SECTION 2
CONTAINER-GROWN PLANT PRODUCTION

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Growth Enhancement of Neem Tree Seedlings with Mycorrhizal Fungi

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Nature of Work: The Neem tree *(Azadirachta indica* Juss. var. *siamensis* Valeton) is of ornamental, revegetation, medicinal and biomass value in India, Burma (Myanmar) and southeast Asia (1,3). The compound azadirachtin, which is derived from Neem seeds, is commercially used for insecticidal properties, i.e. the botanical insecticide Margosan-O® for control of thrips, whiteflies and other insects in nurseries and greenhouses. The Neem tree has a fairly coarse root systems and it was of interest to determine if beneficial soil microorganisms such as vesicular-arbuscular mycorrhizal fungi (VAM) would enhance growth and development, particularly under low phosphorus levels which are characteristic of many soils in southeast Asia. The objective of this research was to determine the effects of the VAM fungi *Glomus infraradices* on the growth and development of Neem tree seedlings grown at low and moderate phosphorus levels.

Materials and Methods: In a 2x2 factorial experiment, 2-month old Neem seedlings were either colonized with the mycorrhizal fungi *Glomus intraradicies* or noninoculated and fertilized with full strength Long Ashton Mineral solution at 11 or 22 ppm P. There were twelve seedlings per treatment. Approximately (10000-20000 spores) were banded in VAM containers, whereas controls received sieved (11 µm) inoculum solution to reestablish background microflora. Seedlings were grown in 2-gallon pots containing fritted clay media. The glasshouse environmental conditions were 30/23 ± 2 C (86/73 ± 3 F) day/night temperature, maximum PPF of 800-900 $\mu mol \bullet m^{-2} \bullet s^{-1}$ and 30-95% relative humidity. The experiment was terminated after 8 months.

Results and Discussion : Mycorrhizal and phosphorus main effects were highly significant (p-value<0.0001) with all growth parameters except the root:shoot ratio. VAM plants had greater leaf number, leaf area, leaf dry weight, shoot and root dry weight than noncolonized seedlings. The moderately higher P (22ppm) level plants had superior growth compared with low P plants. Leaf area and leaf dry weight were similar in mycorrhizal /low P plants and nonmycorrhizal/high P plants. These results suggested that mycorrhizal growth enhancement has important implications for Neem trees which are frequently transplanted into agriculturally poor soils in hot and arid regions.

Significance to Industry: Mycorrhizal fungi can be advantageous in the transplanting and establishment of trees in sites with marginal soil fertility and drought stress (2). This has particular relevance in the Global Relief program for mass planting of trees to help reduce atmospheric CO_2 levels and the potential global warming effect. The Neem is an important economic tree in SE Asia and its insecticidal properties are utilized in "organically produced" pesticides for the nursery and greenhouse industries in Europe and the US. The mycorrhizal enhancement of Neem seedlings has important implications in the production of this tree species under more marginal land conditions.

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Growth Response of 'Convexa' Holly to Dormant Leaf Tissue N Level and Timing of Spring Fertilization

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Nature of Work: It is necessary for producers of most container-grown woody plants to curtail liquid fertilizer application in the early fall in order to avoid a late final flush of growth, which may not have sufficient time for cold acclimation before the onset of freezing temperatures. Although shoot elongation ceases for many woody plants by late summer, shoot dry weight accumulation often continues well into the fall months. In Virginia, 'Convexa' holly has been observed to accumulated over 40% of its seasonal shoot dry weight between mid-Sept and mid-Nov (unpublished data). This continued increase in shoot dry weight, coupled with decreased fertilizer application, can dilute leaf tissue N below levels considered optimum for growth. Since it has been firmly established that the level of N in dormant woody plants strongly influences the time of bud break and magnitude of the first growth flush in the spring (1,2,4,5), the benefit of restoring nutrient levels in the plant prior to winter storage is apparent. Procedures have been developed for reapplication of fertilizer to the container in the fall when air temperatures are low enough to preclude the initiation of a late growth flush in response to N fertilization (6). However, there appear to be no studies which have determined the critical leaf N concentrations resulting from fall

fertilization which would maximize spring growth of woody plants.
The purpose of this study was to determine the spring growth response of Ilex crenata 'Convexa' to dormant leaf N concentrations obtained through fall fertilization, as well as to examine the interactive effects of dormant leaf N concentration and timing of initial spring fertilization on spring growth.

On June 28, 1991, single stem cuttings of Ilex crenata 'Convexa', one cutting per 1 quart container, were placed under intermittent mist in a medium of 5 pine bark :1 sand amended with 4 lbs dolomitic limestone per yd^3. Following root initiation, 320 plants were grown outdoors on a nursery production bed. Fertilization was supplied as weekly irrigation with a 400 ppm N solution of a 21-7-14 fertilizer with micronutrients. Fertilization was discontinued on September 20, 1991 to allow leaf tissue N concentration to decline prior to the initiation of fall fertilization treatments.

On November 10, 1991, plants were placed in an unheated greenhouse and separated into 5 blocks with 5 groups of plants per block. Three times per week, each group of plants received one of the following treatments as a 200 ml irrigation: 1) tap water, 2) 100 ppm N for 2 weeks, 3) 200 ppm N for 2 weeks, 4) 200 ppm N for 6 weeks, or 5) 300 ppm N for 6 weeks. Nitrogen was supplied as 21-7-14. Containers were thoroughly leached with tap water after their treatment period to prevent further increase in leaf tissue N. Treatment application resulted in mean leaf tissue concentrations in the uppermost leaves of 1. 6, 2 . 2, 2 . 6, 3 . 4 and 4 . 3% N on January 2, 1992 . Treatments with the lowest, middle and highest levels of tissue N included additional plants which would receive early spring fertilization. Thus, there were a total of 8 treatments, with 8 plants per treatment replication.

On January 2, 1992, plants were placed in winter storage on a nursery bed under a white polyethylene cover and arranged in a randomized complete block design. The protective cover was removed on March 1 and plants were rated for leaf drop (1-5, 5=no leaves). Early spring fertilization (irrigation with 100 ppm N as 21-7-14, 3 times weekly) began on March 6, 1992. Fertilization for all other treatments began on April 3, 1992. Bud break was evaluated as the number of days from March 1 until the 8 plants in each treatment replication had emerging buds. Plants were rated for chlorosis on May 12 (l-5, 5=necrotic shoots). On May 15, 4 plants per treatment replication were randomly selected for harvest. The number of new shoots was recorded and these shoots were harvested for dry weight determination. The 4 remaining intact plants in each treatment replication were shifted up into 3 gallon containers for harvest in Fall 1992, in order to evaluate the influence of treatment on a full season's growth.

Results and Discussion: Leaf drop increased in significant linear and quadratic response to increasing N in dormant leaf tissue (R^2=0.99; data not shown). No leaf drop was evident when tissue N was 2.6% or lower, while plants with 4.3% N lost more than half their leaves. Chlorosis was not significantly influenced by dormant leaf tissue N (Fig. IA); however, early spring fertilization increased chlorosis at the highest dormant tissue N level. There was a significant linear decrease in days to bud break (Fig. IB) and a linear increase in bud count in response to increasing dormant leaf tissue N (Fig. IC). Early spring fertilization decreased days to bud break when dormant tissue N was 1.6%, but had no effect at higher N levels. Bud count increased in response to early spring fertilization at all 3 levels of dormant tissue N.

New shoot dry weight showed significant linear and quadratic response to increasing dormant tissue N level (Fig. ID). Initial spring growth of 'Convexa' holly responded positively to leaf tissue N levels in the dormant plant which were higher than the critical leaf N level reported for other Ilex crenata cultivars (1.8 to 2.4% N) during a growing season (3). In this study, the critical leaf N level for maximum spring growth of 'Convexa' holly was 3.4% N. Early spring fertilization significantly increased new shoot growth at the lowest dormant tissue N level, but decreased new shoot growth at the highest N level. The timing of spring fertilization had no effect on new shoot growth when leaf tissue in the dormant plant was 2.6% N.

Significance to Industry: These data emphasize the important role of fall fertilization in nursery production programs. Fall fertilization can promote early, vigorous spring growth which may result in greater overall seasonal growth. Knowledge of the leaf tissue N level in the dormant plant is essential for maximizing spring growth, particularly in light of the leaf drop and chlorosis associated with highest levels of dormant leaf tissue N. Results also indicate that the level of dormant leaf tissue N in 'Convexa' holly should influence a grower's decision on when to initiate spring fertilization.

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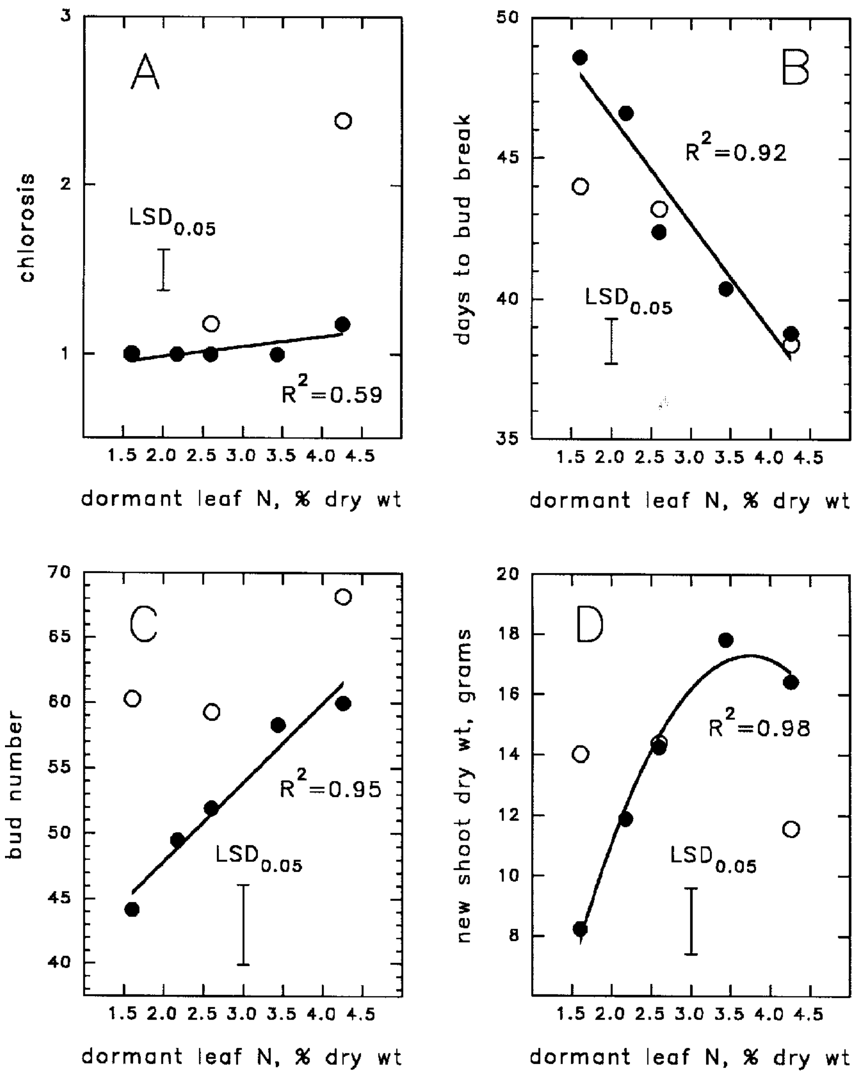

Figure 1. Response of 'Convexa' holly to dormant N level and spring fertilization started on 6 March (O) or 3 April (●). Regression curves are for (●) only.

The Effect of Selected Controlled Release Fertilizers on Azalea Leaf Retention

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Nature of Work: Leaf drop during late fall and winter reduces the perceived quality of some "evergreen" azalea cultivars. Precipitous leaf drop also occurs with these cultivars in landscapes with no adverse effect on plant health. This phenomenon appears to be normal. However, the semi-deciduous appearance of these cultivars has the potential for reducing early spring sales.

Observations suggest that this leaf drop may be due to low foliar nutrient content, particularly in nurseries applying an 8 to 9 month controlled release fertilizer in early spring. Tissue nutrient levels resulting from spring application of these fertilizers may be too low for adequate leaf retention by late fall. The objective of this test was to evaluate fertilizers with differing fertilizer release mechanisms as well as release patterns. All fertilizers were applied at the same nitrogen rate. Effectiveness of treatments was determined by plant growth and development, leaf retention and winter injury.

Well rooted liners of 'Delaware Valley White,' 'Glacier' and 'LaRoche' azaleas were potted into two gallon pots in fall 1990 at Piney Ridge Nursery, Bostic, NC. All three cultivars have a leaf drop problem. The Piney Ridge potting mix is 97% composted hardwood and pine bark plus 3% sand. To each cubic yard 6 lbs of ground dolomitic limestone and 2 lbs of gypsum were added then thoroughly mixed. Since the Purcell fertilizer contained no minor elements, Prostart was added to the media the Purcell treated plants were potted into at the suggested label rate.

Four plants of each cultivar were treated in each of 4 replicates. Following fertilizer application, Ronstar 2G was applied at the rate of 200 lbs/acre then plants were irrigated. All plants were pruned mid-season to encourage branching. A total of 160 plants of each cultivar were treated in a RCB design .

Fertilizers were top dress applied at the rate of 3 or 4 pounds of nitrogen per 100 sq. ft. on April 18, 1991. Fertilizers included in the test were: Purcell 22-4-15 270 RLC, Scott's ProKote Plus 20-3-10, Sierra Customblen 22-4-8, Woodace 20-6-12, and Woodace 18-6-12. The control fertilizer treatment was Scott's SREF II applied at the rate of 2 lbs per 100 sq. ft. This was the standard fertilizer and rate being used at Piney Ridge Nursery.

All plants were measured immediately after treatment to determine a growth index by adding the total height to total width and dividing the sum by two.

November 22, 1991 the same growth measurements were taken with the beginning index subtracted from the season end index. The resulting figure represents total growth for the season. November 26, 1991, a composite foliage sample was obtained from each treatment for 'Delaware Valley White' and submitted to the NC Department of Agriculture laboratory for nutrient analysis. Every two weeks during the growing season then monthly in December thru March soluble salts and pH were determined using VTEM.

Results and Discussion: Growth - Plants fertilized with Purcell, ProKote and the 20% nitrogen Woodace products needed to have less vegetative growth removed during the mid season pruning. However, no quantitative data was collected at time of pruning.

The quantity of growth produced on azaleas 'Glacier' and 'LaRoche' was greater than that produced with the SREF II control for all fertilizers tested (Table 1) regardless of rate. This could be expected since SREF II was applied at a lower rate. For 'Delaware Valley White' all fertilizers except Woodace 18-6-12 produced as much growth as the control treatment without any reduction in plant quality. All plants were well branched and heavily flower budded.

Table 1. Single season growth index for azaleas treated with controlled release fertilizers.

Table 1.		Azalea Cultivar		
Fertilizer		'Delaware Valley White'	'Glacier'	'LaRoche'
Purcell	22-4-15	6.0 a**	9.4 a**	6.0 b**
Prokote Plus	20-3-10	5.1 a	8.9 ab	6.1 ab
Sierra Customblen	22-4-8	5.0 a	9.1 a	6.7 a
Woodace	20-6-12	5.2 a	9.1 a	6.0 ab
Woodace	18-6-12	4.0 b	8.0 bc	6.3 ab
Control		5 .1 a	7 . 2 c	5 .1 c

**RpO1 Duncan's New Multiple Range Test

Soluble Salts and pH - Based on prior VTEM system experience with controlled release fertilizers, we have established the following guidelines: below 25 - insufficient fertilizer; 25 to 75 - adequate fertilizer for normal growth; 75 to 125 - adequate fertilizer for heavy feeders but don't ever let media dry out; over 125 - danger, leaching may be appropriate.

Purcell, Prokote Plus and Woodace 20-6-12 never exceeded 75, the maximum safe conductivity range for salt sensitive plants. During the hottest period of the season, i.e., a combination of hot sunny days, low rainfall and containers not yet shaded by plant foliage, Woodace 18-6-12 at the high rate, Sierra Customblen at the high rate, and SREF II all reached the higher "heavy feeders" range.However, there was no visual sign of injury from these high soluble salts, probably due to the nursery's experience with SREF II. When conditions such as these exist, they are careful to irrigate so that excess salts are leached plus they never allow plants to dry out.

With only SREF II did media solution pH drop below 5.0. No deleterious effect was noted. Leaf Drop - By October some leaf yellowing was apparent in nearly all the 'Delaware Valley White' and 'Glacier', with older leaves turning reddish pink on 'LaRoche' azaleas in the SREF II and lower rate of Woodace 18-6-12 treatment. By late November dramatic leaf drop had occurred in the SREF 11 and Woodace 18-6-12 treatments. Little or no leaf drop had occurred in the Purcell and ProKote Plus treatments with minimal leaf drop in the high rates of Woodace 20-6-12 and Sierra Customblen.

At the commencement of shipping season for garden center sales, i.e., as flower buds were swelling and beginning to show color, each plant was evaluated subjectively for foliage retention. A scale was established in which a rating of 0 indicated that no leaves remained on the plant while a rating of 10 indicated no leaf drop had occurred.

Table 2. Foliage retention as measured on March 28, 1992. 0 = total defoliation, 10 = no leaf drop.

Table 2. Fertilizer	Rate	'Delaware Valley White'	'Glacier'	'LaRoche'
Purcell 22-4-15	3	9.5 a*	7.6 bc*	6.6
	4	9.5 a	8.8 a	8.0 a
Prokote Plus 20-3-10	3	8.7 ab	7.4 bcd	6.9 b
	4	8.1ab	8.3 ab	7.6 a
Sierra Customblen 22-4-8	3	8.2bc	7.1 cd	5.7cd
	4	7.8bc	8.3 ab	7.6 a
Woodace 20-6- 12	3	8 . 1bc	6 . 9cd	4 . 9de
	4	7.5bc	7.6bc	6.7
Woodace 18-6-12	3	4.4d	5.5e	2.1f
	4	5.3d	6.8cd	2.8
Control	2	7.0c	6.6d	4.3e

*RpO5 Duncan's New Multiple Range Test

Tissue Nutrient Levels - Levels of tissue nitrogen appear to correlate well with what was observed in fall leaf drop (Tables 2 and 3). The fertilizers with the greatest leaf drop were SREF II and Woodace 18-6-12. Tissue nitrogen levels were lower where these fertilizers were used.

It should be noted that no tissue nutrient level standards have been established for azaleas in NC container culture. However, for azalea culture in field soil guidelines the Woodace 18-6-12 and SREF levels of tissue nitrogen would have been considered low (below 1.5% N). The levels of phosphorous tissue in the SREF, lower ProKote and both Purcell treatments would also be considered low (below 0.2% P) using these standards. However, these results are interesting for purposes of comparison only since there were no indications of reduced plant growth and vigor or reduction in visual quality of plants in these treatments.

Table 3. Levels of nitrogen, phosphorous and potassium in tissue of Azalea ‘Delaware Valley White’ following treatment with controlled release fertilizers and one full season of growth.

Table 3.

Fertilizer	Rate	% N	%P	%K
Purcell 22-4-15	3	2.32	0.15	0.58
	4	2.57	0.19	0.69
ProKote 20-3-10	3	2.32	0.18	0.72
	4	2.37	0.21	0.75
Sierra 22-4-8	3	2.55	0.26	0.84
	4	2.27	0.23	0.84
Woodace 18-6-12	3	0.99	0.38	0.94
	4	1.15	0.37	0.94
Woodace 20-6-12	3	2.24	0.26	0.88
	4	2.41	0.27	0.85
SREF	2	1.22	0.11	0.82

Summary: No winter injury was observed in any of the treatments in this test.

As far as we know, leaf retention is a cosmetic effect on these cultivars. We are attempting to make a plant more attractive for spring sales but not doing anything to enhance landscape survival or subsequent performance. When evaluating the worst plants in these tests by standards previously applied, they would be deemed healthy and salable. Flower bud set was adequate in all fertilizer treatments as was overall growth. While a difference of one or two inches in a growth index is statistically significant, it should not affect the salability of plants if plants of the same variety were displayed together and no enhanced leaf retention had occured.

Some fertilizer treatments significantly improved the appearance of these winter leaf drop plagued azalea cultivars. A leaf retention rating of 7.5 or higher for ‘Delaware Valley White’ and ‘Glacier’ or 7.0 or higher in the more leaf drop prone ‘LaRoche’ would be likely to influence customer buying patterns if plants were displayed side-by-side in a garden center. Using these standards: (1) ‘Delaware Valley White’ leaf retention was enhanced and might result in improved salability when fertilized at either rate with the

Purcell, ProKote, Sierra or Woodace 20-6-12 products. (2) 'Glacier' leaf retention when fertilized at either rate with Purcell and at the higher rate with ProKote, Sierra and Woodace 20-6-12 was enhanced and might result in improved salability. (3) 'LaRoche' leaf retention when fertilized at only the higher rate with the Purcell, Pro Kote or Sierra product was enhanced and might result in improved salability.

Significance to Industry: The difference in leaf retention when compared to growth is that there was a significant difference due to rate of fertilizer application as well as the fertilizer applied. Therefore, growers wishing to enjoy the benefits of leaf retention on all three of these azalea cultivars, using the same fertilizer on each, would be advised to used the higher application rate of either the Purcell 22-4-15, ProKote Plus 20-3-10 or Sierra Customblen 22-4-8 fertilizers. The determining factors in their use would be (1) availability of the product (2) cost, and (3) suitability for other crops in the overall nursery production program.

Evaluation of High Nitrogen Slow Release Fertilizers

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Nature of Work: This study evaluated the use of slow release fertilizers with analyses of 24-4-6 and 24-4-7 and 17-7-12 (manufactured by Grace Sierra Horticultural Products, Milpitas, CA). High N® 24-4-6 at 70 F° has an expected release pattern of 14 - 16 months and is recommended at 10 - 18 lb/yd$^{3.}$ High N® 24-4-7 at 70°F has an expected release pattern of 12 - 14 months and is recommended at 6 - 12 lb/yd^3. The analysis 17-7-12 at 70°F has a slow release pattern of 12 - 14 months and is recommended at 8 - 16 lb/yd .

Liners of <u>Ilex</u> <u>crenata</u> 'Compacta' and <u>Rhododendron</u> 'Rosea' in 3 inch pots were planted in 4 quart containers 11 April 1991. The growth medium of 4 parts pine bark:l part sand (v/v) was amended with 4 lb of dolomitic limestone and 1 lb of Micromax/yard^3. Fertilizer rates with the three complete fertilizers were 1.25, 2.00, 2.75, 3.50 and 4.25 lb of nitrogen/ yard^3. A randomized complete block design was used with treatments in a factorial arrangement of 3 complete fertilizers at 5 nitrogen rates, Table 1. Treatments were replicated six times and each cultivar was analyzed separately where each plant represented an experimental unit. All plants were grown in full sun and irrigated with an overhead system.

The study was terminated on 11 October 1991. Growth data taken for statistical analysis included plant height and width, shoot fresh weight and visual root quality ratings. Plant height was taken from the rim of the container, plant width was taken in two directions perpendicular to each other and averaged. Shoots were severed at the surface of the growth medium to obtain fresh weight. Visual root ratings were from 10 (excellent) to 0 (very poor). Soluble salt and pH levels of the growth medium of container-grown Ilex crenata 'Compacta' were taken on 1 July and 9 September 1991 from leacheates using the Virginia Tech Extraction Method (4).

Results: There was an interaction between fertilizers and rates on the plant height of Rhododendron 'Rosea', Table 1. With 17-7-12 Azalea 'Rosea' at the 1.25 N rate plants were taller than those at the 3.5 and 4.25 N rates. With 24-4-6 plants at the 1.25 rate were shorter than plants at the 2.75 N rate. With 24-4-7 plants at the 3.5 N rate were taller than plants at the 2.75 N rate. Shoot width, fresh weight and root ratings of Rhododendron 'Rosea' were not affected by the three fertilizers used in this study, Table 2. Significant main effects due to complete fertilizers were obtained on root ratings, but not on shoot height, width and fresh weight of Ilex crenata 'Compacta'. Although most root evaluation ratings were excellent, slightly lower root ratings were obtained with 24-4-6 compared to 24-4-7 fertilizer, Table 3.

Increases due to nitrogen rate on plant height and root quality with Ilex crenata 'Compacta' were not obtained, Table 3. Plant width increased linearly with Rhododendron 'Rosea', and linearly and quadratically as nitrogen rate increased with Ilex crenata 'Compacta'. Shoot fresh weight and root ratings increased linearly as nitrogen rate increased with Rhododendron 'Rosea', Table 2. Shoot fresh weight increased linearly as nitrogen rate increased with Ilex crenata 'Compacta', Table 3.

Slight, but significant, differences due to complete fertilizers on pH and soluble salt levels of the growth medium were obtained from leacheates taken 1 July l991, but not 9 September 1991 with Ilex 'Compacta', Table 3. Growth medium leacheates taken 11 weeks (1 July 1991) and 17 weeks (9 September 1991) after planting indicated that pH decreased as nitrogen rate increased and soluble salt levels increased as nitrogen rate increased, Table 3. Very low soluble salt levels were obtained with all treatments 17 weeks after planting indicating low availability of nutrients late in the growing season.

Five landscape plant cultivars were fertilized in the spring of 1974 with a slow release fertilizer. Increased plant size and improved quality were obtained by applying additional slow release fertilizer in late summer (2). Plants receiving supplemental fertilizer at a rate of at least 3.33 lbs of 18-6-12/yd^3 retained more leaves and had better foliage color than plants not receiving a late summer fertilizer supplement. Work by others also shows that low nutrient levels late in the growing season indicate that reapplication of slow release fertilizer may be necessary to avoid a loss in plant growth and quality (1, 3 and 5).

In summary, the results of this study showed that plant growth as measured by plant height, width, fresh weight and root ratings was similar regardless of complete fertilizer. Growth did not increase as rate increased with Rhododendron 'Rosea' at rates higher than 3.50 lb/yd whereas, with Ilex 'Compacta' an increase in shoot fresh weight was obtained at the 4.25 lb/ yd^3 rate.

A substantial savings in fertilizer costs may be possible by using a high nitrogen slow release fertilizer. For example, at a rate of 3.50 lb of nitrogen/ yd^3, 20.6 lb of 17-7-12 will be required compared to only 14.6 lb of formulation of either high nitrogen slow release fertilizer evaluated in this study to produce plants of similar size and fresh weight in one growing season.

Significance to Industry: Very low soluble salt levels were obtained with all three fertilizers late in the growing season indicating low availability of nutrients and supplemental fertilizer application may be required to avoid a possible loss in growth. Also, the use of high nitrogen formulations of slow release fertilizer may be more cost-effective than formulations containing less nitrogen per pound of fertilizer.

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Table 1. Interaction of slow release fertilizer and nitrogen rate on the height of Rhododendron 'Rosea'.

Number	Complete Fertilizer formulation	Fertilizer Rate (lb/cu yd)	Nitrogen Rate (lb/cu yd)	Height (cm)
1	17-7-12	7.35	1.25	54.3ab[1]
2	17-7-12	11.76	2.00	50.5abcdef
3	17-7-12	16.18	2.75	49.Oabcdef
4	17-7-12	20.59	3.50	43.7f
5	17-7-12	25.00	4.25	44.8ef
6	24-4-6	5.21	1.25	45.3def
7	24-4-6	8.33	2.00	53.0abcd
8	24-4-6	11.46	2.75	53.3abc
9	24-4-6	14.58	3.50	52.3abcde
10	24-4-6	17.71	4.25	45.7cdef
11	24-4-7	5.21	1.25	53.8ab
12	24-4-7	8.33	2.00	53.5ab
13	24-4-7	11.46	2.75	48.0bcdef
14	24-4-7	14.58	3.50	56.7a
15	24-4-7	17.71	4.25	55.2ab
F Test[2]				*
LSD (.05)				7.75

l- Means not followed by the same letter are significantly different within slow release fertilizers according to the LSD(0.05).
2- * significant at the 5% level of probability.

Table 2. Effects of slow release fertilizer and nitrogen (N) rate on the width, fresh weight and root growth of container grown Rhododendron 'Rosea'.

	Width (cm)	Fresh weight (g)	Root ratings[1]
Fertilizer			
17-7-12	35.9	233.9	8.0
24-4-6	34.5	223.7	7.9
24-4-7	34.3	231.1	7.4
F Test[2]	NS	NS	NS
LSD (. 0 5)			
Nitrogen Rate			
1.25	31.2d[3]	175.3c	6.9c
2.00	33.7cd	215.5b	7.7abc
2.75	34.7bc	231.3b	7.6bc
3.50	36.9ab	264.4a	8.4a
4.25	38.Oa	261.la	8.3ab
F Test	L ** Q NS	L ** Q NS	L ** Q NS
LSD	3.06	25.1	0.81

1- Rooting rating = 10-excellent, O-very poor.
2- **, *, NS, L, Q = significant at the 1% and 5% level of probability, nonsignificant, linear or quadratic, respectively.
3- Means not followed by the same letter are significantly different according to the LSD(0.05).

Table 3. Main effects of slow release fertilizer and nitrogen rate on shoot and root growth, and growth medium pH and soluble salt (SS) levels of container grown Ilex crenata 'Compacta'.

	Height	Width	Fresh weight	Root rating[1]	Growth medium pH	Growth medium pH	Growth medium S.S.	Growth medium S.S.
	(cm)	(cm)	(g)		7/1/91	9/9/91	7/1/91 (mmhos/cm)	9/9/91 (mmhos/cm)
Fertilizer								
17-7-12	47.8	49.3	237.1	9.3ab	5.05b	5.00	.389a	.079
24-4-6	48.1	48.8	222.7	9.2b	5.21a	5.10	.194b	.060
24-4-7	48.6	51.2	229.8	9.5a	5.27a	5.17	.214b	.042
F Test[2]	NS	NS	NS	*	**	NS	**	NS
LSD(0.05)	--	--	--	.25	.060	--	.038	--
Nitrogen Rate								
1.25	47.0	42.5c[3]	175.8d	9.2	5.42a	5.74a	.113d	.000c
2.00	48.2	49.4b	207.2c	9.5	5.35a	5.29b	.176c	.007bc
2.75	47.5	50.7ab	244.1b	9.3	5.12b	5.19b	.309b	.042b
3.50	49.4	52.7a	245.2b	9.4	5.02c	4.75c	.366a	.110a
4.25	48.7	53.6a	277.1a	9.4	4.98c	4.47c	.363a	.143a
F Test	NS	L **	L **	NS	L **	L **	L **	L **
	NS	Q *	Q NS	NS	Q NS	Q NS	Q NS	Q NS
LSD(.05)	--	2.98	19.37	--	.0768	.2331	.0489	.0383

1-Root ratings = 10-excellent, 0-very poor.
2-**, *, NS = significant at the 1% and 5% level of probability, nonsignificant respectively.
3-Means not followed by the same letter are significantly different according to the LSD(0.05).

Effect of Fertilizer Placement on the Growth of Containerized Woody Ornamentals

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Alabama

Nature of Work: Over 30 years ago Poole and Waters (8) showed that a controlled release fertilizer (CRF) could produce comparable quality woody plants as a water soluble fertilizer. In 1976, Furuta (3) determined that runoff water from a liquid fertilizer regime contained 100 times more nitrogen than a CRF regime. Recent concerns in some areas about groundwater contamination have brought laws regulating the amount of nitrogen permitted in nursery discharge water (11). In addition to reducing fertilizer pollution, the nitrogen recovery from CRF is greater than from liquid fertilizer (4). As more growers have switched to using CRF on nursery crops, researchers have sought to increase CRF efficiency by various application methods such as dibbling (1, 2, 5, 6). Most of the studies have considered granular materials which can be laborsome to apply, misapplied to the ground, inaccurately applied, and delivered to the ground by irrigation or spillage. Preplant incorporation solves many of the loss problems with CRF use, however it has not always resulted in the best plants or most efficient use of a CRF (1, 2, 6, 12). Perforated plastic envelopes and compressed tablets have produced acceptable plants (9) and can be placed in the container to minimize leaching and spillage losses. Recently, the Sierra Chemical Co. has combined the Osmocote™ coating and Micromax™ nutrient technology to produce a 7.5 g tablet (10). Sierra recommends that the tablet be placed or pushed into the media. The purpose of this study was to compare pushing the tablet into the media, surface application of the tablet and a broadcast granular application on the growth of containerized woody ornamentals.

Four separate experiments involving different woody species were conducted outdoors in 1991.

Experiments 1, 2, and 3. Liners of _Camellia_ _sasanqau_ Thunb., x _Ilex_ _aquipernyi_ Gable ex Clarke and _Ilex_ cv. Nellie R. Stevens were potted May 19 (by volume) in a 1 top soil, 1 pinebark, 1 sphagnum peat moss and 1 perlite medium. 'Nellie R. Stevens' plants were grown in 6 liter ("2 gallon") containers, however 1.2 liter ("gallon") containers were used with the other species. Fertilizer treatments applied on May 19 and August 22 were: 1) a 7 . 5 g 16-8-12 (16 . ON-l . 7P-10 . OK) Sierra tablet pushed level with the medium surface, 2) a Sierra tablet placed on the medium surface, and 3) two level teaspoons (approximately 7.5 g) of granular 16-8-12 Sierra fertilizer broadcast on the medium surface. A randomized block design was used in all experiments. Replications for the fertilizer treatments for Exp. 2

(Sasanqua), Exp. 3 (Aquapernyi holly) and Exp. 4 (N.R. Stevens holly) were 6, 5 and 4, respectively . A liquid micronutrient solution (7) containing (ppm) 32 Fe, 5 Mn, 7 Zn, 4 Cu, 3 ppm and 38 Mo was applied on June 25 to assure readily available micronutrients (mostly sulfates) . Plants were mulched with 1. 25-2.5 cm (1/2-1 in.) pea-sized Livite clay granules (American Resource Recovery, Forrest Park, GA 30051). On October 4, plant height, spread or area (diameter measured in 2 directions), branch numbers and quality were measured. The rating index for plant quality was: 0 = dead, 2 = good, 3 = average, 4 = above average and 5 = excellent.

Experiment 4. Liners of Rhododendron cv. Patapsco (Scott's Lavender) were potted in 1.2 liter ("gallon") nursery containers and sheared to 40 cm (8 in.) height on June 2. A 100% pinebark medium was used. Fertilizer treatments (same as Exps. 1-3) were applied on June 19 and August 22. Plants received a liquid microelement solution as in previous experiments on June 25. Data was also collected as in Exps. 1-3 on October 9.

Results and Discussion: Fertilizer treatments did not produce any differences in plant spread, branch numbers, and quality rating (data not shown). With the exception of Rhododendron, the order of best response for these growth parameters was: media inserted tablet, surface applied tablet and broadcast granular. Broadcast granular fertilizer ranked first followed by the tablet treatments in these parameters for Rhododendron, however for plant height azaleas responded similarly to the other species. Tinga (personal communication) has suggested that a highly concentrated tablet might cause irreparable damage in the immediate area of application on fine delicate roots of plants such as Rhododendron. The type and location of roots warrants attention. Significant differences in Rhododendron plant height occurred due to fertilizer treatment (Table 1). Meadows and Fuller (6) have stated that broadcast or dibble applications result in the most efficient use of a CRF on Rhododendron.

Significance to Industry: This work shows that Sierra CRF tablets can be used to produce satisfactory plant growth. Generally, inserting the tablet into the medium resulted in the best results and eliminated the possibility of nutrient loss through spillage. The tablet can be applied to the surface with less labor but greater risk of spillage (can be total) and less satisfactory results may be obtained with some species. Broadcast granular applications are more laborsome to apply than the tablets, resulted in some spillage and generally ranked third in growth performance.

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Table 1. Comparison of fertilizer tablet placement and broadcast granular on the height (cm) of selected woody species.

Material and application method	Species height (cm[2]) Camellia sasanaua	Ilex aquapernyi	Ilex N.R. Stevens	Rhododendron 'Patapsco'
Sierra 16-8-12 tablet				
Pushed to medium surface	58 NS[X]	58 NS	76 NS	51a
Placed on surface	51 NS	57 NS	65 NS	49ab
Sierra 16-8-12 qranular				
Broadcast	54 NS	59 NS	72 NS	44b

[z]Metric conversion 2.5 cm equal 1 inch.

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

[X]NS = not significant.

Commercial Production of Landscape Plants Using Yard Waste Compost

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Florida

Nature of Work: Many states including Florida, have banned yard waste (grass clipping, leaves, branches and other plant debris) from municipal lined landfills. If yard waste is composted, a potential alternative potting mix component is produced. Previous research has shown composted yard waste (CYW) can be used as a potting mix component with plant growth equal to or greater than plant growth in typical nurseries mixes (2, 3, 4). The objectives of this research were to expand the database of landscape plant growth response to potting mixes formulated with CYW and determine if CYW formulated potting mixes could be used in a commercial nursery with normal production practices. *Lagerstroemia indica* L. (crape myrtle), *Ilex vomitoria* Ait. 'Shellings Dwarf' (dwarf yaupon), *Juniperus chinensis* L. 'Parsonii' ('Parsonii' juniper), and *Rhododendron indicum* L. 'Formosa' ('Formosa' azalea), were potted in trade one gallon containers using one of five mixes: (a) Commercial mix (100%), b) Commercial mix: CYW (3:1), c) Commercial mix: CYW (1:1), d) Commercial mix: CYW (1:3) and e) CYW (100%).

Potting mix components were blended on a volume basis. The commercial mix used for crape myrtle, dwarf yaupon and ‘Parsonii’ juniper was formulated with Florida peat, pine bark and sand, while the commercial mix used for the ‘Formosa’ azaleas was formulated with Florida peat and pine bark. The CYW (Wood Resource Recovery, Inc., Gainesville, FL) used was obtained from an in-vessel system which was turned twice weekly for 12 weeks with a Farmer Automatic Compostamatic compost turner. The compost feedstock was a mixture of grass clippings and woody yard waste (1:1) ground with a Farmhand hammermill tub grinder to pass through a 1 inch screen. Moisture content of the composting material was maintained between 50-60% (wet weight basis). Thirty-five liners of each plant cultivar were potted in each mix, and transferred to a full sun nursery production site with overhead irrigation. There were 4 replications of three plants for each treatment arranged in a randomized complete block design. The remainder of the plants were used as border plants. The experiment was initiated on May 4, 1991 and terminated on July 28, 1991. All plants except the ‘Formosa’ azaleas had 1 tsp. of Osmocote 18-6-12 (N, P_20_5, K_20) incorporated per container at potting. All plants except the ‘Formosa’ azaleas were top-dressed with one tbs. of 6-6-6 (N,P_20_5,K_20) on May 4th, June 3rd and July 12th. The Formosa azaleas were fertilized with 1 tbs. of a 4-6-8 (N,P_20_5,K_20) containing Cu (0.1%), Fe (0.7%), Mn (1.2%), Mn (0.2%) and S (3.0%) on May 4th, June 3rd, and July 12th. On June 20th they received 1 tsp. of $(NH_4)_2S0_4$. Height and width (average of two measurements) measurements were taken every two weeks starting May 5th. The growth index at experiment termination was calculated by adding the height and average width and dividing the total by two. All plants were grown at Harrell’s Nursery, Plant City, FL.

Results and Discussion: This experiment shows a differential response by plant species to CYVV as a potting mix component (Table 1). Growth of crape myrtle in potting mixes containing CYW was greater than the growth of crape myrtle in the commercial potting mix used at Harrel’s Nursery. Dwarf yaupon and ‘Parsonii’ juniper did not exhibit any detectable growth differences related to potting mix composition. However, the growth index of ‘Formosa’ azalea was lower in mixes formulated with 75 or 100% CYW than mixes formulated with 0 or 25% CYN. The foliage of ‘Formosa’ azalea plants grown in mixes containing more than 50% CYW was lighter green than foliage of plants grown in the commercial mix. The youngest leaves of some plants grown in 75 or 100% CYW exhibited slight interveinal chlorosis. Broschat (1) has presented data that suggests composted organic matter reduces Mn bioavailability to some plants via formation of organometallic complexes.

Significance to Industry: This experiment demonstrates that CYW can be used as a potting mix component to grow commercially acceptable plants under commercial management practices. However, additional research is needed to determine the factors responsible for the chlorosis and reduced growth rate of 'Formosa' azaleas when grown in potting mixes containing more than 50% CYW.

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Table 1. Growth index of four nursery plants as affected by the use of composted yard waste (CYW) as a potting mix component.

Potting Mix	Formosa Azaleas	Crape-Myrtle	Dwarf Yaupon	Parsonii Juniper
Commercial Mix (1 00%)	23.3a	40.2b	11.9a	13.2a
Commercial Mix: CYW (1 :3)	22.6a	44.3ab	11.8a	13.7a
Commercial Mix: CYW (1:1)	18.0ab	47.0a	11.8a	14.6a
Commercial Mix: CYW (3:1)	14.0b	48.0a	10.8a	13.8a
CYW(100%)	15.0b	47.7a	11.4a	15.1 a

Mean separation within columns by Waller-Duncan K ratio t-test (P = 0.05).

Ground Tea Leaves as a Bedding Plant Medium Amendment

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Nature of Work: Recent efforts have been made in the horticulture industry to utilize agricultural waste materials and manufacturing byproducts as constituents of growing medium. These materials have included composted yard waste (4), poultry litter compost (1), composted wood products (2), and rice hulls (3). In some instances, these materials have been successfully used in media for container-grown plant production. The objective of recent research at Mississippi State University was to determine the suitability of ground tea leaves, a byproduct of tea processing, as a peat moss substitute in the container production of three bedding plant species.

Seeds of 'Better Boy' tomato, 'Inca Gold' marigold, and 'Novalis Scarlet' verbena were sown in a germination medium January 5, 1991. Resultant seedlings were transplanted into 1206 cell trays (1 seedling/cell) January 19, 1991 containing one of the following medium treatments: Metro Mix 360, Peat Moss/Perlite/Vermiculite (1:1:1 v/v/v), Tea Leaves/Perlite/ Vermiculite (1:1:1 v/v/v), Tea Leaves/Perlite/Vermiculite (2:1:1 v/v/v), and Tea Leaves. Eight replications consisting of 1 cell pack were arranged in a completely randomized design. Plants were grown in a quonset greenhouse and fertilized weekly with a 250 ppm N solution of Peters 20-20-20. Visual quality ratings based on a scale from 1 to 4 (1=worst, 2.5=marketable, 4=best) were taken March 4, 1991. Treatment means were separated statistically by Least Significant Differences (LSD) at a=0.05.

Results and Discussion: Incorporation of tea leaves into growing media decreased visual quality ratings of verbena and marigold in all instances (Table 1). 'Better Boy' tomatoes grown in a medium of tea leaves/perlite/ vermiculite (1:1:1 v/v/v) were comparable to those grown in Metro Mix 360 (Table 1). In production of marigold and verbena, substitution of peat moss with tea leaves did not alter visual quality ratings of plants; however, these treatments produced plants that were inferior to those grown in Metro Mix 360. Media containing tea leaves also tended to have added pest problems, primarily an attraction of fungus gnats. Plants grown in medium consisting of only tea leaves died prior to experiment termination.

Significance to the Industry: Incorporation of tea leaves into bedding plant production media decreased plant quality. Considerable additional research needs to be conducted to determine if there is any benefit to utilizing tea leaves in growing media.

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Table 1. Visual quality ratings of three bedding plant species as influenced by growinq medium composition.

Growing Medium	Ratio (by volume)	Verbena	Tomato	Marigold
		Visual Ouality Ratings[z]		
Metro Mix 360	1	2.28 a	3.25 a	3.91 a
Peat/Perlite/Verm.	1:1:1	1.41 b	2.34 b	2.75 b
Tea Leaves/Perlite/Verm.	2:1:1	1.00 b	2.31 b	2.84 b
Tea Leaves/Perlite/Verm	1:1:1	1.16 b	2.66 ab	3.00 b
Tea Leaves	1	1.00 b	1.03 c	1.00 c
	LSD(a=0.05)	0.40	0.80	0.75

[z]Means of visual quality ratings based on a scale from 1 to 4 where 1=worst, 2.5=marketable, and 4=best and separated within columns by LSD (a=0.05).

Predicting NO_3-N Concentrations from Electrical Conductivity Measurements with Controlled Release Fertilizers

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Georgia

Nature of Work: Producers of container-grown plants are faced with water contamination problems due to high concentrations of nutrients in runoff water which result in the waste of fertilizer. Controlled release fertilizers are used to reduce fertilizer application waste when compared to other fertilization systems (1,2). The Virginia Tech Extraction Method (VTEM) is a simple procedure which nursery growers can use to monitor the nutritional status of container-grown plants (4). Data is currently lacking regarding the use of the VTEM procedure with controlled release fertilizers. As a result of experiments conducted in 1990, it was determined that NO_3-N concentrations could be estimated from electrical conductivity measurements (3). The purpose of this paper is to report the application of these findings.

Rooted cuttings of *Ilex x* attenuata Ashe 'Savannah', *Ilex* cornuta Lindl. & Paxt. 'Burfordii', and *Ilex x* 'Nellie R. Stevens' were grown in 2.8 liter (#1) containers and treatments were applied on 7 June 1990 at the Coastal Plain Experiment Station in Tifton, GA. The potting medium consisted of milled pine bark and sand (4:1 by vol) amended with Micromax (Grace/Sierra) at 1.5 lb/cu yd and dolomitic limestone at 6 lb/cu yd. Plants were grown in factorial combinations of three fertilizer sources (Osmocote 17-7-12, Sierrablen 17-7-10, and High-N 24-4-7), three rates of application (1.5, 2.5 and 3.5 lb N/cu yd), and two methods of application (incorporation and topdress) with eight replications.

Plants were irrigated twice daily with 0.5 in of water using overhead sprinklers. This resulted in a leaching fraction of approximately 0.3. At 7, 30, 60, 90, and 120 days after treatment, the VTEM procedure was used to collect leachate from four replications. Electrical conductivity and NO_3-N were measured using a conductivity meter and ion specific electrode, respectively. Data for leachate analysis was analyzed using SAS (SAS Institute, Cary, NC).

Results and Discussion: For 'Savannah' and 'Burfordii' holly, there was an interaction between fertilizer source, rate, method of application and days after treatment for electrical conductivity (dS/m) and NO_3-N. When the relationship between electrical conductivity and NO_3-N was analyzed using regression analysis, the following linear relationships were found for 'Savannah' holly (R^2=0.97, NO_3-N = 409 (electrical conductivity)) and

'Burfordii' holly (R^2=0.96, NO_3-N = 414 (electrical conductivity)). Fertilizer source and method of application did not influence electrical conductivity and NO_3-N values for 'Nellie R. Stevens' holly. As a result, there was only an interaction between rate of application and days after treatment for 'Nellie R. Stevens' holly (R^2=0.96, NO_3-N = -11.4 + 425 (electrical conductivity)).

Osmocote and Sierrablen had similar release patterns whereas High-N had lower mean electrical conductivity and NO_3-N values. Sierrablen is similar to Osmocote except that 20% of the fertilizer product is uncoated and is therefore quickly available for plant use (William Foster, personal communication). In contrast, 50% of the N in High-N is coated urea nitrogen. Differences in N source and the amount of coated material in each fertilizer accounted for differences between fertilizers.

Significance to Industry: This research demonstrates that NO_3-N concentrations can be estimated from electrical conductivity readings when multicoated controlled release fertilizers are used. Differences can occur due to use of different fertilizers (Ruter, unpublished data), different species, and may be influenced by environmental conditions such as differences in irrigation, potting medium and temperature. However, once a grower decides on a particular fertilizer and crop to be grown, the VTEM can be easily used to monitor the electrical conductivity of container leachate and NO_3-N can then be estimated from established relationships between electrical conductivity and NO_3-N. Research is currently being conducted with different fertilizer technologies to determine if similar linear relationships between electrical conductivity and NO_3-N can be found.

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Container Design and Potting Media Influence the Growth of Two Rabbiteye Blueberry Cultivars

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Georgia

Nature of Work: Rabbiteye blueberries are an important small fruit crop in the southeastern United States. Under production practices for rabbiteye blueberry nurseries, plants grown in containers have become pot bound before marketing by producing circling roots in traditional round plastic containers. Austin (2) noted that rabbiteye blueberries produce vigorous root systems in comparison to other species of blueberries. Pot bound blueberries grow poorly and frequently die if exposed to drought and weed stress (3,4).

In 1985, a rigid stepped-pyramid container was designed which prevented roots from circling and increased branching of roots (6). For shrubs, the stepped-pyramid container was found to have either no effect (1) or decreased the amount of root circling (5) compared to a traditional straight-walled round container. Therefore, the purpose of this investigation was to evaluate the growth and root circling of two rabbiteye blueberry cultivars in response to container designs and potting media.

Rooted cuttings of Vaccinium ashei 'Tifblue' and 'Brightwell' were potted in traditional straight-walled round containers and stepped-pyramid containers on 19 March 1991 at the Coastal Plain Experiment Station in Tifton, Georgia. The two potting media used consisted of milled pine bark and sand (4:1 by vol) or milled pine bark, sphagnum peat moss, and sand (3:1:1 by vol) amended with micronutrients (Micromax - Grace/Sierra, Milpitas, CA) at 1.5 lb/cu yd and ferrous sulphate at 0.4 lb/cu yd. The same volume of media (159 cu in) was added to each container. Sierrablen 17-7-10 (17N-3.OP-8.3K Grace/Sierra) was topdressed on the potting medium at the rate of 1.3 lb N/ cu yd at the time of potting and again on 3 June 1991. Plants were grown in factorial combinations (eight replications) of each of two cultivars, two container types, and two potting media.

Plants were spaced 12 in on center and irrigated twice daily at the rate of 0.25 in water per irrigation using solid set sprinklers. Initial plant height was measured 4 April 1991. Plants were pruned 7 June 1991 and 7 August 1991 to maintain plant shape. Growth index ((height + width 1 + width 2) / 3) measured in cm, root dry weight, shoot dry weight, and a root circling rating (1= no circling, 3= moderate circling, 5= extensive circling) were calculated at the termination of the experiment on 8 October 1991. The data were evaluated by analysis of variance using SAS (SAS Institute Inc., 1985, Cary, NC). Where appropriate the mean + SE is presented.

Results and Discussion: Growth index was the only measurement influenced by cultivar. 'Brightwell' (47.1 ± 1.3) was larger than 'Tifblue' (42.4 ± 1.3). Combining the data for the two cultivars, there was a significant interaction between container design and potting media for growth index. The growth index of rabbiteye blueberries in traditional round containers with the 4:1 potting medium was approximately 25% less compared to the other three treatment combinations.

Root dry weight was influenced by container design. Plants grown in the stepped-pyramid container had a greater root dry weight (30.0 g ±2.4) compared to plants in the traditional round container (22.9 g± 2.4). Similar to growth index, shoot dry weight was influenced by an interaction between container design and potting medium. Blueberry plants grown in the traditional round container with the 4:1 potting medium had reduced top growth on the basis of shoot dry weight compared to the other treatment combinations. In contrast, the root:shoot ratio (root dry weight/shoot dry weight) was affected by potting media alone. Plants grown in the 4:1 potting medium had a higher root:shoot ratio (0.95 ± 0.05) compared to plants in the 3:1:1 potting medium (0.77 ±0.05).

Plant biomass (root dry weight + shoot dry weight) was independently influenced by container design and potting media. Plants grown in the stepped-pyramid container had more biomass (65.6 ±3.5) compared to plants in the traditional container (49.4 ± 3.5). While the 4:1 potting medium resulted in an increased root:shoot ratio, blueberry plants grown in the 4:1 potting medium had less total biomass (52.2 ± 3.6) than in the 3:1:1 medium (62.8 ± 3.6). Smaller plants with an increased root:shoot ratio may have an advantage when transplanted to the field, however, results with other plants have been variable and species dependant (5).

An interaction between container design and potting media was found for the root circling rating. The only difference among the four treatments was an increase in root circling of plants grown in the 3:1:1 medium with the traditional round container. The lack of root circling in the traditional round container with the 4:1 potting medium may have been the result of a less vigorous plant as indicated by a decrease in plant biomass. None of the plants observed had extensive root circling at the termination of this study. This observation is in agreement with the findings of Appleton (1) who noted that the selection of a container to prevent circling roots was not an important consideration for three shrub species grown in containers for less than 180 days.

Significance to Industry: Root circling does not appear to be a problem in container-grown rabbiteye blueberry plants after seven months of growth in this research environment. The results of this study indicate that the proper container design/potting medium combination should be chosen for the optimal growth of rabbiteye blueberry plants.

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The Relationship Between Container Size, Fertilization and Plant Growth

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Nature of Work: Plant size is very much dependent on container size yet very little information is available to help nurserymen choose container sizes for growing larger nursery stock. After a container size is chosen, should the plant be fertilized with the same total amount given to equal sized plants in smaller containers or should it be fertilized in proportion to the container size? This research was undertaken to determine the best choices of container size and fertilization rate for quickly growing large nursery stock.

Heller's holly, Ilex crenata 'Helleri' and Hershey's Red azalea, Rhododendron x obtusum 'Hershey's Red' liners were planted in 1 (no. 400), 1 1/2 (no. 600) and 3 gallon (no. 1200) containers filled with 3:1 pine bark and sphagnum peat amended with 1 1/2 lb Micromax and 5 lb ground limestone per cubic yard. Plants were fertilized with three formulations of controlled release fertilizer (Osmocote 24-4-7, 17-7-12 and 18-6-12) incorporated in the container medium at 5, 7.5, 10 and 15 lbs of 18% N fertilizer per cubic yard. The 17 and 24% fertilizer rates were adjusted to provide the same amounts of nitrogen as the 18% N fertilizer. Rates were selected to provide comparisons between rates and total amounts of fertilizer per container for three container sizes. Plants were arranged in a randomized complete block design with three replicates and four plants per treatment. Plant were grown for one growing season and tops were cut and weighed as a measure of plant size.

Results and Discussion: All plants were healthy, but the higher fertilization rates produced darker green plants than the lower rates particularly among the azaleas. Each additional gallon of container volume increased azalea plant weights 25 grams (12% of total weight, Fig. 1). Each additional pound of fertilizer applied increased azalea plant weights 10 grams (5% of total weight). Fifteen pounds of 18% N per yard did not produce any heavier plants than 10 lb because the higher rates supplied more nutrients than azaleas could use.

Holly plant weights increased 9.4 grams (5%) for each additional gallon of container volume (Fig. 2). Each additional pound of fertilizer added 8.3 grams (5%) to plant weights. Within the range of applications used in this research, larger containers and heavier applications of fertilizer increased plant size. The performance of different fertilizer formulations was not significantly different.

When the total amount of fertilizer per container remained the same (larger containers fertilized at lower rates), plant weights were equal or smaller when grown in larger containers. For holly plants, increasing the container size 1 gallon without increasing the fertilizer content, reduced plant weights 24 grams (15%, Fig. 3). Holly plant weights were not increased by planting in larger containers unless the amount of fertilizer was also increased. Azalea plants grew similarly except when fertilized at greater than optimal rates.

Significance to the Industry: Success in the nursery business has depended upon growing quality plants in a minimum of time. This research has shown the importance of fertilizing at optimal rates for obtaining optimal growth. At optimal rates, larger containers produced larger plants. Larger containers also required larger fertilizer applications to maintain optimal fertilization. If optimal fertilizer applications cannot be maintained in larger containers, the choice of growing plants in smaller containers fertilized at optimal rates grew larger plants than the choice of growing plants in larger containers fertilized at sub-optimal rates.

Fig. 1. Increased azalea plant weights from increased container size and rate of fertilization.

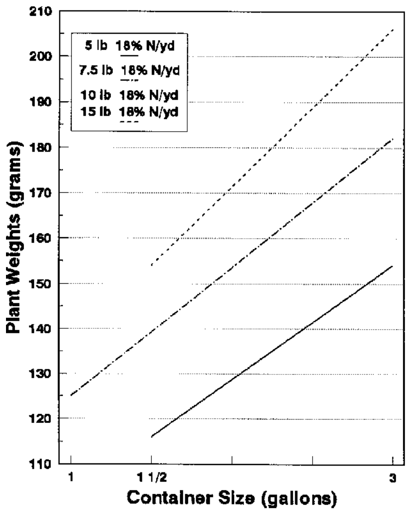


Fig. 2. Increased holly plant weights from increased container size and rate of fertilization.

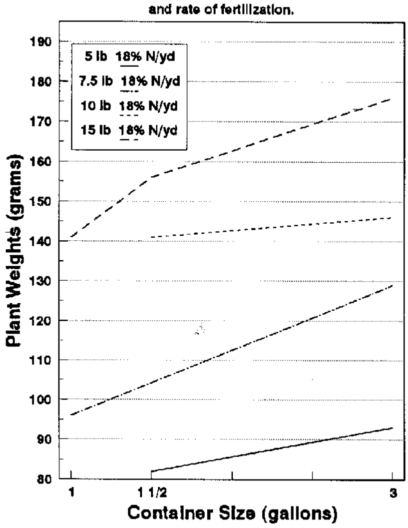
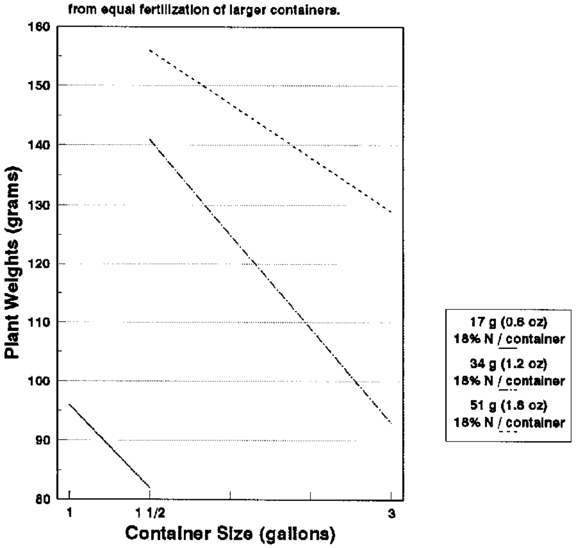


Fig. 3. The decrease in holly plant weights from equal fertilization of larger containers.



Horticultural Uses for Composted Municiple Wastes

D.F. Wagner
South Carolina

Nature of Work: The potential value of composted sewage sludge as a media component for container grown horticultural crops has been recognized for many years (1,3,5,7,8). More recently, the need to adapt to more restrictive environmental regulations limiting the disposal of refuse that was typically dumped into a landfill has provided the renewed research support to expand and improve the methods of utilizing these materials. The DYNATHERM in-vessel composting system adopted by the Broad Creek Public Service District (Hilton Head Island), provides a waste management composting program capable of efficiently converting human sludge and organic yard waste into a valuable soil conditioner in an environmentally sound manner (personal communication). The in-vessel composting system is capable of treating up to forty-five tons of sewage sludge generated by the District's wastewater treatment plant per week. Several times each week dewatered sludge is combined with recycled compost, tree trimmings (yard waste) and/or sawdust and placed in the batch mixer (2). Utilizing tree trimmings, collected within thc District, saves money both in disposal fees and the costs of bulking agents for the composting process. After mixing, the material stays in the composting reactor for a minimum of fourteen days during which temperatures in excess of 140 degrees F. are reached. The resulting compost is pathogen-free, organically stable and odor free.

In this investigation, composted sludge was evaluated as a container grown horticultural crops medium. Three additional bulking agents were also evaluated in these studies. These additional agents were coal cinders (4,6), pine straw (needles) and pine bark. Two experiments, the first initiated 2/6/92 and the second initiated 3/3/92, compared the growth of Marigold 'Discovery Yellow' grown in this compost material with plants grown in a medium commercially available. Plants were germinated in Fafard Peat-Lite medium in plug trays (cavities 3/4 x 3/4 x 1 1/8 inches) and transplanted into the various experimental media two weeks after planting. The five media in experiment 1 were (a) sludge, (b) sludge + pine bark (3 :1 v/v), (c) sludge + cinders (3 :1 v/v), (d) sludge + pine straw (3 :1 v/v), and (e) pine bark. The same media were used in experiment 2 with the exception that the commercial mix (Fafard Peat-Lite) replaced the bark medium. The experiments were conducted as a randomized block design, with each flat representing a block, replicated five times with eight plants per treatment. Plants were grown in a glass greenhouse following standard cultural procedures and were fertilized with Peters 20-20-20 soluble fertilizer (500 ml per flat) on a weekly basis. Top visual evaluations were made every two weeks until termination at the end of ten weeks. Root visual evaluations were made at the termination of the studies. A visual rating equal to 7 or greater was considered consumer acceptable. Plant tops were collected and dried for forty-eight hours at 160 degrees F. before determining dry weights.

Results and Discussion: The bark medium in experiment 1 demonstrated significantly lower levels of plant top quality and the sludge + cinders medium suggested a similar trend when compared to the other media (Table 1). Evaluation of the roots supported this trend in the sludge + cinders medium. Dry weights of plant tops were significantly lower in the bark medium.

Top visual ratings of sludge + bark in experiment 2 resulted in a significant drop in plant quality. Root ratings of the commercial mix were better than the other media studied and the sludge + pine straw mix demonstrated the least accumulation of dry weight. All other media responded positively as plant growing material when compared to the commercial mix.

Significance to Industry: Results of this study suggested that sludge, mixed with bulking agents and composted in this manner, could potentially be used as a plant growing medium in the production of bedding plants. It also demonstrated a novel way of disposing of yard wastes in a manner that is environmentally friendly. With the overwhelming trend in the support of recycling and concern for the environment, I would expect that informing the public of the use of this mulch and growing media in nursery production would meet with favorable comsumer acceptance and a possible means of getting additional free advertising.

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Table 1. Comparison of five media on the growth of marigold 'Discovery Yellow'. Top and root visual rating comparisons, 1=worst through 9=best, with 7 or greater consumer acceptable.

	Experiment I						
	Top Visual Ratings (1-9)					Root	Dry Weight
Media	2/20	3/5	3/19	4/2	4/14	Ratings	(g)
Sludge	8.8a	8.2ab	7.2ab	7.5a	7.4ab	6.9ab	12.06a
Sludge + B ark	8.6a	8.5a	7.5a	7.9a	8.0a	8.1a	12.84a
Sludge + Cinders	8.7a	8.1b	6.9b	6.8b	6.7bc	6.8b	11.84a
Sludge + Pine Straw	8.7a	8.2ab	7.6a	7.9a	8.0a	7.5ab	11.49a
Bark	8.6a	7.9b	6.1c	6.3b	5.9c	7.7ab	7.38b
LSD 0.05	0.35	0.36	0.53	0.68	1.04	1.27	2.29
	Experiment 2						
	Top Visual Ratings (1-9)					Root	Dry Weight
Media	3/17	3/31	4/14	4/28	5/11	Ratings	(g)
Sludge	8.5a	8.6a	8.8ab	8.2a	7.4a	7.3b	9.99a
Sludge + Bark	8.5a	8.9a	8.9ab	7.5a	6.2b	7.1b	9.97ab
Sludge + Cinders	8.2a	8.7a	9.0a	8.0a	7.4a	7.4b	11.99a
Sludge + Pine Straw	8.3a	8.6a	8.9ab	7.7a	7.4a	7.2b	9.17b
Com. Mix	8.4a	8.6a	8.6b	8.2a	6.7a	8.5a	10.65ab
LSD 0.05	0.33	0.33	0.39	0.81	1.18	1.08	2.77

Mean separation in columns by LSD, 5% level.

Use of Composts In Commercial Nursery Potting Substrates

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North Carolina

Nature of Work: A variety of composted materials will be introduced to the horticultural industry in the next few years. The origin of the composts may be yardwastes, municipal solid wastes, agricultural and animal wastes, forestry, food and other industry wastes. The horticulture industry is a good marketing audience for many of these composts and the nursery industry in particular, can benefit from the large volume of these resources which will become available. However, because organic amendments effect both the physical and chemical properties of a substrate, it is difficult for nurserymen to incorporate an amendment into the substrate without guidelines on the proper ratio and modifications required in irrigation and fertility programs to account for changes created by the amendments. A previous study using turkey broiler litter compost and horticultural rockwool as amendments to pine bark indicated that addition of rockwool improved growth of cotoneaster compared to a two component substrate of pine bark and compost (1). The study also indicated that sustained levels of some nutrients and particularly phosphate were provided by turkey broiler litter compost in potting media. Preliminary lab analyses suggest that yardwaste composts may provide good physical properties but less nutrient contributions than poultry wastes. This study was designed to compare physical and chemical characteristics and plant response by amending a commercial nursery potting media with turkey broiler litter or municipal yard waste composts under commercial nursery conditions.

Ilex crenata 'Steeds' holly and *Photinia x* 'Fraseri' photinia liners were grown in 11.41(#3) containers in one of five pine bark:sand (4:1 v/v) media with 10 or 20% (by volume) of a turkey broiler litter compost (TBL) or composted yard waste (CYW). Dolomitic limestone and C-Trel (Coor Farm Supply Service, Inc., Smithfield N.C.) a minor element supplement were blended with the pine bark: sand medium at 4.0 and 1.0 lbs./cu.yd. respectively, before blending compost test components. Each species was placed in 5 replications in a completely random block design on a polypropylene fabric growing area in full sun. Containers were drip irrigated with approximately 1400 ml of water daily. Coor sulfur coated fertilizer (1 8-6-12) was surface applied at 20 grams per container at initiation and again at the same rate after 8 weeks. The plants were not pruned during the study. Five fallow pots of each of the five container media were treated as containers with plants, from which physical properties were determined at the termination of the study after 23 weeks. Electrical conductivity and pH were determined by water extraction (VTEM) procedures every 3 weeks. Samples were retained on 5 sampling dates and analyzed for NO_3-N, NH_4-N, P, K, Ca, and Mg. At the termination of the study, plant heights and average widths were measured to determine a growth index, and photinia was removed from containers for dry weight and tissue analyses. (Data not shown for nutrient capacity factors or plant response)

Results and Discussion: Addition of composts to the pine bark: sand medium increased or had no effect on total porosity as compared to the standard medium. The most significant effects on physical properties of adding either of the composts to the pine bark: sand medium was that container capacity was increased 3 to 6% (by volume)(Table 1). However, in the 20% TBL substrate all of the additional water held was held at tensions unavailable for plant use. The addition of 20% CYW and 10% TBL also decreased air space as compared to the standard medium.

Electrical conductivity was increased by addition of TBL compost and was very high (3.5 to 5.5 mmhos x 10^{-5}) on day 1. Electrical conductivity of CYW was approximately the same as the Standard medium throughout the study and ranged from 1.4 initially to 0.1 mmhos after 6 weeks. The pH of leachate tended to be increased by the addition of 20% TBL while CYW tended to have lower pH. The pH of leachates ranged initially from 4.0 to 5.5 but after 23 weeks all treatments were 6.6 to 6.7.

The CYW substrates NO_3-N were 12.2 and 22.0 mg/l for 10 and 20% (by volume) respectively on day 1 and were higher than other treatments. Ammonium-N leachate levels for TBL were 38.0 and 107.0 mg/l for 10 and 20% rates respectively, on day 1 while CYW had no effect on NH_4-N levels. In general, nitrogen leachate concentrations were low to deficient throughout the study compared to liquid fertilizer VTEM guidelines.

The leachate phosphate concentration for the Standard on day 1 was 160.3 ppm which is very high, however the 10% TBL and 20% TBL substrates were 2 and 3 fold higher. The CYW treatments had P leachate concentrations lower than the Standard. After the first day, P solution levels in containers were less than 5.0 ppm except in the TBL substrates.

The 20% TBL compost provided additional calcium and magnesium as compared to the other substrates 61 days after potting. Potassium levels also tended to be higher in the TBL substrates. The CYW compost did not effect K, Ca, or Mg nutrient levels.

The TBL substrates increased foliar phosphate as compared to other treatments and maintained them above minimal suggested levels. The 20% CYW substrate increased iron foliar content and maintained iron within the suggested range while other treatments were lower than recommended levels. Calcium and magnesium foliar content were generally close to suggested foliar concentrations. Potassium and zinc were above minimal concentrations for all substrates while nitrogen was low for all treatments.

Growth index, top dry weight and root dry weight for photinia were not different among the substrate treatments. The growth index for ‘Steeds’ holly was greatest in the 20% CYW medium. Based upon foliar N and EC data, nutrient levels in the study were deficient after 83 days (July 30) and growth of plants might have been greater if additional fertilizer had been applied after this date.

Significance to Industry: From this data and previous studies (1), loss of air space, increased container capacity and increased unavailable water content are characteristic of addition of composted organic components to pine bark substrates. Exclusion of sand may have increased air space and increased plant growth. These characteristics along with some chemical properties of animal wastes limit the volume of composts which should be used in potting mixes.

The most significant effect was the increased leachate and plant tissue phosphate concentrations as a result of addition of the TBL compost. Consensus among researchers is that approximately 7 to 10 ppm should be maintained by slow release fertilizers. Unfortunately, this recommendation can not be met by most slow release fertilizers programs in pine bark potting mixes. This is one attribute of animal waste composts. However, long term benefit over more than one growing season should not be expected as indicated by the lower P levels after 23 weeks.

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Table 1. Physical properties of substrates.[z]

Media	Total Porosity[y]	Air Space[x]	Container Capacity[w] (% Volume)	Unavailable Water[v]	Available Water[u]	Bulk Density[t] (g/cc)
STANDARD	75.7b[s]	17.8a	57.9c	31.2b	26.7c	0.40ab
STD+10%CYW	79.6a	17.2ab	62.5ab	32.8ab	29.7ab	0.36c
STD+20%CYW	75.7b	12.3c	63.5ab	31.9ab	31.6ab	0.40a
STD + 10% TBL	77.5ab	13.6bc	63.9a	31 .3b	32.6a	0.37bc
STD + 20% TBL	76.9ab	1 6.9abc	62.0b	34.0a	28.0bc	0.38abc

[z] Analyses performed using standard aluminum soil sampling cylinders (7.6 cm ID, 7.6 cm h)

[y] Total porosity is equal to container capacity + air space.

[x] Air space was the volume of water drained from the sample÷volume of the sample.

[w] Container capacity was (wet weight-dry weight)÷volume.
[v] Percent volume at 1.5 MPa.
[u] Calculated as the difference between container capacity and unavailable water.
[t] Grams per cubic centimeter after drying samples in a forced-air drying oven at 110 C for 24 hours.
[s] Mean seperation within a column followed by the same letter or letters are not significantly different using the Waller-Duncan k-ratio t-test at k-ratio=100. Each value represents the mean of 7 cylinders.

Composted turkey litter: Effect on chemical and physical properties of a pine bark substrate and plant growth

Helen H. Tyler, Stuart L. Warren, Ted E. Bilderback and William C. Fonteno
North Carolina

Nature of work: Water quality and quantity are two major environmental concerns of growers of container ornamentals (5). Due to the porous nature of container substrates, container production requires large amounts of water and fertilizer to produce rapid plant growth. Unfortunately, most of this water passes through the container, carrying nutrients with it (7). Although several alternative cultural practices may reduce water usage and run-off, engineering container substrates to hold more water and nutrients seems to be one of the more practical approaches. Increased water holding capacity may allow the grower to reduce water usage by reducing irrigation frequency. Research has reported that compost has the potential to improve physical and chemical properties of a pine bark substrate resulting in increased water holding capacity, thereby, reducing leaching (3). Bilderback and Fonteno (1) reported improved growth of Cotoneaster dammeri 'Skogholm' with a substrate composed of pinebark, rockwool, and composted poultry litter compared to pine bark alone. The objectives of this study were to characterize the chemical and physical properties of a pine bark-based substrate amended with composted turkey litter, and subsequent plant growth.

The experiment, a 3 x 5 factorial in a split-plot design with eight single plant replications, was conducted on a gravel pad at North Carolina State University, Horticultural Research Unit 4, Raleigh. The two factors were 3 irrigation frequencies (main plots) of 1, 2 or 3 days and 5 compost rates (subplots) of 0, 4, 8, 12, 16 % (v/v). Milled pine bark [(<13 mm) (0.5 in)] was amended on a m3 (yd^3) basis with compost. For comparison to a common commercial substrate, 48 pots of milled pine bark were amended on a m^3(yd^3) basis with 908 g (31.78 oz)dolomitic limestone and 272 g (9.5 oz) Micromax micronutrient fertilizer and incorporated into the irrigation x compost rate split plot design. These “commercial substrate” plants were top dressed with 18 g (0.6 oz) Osmocote 17-3-10 (17-7-12) on May 24, 1991 (Day 0). Uniform rooted cuttings of ‘Skogholm’ cotoneaster were potted into 3.8 liter (#1) containers on May 13, 1991. All plants received 1400 ml (47 oz) of water daily via pressure compensated drip emitters until May 24, 1991, thereafter plants received 1400 ml (47 oz) per specified irrigation frequency. On September 11, 1991, the shoots (aerial tissue) were removed and dried at 62°C (144°F) for 5 days. Leaves were stripped from the stems to obtain leaf dry weight. Roots were placed over a screen and washed with a high pressure water stream to remove the substrate and dried at 62°C (144°F) for 5 days. The substrate solution was extracted from the containers via the pour-through nutrient extraction method (VTEM) at 0, 18, 36, 54,78, and 102 days after initiation (6). Leachates were then frozen for future NO_3 analysis and NH_4 analysis using a spectrophotometer (Spectronic 1001 Plus, Milton Roy Co., Rochester, NY). Phosphorus, K, Ca, Mg, Mn, Cu, Zn, Fe, and B were determined by inductively coupled plasma emission spectroscopy.

Results and Discussion: Compost had no effect on total porosity. However, it decreased air space while increasing container capacity, available water, unavailable water, and bulk density compared to pine bark (data not shown). Irrigation frequency significantly effected the substrate concentrations of NO_3, NH_4, K, P, and Ca while it did not effect the Mg substrate concentration or pH (data not shown). Compost addition had a significant effect on the concentrations of all measured nutrients and pH except for K at 102 days. Substrate NH_4, NO_3, K, P, and Ca concentrations increased with decreasing irrigation frequency (data not shown) due to decreased leaching. Substrate NH_4, NO_3, K, P, Ca, Mg concentrations and pH increased with increasing compost rate regardless of irrigation frequency (data not shown). Irrigation frequency did not significantly effect substrate Mn, Cu, Zn, Fe and B concentrations at any sample time (data not shown). Compost rate significantly effected substrate micronutrient concentrations at 18 days but not at 54 days. By 78 days, substrate Mn, Cu, Zn, Fe and B concentrations were below the detection level.

Cotoneaster ‘Skogholm’ leaf and root dry weights were significantly effected by irrigation frequency and compost rates. Leaf dry weight increased with increasing rates of compost under 1 day irrigation while there were no discernable trends in leaf dry weight under the 2 and 3 day irrigation regimes (Table 1). This increase in leaf dry weight with increasing rate of compost addition is most likely due to the increased water holding capacity and nutrient levels of these substrates. Leaf dry weight decreased with decreasing irrigation frequency for all compost rates. Plants grown in the commercial substrate produced comparable leaf dry weights as the plants grown in the compost substrates under the 1 and 2 day irrigation regimes. Under the 3 day irrigation, the commercial substrate produced significantly greater leaf dry weight than the compost substrates.

Root dry weight yielded a quadratic response to increasing rate of compost addition with daily irrigation, maximum dry weight occurred at 12% (Table 1). There was a linear decrease in root dry weight with increasing compost when irrigated every 3 days. This could be reflective of increasing electrical conductivity (EC) with increasing compost rates (data not shown). However, Hicklenton (4) reported that Cotoneaster dammeri 'Coral Beauty' was tolerant of high EC levels as the plants responded with increased growth as weekly N applications increased from 70 to 420 mg N per week. The decrease in root dry weight at 16% could also be an artifact of the higher nutrient concentration and water content of the 16% compost amended substrates. Brouwer (2) reported decreased root growth with increasing water and nutrient supply. There was no discernable trend in root dry weight under the 2 day irrigation regime. Generally, the commercial substrate produced similar root dry weights as the compost substrates.

Significance to the Nursery Industry: Composted turkey litter (compost) has the potential to increase water retention properties of pine bark substrates, thereby potentially increasing nutrient efficacy. Reduced frequencies of irrigation and increased water holding capacity of the substrate resulted in less N, P, K, Ca, Mg, and micronutrients lost from the container due to leaching. Compost increased the concentrations of all nutrients and pH in the substrate solution. Decreased frequencies of irrigation reduced growth of 'Skogholm' cotoneaster plants. In general, plants grown in compost amended substrates grew as well as those grown in the commercial substrate.

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Table 1. Effect of irrigation frequency and compost rate on dry weights of cotoneaster 'Skogholm '.

Compost rate	**Dry weight** (g)							
	leaf				root			
	Irrigation frequency (days)							
(v/v)	1	2	3	L[z] (irr)	1	2	3	L[z] (irr)
0	1.1	1.2	1.0		1.7	1.3	1.2	
4	20.9	15.4	11.9	**	11.7	7.7	7.4	**
8	20.0	14.8	11.4	**	13.6	6.5	5.0	**
12	24.6	16.5	12.4	**	16.3	6.7	4.8	**
16	25.3	16.3	11.8	**	7.4	5.8	3.6	**
comm.[y]	24.8	17.4	15.6		9.7	7.7	4.4	
<u>Significance</u>[x]								
L[z]* NS	NS	NS	NS	**				
QNS NS	NS	**	NS	NS				

[z]NS,**,*, Nonsignificant or significant at p ≤0.01 or p ≤ 0.05, respectively.
yCommercial substrate data not included in the regression analysis. Comparisons of commerdal substrate to compost substrates based on LSD=3.2 g leaf, and LSD=2.6 g roots.
[x] L= linear, Q= quadratic. Zero compost rate excluded from regression analysis.

Cupric Hydroxide-Treated Containers Decrease Pot-Binding of Five Species of Vigorously Rooted Greenhouse Crops

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Nature of the Work: Painting interior surfaces of containers with latex paints containing various formulations of copper have been shown to effectively decrease the amount of circled, kinked and matted roots forming at the container wall - media interface during the production of conifers for reforestation (4) and deciduous species for landscape use (1,2,3). Although control of root deformation with cupric carbonate containing paints is via a mild Cu toxicity in the root tips, phytotoxicity symptoms to copper in shoots were not found in plants treated with copper concentrations of less than 100 g Cu/liter of paint (1,3).

Two limiting factors in using latex paints to apply copper compounds to container surfaces were that commercial latex paints contain phytotoxic chemicals and that the slurry resulting from mixing cupric carbonate and latex paint required that it be applied by hand with a brush or sponge. Recently cupric hydroxide at 100 g/liter (3.34 oz/qt) of white latex paint or latex carrier (Spin Out™, Griffin Corp., Valdosta, GA) has been shown to control root deformation of northern red oak (Ouercus rubra) and common baldcypress (Taxodium disticum) (2). The Spin Out™ formulation can be applied with a commercial paint sprayer, greatly reducing labor requirements during application.

A local producer of greenhouse plants indicated that they were having difficulties with pot-binding of several vigorously rooted tropical species during production. Thus, a study was undertaken to determine if cupric hydroxide formulated as Spin Out™ could effectively control the development of circled, kinked and matted roots (pot-binding) of tropical greenhouse plants at container surfaces without adversely affecting shoot growth.

Five starter plants (2" pots from Burgess Falls Nursery, Cookeville, TN) of five tropical greenhouse crops, chenille plant (Acalypha hispida), asparagus fern (Asparagus setaceus), spider plant (Chlorophytum comosum), schefflera (Schefflera arboricola), and Hawaiian hibiscus (Hibiscus rosa-sinensis), were destructively harvested to determine initial growth parameters. An additional ten plants of each species were planted in Pro-Mix BX media (Premier Brands Inc., Stamford, Conn.) in 5.5" round pots (National Polymers Inc., Lakeville, Minn.) painted on interior surfaces with 100 g $Cu(OH)_2$/liter (3.34 oz/qt) latex carrier formulated as Spin Out™ or in nontreated pots. Plants were placed in a greenhouse, set at day/night temperatures of 24/18 C (75/65°F), in a randomized complete block design for each species consisting of 2 blocks with 5 plants per treatment per block. Plants were watered by hand as needed. Fertilizer was applied weekly at 300 ppm l9N-8.3P-15.8K water-soluble fertilizer (Peters Fertilizer Products, Fogelsville, Penn.).

Plants were harvested as it became difficult to maintain them in a turgid condition with hand watering; 67, 78, 65, 67, 76 days for chenille plant, asparagus fern, spider plant, schefflera, and Hawaiian hibiscus, respectively. Root and shoot fresh and dry weights were recorded. Total plant fresh and dry weights and root/shoot ratios, and a plant growth index (height x greatest width x least width) were calculated. Root ratings for control of circled, kinked, and matted roots were recorded; O = no apparent control of root deformation, 1 = more than 5 roots elongating > 1 cm (0.5") along a container surface, 2 = 1 to 5 roots elongating > 1 cm (0.5") along a container surface, 3 = no roots elongating > 1 cm after contact with a container surface. The number of flower spikes longer than 1" in length were recorded for chenille plants at weekly intervals. Morphological data were analyzed using analysis of variance and Fisher's least significant difference test at the 5% level and flower number via step-wise polynomial regression.

Results and Discussion: For the time periods tested, cupric hydroxide-treated plants of all species averaged less than 5 roots elongating more than 1 cm (0.5") after contacting a treated container surface (Table 1, Fig. 1). Chenille plants and spider plants had the most escaped roots (Table 1), but even for these species root deformation was visibly reduced (Fig. 1). The only significant effects on vegetative growth of any species was a reduction in the root:shoot ratios on a fresh weight (2.74 vs. 2.30) and dry weight (1.46 vs. 1.18) basis for asparagus ferns grown in copper treated pots. Copper-treated containers have been reported to reduce the root:shoot ratios in some woody species (1,3). No foliar copper toxicity symptoms were observed on any plants during the course of the study. A slight yellowing of some leaves on schefflera was apparent on both controls and copper-treated plants late in the study, probably due to water stress. Flower numbers for chenille plants remained at similarly increasing levels throughout the study until two weeks prior to harvest when the flower number on control plants began to decline (Fig. 2). This two-week period was when pot-binding was most severe. Improved flowering of forsythia (5) and impatiens and celosia (author's unpublished data) has been shown for plants grown in copper-treated containers.

Significance to the Industry: The development of circled, kinked and matted roots at container surfaces (pot-binding) of greenhouse grown crops gives the appearance to consumers that plants have remained too long in a pot and in severe cases may result in difficulties in removing the old container at repotting. Controlling root deformation during container production of woody plants with copper compounds has resulted in improved growth following outplanting and/or transplanting to larger containers (1,3). Producing vigorously rooted greenhouse crops in cupric hydroxide-treated containers can reduce the pot-bound appearance, and although additional study is needed, might result in improved growth after repotting to larger containers.

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Table 1. Root ratings of five vigorously rooted greenhouse crops grown in cupric hydroxide treated or nontreated containers. Each entry is a mean of 10 observations.

	Treatment	
Species	Cupric hydroxide	Nontreated
Spider plant	2.7 a[z]	0.0 b
Asparagus fern	3.0 a	0.0 b
Hawaiian hibiscus	3.0 a	0.0 b
Chenille plant	2.0 a	0.0 b
Schefflera	3.0 a	0.2 b

[z]Means followed by the same letters in the same row are not significantly different (P>0.05, Fisher's LSD).

Fig. 1. Asparagus fern (A), spider plant (B), Hawaiian hibiscus (C), chenille plant (D), and schefflera (E) grown for 78, 65, 76, 67, and 67 days, respectively, in cupric hydroxide-treated (left plant in each pair) or nontreated (right plant in each pair) containers. Plants were randomly selected for photographs.

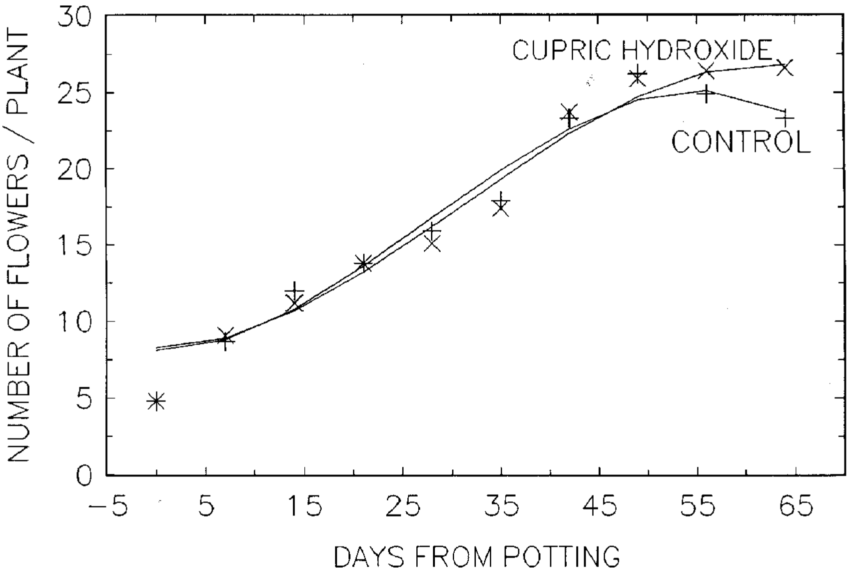
(Photos here)

(Photos here)

(Photos here)

(Photos here)

Fig. 2. Polynomial regression equations for the number of flower spikes longer than 1" on chenille plants grown in cupric hydroxide-treated (flower number = 7.544 + 0.0157*days^2 -0.000173*days^3, r^2 = 0.79) or nontreated containers (flower number = 7.435 + 0.0178*days^2 - 0.000217*days^3, r2 = 0.71). Observed means are indicated by “x” and “+” for cupric hydroxide-treated and nontreated plants, respectively.



Initial Growth of Seedlings of Flame Azalea in Response to Day/Night Temperature

Asiah A. Malek, Frank A. Blazich, Stuart L. Warren, and James E. Shelton
North Garolina

Nature of Work: Seedlings of flame azalea [Rhododendron calendulaceum (Michx.) Torr] were grown in controlled-environment chambers for 12 weeks under long-day conditions with days at 18, 22, 26, or 30°C (64, 72, 79, or 86°F) for 9 hr in factorial combination with nights at 14, 18, 22, or 26°C (57, 64, 72, or 79°F) for 15 hr (1).

Results and Discussion: Total plant dry weight, top dry weight, leaf area, and dry weights of leaves, stems, and roots were influenced by day and night temperatures and their interactions. Dry matter production was lowest with nights at 14°C (57°F). Root, leaf, top, and total dry weights were maximized with days at 26°F (79°F) in combination with nights at 18 to 26°C (64 to 79°F). Stem dry weight was maximized with days at 26 to 30°C (79 to 86°F) and nights at 22°C (72°F). Leaf area was largest with days at 18 and 26°C (64 to 79°F) in combination with nights at 18 or 26°C (64 or 79°F). Within the optimal day/night temperature range of 26°C/18-26°C (79°F/64-79°F) for total plant dry weight, there was no evidence that alternating temperatures enhanced growth. Shoot:root ratios (top dry weight:root dry weight) were highest with days at 18 and 30°C (64 and 86°F). Leaf area ratio (total leaf area:total plant dry weight) was highest and specific leaf area (total leaf area:leaf dry weight) was largest when days and nights were at 18°C (64°F) and were lower at higher temperatures. Regardless of day/night temperature, leaf weight ratio (leaf dry weight:total plant dry weight) was higher than either the stem weight ratio (stem dry weight:total plant dry weight) or root weight ratio (root dry weight.total plant dry weight). Net leaf photosynthetic rate increased with day temperatures up to 30 C (86°F).

Significance to Industry: Results reported herein should be of benefit to nurserymen who raise seedlings of flame azalea, not only under greenhouse conditions, but also when seedlings are moved outdoors for accclimation and further growth. These findings should be particularly useful in accelerating and maximizing growth of seedlings.

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Faster Growth Of Radermachera sinica After Transplanting From Copper-Treated Liners

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Florida

Nature of Work: Roots growing in a circle at the base of containers can lead to slow root growth after field transplanting, while the use of copper-treated containers supresses root circling, and may increase root growth after transplanting (6). Response to copper-treated containers differs for various ornamental species (2). Copper treatment has helped suppress root circling in flats (4) and tree seedling tubes (3, 5), but routine use of copper-treated liners for production of ornamental species has received less study. Since plants grown in copper-treated pots may exhibit faster growth after transplanting in the field (1), transplanting from copper-treated liners to larger containers may support faster growth during production.

Radermachera sinica (Hance) Hemsl., commonly called China doll, radar plant, or false coffeeberry, is a tropical-subtropical tree from southeast Asia. Nurseries in southern Florida are growing China doll from seedling plugs or liners for use as landscape trees or interiorscape plants. The rapid seedling growth rate restricts the storage or “holding-time” before liners must be sold and shipped. The objectives of this study were: 1) to determine if transplanting into larger containers from copper-treated liners of China doll leads to faster growth during production, and 2) to determine if copper-treated liners of China doll can be stored longer than non-treated liners.

Plugs (l-in) of China doll were potted into 2 1/4-in liners filled with ProMix BX.™ Half of the liners had all interior surfaces painted with SpinOut™ (a commercially prepared copper hydroxide and paint mixture, Griffin Corp., Valdosta, GA). Liners were top-dressed with 1.5 g of Osmocote™17-7-12, and grown under 63% shade (average of 4000 ft-c of light at solar noon). After 3-weeks growth, liners were transplanted into 6-in pots filled with the same ProMix BX™ medium, and top-dressed with 9 g of the same Osmocote.™Pots were irrigated daily, and pests (aphids on young expanding leaves causing distorted leaf expansion) were controlled using standard procedures used in commercial production. The experiment was a completely randomized design, with 10 plants per treatment. Shoot height and dry weight of ten plants for each treatment were recorded at transplanting, and 2 months after transplanting. After transplanting, growth rate relative to initial plant size was calculated as [ln(final dry weight) - ln(initial dry weight)/number of days].

Results and Discussion: No root circling was observed at the base of plants grown in copper-treated liners during transplanting. After three weeks growth in liners, plants grown in copper-treated pots had less shoot dry weight, and were shorter than plants grown in unpainted pots (Table I). Seedlings were more easily removed from copper-treated pots during transplanting. Shoot dry weight and plant height did not differ after 2 months growth in 6-in pots. While plants in copper-treated liners grew slower, plants transplanted into 6-in pots from copper-treated liners grew faster, compared to plants grown in untreated liners. Copper treatment helped slow growth in liners without inhibiting growth after transplanting into 6-in pots. This provides the plug or liner grower with more time to sell and ship the crop before seedlings become oversized.

Significance to Industry: Copper-treatment prevented root circling of China doll. Plants were more easily removed from copper-treated liners, which may ease labor during transplanting, or reduce plant damage during mechanical transplanting. Before transplanting, plants in copper-treated liners were smaller than plants in non-treated pots, allowing China doll to remain in liners for a longer period of time before they must be sold and shipped. Faster growth of China doll was recorded after transplanting into 6-in pots from copper-treated liners. Use of copper-treated plugs or liners during propagation appears to support faster growth after plants are transplanted into larger containers.

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Florida Agriculture Experiment Station Journal Series No. N-00611. The authors thank Double-E Enterprises, Miramar, FL for supplying plugs, and Griffin Corporation, Valdosta, GA for supply SpinOut™ Trade names and companies are mentioned with the understanding that no discrimination is intended nor endorsement implied.

Table 1. Initial shoot size, final shoot size, and growth rate of Radermachera sinica grown in 6-in pots for 2-months after transplanting from liners. Liners were either treated with copper-hydroxide [$Cu(OH)_2$], or not treated.

Liner Treatment	Initial shoot dry weight (grams)	Final shoot dry weight (grams)	Initial shoot height (cm)	Final shoot height (cm)	Relative growth rate (g/g/day)
$Cu(OH)_2$-treated	1.0 b[z]	16.3 a	11.2 b	471.9 a	0.040 a
Not treated	1.2 a	17.4 a	11.5 a	465.0 a	0.038 b

[z] Means within columns followed by the same letter are not different ($P<0.05$) according to Analysis of Variance; n=10. 28.35 grams = one ounce; 2.54 cm = 1 inch.

Faster Growth of Schefflera Using Exterior Retractable Shading

Sven E. Svenson Diane L. Johnston, and William L. Schall
Florida

Nature of Work: The growing environment influences quality, size, and scheduling of nursery crops, thereby establishing production costs and profitability. Improper light levels in the production environment may limit plant growth. However, adjustments to the production light environment must be made carefully, because changes may not always be cost-effective (1).

In southeast Florida, schefflera (Brassaia actinophylla Endl.) is routinely grown in full sun, or within saran-covered pole-and-cable shade houses providing a maximum of 5000 to 8000 ft-c of light (solar noon). Stationary shading systems often provide periods of insufficient light that do not support rapid growth, or periods of excessive light that inhibit growth. Depending on the shade factor (percentage of light excluded), both insufficient and excessive light intensities may occur within the same photoperiod. Exterior retractable shading systems provide shade only at times when natural light levels are too high (e.g. mid-day). Thus, a larger percentage of each photoperiod is maintained within the optimal light intensity range for photosynthesis, maximizing the use of available light to increase growth (3). A grower who is able to extend the period of maximum growth one hour each day could produce plants 10% faster (2). The objective of this study was to determine if a retractable shading system would provide an environment supporting faster growth of schefflera compared to stationary shading or no shading. Liners of schefflera 'Amate™(Oglesby Plant Laboratories, Altha, FL) were potted four per pot in 14-in containers filled with a standard commercial growing medium. Pots were top-dressed with 70 g of Osmocote™ 18-6-12 (8 to 9 month formula), and placed under stationary shading (saran-type shade cloth) providing a shading factor of 40X, retractable shading with a shading factor of 40%, or under no shading (full sun). The experiment was a split-plot treatment arrangement within a completely randomized design, with 30 plants per treatment. Maximum full sun was measured at 8850 to 11200 ft-c during the measurement period from February to October 1991. Pots were drip irrigated as needed, and pests were controlled with standard procedures used in commercial nursery production. The retractable shading was operated with a photosensor, pulling the shade cloth over the plants when light intensities exceeded 7000 ft-c for 20 minutes, or retracted the shade cloth when light intensities remained below 7000 ft-c for 20 minutes. The system required 5 minutes to completely extend or retract the shade cloth. Stem caliper, stem length (soil to stem apex), and shoot dry weight were recorded monthly on three plants in ten pots for each light environment. The study was conducted at Kraft Gardens, Deerfield Beach, Florlda .

Results and Discussion: Stems of plants produced under retractable shading were 33%, 60%, 77%, and 89% longer 2, 3, 4 and 5 months after potting, respectively, compared to plants grown without shading (Table 1). Retractable shading supported 10%, 31%, 28% and 28% more stem length, respectively, compared to stationary shading. Stem caliper growth trends were similar to the length growth responses (Table 2). Dry weights of shoots showed similar trends as heights and calipers (data not shown). Plants produced using retractable, stationary or no shading required 5, 6, and 9 months, respectively, to grow to a stem length of 24-in (minimum salable stem length contributing to overall plant height). Plants grew faster under retractable shading compared to stationary shading, reaching a salable size one month sooner (10 to 20% faster production cycle). Plants produced using either retractable or stationary shading grew faster than plants grown without shading.

Increased growth associated with retractable shading must be balanced against additional costs of installation. Cost comparisons will indicate if the installation of a retractable shading system can be justified in terms of the profitability of a specific crop. The best way to use exterior retractable shading systems is still unknown. The optimal shade percentage and the best light intensity to begin shading each day will need to be determined for each individual crop and growing location. The time period before the shade is pulled or retracted after the light intensity exceeds or drops below the "set" light intensity may be very important. The time required to pull or retract the shade may also be important on days with broken clouds.

Significance to Industry: Faster growth of schefflera was recorded using exterior retractable shading compared to stationary shading or no shading. Our plants may have grown differently if alternative shading factors and shade initiation regimes had been used. Adjustments in other cultural factors (eg. fertilization, irrigation, growing medium, pot size) may be needed to support the faster growth under retractable shading.

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Table 1. Stem length (in) during production of Brassaia actinophylla 'Amate' grown under retractable shading, stationary shading, or no shading.

Shading Environment	Months after potting 2	3	4	5
Retractable Shading	4.4 a[z]	9.0 a	15.5 a	23.5 a
Stationary Shading	4.0 a	7.2 b	13.0 b	20.1 b
No Shading	3.3 b	5.6 c	8.8 c	12.4 c

[z] Means within columns followed by the same letter are not different ($P<0.05$) according to the Duncan's New Multiple Range Test; n=30.

Table 2. Stem caliper (in) during production of Brassaia actinophylla 'Amate' grown under retractable shading, stationary shading, or no shading.

Shading Environment	Months after potting 2	3	4	5
Retractable Shading	0.49 a[z]	0.57 a	0.70 a	0.81 a
Stationary Shading	0.41 b	0.52 b	0.64 b	0.76 b
No Shading	0.37 b	0.46 c	0.54 c	0.61 c

[z] Means within columns followed by the same letter are not different ($P<0.05$) according to the Duncan's New Multiple Range Test; n=30.

Photinia Upcanning Steps Depend on Fertilizer Type

R. C. Beeson, Jr.
Florida

Nature of Work: Ornamental container production can follow two paths; transplanting liners directly into market-size containers; or transplanting liners into smaller containers, later upcanning into market-size containers. While more labor intensive, upcanning has advantages of reduced space requirements, cooler pot medium due to more rapid shade development and less economic loss should liners die.

Nursery operators who practice upcanning contend that shoot growth is more rapid than planting in the market container, reducing overhead cost. Supporting evidence comes from peach (Richards & Rowe, 1977) and alder (Tschaplinski & Blake, 1985) seedlings grown in aerated liquid cultures. However, studies with commercial container sizes revealed that growth increased with increased container size when plants were potted into the container in which they were marketed (Gilliam et al., 1984; Keever & Cobb, 1987). Yet container size did not affect Leyland cypress growth the first season, though it followed the general trend of increased growth after the second season (Bilderback, 1985). In the present study, upcanning during production was compared with production in the market container. Fertilization was hypothesized to influence the results, thus liquid and granular fertilization was also compared.

Photinia x fraseri 'Red tip' cuttings were planted into quart, 1 gal or 3 gal black plastic containers in June 1990. Container medium used was a 3 pine bark fine: 1 Florida peat moss: 1 coarse sand amended with 1.5 lbs per yd^3 micronutrients (Micromax, Grace-Serra Chemical Co. Milipitas, Calif.). Plants were irrigated at 0600 hr daily (0.35in/day) except during the winter when the frequency was reduced to every other day.

Two-thirds of the quart containers (QT) were upcanned to 1 gal pots (QT-1) when the root systems had filled the container (10/29/90). Half of these QT-1 plants were upcanned to 3 gal containers (QT-3) when the root systems had again filled the containers (3/8/91). Fifty percent of the liners initially planted into 1 gal containers (GAL) were upcanned into 3 gal containers (GAL-3) at a similar root system development (1/3/91). Liners initially transplanted into 3 gal pots (3GAL) remained in these containers during the 2-year production cycle.

Plants were fertilized either by topdressing with a controlled fertilizer or by liquid fertilization using a siphon applicator. The controlled fertilizer (Osmocote 18-6-12; Grace Serra Chemical Co., Milipitas, Calif.) was applied at rates of 1.1 g, 2.2 g, and 9 g N for the quart, 1 gal and 3 gal pots, respectively, on July 6,1990, Mar 20, 1991 and June 24, 1991. Liquid fertilizer (Peter's 20-20-20, Grace Sierra Chemical Co. Milipitas, Calif.) was applied at rates of 3.1 g N per gallon per week from July 6, 1990, through Oct 29, 1990. It was resumed on Mar 20, 1991, and continued until Oct 22, 1991. Differences in container surface area led to similar amounts of total N applied per pot size per year between fertilizer regimes.

On Nov 15, 1991, plant heights and stem caliper were measured on 20 plants per treatment. Canopy dry weight was measured on 10 plants per treatment. Final growth measurements were analyzed as a split-plot design, with fertilizer regime as the main plot and 6 container treatments as the subplot.

Results and Discussion: The interaction between fertilizer regime and container treatment was significant for final growth measurements. Plants transplanted from quart containers, liquid fertilized, and upcanned to 3 gal containers (QT3) were as tall and accumulated more dry weight than the best granular-fertilized treatment; plants transplanted into 1 gal pots then upcanned to 3 gal (GAL3). However, granular-fertilized GAL3 had smaller stem calipers than liquid-fertilized QT3. Plants of either of these two treatments were larger (a =0.05) than the other treatments. There were generally no other differences between fertilizer regimes for the same pot size within a container treatment.

Fertilizer regime greatly influenced the number of steps needed during upcanning. With liquid fertilization, two upcanning steps resulted in the largest plants. Whereas with granular fertilizer one upcanning step was needed. Upcanning with either fertilizer regime resulted in photinia that were superior to those transplanted directly into 3 gal containers. Improved growth through upcanning is proposed due to increased efficiency of absorption of applied nutrients by the root system due to increased root density. Plants with higher root densities would absorb more of the nutrients (Barley, 1970) with water drainage. Higher absorption of nutrients may explain why liquid fertilized QT3 plants were larger than the other treatments.

Significance to Industry: Upcanning during container production of photinia resulted in larger plants over a two-year period than production in the market-size 3 gal containers; perhaps due to a more efficient absorption of applied nutrients. The number of upcanning steps required to produce the largest plant was dependent on fertilizer regime. However, unpublished data on slash pine suggest growth benefits of upcanning are species specific.

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[1]FloridaAgricultural Experiment Stations Journal Series No. N-00616.

Shade Influences Yellow Spotting of Sago Palm Leaflets

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Florida

Nature of Work: Container-grown *Cycas revoluta* (Sago palm) commonly exhibits yellow spots or blotches about one-eighth inch long on the mature leaflets. The yellow spots often coalesce, turn necrotic and eventually encompass most or all of a leaflet. The causal agent of the leaf spotting is unknown, although the yellow spots do not seem to be associated with a disease organism. The purpose of the following study was to determine if growing sago palms in the shade as opposed to sun, results in a reduction in the number of yellow spots exhibited on the leaflets.

Twelve 7-gallon sago palms growing in a 7 pine bark: 9 Florida peat: 4 fine cypress sawdust: 1 sand medium (by volume) were obtained from Glen St. Mary Nursery, Glen St. Mary, Florida in July 1989. Yellow spots were evident on 7 -14 leaves per plant. The medium was removed from 8 plants; 4 of which were potted with Metro Mix 500 (GracetSierra Horticultural Products, Cambridge, Mass.) and 4 plants were repotted with the original medium. Four control plants were not repotted. The container medium of each plant was topdressed with 98 g (3.5 oz.) of Osmocote (Grace/Sierra Horticultural Products, Milpitas, Cal.) 18-6-12 and all plants were watered with a hose as needed. The plants were placed under 30% polypropylene shade until May 1990, then placed under 63% shade. The container medium of each plant was topdressed with 87.5 9 (3 oz.) of Escote (Vigoro Industries, Inc., Fairview Heights, IL) 20-4-11. On October 29,1990, 3 media samples (4.5 oz. or 135 ml each) were removed from 1 container of each treatment for percent moisture determination immediately prior to placing 2 replicate plants for each treatment in full sun.

In mid November, plants in sun and shade exhibited a marginal leaf chlorosis near the apex due to yellow leaflet tips. The yellow leaflet tips are seen as a marginal leaf chlorosis when looking at the whole leaf and this marginal yellowing is exhibited differently than the yellow spots or blotches that are located within the leaflet and not on the leaflet tip. Generally, plants in sun had twice as many leaves with marginal yellowing as plants in shade with an average of 6, 3, and 3 lower leaves of control, repotted, and Metro Mix 500 treatment plants, respectively, exhibiting marginal yellowing on leaf tips for plants grown in sun. Plants were place in a polyethylene house for winter protection and returned to designated sun or shade area in March 1991 where they remained until November 1991 when heights and 2 perpendicular widths for each plant were measured, total number of leaves were counted, and leaves with yellow margins and yellow spots on the leaflets were counted.

Results and Discussion: Plants grown under 63% shade for 14 months had greener leaves than sun-grown plants regardless of treatment. Shade plants grown in Metro Mix 500 and the control plants had a higher growth index and fewer leaves with yellow margins after 14 months compared to plants grown in the sun even though plants grown in Metro Mix 500 in the shade had more leaves than plants in sun (Table 1). This response was not evident for the plants repotted in the original medium; however, the number of yellow spots on the leaflets dramatically decreased for plants grown in the shade. For shade and sun-grown plants, a larger number of spots were observed on leaflets of plants grown in Metro Mix 500 indicating the yellow spots were not directly associated with the water content of the container medium, since the Metro Mix 500 (196% moisture) contained 2.6 and 1.6 times more water than the control (75%) and repotted (121%) medium when sampled in October.

Significance to Industry: These data indicated that sago palms grown under 63% shade exhibit fewer yellow leaflet spots or blotches and yellow leaf margins than plants grown in full sun. The specific cause of the spots or yellow margins was not determined.

Acknowledgement: The authors gratefully acknowledge Glen St. Mary Nursery for providing the plant material. Mention of trade names and companies does not constitute an endorsement nor is discrimination implied for similar products. Florida Agricultural Experiment Stations Journal Series No. N-0061 4.

Table 1. Growth parameters of Cycas revoluta plants after 14 months in 63% shade or 5.5 months in 63% shade then 8.5 months in sun[z].

Growth medium treatment	Growth[y] index	Number of leaves	Number of leaves with yellow margins	Leaflets with yellow spots
		Shade		
Metro Mix 500	225	56	6	158
Repot	209	52	16	95
Control	205	47	23	73
		Sun		
Metro Mix 500	212	48	12	2457
Repot	219	44	13	1041
Control	164	53	37	1206

[z]Data are the mean of 2 plants.

[y]Growth index = height + (width1 + width2/2)

Control plants were grown in a 7 pine bark: 9 Florida peat: 4 fine cypress sawdust: 1 sand medium (by volume). This medium was removed from roots of the repot plants and plants were repotted with same medium. Metro Mix 500 is a commercial product of Grace Sierra Horticultural Products.

Liming Requirements of Lilac

Carol E. Leda and Robert D. Wright
Virginia

Nature of Work: General nursery recommendations are to amend pine bark media with dolomitic limestone. Previous research has shown that liming requirements of containerized plants grown in pine bark are species specific. Liming needs have been determined for fraser fir (1), holly, azalea and juniper (2,4), barberry, photinia and nandina (personal observations).

A study was conducted to determine the influence of dolomitic limestone amendments on the growth and quality of lilac (Syrinqia vulqaris). Liners were transplanted into 1 gallon plastic containers using a 9:1 (v/v) pine bark and sand mixture on 21 June, 1990. Pulverized dolomitic limestone was incorporated into the pine bark medium at two rates: 5 and 10 lb/yd^3 (3 and 6 kg/m$^{3)}$. In addition, a control treatment with no limestone additions was included. The plants were topdressed with 15 g Osmocote (18N-2.6P-7.6K) and grown outdoors under daily overhead irrigation. There were 8 replications per treatment, arranged in a completely randomized block design.

Medium solutions were collected using the pour-through technique (5) on 20 September and analyzed for pH using a pH electrode. Also on this date, shoots were harvested for dry weight determination. The most recently matured leaves were collected for tissue nutrient analysis of Ca, Mg, Fe and Mn.

Results and Discussion: Medium solution pH was approximately 2 pH units higher for the limed treatments compared to the control, but there were no statistical differences between the two lime treatments (Table 1). Shoot dry weight was less for unlimed plants. The limed plants, especially the 10 lb/yd^3 treatment, exhibited visual symptoms of interveinal chlorosis throughout the growing season. Analysis of leaf tissue from the limed treatments revealed Fe levels below those typically found in a healthy woody species (3). In addition, there were lower tissue Mn associated with limed plants. This result is probably due to the reduced availability of micronutrients at the higher pH. There were no differences in percent tissue Ca and Mg among the treatments.

Significance to Industry: These results show that lilac benefit from amending pine bark with limestone. With limestone additions, plants may develop chlorotic leaves typical of either Fe or Mn deficiencies. Addition of a suitable micronutrient fertilizer source is thus advisable to produce plants of optimal size and quality. Further investigations need to be conducted on possible micronutrient requirements of lilac grown in limestone amended pine bark.

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Table 1. Medium solution pH levels, shoot dry weight, and shoot tissue nutrient concentrations of lilac grown in limestone amended pine bark.

Treatment Lime Rate			Shoot	Shoot Tissue			
(kg/m^3)	(lb/yd^3)	pH	Dry Wt(g)	Fe(ppm)	Mn(ppm)	Ca(%)	Mg(%)
0	0	4.5 b^z	7.8 b	39 a	156 a	0.46 a	0.25 a
3	5	6.2 a	13.1 a	23 b	137 a	0.38 a	0.24 a
6	10	6.6 a	12.1 a	23 b	89 b	0.43 a	0.28 a

^{z}Means comparison by Tukey's (HSD), p=0.05.

Evaluation of 1988-90 Garden Chrysanthemums Cultivars Grown in 6-Inch Pots

Kenneth C. Sanderson and John McGuire
Alabama

Nature of Work: Garden chrysanthemums Dendranthema arandiflora (Ramat) Kitamura have become popular landscape plants and are often sold in both the fall and spring (2). Two production programs are used in the spring production of chrysanthemums: 1) no controlled photoperiod or no supplementary light and no shade (black cloth) and 2) controlled photoperiod or supplementary lighting and shading (black cloth). No light/no shade programs produce short plants and are best used with 4-inch pots. For larger pot size and for crops flowered after Mother's Day, supplementary lighting for adequate vegetative growth and shading are necessary to produce satisfactory plants. Also, some cultivars are not suited to no light/ no shade production (1). Each year many new cultivars are released to growers for production. Cultivar evaluations of chrysanthemums in the landscape are available (3), however no evaluations for large pots or containers produced in the spring in Alabama exist. The purpose of the present investigation was to evaluate the growth of some of the 1988-90 garden chrysanthemums (released by Yoder Brothers, Barberton, OH) grown in 6-inch (15 cm) pots in the spring.

Rooted cuttings (four per pot) of the chrysanthemum cvs. Allure (1988 introduction), Hekla (1989-90), Illusion (1988-89), Naomi (1990-91), Stardom (1973, a standard), and Sunny Morning (1989-90) were potted into 15 cm (6-inch) plastic pots containing ProMix BX (Premier Brands, Inc., Stanford, CT) March 6, 1990. Plants were grown in full sun at 17C (62°F) minimum night temperature in a glasshouse. Standard commercial culture for spring production of chrysanthemum was used (7). Fertilization consisted of liquid 20-10-20 (20N-4.4P-16.6K) Peters Peatlite liquid fertilizer (W.R. Grace, Inc., Fogelsville, PA) at the rate of 2.2 g per liter or 2 lb per 100 gal. every 2 weeks. Supplementary light for vegetative growth was provided by incandescent lighting (10PM to 2AM) from March 6 to March 16. After March 16 and until buds showed color, the plants were covered daily with black cloth from 4:30 PM to 8:00 PM. Plants were pinched on March 26 and a 2,500 ppm daminozide (B-Nine™, Uniroyal Chemical, Bethany, CT) spray was applied to the foliage of the plants until runoff when the emerging shoots were 5 cm (2-inches) long. Five pots of each cultivar were arranged in a randomized complete block design. When half of the flowers on a plant were open, the plant height and area (diameter of the plant in two directions), number of flowers per plant and a quality rating were measured. Plant quality was rated: 0 = dead, 1 = very poor, totally unsalable; 2 = poor, some salable; 3 = average, good salable; 4 = above average, very good, salable; and 5 = excellent, salable.

Results and Discussion: The cultivars did not differ in plant quality ratings. 'Hekla' ranked the highest in every growth parameter measured (Table 1). Plant height was usually between 22 cm ('Sunny Morning') and 27 cm ('Hekla'), however Allure (17 cm) and Illusion (21 cm) were the shortest cultivars. All the cultivars exceeded the one and half the height of the container criterion for acceptable plant height established by Sachs and Kofranek (5). The PMA standards for 6-inch potted chrysanthemum also includes the height of the pot, therefore only 'Hekla', 'Naomi', 'Stardom' plants met the 35 cm (13-17 inch) PMA standards (4). 'Hekla' produced the most flowers per plant but did not differ in flower number from 'Naomi'. 'Naomi', 'Stardom' and 'Sunny Morning' plants had similar flower numbers. 'Allure' plants had the fewest flower per plant and did not differ from 'Illusion' plants in flower number. All the cultivars meet the PMA standards (4) for flower number. 'Hekla', 'Stardom' and 'Sunny Morning' plants had the greatest plant areas and differed from 'Allure' and 'Illusion' plants in areas. These two cultivars had the smallest plant areas. PMA standards (4) for top of the plant width are 30 cm (12 inches). A 30 cm or 12 inch diameter plant would average a minimum plant area of 900 cm^2 or 14.4 sq. in. All cultivars except 'Allure' produced plant areas exceeding 900 cm^2 or 144 sq. in.

Significance to Industry: This research reveals that the cvs. 'Hekla', 'Naomi', 'Stardom' are outstanding cultivars for production in 6-inch containers. 'Illusion' and 'Sunny Morning' plants are equal to the other cultivars in growth except for being slightly shorter in height. 'Allure' appeared to be unacceptable for production in 6-inch pots. 'Hekla', 'Illusion' and 'Naomi' were found to be superior new cultivars for no light/no shade production as 4-inch potted plants in the spring (6).

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Table 1. Plant height and area and number of flowers per pot of 1990-91 chrysanthemum cultivars flowered in 15 cm (6-inch) pots during the spring.

	Height (cm)[z]	Flowers per pot	Area (cm^2)[y]
Allure	17d[x]	43c	512d
Hekla	27a	104a	1597a
Illusion	21c	57c	1055c
Naomi	25ab	93ab	ll9lbc
Stardom	24bc	86b	1372ab
Sunny Morning	22bc	79b	1437ab

[z]English conversion 2.5 cm = 1 inch.

[y]Area = diameter at the top of the pot measured in two directions and multiplied together. 2.5 cm x 2.5 cm = 6.25 cm^2 or 1 $inch^2$.

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

Comparison of Selected Chrysanthemum Cultivars Grown in Hanging Gardens With and Without Hydrophilic Polymer Treatment

Kenneth C. Sanderson and John A. McGuire
Alabama

Nature of Work: The production of flowering hanging baskets doubled during 1985-1989 and had a wholesale value of $100 million, (2). Hanging basket chrysanthemum, Dendranthema qrandiflora (Ramat). Kitamura are widely used in homes, restaurants and interior and exterior landscapes (6). Both garden and florist chrysanthemum cultivars are grown in hanging baskets. Cultivar evaluations of hanging basket chrysanthemums are not available and one must select cultivars from landscape evaluations (9) or plant supplier recommendations (1).

Supplying adequate water to plants in hanging baskets is a special challenge to the grower, marketer, and consumer due to their exposure on all sides, holes in the basket wall (i.e., Belden hanging gardens), or basket walls made of wire. Amendment of hanging basket media with hydrophilic polymers may meet some of the challenges of supplying water to plants growing in these containers. Hydrophilic polymers have been shown to: 1) increased water holding capacity (10), 2) reduced watering frequency (12), 3) improved soil texture (14), 4) reduced water infiltration (14), and 5) reduced erosion and runoff (15). Certain studies have shown that they have no effect on plant growth (5,8). Furuta and Autio (7) noted that many uncertainties remain in evaluating hydrophilic polymers. Media ingredients (3), soil type (7), type of polymer (7), polymer rate, applied (12,14), phytotoxicity (13) and fertilizer concentration (4) can influence the effectiveness of a hydrophilic polymer.

The purpose of the present investigation was to evaluate the growth of selected chrysanthemum cultivars grown in hanging garden baskets with and without hydrophilic polymer treatment.

Rooted cuttings of the garden chrysanthemum cvs. Allure (1988 introduction), Hekla (1989-90), Illusion (1988-89), Naomi (1990-91), Stardom (1973, an outstanding cultivar from previous tests) and Sunny Morning (1989-90) were potted in 8-inch Belden Hanging Gardens™ (Belden Plastics, St. Paul, MN) on March 2, 1990. Two outstanding florist chrysanthemum cultivars, 'Solo' (1985) and 'Surf' (1985) were also included in the test because of their outstanding growth habits and flower production (observation from previous tests). Pro-Mix BX medium (Premier Brands, Inc., Stanford, CT) was used to plant 3 cuttings in the top of the basket and 5 cuttings in the side holes. Commercial procedures for the production of garden chrysanthemum hanging baskets were followed (1, 6). Plants were grown in full sun at 17C (62°F) minimum night temperature in a glasshouse. Supplementary light for vegetative growth was provided by incandescent lighting (10 PM to 2 AM) from March 2 to March 16. After March 16 and until buds showed color, the plants were covered daily with black cloth until 4:30 PM to 8:30 PM to initiate flowering. Plants were pinched on March 14. A 2,500 ppm daminozide (B-Nine™, Uniroyal Chemical, Bethany, CT) growth retardant spray was applied to the foliage of the plants until runoff on March 26. Fertilization consisted of liquid 20-10-20 (20N-4.4P-16.6K) Peter Peatlite liquid fertilizer (W.R. Grace, Inc., Fogelsville, PA) applied at the rate of 2.2 g per liter or 2 lb per 100 gal every 2 weeks starting March 2 and continuing until buds were 0.6 cm or 1/4 inch in diameter. On March 26, 1 teaspoon (approximate 4 g) of Osmocote 14-14-14 (14N-6.IP-11.6K) was broadcasted on the growth medium's surface. Hydrophilic polymer treatments consisted of three replications of the following: 1) no treatment, 2) media amended with 23 g (0.8 oz) Supersorb "C" hydrophilic polymer (Aquatrols Inc., Pennsauken, NJ) and 3) ten second Supersorb "F" root ball dips (28 g or 1 oz per 5.8 liters or 1.5 gal) prior to planting. Nine pots of each cultivar were arranged in a randomized complete block design. When half of the flowers on a basket were open, the plant height and area (diameter of the plants in two directions), number of flowers per basket, date of flowering and a quality rating were measured. Plant quality was rated: 0 = dead; 1 = very poor, unsalable; 2 = poor, some salable; 3 = average, good, salable; 4 = above average, very good, salable; and 5 = excellent, salable.

Results and Discussion: In general, the florist cvs. Solo and Surf outperformed the garden cvs. in most growth parameters (Table 1). 'Surf' produced the tallest plants and differed from all cvs. in plant height. Garden cvs. Hekla, Naomi and Stardom were comparable in height to the florist cv. Solo. An 8-inch Belden Hanging Garden is 13 cm or 5 inches tall, therefore all the cultivars except 'Allure' met the criterion for potted plants established by Sachs and Kofranek (11). 'Surf' and 'Solo' baskets occupied the most area (largest plant spread). 'Sunny Morning' baskets had the least plant spread but most of the garden cvs. were similar in plant spread except 'Hekla'. 'Surf', Stardom and 'Solo' had the highest plant quality ratings (5.0 to 4.5). 'Sunny Morning' rated the poorest of any basket and produced the most unsalable baskets. Most of the 7 week garden cultivars flowered on time, however 'Sunny Morning' required 59 days. The 6 weeks cvs. 'Allure' and 'Illusion' flowered one week late.

Supersorb treatment did not influence plant height, area, or flower number (Table 2). This result agrees with other research that has indicated hydrophilic polymers do not affect these plant growth parameters (5,8). Plant quality and the number of days to flowering was influenced by Supersorb™ treatment. No treatment and media incorporated Supersorb™ "C" treatment produced the best quality plants. Untreated plants flowered first and differed in flowering time from Supersorb™ "F" root ball dips. The results for quality rating and days to flower may be an indication of the phytotoxicity observed by Taylor and Halfacre (13) with hydrophilic polymer use.

Significance to Industry: Florist chrysanthemum cvs. Solo and Surf are recommended over the garden chrysanthemum cvs. tested for Belden hanging garden production. 'Hekla', 'Illusion', 'Naomi' and 'Stardom are recommended garden chrysanthemum cvs. for hanging basket production. 'Allure' and 'Sunny Morning' are not recommended for baskets. Hydrophilic polymer treatments incorporated or as rootball dips had very little effect on the growth of the plants in this study. It is felt that hydrophilic polymers are best viewed as water management materials and their use and value should be judged in water management rather than plant growth.

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Table 1. (see page 118)

Table 2. Effect of Supersorb hydrophilic polymer treatment on chrysanthemum hanging garden plant quality and plant quality and days to flowering.

Treatment	Quality rating[z]	Days to flower[y]
None	4.1a[x]	49b
Supersorb C incorporated	3.9a	50ab
Supersorb F root ball dip	3.4b	51a

[z]Quality rating scale: o = dead; 1 = very poor, unsalable; 2 = poor, some salable; 3 = average, good, salable; 4 = very good, salable; and 5 = excellent, salable.

[y]Days to flower after the start of short days caused by covering plants daily from 4:30 pm to 8:30 am.

[x]Means in columns followed by the same letter(s) are not significantly different according to Duncan's multiple range test.

Table 1. Plant height, area, quality and days to flower for selected chrysanthemum cultivars growth in 10-inch Belden hanging gardens.

Cultivar	Height (cm)^{z}	Area (cm^{2})^{y}	Quality rating	Days to flowering
Allure	19d^{v}	1589de	3.7bc	49cd
Hekla	23bc	2199bc	4.6ab	48d
Illusion	20cd	1790cde	2.5d	49cd
Naomi	24b	2037cd	3.5c	57ab
Solo	23bc	2590ab	4.5abc	53ab
Stardom	23bc	2009cd	4.8a	51cd
Sunny Morning	20cd	1481e	1.5e	59a
Surf	26a	2875a	5.0a	60a

^{z}English conversion 2.5 cm = 1 inch.

^{y}Area = diameter at top of container measured in two directions and multiplied together i.e. 2.5 cm x 2.5 cm = 6.25 cm^{2} or 1 inch^{2}.

^{x}Rating scale: 0 = dead; 1 = very poor, unsalable; 2 = poor, some salable; 3 = average, good, salable; 4 = very good, salable; and 5 = excellent, salable.

^{w}Days to flower after the start of short days caused by covering plants daily from 4:30 pm to 8:30 am.

^{v}Means in columns followed by the same letter(s) are not significantly different according to Duncan's multiple range test.

Computer Model for Predicting Volume Shrinkage Upon Mixing Three Different Container Medium Components

Silvia Bures and Franklin A. Pokorny
Georgia

Nature of Work: Volume shrinkage occurs when medium components of different particle sizes are mixed. Small particles fill pores located between large particles resulting in a decrease of mixture volume in relation to the additive volume of seDarate components.

Shrinkage has to be taken into account in computer modeling of container media mixtures because knowledge of actual mixture volume is necessary for establishing substrate properties on a volume basis. Previous work (3, 4, 5) shows that, once corrected for shrinkage, mathematical equations can be used to predict mixture properties, such as pH, CEC or water retention and aeration, from analysis of individual components. To use these equations with a computer program to predict container media properties, a model for predicting shrinkage should also be used.

Amount of shrinkaqe depends on the proportion of components being mixed and differences in particle size. When a coarse component is added to a fine component, shrinkaqe increases and reaches a maximum when the coarse component is added in proportion between 50% and 70% (1). A simplified model that accounts for one value, volume shrinkage when 50% of each of two components are mixed, would lessen the number of laboratory measurements necessary for shrinkage characterization and has proven useful in predicting shrinkage for two component mixtures (2).

Objectives of this research were to devise and test a mathematical model that predicts shrinkaqe of container medium mixtures of up to three components.

The predictive model consists of a set of four equations. Percent shrinkaqe (S) of a mixture of up to three components (1, 2 or 3) for any given proportion (x) of each of those three components, can be expressed as:

$$\text{if } x_l > O.5,\ S = 2x_2 Smax_{l2} + 2x_3 Smax_{l3}$$
$$\text{if } x_2 > O.5,\ S = 2x_l Smax_{l2} + 2x_3 Smax_{23}$$
$$\text{if } x_3 > O.5,\ S = 2x_l Smax_{l3} + 2x2Smax_{23}$$
$$\text{if } x_l,\ x_2 \text{ and } X_3 < O.5,\ S = (1 - 2x_l)\, Smax_{23+}$$
$$(1-2x_2)Smax_{13}+(1-2x_3)Smax_{12}$$

where Smax is maximum percent shrinkage of each of the binary combinations (1-2, 2-3 and 1-3), which occurs when 50% by volume of each of the two components are mixed.

This model was tested for two 3-component mixtures: a) pine bark (1-2 mm), sand (0.42-0.60 mm), and calcined clay (2.38-4.76 mm), and b) ungraded pine bark, ungraded sand, and ungraded calcined clay. Experimental design was a randomized complete block with five replicates of each of the 66 medium combinations that are obtained when three components are mixed in 10% increments. Shrinkage was also determined for the three binary combinations (1-2, 2-3, and 1-3) for both sets of mixtures. These three sinqle values were introduced in the model to predict shrinkage for each of the 66 experimental combinations.

Results and Discusslon: Shrinkage was predicted with the proposed model and there was good agreement between experimental and predicted data. The assumption that maximum shrinkage takes place when 50% of each of two components are blended gave some underestimation of shrinkage. Nevertheless, the model proved useful and can be applied to computer modeling of container medium mixtures. Its main advantaqe is that only shrinkage characterization for three mixture proportions is required, those occurring when 50% by volume of each of two components are blended, as opposed to shrinkage characterization for all possible combinations in a three component mixture.

Significance to Industry: The proposed model does not require intensive laboratory work and can be easily utilized by container medium manufacturers and plant growers. Introduction of such models into computer programs will allow for future computer selection of container media which will automate mixture selection processes.

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