diameter), 3) 3-quart mum pot (8" diameter), 4) full 1-gallon (4-quart), and 5) 2-gallon (6-quart). Divisions were potted in Morton's Nursery Mix, containing 60% pine bark, 20% Canadian peat moss, and 20% sand. Osmocote 14-14-14 at 7 lb/cu yd was incorporated into the mix along with lime and minor elements at recommended rates. Plants were grown under shaded conditions for 12 months. Final data collected included plant number, total leaf number, and fresh weight on a per pot basis.

Results and Discussion: For both cultivars there was a general trend of increased plant growth in larger pots. This trend has been observed with other containerized ornamentals (1,3). Growth of both cultivars was greater in the mum pot than in the 1-quart container. However, growth in the shallow, 3-quart mum pot equalled or exceeded growth in the deeper, 4- and 6-quart containers. Container height is a factor in the growth of containerized pecan (2), and for hostas may be as important as container volume.

Significance to Industry: This research demonstrates that container selection has a significant effect on growth of hostas. Container volume is not the only factor to consider. Container height and thus the ratio of diameter to depth also appear to affect growth. Savings in materials, labor and shipping may be achieved without reducing plant size by growing 'Gold Standard' and 'Golden Tiara' hostas in 3-quart mum pots (8" diameter) rather than 4- or 6-quart containers.

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