SECTION 2
CONTAINER-GROWN PLANT PRODUCTION

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Section Editor and Moderator

Biobarrier Rate Influences Rooting-Out of Five Tree Species Produced Pot-in-Pot

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Nature of Work: A problem the pot-in-pot production system has been the growth of roots out of the planted container, through the holder pot and into surrounding soil (1-3). Biobarrier is a permeable geotextile fabric with trifluralin (Treflan) impregnated nodules bonded to the fabric. Previous studies have shown that Biobarrier can be successfully used to control rooting-out of some species grown pot-in-pot (1,3). The purpose of this study was to determine if rate of Biobarrier application had an affect on plant growth and rooting-out of five tree species produced pot-in-pot.

The experiment was conducted outdoors under full sun at the University of Georgia Coastal Plain Experiment Station in Tifton, GA. Uniform liners in 2.8 l (#1) containers of *Lagerstroemia indica* x *fauriei* 'Natchez' (crape myrtle), *Myrica cerifera* (wax myrtle), *Platanus occidentalis* (sycamore), *Prunus incisa* x *speciosa* 'Snow Goose' (cherry), and *Taxodium distichum* (bald cypress) were potted into 26 l (#7) containers (Model 070, The Lerio Corporation, Valdosta, GA) on 9 May 1995. Potting substrate consisted of milled pine bark and sand (8:1, v/v) amended with Micromax micronutrients (Grace-Sierra) at 0.6 kg/m^3 (1.0 lb/yd^3) and dolomitic limestone at 3.0 kg/m^3 (5.0 lb/yd^3). Plants were topdressed with Osmocote 16N-3.1P-10K (16-7-12, Grace-Sierra) at 250 g (8.8 oz) per container. Holder pots (model 070 with no side drain holes) were placed in the ground with 2.5 cm (1 in) at the top of the container remaining above grade. Three 5 cm (2 in) diameter holes were drilled in a line for drainage.

The experiment was a randomized complete design with six single-plant replications and three rooting-out reduction treatments grown in a pot-in-pot production system arranged by species. The treatments were: 1) no treatment (control), 2) 32 nodule piece of Biobarrier (Reemay, Inc., Old Hickory, TN), and 3) two 32 nodule pieces of Biobarrier. Biobarrier was placed between the planted container (herbicide beads facing the planted container) and the holder pot with the Biobarrier covering the drain holes of the holder pot. Planted containers were then placed in the holder pots for the duration of the study. Plants were irrigated daily with 160^o low volume spot spitters (Roberts Irrigation, San Marcos, CA) at the rate of 3.8 l (1.0 gal) per container.

At the termination of the study 26 September, 1995, growth index measurements [(height + width 1 + width 2 (perpendicular to width 1))/3] were taken for wax myrtle and crape myrtle. Height and stem diameter (6 in. above soil line) measurements were taken on bald cypress, 'Snow Goose' cherry, and sycamore. Shoot dry weight, root dry weight inside the planted container, and root dry weight between the planted container and the holder pot measurements were made after drying at 66C (150 F) for 72 hr. Roots which grew into the surrounding soil beyond the holder pot were not harvested. Containers were considered harvestable if they could be manually removed by two men. Data were evaluated by general linear models procedures using SAS (SAS Institute, Cary, NC).

Results and Discussion: Wax myrtle - Growth indices and shoot dry weight were reduced by Biobarrier treatments compared to control plants. When Biobarrier was used, there were no roots growing between the planted container and the holder pot, compared to 15 g for the control. All treatments were harvestable, indicating rooting-out may not be a problem for this species.

Crape myrtle - Growth index and shoot dry weight were reduced 15% and 25%, respectively, for plants treated with 64 nodules of Biobarrier compared to the control. All treatments had some rooting-out which influenced harvestability of all treatments. Percent root dry weight between the planted container and the holder pot was 4.5x greater for control plants compared to plants grown with 64 nodules of Biobarrier.

Bald cypress - Treatment with Biobarrier had no effect on the shoot and root growth inside the planted container. Root dry weight between the planted container and the holder pot decreased as rate of Biobarrier increased. Two of the six replicate control plants could not be manually harvested.

'Snow Goose' cherry - Treatment with Biobarrier had no effect on the shoot or root growth inside the planted container. Root growth between the planted container and the holder pot was reduced approximately 17x by use of Biobarrier. Although control plants had 3.1% of their root dry weight between containers, all plants were harvestable.

Sycamore - Plant height, stem diameter, and shoot dry weight were reduced by 21%, 25%, and 56%, respectively for plants treated with Biobarrier compared to the control. Root dry weight between the planted container and the holder pot was reduced 5x by the 32 nodule treatment and 124x by the 64 nodule treatment. Root:shoot ratio increased as rate of Biobarrier increased.

Significance to Industry: Biobarrier did an excellent job of controlling rooting-out at the 32 nodule rate for all species in this test except crape myrtle. Crape myrtle is an extremely vigorous plant and previous research has shown that some root growth outside the planted container can occur at 128 nodules per pot. The reductions in shoot growth for crape myrtle and sycamore may not be entirely due to phytotoxic effects of trifluralin because the growth of control plants may have been influenced by extensive rooting into the surrounding soil by these species. A tight seal between the planted container and the holder pot is critical to the success of Biobarrier for pot-in-pot applications.

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The Cellugro System™ - A New Nursery Production Method

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Virginia

Nature of Work: Over the past few years, several new nursery production methods that attempt to combine some of the advantages of both field and container production into one production method, have been introduced (1, 2). Field production advantages include root zone temperatures that are buffered year-round, less frequent irrigation, and no blow-over of trees and large shrubs. Container production advantages include a plant that is "harvestable" at any time of the year, plants with entire root systems, and a lighter weight product. Included among the new combination production methods are pot-in-pot (P&P, Nursery Supplies, Inc., Chambersburg, PA; The Lerio Corp., Mobile, AL; Zarn Inc., Reidsville, NC) and the AGS™ (Above Ground System, Nursery Supplies Inc., Chambersburg, PA).

The Cellugro System™ (ACF Environmental, Richmond, VA), introduced in 1995, is another example of a "field production/container production hybrid". To test various manufacturer claims, a unit was installed at the Hampton Roads Agricultural Research and Extension Center in February, 1995. The unit was installed inground by the manufacturer, and filled with a 8:1 (v:v) pinebark:sand medium amended with 8 lbs. Osmocote 22-4-7 (The Scotts Company, Marysville, OH), 4.5 lbs. lime and 1.5 lbs. Micromax (Scotts) per cubic yard.

In May, liners of a variety of trees, shrubs, ornamental grasses and perennials, including *Acer palmatum*, *Koelreuteria bipinnata*, *Magnolia virginiana*, *Oxydendrum arboreum*, *Pinus rigida*, *Rhododendron obtusum* 'Hino-Crimson', *Ilex verticillata*, *Ilex aquifolium*, *Festuca ovina glauca*, *Pennisetum setaceum* 'Rubrum', *Hemerocallis* spp., *Heuchera micrantha* 'Purple Palace', *Sedum* spp., and *Stachys byzantina* were planted by rows in the individual cells of the Cellugro System™ (Figure 1). Several of the same plants were also lined out in the same medium in containers of approximately the same volume (5 quart) as the individual cells in the Cellugro System™ unit. The containerized plants were grown on a conventional container bed with overhead irrigation. The Cellugro System™ unit had overhead irrigation erected around its periphery. This was a comparative test, not replicated research, since only one Cellugro System™ unit was available.

Results and Discussion: Plants on the container bed were irrigated daily. Plants in the Cellugro System™ were only irrigated when an indicator plant, *Koelreuteria bipinnata*, had considerably wilted leaves. The amount of water applied to the Cellugro System™ plants was recorded, and compared to the amount of water applied to the container bed plants for the same growing season. The Cellugro System™ plants required only 10% of the water applied to the container bed plants, yet were of equal or greater size (varied by species). The only negative seen relative to watering were azaleas on the low (drain) end of the Cellugro System™ that died due to root rot, whereas no azaleas on the high end of the Cellugro System™, or in containers, died from root rot due to medium wetness.

Close plant spacing and medium shading allowed few weeds to grow in the Cellugro System™ compared to considerable weeds in the container-grown plant pots. No plants in the Cellugro System™ blew over whereas the trees in the containers frequently blew over.

All of the tree and shrub species were left in the Cellugro System™ to overwinter, with the matching container-grown plants left on the container bed unprotected. Numerous English hollies in containers were winter killed, with some in the Cellugro System™ experiencing basal bark crack. No other plant damage was seen for either overwintering method.

Trees and shrubs from both production methods were harvested in March, 1996, to compare root systems (Figure 2). Roots on several species in containers were either circling, matted, or both. No circling or matted roots were found on plants grown in the Cellugro System™ (Figure 3).

The intermixed planting of woody and herbaceous plants proved a mistake (authors' decision, not a manufacturer recommendation) (Figure 4). The trees often shaded the perennials, reducing the growth of those preferring full sun. The difference in growth rate among the various perennials and ornamental grasses caused some to overgrow and suppress others.

Significance to Industry: The Cellugro System™ was easy to install and fill with medium. It was relatively easy to plant, and easy to row-run harvest with a modified post-hole digger made by the Cellugro System™ designers (Hunters View Nursery, Finksburg, MD).

The Cellugro System™ proved a space and water conserving way to grow a variety of plants. Cooler summer and warmer winter root zone medium temperatures produced larger plants for some species, and gave adequate overwintering protection (zone 8) without any supplemental cover or heat. Plant blow over was nonexistent, and weed pressure was greatly reduced.

With careful planning of species positioning, more than one species can be grown in the unit together if the growth rate and harvest time of each is considered. For some ornamental grasses and perennials multiple crops can be harvested within one growing season.

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Figure 1. Cellugro installed in ground and planted, May 1995.

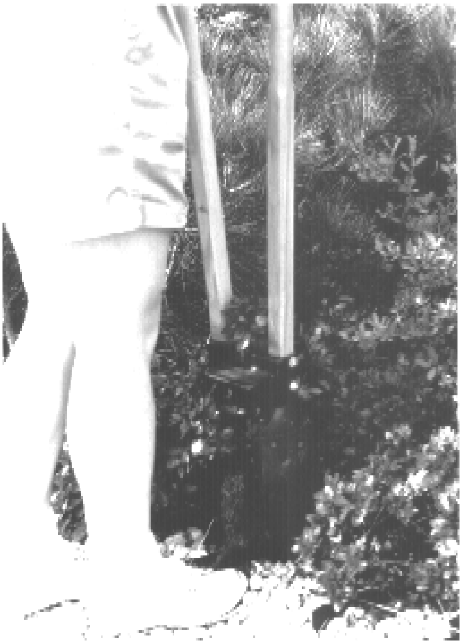

Figure 2. Modified post hole digger used for harvesting plants.

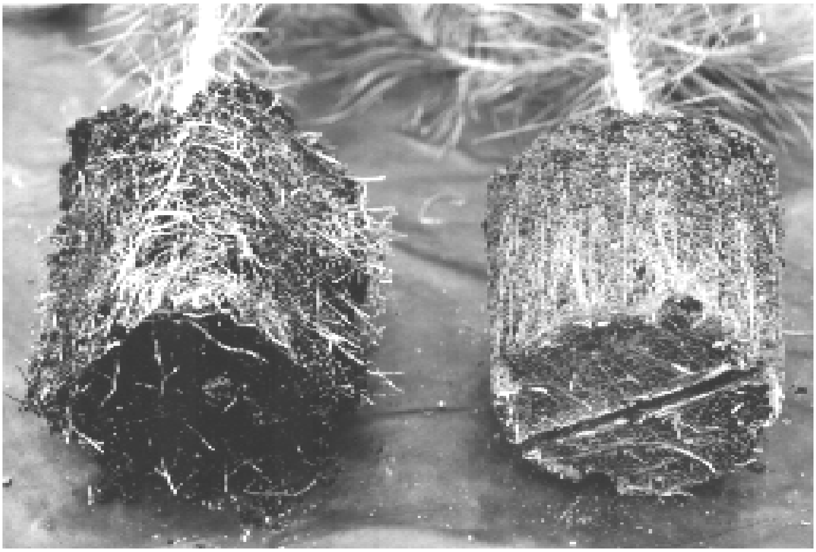

Figure 3. Root ball on pine harvested from the Cellugro System™ (left) vs. harvested from a conventional container (right).

Figure 4. After five months growth (October, 1995), larger and/or faster growing plants had crowded out some of the small and/or slower growing plants.

The Use of Crumb Rubber Amendment in the Production of Poinsettias

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Nature of Work: Greenhouse studies were conducted to determine the effects of shredded tire rubber as a media component on the growth and quality of Poinsettias (Euphorbia pulcherrima Gutbier™ V-14 Glory' and 'Gutbier™ V-17 Angelika Red'). Media components included pine bark, sharp sand, peat, and 1/4 inch shredded tire rubber. A prepared media consisting of a 2:1:1 ratio of bark, peat and sand, respectively and Metro 366™, a commercially prepared media were used as standards for this experiment. Ten rooted cuttings of each cultivar were planted separately in 6 inch pots in each media, for a total of 180 pots. The treatments were arranged in a randomized complete block design. Normal fertilization practices were followed using 300 ppm Peters Excel 15-5-15/Ca/Mg. Scotts Corp., Foglesville, PA. Plants were pinched to five to seven nodes when roots reached the outer edged of the growing media. Production techniques were followed, including pest control, when warranted. After bract development, plant parameters, including growth index, stem and bract count, shoot dry weight, root dry weight, and bract area were measured. A visual rating from 1 to 10, based on the overall appearance, was also assigned to each plant. Chemical analysis of leachates from different media were conducted. Electrical conductivity, pH, nitrate, zinc were measured to detect any differences in the various media.

Results and discussion: This study indicated that two varieties of poinsettia could be grown successfully in media containing up to twenty percent 1/4 inch shredded tire rubber by volume. However, some reduction in growth did occur among plants grown in media treatments containing forty percent and greater of rubber. Air filled porosity and bulk density increased while water holding capacity decreased with the addition of rubber to media. Except for the commercial medium, Metro 366, few differences in the chemical properties of the media treatments occurred. The addition of rubber to media had more pronounced effects on the physical properties than the chemical properties of media. The pH of all nine media treatments used in the studies rose over the course of time. The addition of rubber to media did not appear to affect the soil pH since it was consistent among both media containing no rubber and rubber containing media. Analysis of eachate for week 7 showed that zinc content was significantly higher for all rubber containing media than for either control, but was not significantly different among the various shredded tire rubber media extracts (Graph 1). This study seems to coincide with that of Rogers, et al., 1994, whereby the addition of 10 to 20 percent rubber to native loam soil, typically used to grow ryegrass, increased yields. They also found that up to 80 percent rubber, by volume, could be added to sandy soils with no phytotoxic symptoms.

Significance to Industry: Although poinsettias are only grown seasonally in the United States, they are one of the most important floricultural crops produced. In 1980, the industry was valued at 66 million dollars in the United States alone. This was a three hundred percent increase over the estimated worth of poinsettia production value ten years previous (Wilkerson et al., 1990). The rise of mass markets has also made this market a highly competitive one, bringing about a need for reductions in production costs as well as creative marketing techniques such as miniatures and hanging baskets (Larson et al, 1978; Nelson, 1991). A variety of other waste materials have been studied for their applicability as media amendments for container production (Wang and Pokorny, 1989; Bilderback, Fonteno and Johnson, 1982; Neal and Wagner, 1983). Experimentation with the use of waste tire or poly rubber began in the 1970's (Milbocker, 1974). Pertuit and Mazur (1981) used tire rubber amendments in poinsettia studies and found plants grown in media amended with rubber were of poor quality. Zinc toxicity has been associated with the use of rubber in growing media (Bowman et al., 1994). The symptoms that are generally associated with zinc toxicity are similar to effects of toxic amounts of other heavy metals such as cobalt, nickel and cadmium. Riggle (1992) reported that in 1992 over two billion tires were stockpiled in the United States. The nursery industry is known for its initiative in using waste products in producing aesthetically acceptable ornamentals and floriculture crops for the general consumer. To insure quality and performance, research should precede the widespread use of any waste product in our industry.

Special thanks of appreciation to the Mississippi Department of Environmental Quality, Office of Pollution Control, Solid Waste Division for their financial support of this study and to The Scotts Corporation for their generosity of supplying media and fertilizer for this study.

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12. Zinc Content from Leachate Over Seven Weeks for Six media treatments

Zinc Content from Leachate Over Seven Weeks for Six Media Treatments

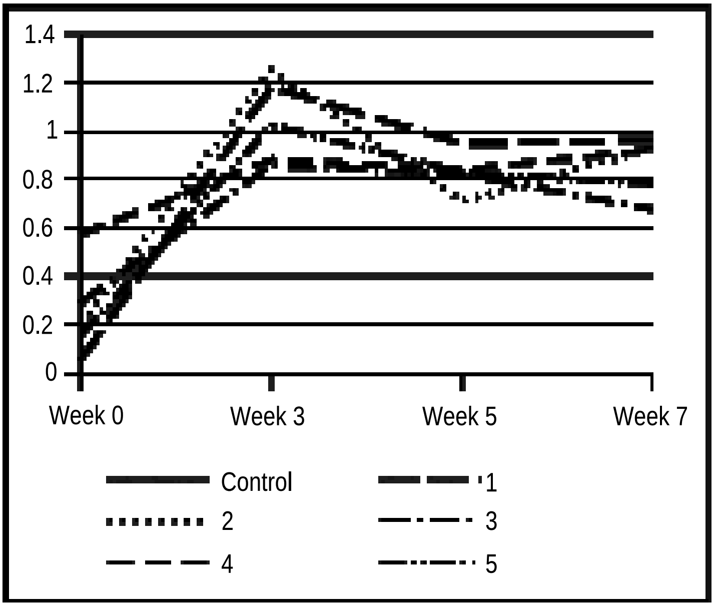

Table 1. Nine media treatments included in Shredded Tire Rubber Study on Poinsettia 'V-17 Angelika Red' and 'V-14 Glory'.

Mediz[YZ]	Sphagnum Peat Moss	Sand	Pine Bark	1/4 Inch Shredded Tire Rubber
Metro 366TM				
Control	25%	25%	50%	0%
1	25%	25%	40%	10%
2	25%	25%	30%	20%
3	25%	25%	20%	30%
4	25%	25%	10%	40%
5	25%	25%	0%	50%
6	25%	25%	37.5%	12.5%
7	25%	25	33.5%	16.5%

[Y]percentages are by volume.
[Z]The Control media and media 1-7 were amended using 1.5 lb. yd^3 Micromax and 10 lb. yd^3 Dolomitic limestone.

Table 2. Visual Quality Rating for 'V-17 Angelika Red' and 'V-14 Glory' in nine media treatments

Media[z]	Visual Quality Rating[xy] 'Angelika Red'	'Glory'
Metro 366™	8.5a	7.5a
Control	6.9cd	6.6bc
1	7.3bc	7.3ab
2	7.6	7.2ab
3	7.4bc	6.7abc
4	6.8cd	6.1c
5	6.6d	4.5d
6	7.3bc	6.2c
7	7.3bcd	6.5bc

[X]visual ratings assigned on a scale ranging from one to ten, one = least desirable, 10 = most desirable.
[Z]Means averaged over ten replications, and separated within columns by LSD at P = 0.05 level. Means followed by the same letter are not significantly different.

Nitrogen Nutrition of Containerized Cupressus arizonica var. glabra 'Carolina Sapphire'

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Nature of Work: A study was conducted to determine the influence of N concentration on growth of containerized 'Carolina Sapphire' smooth Arizona cypress.

Containerized, rooted stem cuttings of 'Carolina Sapphire' smooth Arizona cypress [*Cupressus arizonica* var *glabra* (Sudw.) Little 'Carolina Sapphire'] grown in calcined clay were fertilized daily for 16 weeks with a complete nutrient solution containing 0, 20, 40, 80 or 160 mg N/liter supplied as ammonium nitrate. Plants were grown in a glass greenhouse under natural photoperiod and irradiance with day/night temperatures of 27 ±5C (80 ±9F) /21 ±5C (70 ±9F). The experiment was a randomized complete block design with 10 single-plant replications. All nutrient solutions were adjusted to pH 6.0 using 1N H2SO4. Eight hundred ml of nutrient solution was applied daily at 0900 HR to each container. No other irrigation was needed throughout the study.

At treatment initiation, plant heights and stem diameters were taken at the surface of the substrate. Initial heights and stem diameters were 22 cm (8.7 in) and 2.3 mm (0.09 in), respectively. After 16 weeks, plant heights and stem diameters were measured. Data were subjected to regression analyses. The analyses showed statistical significance for growth measurements only if the nontreated control (0 mg N/liter) was included. Therefore, the nontreated control was excluded from the regression analyses and a linear contrast was utilized to test for differences between a pooled N treatment effect and nontreated control.

Results and Discussion: Plant heights and stem diameters were not affected by N rate suggesting that 20 mg N/liter was adequate for maximizing growth (Table 1). Nitrogen fertilization increased heights and stem diameters by 71% and 56%, respectively, compared to the nontreated controls (0 mg N/liter).

Significance to the Nursery Industry: 'Carolina Sapphire' smooth Arizona cypress is a versatile, fast growing evergreen tree which can be utilized as a specimen plant, an attractive screen or as a Christmas tree. Since its introduction in 1987, interest and subsequent demand for this cultivar have increased, accompanied by a need for information related to container production. Maximum shoot growth were realized by daily application of a complete nutrient solution containing 20 mg N/liter. Rates of N > 20 mg/liter did not stimulate additional growth.

Table 1. Effect of N concentration on height and stem diameter of 'Carolina Sapphire' smooth Arizona cypress.

Nitrogen concn. (mg/liter)	Height (cm)	Stem diam. (mm)
0	28	3.4
20	49	5.0
40	42	4.8
80	48	5.5
160	51	5.6
Significance[z]		
Linear	NS	NS
Quadratic	NS	NS
N rate vs. control[y]	***	***

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

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

Calcium Carbonate Used to Reduce Zinc Toxicity in Media Containing Shredded Waste Tires

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Nature of Work: The use of shredded waste tires as a media amendment has been explored by various authors (Bowman et al., 1994; Milbocker, 1974; Harkess et al., 1995; Zhao, 1995). Used in high percentages of the media, it has been reported that a potential for zinc toxicity exists (Bowman et al., 1994). Tests on the waste tire material conducted by the Mississippi State Chemical Laboratory have confirmed the presence of as much as 13,000 ppm zinc from an acid digestation extraction. The readily available surface zinc is likely considerably lower. Temperature, media acidity, and particle size were reported to increase the available zinc in shredded waste tire containing media (Milbocker, 1974).

Zinc and iron are competitively taken up by plants with zinc more easily absorbed. The symptoms of zinc toxicity displayed by the plant are often the same as iron deficiency and can be reduced with an application of chelated iron (Milbocker, 1974). Calcium carbonate raises the medium pH which effectively reduces zinc availability. In addition, zinc possibly complexes with the carbonates forming insoluble compounds with deficiencies occurring in recently limed soil even when pH values remained below 6.0 (Mortvedt et al., 1972).

Rooted cuttings of *Euphorbia pulcherrima* 'Eckespoint Freedom Red' were potted on 24 August 1995 into 5 inch pots. They were potted into media containing shredded waste tires at 25, 50, or 75% by volume mixed with peat moss. Two grinds of waste tire were used, 2.0 mm or 2.0-6.3 mm particle size. Calcium carbonate was added to the different media at 0, 3.5, 7, or 10.5 lb/yd^3. After planting, all media was drenched with 4 oz./pot of Aquagro 2000L at 6.0ml/gal .

The potted cuttings were placed on the greenhouse benches at 12 x 12 inch final spacing. The plants were fertilized with 250 ppm 15-5-15 Peters Excel Cal/Mag poinsettia fertilizer (The Scotts Company, Marysville, Ohio) on a continuous liquid feed. On 13 September 1995, the cuttings were pinched to leave 5 nodes. Natural photoperiods were relied upon for flowering. At termination of the experiment on 20 November 1995, number of flowering branches, plant height measured from the pot rim, fresh weight, dry weight, total bract area, and foliar analysis were measured.

Results and Discussion: Bract area increased as added calcium carbonate increased. However, the differences in bract area between amounts of added calcium carbonate were not significant. The bract area was 228a, 263ab, 277b, and 281b square inches on plants grown in media amended with 0, 3.5, 7, or 10.5 lbs/yd^3 calcium carbonate respectively (Student-Newman-Keuls' mean separation at P=0.05). Bract area was greatly affected by the size grind of waste tire and the percent of the media it comprised. Plants grown in media with levels of shredded tire greater than 50% coarse or 25% fine had significantly reduced bract area (Fig. 1). Although all cuttings were pinched to leave 5 nodes, there were significantly more flowering branches per plant in 25 and 50% waste tires (4.5 branches) than on plants grown in media containing 75% waste tires (4 branches).

Plant height was not significantly affected by the calcium carbonate, rubber grind, or rubber percent in the media. All plants were about 10 inches in height at the termination of the experiment. With all plants the same height, the differences in number of branches and bract size determined overall appearance and quality of the plants. The plants grown in 50% or less coarse grind rubber or 25% fine grind rubber were the largest plants but, at 10 inches in height, were not too large for the 5 inch diameter container.

There was a significant interaction in foliar zinc levels between calcium carbonate level, percent waste tire, and waste tire particle size (Figs. 2-4). Zinc levels decreased with increasing calcium carbonate levels at all levels of waste tire concentration regardless of the grind. In addition, zinc levels were highest in the 50 and 75% waste tire media. Foliar iron levels were not significantly affected by any of the factors tested.

Although foliar zinc levels were high in plants grown in 50% waste tires, bract area was not significantly affected when grown in the coarse grind. The largest plants, as indicated by bract area, were those grown in the media with the highest rate of calcium carbonate and coarse waste tire. The initial pH of the medium with 10.5 lb/yd^3 calcium carbonate added was approximately 6.4 (data not shown).

Significance to Industry: A coarse grade of shredded waste tires may be a viable media amendment. Poinsettias can be successfully grown in media containing as high as 50% shredded waste tires. The addition of calcium carbonate helped to alleviate problems of zinc toxicity to produce a quality plant.

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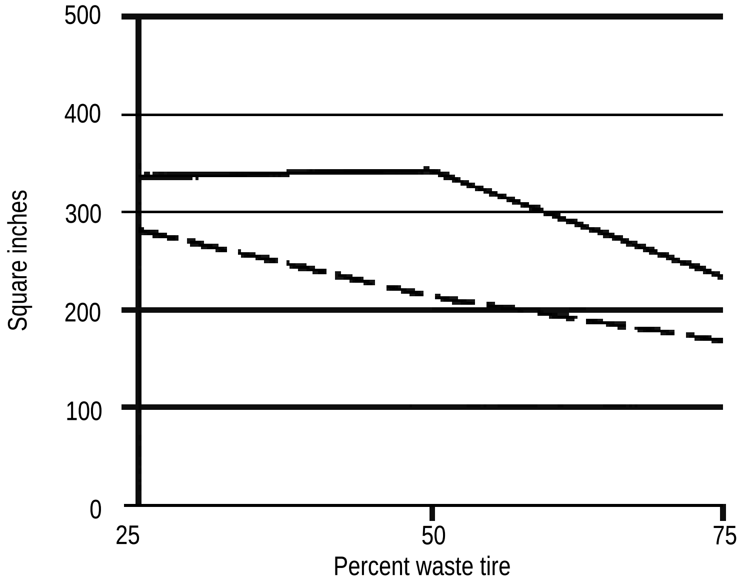

Fig. 1. Poinsettia bract area as affected by percent waste tire in the medium and waste tire particle size. ______ coarse (2.0-6.3 mm); __ __ __fine (2.0 mm).

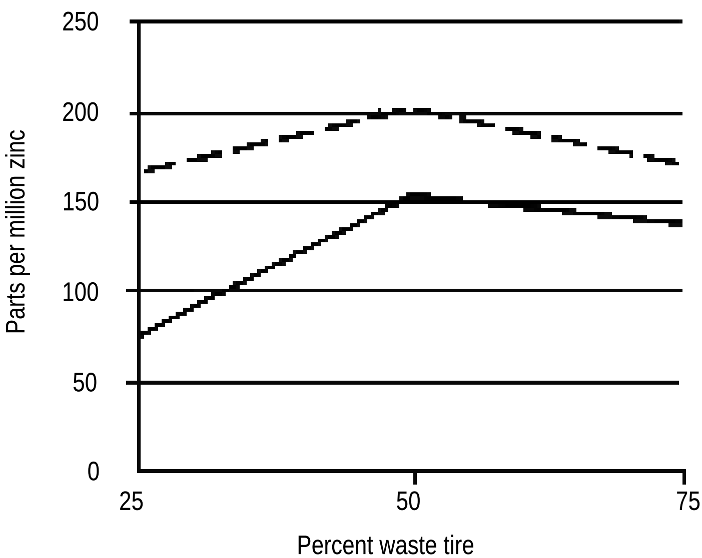

Fig. 2. Foliar zinc concentration by percent waste tire in the medium and waste tire particle size. ______ coarse (2.0-6.3 mm); __ __ __fine (2.0 mm).

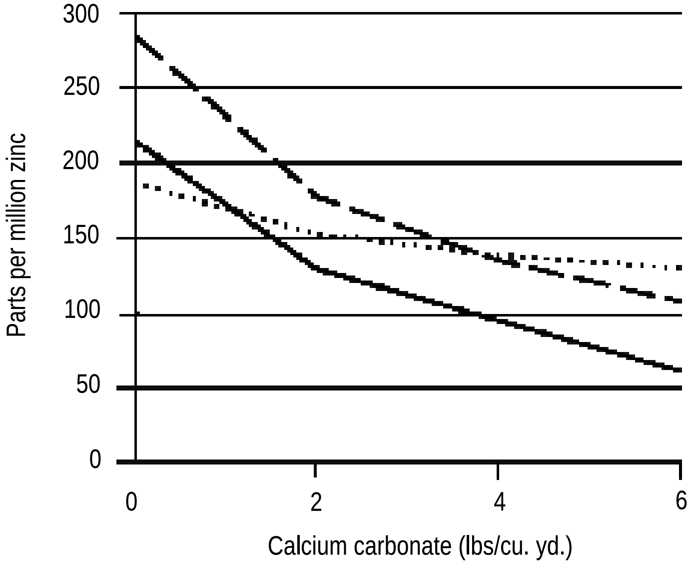

Fig. 3. Foliar zinc concentration as a function of added calcium carbonate and percent waste tire. ______ 25%; __ __ __ 50%; . . . . . 75% waste tire with peat moss.

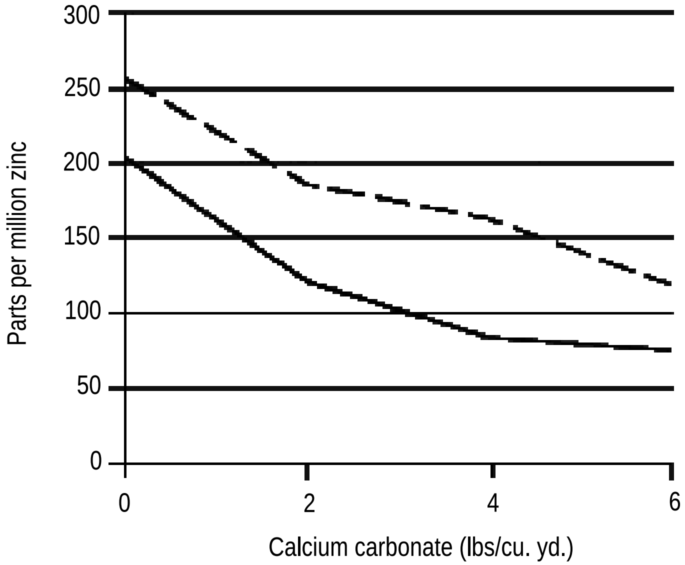

Fig. 4. Foliar zinc concentration as a function of calcium carbonate and waste tire particle size. ______ coarse (2.0-6.3 mm); __ __ __ fine (2.0 mm).

Maximizing Efficiency of Greenhouse Space Use

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Nature of work: Indirect costs (e.g., structure, heat, lights) are a significant part of the total cost of ornamental crop production. The yearly indirect cost per square foot of greenhouse bench space is approximately $9.00 (McCormick, 1996). The cost of polyhouses used in overwintering perennial herbaceous and woody plants is approximately $0.50/ft^2/yr (Badenhop, 1985). In all situations, the ability to maximize space use translates into increased profits. To this end, growers are concerned about how they can arrange pots to get the greatest number in a given area of bench or floor space without sacrificing plant quality. The objective of this work was to determine how to best answer this question.

We have developed a model that will calculate the maximum number of pots and their most efficient arrangement using mathematical descriptions of the geometric relationships between pots and bench size. Two types of staggered patterns were evaluated: long rows parallel to the short dimension of the bench or floor space (staggered ‘short’), and long rows parallel to the long dimension (staggered ‘long’) (Figure 1). These were compared to pot placement in a square pattern. Equation inputs include dimensions of the usable space and pot size (top diameter), and pot spacing distance where appropriate. When pots are to be spaced, as on 14 in centers, this spacing is used as the pot size (i.e., 14 in).

To illustrate the application of the model for maximizing space use we used several representative schemes for overwintering perennials and woody plants in polyhouses. These houses typically vary in width between 28 and 40 ft, and in length between 84 and 96 ft. Either one middle or two side aisles of approximately 2-ft width allow access to the plants. Plant material is generally overwintered in 1, 3, or 5-gal pots. The diameter of the top rim of a 1-gal pot depends on whether it is a blow-molded (approx. 7.6 in) or injection-molded (6.5 in) full gallon pot, or a trade gallon pot (approx. 6.5 in). The diameter of a 3-gal pot is 10.5 to 11 in, and of a 5-gal pot approximately 12 in. House dimensions used in the model were: length 84, 90, or 96 ft; width 28, 30, 32, or 40 ft; one or two aisles of 2-ft width. All of the above mentioned pot sizes were evaluated.

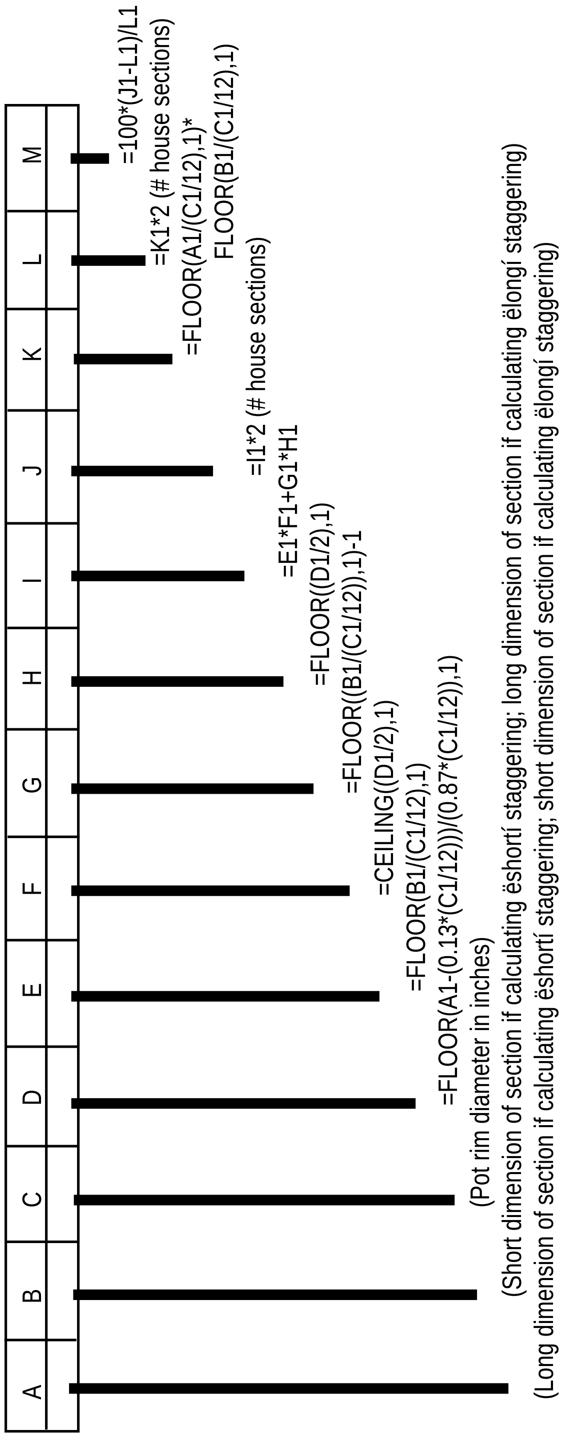
Calculation of the number of pots that will fit in a house of given dimensions can be made into a computer spreadsheet program such as QuatroPro, Excel, or Lotus 1-2-3. The necessary equations and their location in an Excel spreadsheet are given below. We assume that the file data begins on Row 1. If data begins on Row 2 then appropriate changes need to be made in the equations (e.g., A1 becomes A2, B1 becomes B2, etc.). Note that the equation in Columns J and L take into account the number of sections in the house. It is assumed that there is at least one 2-ft aisle. Aisles of different widths may be incorporated in the equations by adjusting the values entered for house section dimensions (Column A and B). In Lotus 1-2-3, substitute 'ROUNDDOWN' for 'FLOOR' and 'ROUNDUP' for 'CEILING'. In QuatroPro, substitute '@FLOOR' for 'FLOOR' and '@CEILING' for 'CEILING'. Column definitions are as follows:

A - Long dimensions of the section if calculating 'short' staggering; Short dimension of the section of calculating 'long' staggering
B - Short dimensions of the section if calculating 'short' staggering; Long dimension of the section of calculating 'long' staggering
C - Container rim diameter (in)
D - Total number of rows/section
E - Number of containers/long row
F - Number of long rows/section
G - Number of containers/short row
H - Number of short rows/section
I - Number of containers/section in staggered pattern
J - Total number of containers/house in staggered pattern
K - Number of containers/section in square pattern
L - Total number of containers/house in square pattern
M - % increase (decrease) in number of containers fitting in house in staggered as compared to square arrangement

Results and discussion: In most cases, a staggered arrangement allowed a significant increase in number of pots fitting into a polyhouse as compared to square placement. A selection of the results are shown in Table 1.

For 1-gal pots of any type in polyhouses having one aisle, 'short' staggering of pots permitted an increase of 12 to 13.5% in number of pots fitting in house the over that allowed by a square pattern. For example, in a house of dimensions 32 ft by 84 ft having a 2-ft central aisle, 12.7% more 1-gal blow-molded pots can be fit in a 'short' staggered arrangement than in a square. This translates into 768 more pots. When pots are 'long' staggered, the advantage may increase to 16 to 17%. For example, in a house of dimensions 32 ft by 84 ft having a 2-ft central aisle, 17% more 1-gal blow-molded pots can be fit in a 'long' staggered arrangement than in a square. This is 1030 more pots. The advantages remain, although slightly lower, for 3- and 5-gal pots in polyhouses with one central aisle.

Houses with two aisles have smaller individual sections and less advantage to 'short' staggering of pots as compared to square placement. The gain in numbers is still 5 to 12% with the greatest advantage for smaller pots. The advantage of 'long' staggering pots up to 11 in diameter in a two-aisle house ranged from 7 to almost 22% for 10.5-in pots in 30-ft wide houses of any length. For 5-gal pots, the improvement in number of pots by ëlongí staggering ranged from about 8 to 12% in houses 30 ft and wider. However, in 28-ft wide polyhouses with two aisles, square placement of the


A
B
C
D
E
F
G
H
I
J
K
L
M
(Long dimension of section if calculating ëshortí staggering; short dimension of section if calculating ëlongí staggering)
(Short dimension of section if calculating ëshortí staggering; long dimension of section if calculating ëlongí staggering)
(Pot rim diameter in inches)
=FLOOR(A1-(0.13*(C1/12))/(0.87*(C1/12)),1)
=FLOOR(B1/(C1/12),1)
=CEILING((D1/2),1)
=FLOOR((B1/(C1/12)),1)-1
=FLOOR((D1/2),1)
=E1*F1+G1*H1
=I1*2 (# house sections)
=FLOOR(A1/(C1/12),1)*
FLOOR(B1/(C1/12),1)
=K1*2 (# house sections)
=100*(J1-L1)/L1

Significance to the industry: Significant increases in space use efficiency can be achieved by using our model to determine the best arrangement of pots in overwintering polyhouses. This translates into decreased overhead costs per container, thus increased profits for growers.

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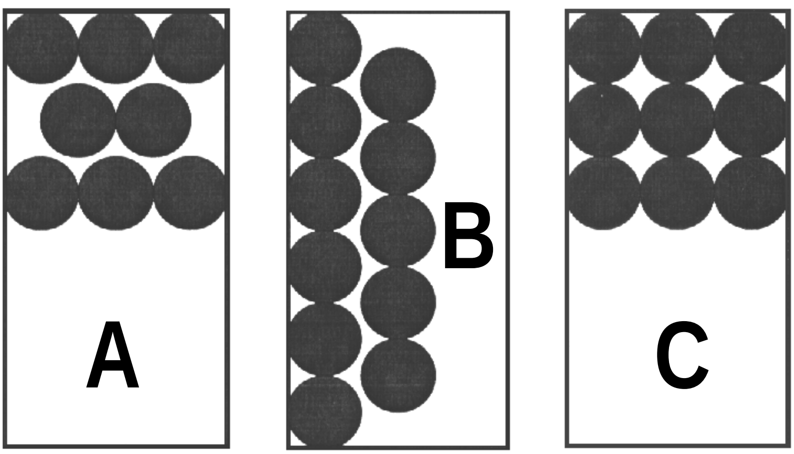

Figure 1. Three possible arrangements of pots: A - Staggered 'short'; B - Staggered 'long'; C - Square

Table 1. Number of pots fitting in one-aisle polyhouses of various dimensions in square and staggered arrangements (See Figure 1). Numbers in parentheses are percent increase in pots over square placement.

Pot	House dimensions (ft)	Total pots in 'Square' arrangement	Total pots in ' Short' staggered arrangement	Total pots in 'Long' staggered arrangement
1-gal (injected & trade)	30 x 84	7750	8722 (12.5)	8962 (15.6)
	32 x 90	8964	10070 (12.3)	10262 (14.5
)1-gal (blow-molded)	30 x 84	5808	6536 (12.5)	6576 (13.2)
	32 x 90	6532	7336 (12.3)	7642 (17)
3- gal (11 in)	30 x 84	2730	3046 (11.6)	3078 (12.8)
	32 x 90	3136	3472 (10.7)	3510 (11.9)
5-ga	l30 x 84	2352	2592 (10.2)	2506 (6.6)
	32 x 9	02700	2988 (10.7)	3044 (12.7)

Dairy Cow Compost as a Potting Substrate for Growing Hybrid Rhododendrons

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Nature of Work: With the rising cost of sphagnum peat moss nurserymen are looking at alternatives for growing substrates. Daddy Pete's plant pleaser is a product of composted cow manure. This study was conducted to see if composted cow manure could be used to grow containerized plants and replace sphagnum peat moss. Research was conducted using two Rhododendron cultivars 'English Roseum' and 'Scintillation'. Plants of each cultivar were potted into 3 gallon containers and placed in completely random block design in 10 replicated blocks of each species. Test substrates, Daddy Pete composted cow manure (80:20 by volume), Daddy Pete's composted cow manure (60:40 by volume), Daddy Pete's composted potting mix (80:20 by volume), and Daddy Pete's Pro C mix (80:20 by volume) were tested against the growers standard mix of pine bark and sphagnum peat moss (80:20)% by volume amended with 20 lbs. of Scotts Prokote, 8lbs. dolomitic limestone and 1.5 lbs. step minor elements package per 1.7 yrd. Daddy Pete's compost was tested mixing pine bark 80:20 and 60:40 by volume. Test substrates were treated equally. 'English Roseum' was grown on gravel beds under sunny conditions and 'Scintillation' was grown on gravel under 30% black shade cloth. All cultural practices including, irrigation, fertilizer, and minor element supplement were those of Buds and Blooms Nursery.

Results and Discussion: Physical Properties - Total porosity fell within range for all substrate combinations. The air space, however, was higher in the Buds and Blooms standard mix (probably due to the larger size particle in the bark mix). Available water was higher in the Daddy Pete's mix because the composted manure held more water. Container capacity, unavailable water and bulk density all were within guidelines. In regards to physical properties all four substrates could be used to produce plants in containers if irrigation management was tailored to the substrate. The Daddy Pete's mix would need less watering due to the high water holding capacity.

Electrical Conductivity and pH - There was no significant differences in pH values. All substrates pH's fell within optimum growing range (5.2 - 6.5). Conductivity levels (EC) initially started out in the high range which is expected in unleached containers immediately after potting. From the 8th week to the 16th week conductivity levels fell below optimum levels of 0.5 to 2.0 mmhos/cm.

NO3-n and P - After 16 weeks there was no significant difference in the levels of nitrate nitrogen. Ammonium nitrate levels were high in pine bark and Daddy Pete's composted cow manure and pine bark and peat moss.

Container Leachate - Phosphorous levels were very high when readings were taking in the fourth week. Optimum growing levels for phophorous are 10-15 ppm for Virginia Tech extraction method leachates. The Buds and Blooms standard showed phophorus readings 66.5 ppm at the end of 16 weeks, readings fell below the growing range. The authors concluded that the phosphorus was leached out of the container. There was no significant differences among mixes.

Foliar Nutrient Levels - Tissue samples showing N,P,K, Ca and Mg levels were all within growing range of .8 - 1.4 Ca and .2 - .8 Mg. There were no significant differences among samples.

Significance to Industry: Daddy Pete's Plant Pleaser can work as a substrate for sphagnum peat moss in a growing mix containing pine bark. The Daddy Pete's compost grew the same high quality plant as did the Buds and Blooms standard mix containing sphagnum pete moss. Our research showed that the test substrate contained the physical and nutritive properties needed to grow a high quality plant. Water management turns out to be a very important factor, because the test substrate containing composted cow manure consistently retained more water, therefore limiting the need for frequent irrigation.

Growth Responses of Container-Grown Baldcypress to Media Drench Applications of Mineral 22 (Mineral Soil Derivative) and Alternative Commercial Fertilizers

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Nature of the Work: While the macronutrients, N, P, and K are necessary in the greatest quantities for vigorous plant growth, the macronutrients, Ca, Mg, and S, and micronutrients B, Fe, Mn, Cu, Zn, Mo, Co, and Cl are also required. Iron and Mg can become limiting when high pH irrigation water and/or growth media are used (3). Maintenance of appropriate Ca and Mg levels is particularly important when irrigation water contains high Na levels (4). Such nutrient imbalances are routinely treated in a preventative manner by the addition of controlled release fertilizers to growth media prior to planting or use of fertigation on a regular schedule. Unfortunately, many available fertilizers are formulated for solubility in acidic to neutral solutions, while the available nursery irrigation water in many regions of the SW USA is high pH, alkaline, or contains excess Na. Acid injection in the irrigation stream or acidifying fertilizers are methods to enhance nutrient availability, but add to production costs.

Mineral 22 is a concentrated solution (derived from a mined mineral soil in Japan that is heat treated to 2000F) (2) containing significant levels of Fe (855 mg/liter (ppm)), Mg (675 mg/liter (ppm)), and Ca (428 mg/liter (ppm)) (1), and is perported to remain in solution below pH 11.0 (2). Anticdotal reports of increased yields and plant vigor in response to foliar applications of Mineral 22 to several agronomic and horticultural crops have been reported (1, 2). An effective micronutrient/macronutrient fertilizer that remains soluble in high pH irrigation water could be useful in production of nursery crops if competatively priced, or improved growth sufficiently to reduce production times, or result in premium quality plants.

The objectives of these experiments (funded in part by UNAM, Mexico through Y.B. Planning Co. Ltd., Japan) were to determine growth responses of container-grown *Taxodium distichum* to: 1) media drenches of Mineral 22 at manufacturer recommended rates and 2) media drenches of mineral 22 and alternative commercial fertilizers containing similar levels of Fe, Ca, and Mg.

Stratified (4 months at 4 C (40F)) seeds of *Taxodium distichum* were sown 2 cm (0.75 in.) deep in Sunshine Mix #2 (Fison's) in 41 cm (16 in.) x 31 cm (12 in.) x 8.5 cm (3.25 in.) black plastic flats. Seedlings were fertigated daily, until transplant, with 50 mg/liter (ppm) N from a 24-8-16 (24N-3.5P-13K) water soluble fertilizer (Peters, Scotts Co., Marysville, OH). Seedlings were gently removed from the germination flats on 1 February, 1996, and transplanted individually to #1 (2.2 liter) black plastic nursery containers (Nursery Supplies, Inc., Fairhills, PA). Containers were filled with a 3 milled pine bark : 1 coarse builders sand (vol.:vol) media amended with 7.0 kg 20-7-10 (20N-3.1P-8.3K) controlled release fertilizer (Nutricote type 360, Chisso-Asahi Fertilizer Co., Tokyo, Japan)/m^3 (12 lb./$yd.^3$) and 3.5 kg dolomite (Vulcan Materials Co., Tarrant, AL)/m^3 (6 lb./$yd.^3$). Containers were placed on benches in a greenhouse set at 22/16C (72/60°F) day/night temperatures and night interrupts provided from midnight to 4:00 AM by incandescent lights suspended 1 m (3 ft.) above container surfaces. Plants were irrigated daily with tap water only (pH 8.5, 227 mg Na/liter (ppm), 451 mg bi-carbonate/liter (ppm), 31 SAR), except when fertilizer treatments were applied.

Determinations of Dose Response Curves to Mineral 22. Five *T. distichum* seedlings were fertigated with 300 ml of 0.0, 0.5, 1.0, or 1.5 ml Mineral 22 concentrate / liter (parts/1000) tap water applied 30 days after planting (acute exposure). Five other seedlings/treatment received repeated applications of the same solutions at 14 day intervals (chronic exposure). Plants were arranged in a completely random design. Plant height, stem diameter (caliper), branchlet number, and presence of chlorosis or necrosis were recorded at two week intervals. Three replicate 60 ml samples of the bulk fertilizer solutions were analyzed for mineral nutrient content. Seedlings were harvested for mass determinations at 91 days from planting.

Mineral 22 Versus Available Alternatives: Forty five plants were propagated as describe above, except that media for five plants had 891 g Micromax trace elements (Scotts Company, Marysville, OH)/m^3 (1.5 lb./$yd.^3$)) pre-incorporated and received no drench treatment. The media of five plants/treatment were drenched at 30 days after planting in 2.2 liter containers with 300 ml (0.32 qt.) of the following fertilizer combinations;
1. STEM (soluble trace element mix, Peters, Scotts Co., Marysville, OH) at the recommended label rate, 599 mg/liter (0.5 lb./100 gal.).
2. Mineral 22 at a rate (53 ml/liter (parts/1000)) of Fe (45 mg/liter (ppm)) equivalent to that in STEM treatment.
3. Sprint 138 (chelated Fe, CIBA-GEIGY Corp., Greensboro, NC) at a rate of Fe (45 mg/liter(45 ppm)) equivalent to that in STEM treatment.
4. Epsom Salts (Giles Chemical Corp., Waynesville, NC) at a rate of 50 mg Mg/liter (ppm).
5. Mineral 22 at a rate (74 ml/liter (parts/1000)) of 50 mg Mg/liter (ppm).
6. Gypsum (Standard Gypsum Corp., Fredericksburg, TX) at a rate of 50 mg Ca/liter (ppm).
7. Mineral 22 at a rate (117 ml/liter (parts/1000)) of 50 mg Ca/liter (ppm).
8. Combination of 45 mg Fe/liter (ppm, Sprint), 50 mg Mg/liter (ppm, Epsom salts), and 50 ppm Ca/liter (ppm, gypsum).
9. A non-soil drench pre-plant incorporation of Micromax at 891 g/m^3 (1.5 lb./yd.3, commercial control (3)).

The plants were arranged in a completely random design in the same greenhouse conditions as previously described and harvested at 94 days after planting

Results and Discussion: Dose Response Study. Mineral 22 applications at manufacturer recommended rates had no significant (P 0.05) effects on dry matter accumulation, caliper, or development of foliar chlorosis or necrosis (data not presented). Chronic applications of Mineral 22 slightly reduced terminal shoot extension (Fig. 1A) and the number of branchlets developing on the main stem (Fig. 1B) of *T. distichum*. Effects of acute Mineral 22 drenches were less consistent (Fig. 1A and 1B). Acute applications of Mineral 22 at 0.5 and 1.0 ml/l (parts/1000) resulted in slightly greater shoot extension, and greater branchlet numbers at 0.5 ml/l (parts/1000) over time, but differences were likely of little commercial significance.

Mineral 22 Versus Alternative Fertilizers: *Taxodium distichum* grown in media containing pre-incorporated Micromax fertilizer had substantially greater dry matter accumulation in both the root and shoot tissue than did media drench treatments (Table 1). Intermediate dry matter accumulation occurred with a combination of Sprint 138, Epsom salts, and gypsum or STEM alone (Table 1). Other treatments had lesser dry matter accumulation (Table 1) and did not differ significantly (P 0.05). Seedlings treated with Micromax, STEM, or a combination of Sprint 138, gypsum and Epsom salts had greater shoot extension (Fig. 2A) and caliper (Fig. 2B) than other treatments. The treatment exhibiting the greatest number of branchlets was a combination of Sprint 138, Epsom salts, and gypsum, while Sprint 138 alone, Epsom salts alone, and Mineral 22 at 50 mg Mg / liter (ppm) had the least (Table 1). Other fertilizers had intermediate numbers of branchlets (Table 1). Most of the larger Micromax treated plants exhibited secondary branching on distal branchlets originating from the main trunk, resulting in a denser canopy. This was observed predominantly only on the larger seedlings among other treatments.

Chemical Analysis of Fertilizer Solutions: Mineral 22 did not remained completely in solution at the higher application rates (53 to 117 ml/liter (parts/1000) in the tap water (pH 8.5) used in this study. A cloudy yellow brown precipitate developed after a short period of time. The chemical analysis of three replicate samples of the Mineral 22 concentrate differed in the concentration of several nutrients from the concentrations initially provided for treatment rate calculations (Table 2). The pH of bulk fertilizer solutions decreased from 8.5, 8.1, 7.6 to 7.5 for solutions containing 0.0, 0.5, 1.0, and 1.5 ml/liter (parts/1000) of Mineral 22, respectively, likely due to the high sulfur content (Table 2). Mineral 22 at 53, 74 and 117 ml/liter (parts/1000) lowered the bulk fertilizer solution pH to 3.2, 2.7, and 2.4, respectively, significantly less than that of alternative fertilizer solutions (between pH 6.1 and 8.1).

Significance to Industry: Standard industry practice of pre-plant incorporation of a controlled release form of micronutrients, such as Micromax, produced the largest seedlings. Media drenches of STEM or a combination of Sprint 138, Epsom salts, and gypsum resulted in larger plants than the drench fertilizers tested. Mineral 22 did not result in commercially significant growth increases in container-grown *T. distichum* under our test conditions compared to alternative commercial fertilizers already on the market. Growth responses and ease of application suggest that pre-incorporated fertilizers would be preferable, but caution should be exercised in extrapolating results from one species and test condition to other species or growing conditions.

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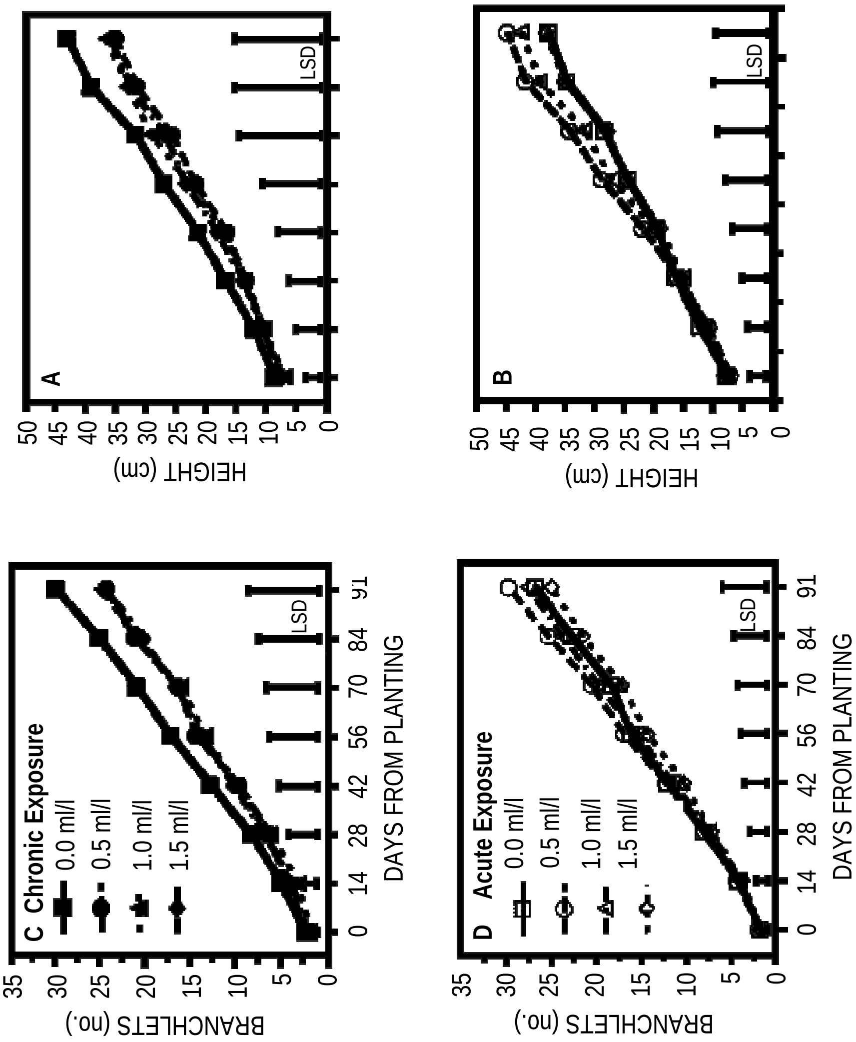

Figure 1. Interactions among chronic (A & C) and acute (B & D) media drench applications of 0.0, 0.5, 1.0, or 1.5 ml Mineral 22 / liter (parts/1000) solutions on the shoot extension (A & B) and number of branchlets (C & D) of *Taxodium distichum* over time while grown in a greenhouse in 2.2 liter (#1) black plastic containers filled with a 3:1 (vol.:vol.) milled pine bark : coarse builders sand media amended with 12 lb. 20-7-10 type 360 nutricote slow-release fertilizer / yd.3 and 6 lb. dolomitic lime/yd.3. Values are means of observations on five plants per treatment combination.

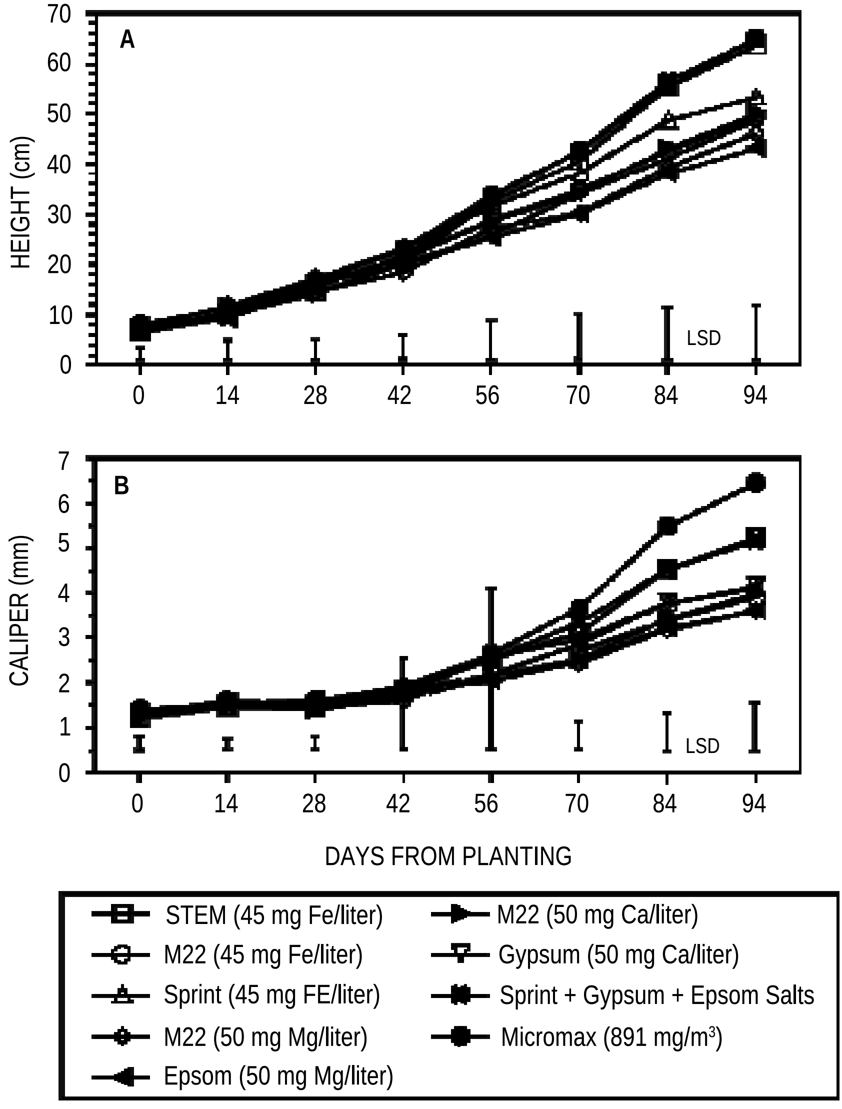

Figure 2. Interactions among alternative fertilizer treatments and days from planting of *Taxodium distichum* seedlings into 2.2 liter (#1) black plastic containers on mean height (A) and caliper (B). Containers were filled with a 3:1 (vol.:vol.) milled pine bark : coarse builders sand media amended with 12 lb. 20-7-10 type 360 nutricote slow-release fertilizer / yd.3 and 6 lb. dolomitic lime/yd.3. All fertilizers were applied as a one time drench of 300 ml, except Micromax which was pre-incorporated at media mixing. Values are means of observations on five plants per treatment combination.

Table 1. Main effects of supplemental fertilizer treatments on dry matter accumulation for *Taxodium distichum* grown for 94 days in 2.3 liter black plastic containers filled with a 3:1 (vol.:vol.) milled pine bark:coarse builders sand amended with 12 lb. 20-7-10 type 360 nutricote slow release fertilizer/yd.^{3} and 6 lb. dolomitic lime/yd.^{3}.

Fertilizer	Rate	Shoot (g)	Root (g)	Total (g)	Branchlets (number)
Media drenches (300 ml):					
Soluble trace element mix (STEM)	45 mg Fe / liter	4.11y b	1.44y bc	5.55y b	15.3z b
Mineral 22	45 mg Fe / liter	1.98 c	0.85 cd	2.83 c	15.4 b
Sprint 138	45 mg Fe / liter	2.15 c	0.93 cd	3.08 c	13.6 c
Mineral 22	50 mg Mg / liter	1.69 c	0.73 d	2.42 c	13.3 c
Epsom Salts	50 mg Mg / liter	1.89 c	0.78 d	2.67 c	13.6 c
Mineral 22	50 mg Ca / liter	2.03 c	0.80 d	2.83 c	15.4 b
Gypsum	50 mg Ca / liter	2.43 c	1.00 bcd	3.42 c	14.3 bc
Combination of;		4.04 b	1.58 b	5.62 b	18.7 a
Sprint 138	45 mg Fe / liter				
Epsom salts	50 mg Mg / liter				
Gypsum	50 mg Ca / liter				
Pre-incorporated:					
Micromax	891 mg / m^3	6.58 a	2.33 a	8.91 a	15.3 b

[y]Means followed by the same letter are not significantly ($P \leq 0.05$) different using paired t-tests, n = 5.

[z]n=40.

Table 2. Comparisons of the mineral composition in Mineral 22 liquid concentrate as provided by the manufacturer (Y. B. Planning Co., LTD., Tokyo, Japan, via Dr. K. Ilongovan (1) and an independent laboratory (Texas Agricultural Extension Service Soil, Water, and Forage Testing Laboratory, College Station, Texas).

Mineral	Manufacturer (mg / liter)	Independent laboratory (mg / liter)
Nitrates	np[z]	0.100[y]
P	np	12.5
K	175	169
Ca	428	65.3
Mg	675	354
Mn	19.5	15.7
S	np	13,699
Fe	855	1077
Cu	0.65	0.47
Zn	2.90	1.80
Bo	3.10	2.10
Na	3.00	19.3
pH	np	1.63

[y]Values from the independent laboratory are means of 3 replicate samples.

[z]np = not provided.

Growth of Ornamental Grass Divisions in Bark-Based Media

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Nature of Work: Many cultivated ornamental grasses and grasslike plants are propagated asexually. A greenhouse study was conducted using 'Ogon' golden variegated sweetflag (*Acorus gramineus* Ait. 'Ogon'), 'Elijah Blue' blue fescue [*Festuca ovina* var. *glauca* (Lam.) Koch 'Elijah Blue'], 'Sarabande' Japanese silvergrass (*Miscanthus sinensis* Anderss. 'Sarabande') and 'Moudry' fountain grass [*Pennisetum alopecuroides* (L.) Spreng. 'Moudry'] to determine the survival and growth rates of plant divisions in four bark-based media. Stock plants (donated by Hoffman Nursery, Inc., Rougemont, NC) were divided into individual plantlets ranging from 6 inches (fescue) to 16 inches (silvergrass) in height, with leaf numbers ranging from 5 (sweetflag) to 16 (fescue, fountain grass). Divisions were grown in 3.5 x 3.5 inch (270 ml) square containers filled with pine bark or one of three pine bark blends (bark plus sand, bark plus peat moss, or bark plus perlite, 3:1 by vol.). Media were incorporated with 10 lb/yd^3 of Howard Johnson's Professional Turf Formula Fertilizer (12N-1.6P-6.6K), 7 lb/yd^3 pelletized lime, and 2.5 lb/yd^3 of triple superphosphate. Plantlets were grown at 75/65 F (day/night) under ambient light conditions, and were hand-watered as needed.

Each species was arranged in a randomized complete block design (single plant replicates) with 12 blocks. The 6-week experiment was run twice in 1995 (July-Aug. and Sept.-Oct.). Growth data collected included plant height and leaf number taken at 0, 3 and 6 weeks after potting. Fresh and dry weights of shoots and roots were taken at 6 weeks, along with a visual quality rating where 1= dead plant and 5=maximal size and vigor and most intense color. Data were analyzed using SAS, and treatment means were separated using the least significance difference test (LSD) at the 5% significance level.

Results and Discussion: Survival rates for fescue, fountain grass and sweetflag were near 100%. However, only three-fourths of the silvergrass plants remained alive after 6 weeks. Survival of silvergrass did not vary with the growing medium. High mortality rates of greenhouse-grown silvergrass divisions have been observed at Hoffman Nursery (1). These findings suggest that silvergrass cannot tolerate the stress of division and regeneration as well as the other grasses tested.

Quality ratings were a more useful estimate of overall plant performance than individual growth parameters because they took into account plant size, vigor, and color. Media affected quality of sweetflag and fescue, but not silvergrass or fountain grass. Quality of sweetflag grown in bark plus perlite was higher than in bark plus peat. Fescue exhibited a different response pattern; quality was higher in bark and bark plus sand than in bark plus perlite.

Data suggest that a range of bark-based media do not differentially affect growth of fountain grass or silvergrass, but do affect growth of fescue and sweetflag. Fountain grass and silvergrass produce more biomass than fescue and sweetflag, which may suggest that fountain grass and silvergrass can readily tolerate a wide range of growing conditions. Sweetflag requires a moist or slightly wet but well drained medium (2). Results indicate that a bark plus perlite mix kept constantly moist meets this requirement. Fescue, which prefers a well drained but moist to dry medium, is well suited for bark or bark plus sand.

Significance to Industry: Small-scale evaluations of containerized ornamental grasses are recommended under a range of propagation and growing conditions prior to mass production. Although mortality of 'Sarabande' Japanese silvergrass divisions was high, silvergrass and 'Moudry' fountain grass can be produced using a range of bark-based media. However, 'Elijah Blue' blue fescue and 'Ogon' variegated sweetflag have more precise medium requirements for optimal growth.

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Fiber Pots Influence the Growth of Three Garden Mum Cultivars

John M. Ruter
Georgia

Nature of Work: Garden chrysanthemums are a versatile crop and are available in a wide assortment of colors and flower forms. Their popularity among consumers increased 39% between the years of 1984 and 1989, with an estimated crop value of $36 million in 1989 (2). Poor aeration/overwatering and high root-zone temperatures during the summer months are two problems associated with the production of garden chrysanthemums in containers (1,3).

Fiber containers treated with cupric hydroxide ($Cu(OH)_2$) have retained structural integrity under production conditions for up to two years (John Ruter, personal observation), thereby eliminating container degradation as a production problem. Previous research with $Cu(OH)_2$-impregnated fiber containers showed root and shoot growth of *Plumbago auriculata* Lam. increased compared to plants produced in black plastic containers (4). The purpose of this study was to evaluate the growth and flowering characteristics of three garden chrysanthemum cultivars produced in black plastic or $Cu(OH)_2$-impregnated fiber containers.

The experiment was conducted outdoors under full sun at Wight Nurseries in Cairo, Georgia using standard cultural procedures. Uniform rooted cuttings of *Dendranthemum x grandiflorum* (Ramat.) Kitamura 'Grenadine', 'Nicole', and 'Tolima' were transplanted into containers on June 28, 1993. Black plastic containers had a height of 16 cm (6.25 in), a top width of 16 cm (6.25 in) and a bottom width of 13 cm (5.12 in) for a volume of 2.64 l (0.70 gal). Fiber containers had a height of 18 cm (7.08 in), a top width of 18 cm (7.08 in) and a bottom width of 14 cm (5.51 in) for a volume of 3.62 l (0.96 gal). Fiber containers were manufactured by Keiding, Inc. (Milwaukee, Wisconsin) and had approximately 3000 mg/l (ppm) $Cu(OH)_2$ impregnated within the container walls.

Potting medium was milled pine bark and sand (4:1 by vol) amended with dolomitic limestone at 4.2 kg/m^3 (7.0 lb/yd^3) and 0.9 kg/m^3 (1.5 lb/yd^3) micronutrient mix (Graco Fertilizer Co., Cairo, GA). The same volume of potting medium (2.6 l (0.68 gal)) was added to each container type. Liquid fertilizer (12.5N-1.4P-8.0K) was applied at each irrigation at 70 mg N/l (ppm). Plants were irrigated as needed at 1.3 cm (0.5 in) using solid set sprinklers. Plants received one manual pinching to remove the terminal and induce branching on July 12, 1993. The experiment was conducted with plants sorted by cultivar and containers arranged in randomized complete blocks with 10 replications.

Plants were harvested on September 27, 1993 just as flower buds were beginning to open on the three cultivars. A growth index [(height + width east-west + width north-south)/3] was measured and number of flower buds per plant determined. Shoot and root dry weights were determined after plants had been oven-dried at 70C (158F) for 72 hr. Root coverage (a visual rating of the amount of root area present at the container:growing medium interface) was rated using the scale: 1 = < 25% of the container:growing medium interface covered with white roots; 2 = >25 but <50% coverage; 3 = >50 but <75% coverage; and 4 = >75% coverage.

Results and Discussion: All three cultivars of garden chrysanthemums had increased growth indices, shoot and root dry weights, total biomass, and number of flower buds when grown in copper-impregnated fiber pots compared to black plastic containers. Increases in growth indices for plants in fiber containers ranged from 10% for 'Grenadine' to 21% for 'Tolima'.

Shoot dry weights of 'Grenadine', 'Nicole', and 'Tolima' increased 33%, 29%, and 42%, respectively when grown in fiber pots compared with black plastic. Corresponding increases in root dry weights for the three cultivars in fiber pots were 36%, 78%, and 52%, respectively. Total biomass, the sum of shoot and root dry weight, increased 34% for 'Grenadine', 52% for 'Nicole', and 46% for 'Tolima'. Container type did not affect the root:shoot ratio of plants in this study.

When grown in copper-impregnated fiber containers, the cultivars 'Grenadine', 'Nicole', and 'Tolima' had 30%, 32%, and 53% more flower buds per plant, respectively, than plants grown in black plastic containers.

Plants grown in copper-impregnated fiber containers had less root coverage at the container:growing medium interface than plants in the black plastic containers. Similar control of root growth at the container:growing medium interface was seen with *Coreopsis verticillata* L. 'Moonbeam' and *Plumbago auriculata* Lam. (4). Root circling was observed on plants grown in black plastic containers but not on plants in fiber pots.

Significance to Industry: With concerns about recycling of black plastic containers, use of biodegradable containers manufactured from recycled paper fiber is an appealing alternative for nurseries and consumers. While nontreated fiber containers degrade too quickly under hot, humid conditions in the southern United States, fiber containers impregnated with $Cu(OH)_2$ have a potential longevity of approximately two years. Results of this study indicate that growth and flowering of garden chrysanthemum cultivars can be enhanced by being produced in $Cu(OH)_2$-impregnated fiber containers compared with black plastic containers. Growth and flowering enhancement occurred with no further modifications in existing production practices other than changing container design. Increased plant size and number of flowers may allow growers to receive more for their product and the idea of a biodegradable container may be an additional sales tool.

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Comparison of SPIN-OUT-Coated and Standard #3 Containers on Marketable Plant Quality

Richard C. Beeson, Jr.
Florida

Nature of Work: Numerous studies have examined the effects of copper hydroxide-impregnated paint (SPIN OUT, Griffin Corp, Valdosta, Ga) on root and shoot growth of landscape ornamentals. For nearly all species tested, coating the interior of containers with SPIN OUT prevented root circling, thereby improving root quality (Struve, et al. 1994). For some species, production in these treated containers increased shoot growth (Beeson and Newton, 1992). Anecdotal evidence hinted that plant quality also increased, increasing uniformity and marketable percentages. The quality increase was supposedly due to lower water stress as a result of the root mod)fications, compared to pot-bound root systems (Case and Arnold, 1993). This experiment tested the hypothesis that use of SPIN OUT-treated containers results in plant canopies of higher quality than standard plastic containers.

In April and May 1993, plants growing in standard #1 (3.X liter) containers were transplanted into standard #3 (10.2 liter) black polyethylene containers, and identical orange #3 containers that had interiors painted with SPIN OUT. Potting substrate consisted of 75% fresh pine bark: 20% Florida sledge peat: 5% sand mixture amended with dolomite and micronutrients. Species tested were *Photinia x fraseri* (Red Tip Photinia), *Pittosporum tobira* 'Variegate' (Variegated Pittosporum), *Juniperus chinensis* 'Parsonii' (ParsonTi Juniper), *Viburnum odoratissimum* (Sweet Viburnum), *Elaeagnus pungens* (Silver/horn), and *Raphiolepis indica* 'Alba' (Indian Hawthorn). About 300 plants of each species were transplanted into each container treatment. All potting and subsequent care was managed by personnel at Lake Brantley Plant Corporation in Longwood, Florida, as part of their normal nursery production. When each species became salable (Nov. 1993 to July 1994), all plants within each container treatment were graded by canopy characteristics, as defined in the Florida Grades and Standards (Division of Plant Industry, 1994; footnotes, Table 1). Plants with canopies not graded at No. 2 or higher were considered culls.

Differences between container treatments for the number of plants within each grade were statistically analyzed using a Chi square distribution (Sigmastat, Ver. 1.0, Jandel Scientific, San Rafael, Ca). Differences between container treatments in total percentage of marketable plants (Fancy and No. 1) were analyzed using a z test (SigmaStat).

Results and Discussion: Plants were grown for 8 to 15 months, depending on species, in the #3 containers prior to evaluation. Distributions of percentages of plants among grade categories were not sign)ficant (a=0.05) between container treatment for any species (Table 1). Percentages of marketable plants (Fancy and No. 1) were also similar among container treatments (Table 1). For most species and container treatments, marketable plants accounted for about 80% of the total crop.

Based on canopy evaluations, production of landscape shrubs in SPIN OUT-treated #3 containers did not improve plant quality compared to standard black plastic containers. Over a season, small differences in water stress result in large differences in growth (Beeson, 1992). Sign)ficant pot boundness would have induced such water stress, but was not evident. Treating containers with SPIN OUT produced no beneficial effects in canopy quality in plants that were not excessively pot bound.

Significance to Industry: One advantage attributed to SPIN OUT-treated containers is higher crop quality compared to standard containers. This presumed benefit in canopy quality was not observed. Although SPIN OUT likely improved root quality, better root quality did not translate into better canopy quality when plants were evaluated at the time they became marketable .

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Table 1. Percentage of plants that met the minimum size for each grade category.

	% Fancy	% No. 1	% No. 2	% Cull	% Mkt.
Photinia[Z]					
Control	40.6	35.5	16.6	7.3	76.0
SPIN OUT	39.3	36.7	17.9	7.1	76.0
Viburnum[Z]					
Control	35.6	52.5	6.1	5.8	88.1
SPIN OUT	43.8	41.0	7.8	7.4	84.8
Hawthorn[Y]					
Control	38.6	41.0	10.3	1.2	79.6
SPIN OUT	32.1	51.8	14.4	1.7	83.9
Eleagnus[Y]					
Control	29.9	47.0	18.4	4.7	76.9
SPIN OUT	22.8	45.9	25.4	5.9	68.7
Pittosporum[X]					
Control	24.3	55.8	15.4	4.5	80.1
SPIN OUT	24.1	57.0	15.2	3.7	81.1
Juniper[W]					
Control	25.1	64.8	9.0	1.1	89.9
SPIN OUT	23.7	65.5	10.1	0.7	89.2

[Z]Minimum ratio width to height - Fancy = 0.75, No. 1 = 0.5, No. 2 = 0.33

[Y]Minimum ratio width to height - Fancy = 1.5, No. 1 = 1.0, No. 2 = 0.67

[X]Minimum ratio width to height - Fancy = 1.0, No. 1 = 0.67, No. 2 = 0.5

[W]Minimum ratio width to height - Fancy = 3.0, No. 1 = 2.75, No. 2 = 2.5

First Year Differences in Growth of Red Maple 'October Glory' Grown in Multiple Locations

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Georgia[1] and Alabama[2]

Nature of work: Red Maple (*Acer rubrum* L.) has a native range from Maine in the east, west to Texas, from southern Canada down through Florida. A thorough compilation of red maple cultivars indicates as many as 52 distinct cultivars readily available in the nursery industry. 'October Glory' is a cultivar with wide appeal and name recognition in the nursery trade, a reputation based on form, consistent fall color, and reputable growth rates in landscapes across the United States.

Witte et al. (5) reported height increases of 24.4" and diameter increases of 0.36" in the first year for field grown 'October Glory' in McMinnville, Tenn. Sibley et al. (4) reported similar height increases (25.6"), but greater diameter increases (0.57") in the first year of growth in field grown 'October Glory' in central Alabama. Dirr (2) found height increases of 21.7" in Athens, Georgia in the first year of growth in the field on 'October Glory'. In Tifton, Georgia, Ruter (3) reported height increases of 10' for 'October Glory' over the first four years following transplanting to the field. However, there have been limited reports for container production of red maple cultivars in the literature, and none for multiple location studies.

The objective of this study was to evaluate the growth of container grown 'October Glory' at three different locations in Georgia and Alabama. Rooted cuttings, 2" tall, were obtained from Grassland Nursery in Muscle Shoals, Alabama in April, 1995. These cuttings were all containerized on the same day in Auburn, Alabama to 3 gal. containers in a pinebark/sand mix amended with 14# Osmocote 17-7-12, 5# dolomitic limestone, and $1^1/_2$# Micromax per cu. yard of medium in May, and grown for one month in Auburn.

The trees were transported to the three locations in the second week of June. Trees were arranged at each location in a randomized complete block design consisting of six blocks with three plants each. The trees were a part of an ongoing study in which eight cultivars are being grown through the second year, with this cultivar initially replicated twice. The trees were equipped with overhead irrigation from 6' risers and grown for six months until dormant, the second week of December.

The three locations were: Blairsville, Georgia (34°51'N x 83°56'W); Auburn, Alabama (32°36'N x 85°29'W); and Tifton, Georgia (31°27'N x 83°31'W). Average rainfall and maximum/minimum temperatures for the period of time trees were grown at each location in 1995 were 39", 71.7/49.3°F; 32", 79.6/58.9°F; and 16", 80.1/58.4°F for Blairsville, Auburn, and Tifton, respectively.

Results and Discussion: The trees were transported to a single location for harvest at the end of December, 1995. There were no differences in final height among the three locations. Using a Duncans multiple range test, diameter (caliper) growth was 33% greater in Tifton than Blairsville, with Auburn similar to Blairsville and Tifton. Tifton trees had 24% greater diameter growth than Auburn, but this was not significant at the 0.05 level.

Shoot dry weights had the same trend as diameter for each location. Tifton trees had greater root dry weight than Blairsville or Auburn with an average of over 10 grams per tree more root dry weight in Tifton than Blairsville or Auburn. Similar to root dry weights, root to shoot ratios were greater in Tifton, than Blairsville and Auburn.

Anthocyanin levels were not quantified among locations, but the color of bark tissue at harvest for the Blairsville trees was noticeably more red than Tifton or Auburn. Cooler nights in Blairsville might have contributed to this coloration which would support findings by Deal et al. (1) in North Carolina where the anthocyanin level in Dwarf Japanese Maples was found to be greater under cool night temperatures.

Significance to the industry: Despite differences in temperature and rainfall among the three locations, growers of container grown ‘October Glory’ could expect similar growth during the first year throughout Georgia and Alabama. Furthermore, ‘October Glory’ appears to be well adapted to a variety of environmental conditions during first years growth. However, we may see greater differences in height growth in the coming year based on root growth data of 1995.

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