Cotton Gin Compost as a Substrate Component in Container Production of Nursery Crops[1]

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Abstract

Shoot and root growth of plants grown in substrate blends containing cotton gin compost (CGC) were compared to plants grown in a traditional pine bark (PB) blend. In 2002 'Winter Gem' boxwood, 'Firepower' dwarf nandina, and 'Midnight Flare' azalea were potted in four substrate blends containing by volume 6:1 PB:sand (S), 4.5:1.5:1 PB:CGC:S, 1:1 PB:CGC, or 1.5:4.5:1 PB:CGC:S. Plants were grown for nine months on a container pad in Auburn, AL. In 2003–2004 this study was repeated with 'Renee Mitchell' azalea as a replacement for 'Midnight Flare' azalea. Periodic growth measurements and a final visual root ball evaluation were conducted in each experiment. Substrates were analyzed to determine physical properties (air space, water holding capacity, total porosity, and bulk density) and chemical properties (pH and electrical conductivity). In both experiments, growth indices of all cultivars in substrates containing CGC were similar to or greater than those of the PB:S control blend. Visual quality of root systems was similar for all plants across all substrates.

Index words: agricultural waste, pine bark substitute, landscape plants, media, ornamental.

Species used in this study: 'Winter Gem' boxwood (*Buxus microphylla* Sieb. & Zucc.); 'Firepower' dwarf nandina (*Nandina domestica* Thumb); 'Midnight Flare' azalea (*Rhododendron indicum* L. & Sweet); 'Renee Mitchell' azalea (*R. indicum* L. & Sweet).

Significance to the Nursery Industry

Pine bark (PB) is one of the most widely used container substrate components in the nursery industry. Supply restrictions as well as fluctuation in production cost of PB invoke a need to search for alternative substrate components. Cotton is a major agronomic crop grown in the southeastern United States, and the cotton gins that clean the cotton lint after it is harvested are numerous throughout this region. During the ginning process, a large amount of cotton by-products are generated. Cotton gin waste (CGW) that had been composted for one year (CGC) was used to replace 25, 50, or 75% of the PB fraction of a substrate blend. Plant growth indices of several important ornamental cultivars were comparable in substrates containing CGC when compared to the traditional PB substrate. EC and pH values of substrates containing CGC were within suitable production guidelines for optimum plant growth. Composting of cotton gin by-products provides a viable substrate for use in the production of container grown nursery crops.

Introduction

Availability and cost of materials used as container substrate blends for horticultural crop production are always a concern. Pine bark is one of the most widely used substrate components, yet the supply of PB is impacted by markets in the timber industry, resulting in inconsistent or unpredictable supplies. The needs for alternative substrates used for container production of nursery plants are evermore urgent. Use of composted materials to replace PB in a substrate is not a new concept; however, factors such as transportation costs, consistency and reproducibility of product, disease and insect infestation, and availability have been concerns for growers leading to reservations about incorporating composts into potting substrates (2). Benefits of composts are often overlooked due to a lack of scientific literature and guidelines on which to base beneficial claims. Some positive features of compost include its organic content, improvement of soil structure, increased water holding capacity, and the destruction of weed seed and pathogenic diseases associated with raw waste products (6, 11, 14).

Cotton gin operations throughout the southeast United States are faced with the dilemma of finding cost effective and legal disposal methods of the CGW (6). Cotton gin waste is a term used to describe the by-products of the cotton ginning process that includes leaves, stems, hulls, and some lint (3, 5, 13). Current practices of disposal of CGW include broadcast spreading the raw waste over farmland, use as a livestock feed, or disposal at a landfill (3, 5, 9, 12, 13). These disposal and utilization methods are very limited and costly to the cotton gins (4, 5, 12).

Producing a consistent composted CGW product provides a potential use of CGW as a substrate component in the horticulture industry (7) and an avenue of disposal for cotton gin operations. The end product, cotton gin compost (CGC), is a fine, dark, peat-like substrate. In a greenhouse study with *Coleus* x *hybridus* 'Golden Bedder', substrates containing 20–60% (volume basis) CGC produced plants with height, shoot dry weight, and visual quality equal to or better than that produced in 100% pine bark substrate (7). Poinsettias grown in substrates containing up to 75% (volume basis) CGC had excellent post-production quality (14). Positive effects on floral crops, such as height reduction and early flowering, resulted from use of CGC as a replacement of up to 60% of the peat fraction of a substrate (8).

The objective of this study was to evaluate the growth of shoots and roots of three nursery crops grown in CGC blended substrates or in a standard PB substrate. Substrates were also compared with regard to physical and chemical properties. Unlike previous work that focused primarily on herbaceous and foliage plant growth in CGC substrate blends, our study evaluated the growth of woody ornamentals common in the nursery trade.

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Materials and Methods

Cotton gin waste was obtained from the Milstead Farm Group, Inc. near Shorter, AL (32° 48'N × 85° 89'W) and composted in a windrow for one year at E.V. Smith Research Center near Shorter, AL. Four substrate blends were mixed by volume in December of 2001: 6:1 pine bark (PB):sand (S), 4.5:1.5:1 PB:cotton gin compost (CGC):S, 1:1 PB:CGC, and 1.5:4.5:1 PB:CGC:S. Substrates were amended with 8.2 kg/m^3 (13.9 lb/yd^3) Osmocote18N–$6P_2O_5$–$12K_2O$ (The Scotts Company, Marysville, OH), 0.9 kg/m^3 (1.5 lb/yd^3) Micromax (The Scotts Co.), and 3.0 kg/m^3 (5 lb/yd^3) powdered dolomitic limestone. 'Winter Gem' boxwood (*Buxus microphylla* 'Winter Gem'), 'Firepower' dwarf nandina (*Nandina domestica* 'Firepower'), and 'Midnight Flare' azalea (*Rhododendron indicum* 'Midnight Flare') were transplanted from 2.8 liter (1 gal) pots to 10.7 liter (3 gal) pots. Loose substrate was shaken off the roots, and roots were loosened before transplanting into the four substrate blends. Plants were placed on a container pad under two daily cycles of overhead irrigation totaling 1.3 cm (0.5 in) of water at the Paterson Greenhouse Complex, Auburn University, AL (32° 36'N × 85° 29'W, USDA Hardiness Zone 8a). Plants were arranged in a randomized complete block design (RCBD) with four blocks and three single container observations of each species and substrate within each replication.

On February 11, 2002, initial growth index (GI) of each plant was determined using the following formula: [(height + widest width + width perpendicular to widest width) / 3]. A second GI was determined 74 days after the initial (DAI) evaluation (10 weeks) and then every 40 days (5 weeks) thereafter until the conclusion of the study in November 2002 (40 weeks).

At the end of the study, root balls of each plant were evaluated using a rating scale of 0–5 (0 = no root growth; 1 = root ball falls apart; 2 = root ball crumbles, but stays somewhat intact; 3 = root ball stays intact, but does not fill the pot; 4 = roots reach bottom of pot, but do not fill the pot; 5 = root bound).

Physical properties including air space (AS), water holding capacity (WHC), total porosity (TP), and bulk density (BD) were determined for each substrate blend using the North Carolina State University Porometer (NCSU-P) (1). Initial physical property data were collected from three representative samples of each substrate. At the end of the study, substrate particles from each species and substrate were shaken into separate containers, from which three representative samples of each were taken. Final physical properties at the conclusion of the experiment were determined for these samples using the NCSU-P.

Initial leachates were collected from three representative samples of each substrate blend using the Virginia Tech Extraction Method (VTEM) (15). Final leachates were collected randomly from one pot of each species and substrate in each block. Leachate samples were analyzed for pH and electrical conductivity (EC) using a Model 63 pH and conductivity meter (YSI Incorporated, Yellow Springs, OH).

This study was repeated beginning in August 2003 with substrate blends mixed by volume in similar to the study in 2002 with the exception of 1:1:1 PB:CGC:S which was used instead of 1:1 PB:CGC. Sand was incorporated to better follow industry standards for container production substrates. Substrate fertilizer amendments for this study were the same as the first year study. The cultivars used in this second study were the same except that 'Renee Mitchell' azalea was used instead of 'Midnight Flare' azalea due to availability at the beginning of this study. GI measurements of each plant were determined using the same formula and measurement intervals described previously. Initial GI was determined on August 11, 2003, and the final measurement was taken at the conclusion of the study on April 23, 2004 (37 weeks). Physical properties were not determined on the substrate blends for the second study. Root balls were evaluated at the end of the study for each plant using the previously described rating scale.

Data from each experiment were analyzed separately using GLM procedures. Regression analysis of GI over time was performed for all plants within each substrate treatment.

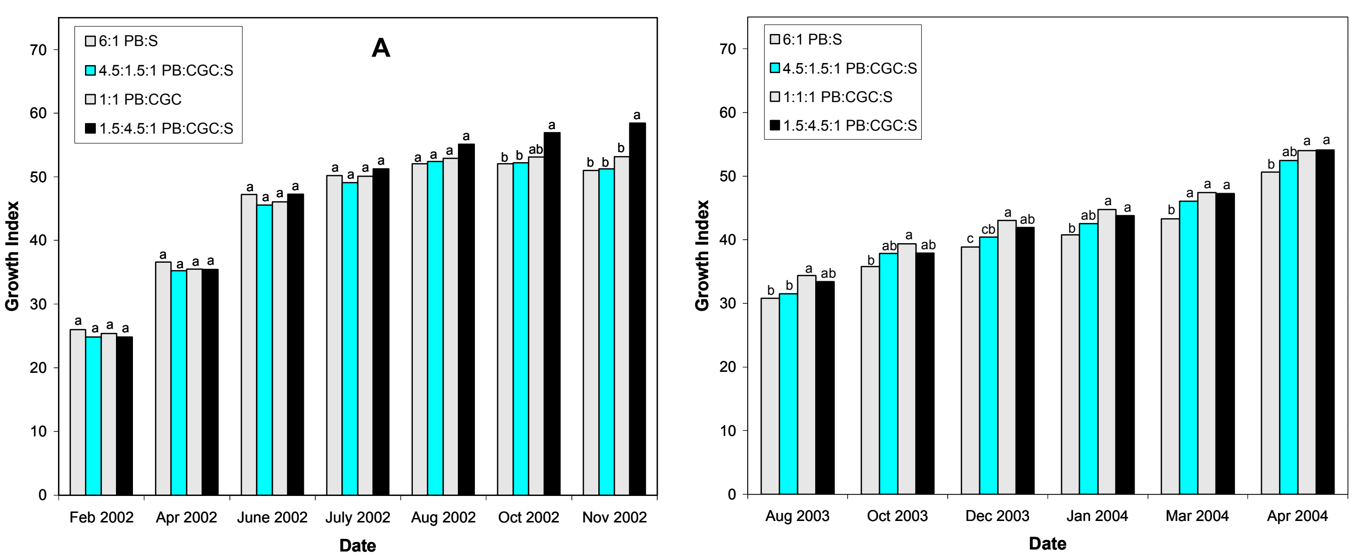

Fig. 1. Growth index (GI) [(height + widest width + perpendicular width) / 3] of 'Winter Gem' boxwood grown in four substrates in (A) 2002 and (B) 2004, with linear (L) trends for all substrates at *P* < 0.001. Within date, bars with the same letter are not significantly different (*P* < 0.05) using Fisher's LSD.

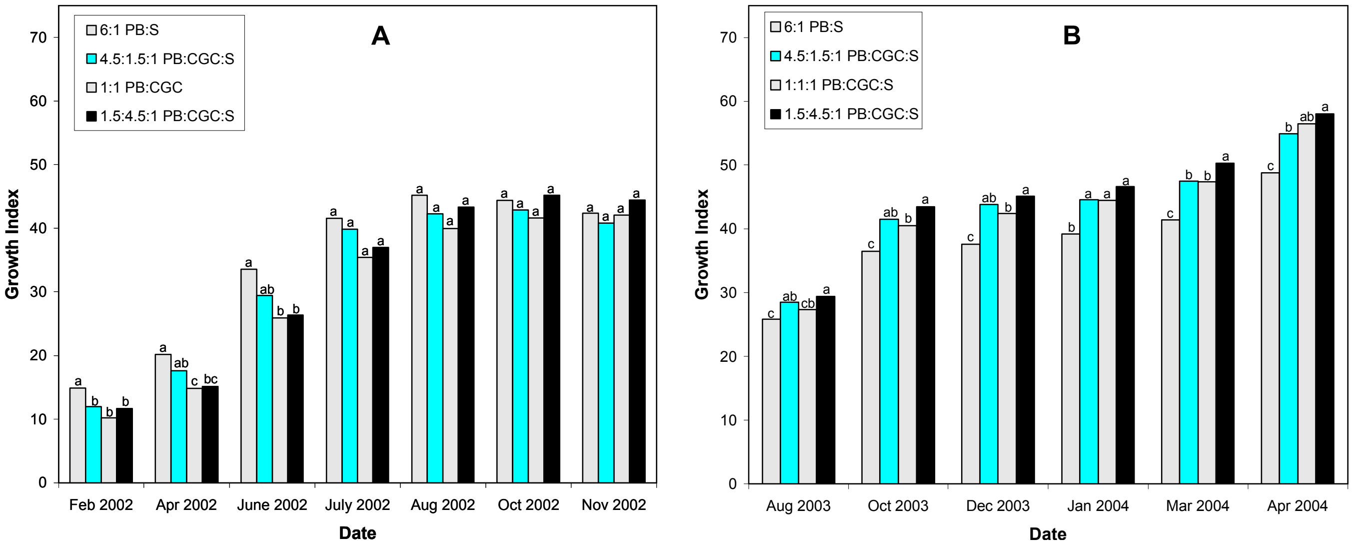

Fig. 2. Growth index (GI) [(height + widest width + perpendicular width) / 3] of 'Firepower' dwarf nandina grown in four substrates in (A) 2002 and (B) 2004, with linear (L) trends for all substrates at $P < 0.001$. Within date, bars with the same letter are not significantly different ($P < 0.05$) using Fisher's LSD.

Fisher's Least Significant Difference ($P = 0.05$) was used to separate means among substrates within each of the measurement dates (10).

Results and Discussion

Plant growth. All cultivars exhibited linear increases in GI over the course of the experiment in all substrates (Figs. 1, 2, 3). At the end of both studies, GI of 'Winter Gem' boxwood grown in all CGC blended substrates was similar to or larger than that of plants grown in the PB:S control (Fig. 1A, 1B). Beginning with the fourth measurement through the conclusion of the first study, GI for 'Firepower' dwarf nandina, were similar across all treatments (Fig. 2A). Data for 'Firepower' dwarf nandina in the second study showed larger GI in all CGC substrates beginning with the second measurement date through the conclusion of the study (Fig. 2B). Growth index of 'Midnight Flare' azalea was similar across all treatments at the conclusion of the first study (Fig. 3A). There was no difference in GI of 'Renee Mitchell' azalea among any of the substrates through the fifth measurement (Fig. 3B). At the conclusion of the study GI of 'Renee Mitchell' azalea was significantly larger in substrates containing CGC than when grown in PB:S (Fig. 3B). Visual rating of root growth was similar across all treatments for all cultivars in both experiments (data not shown).

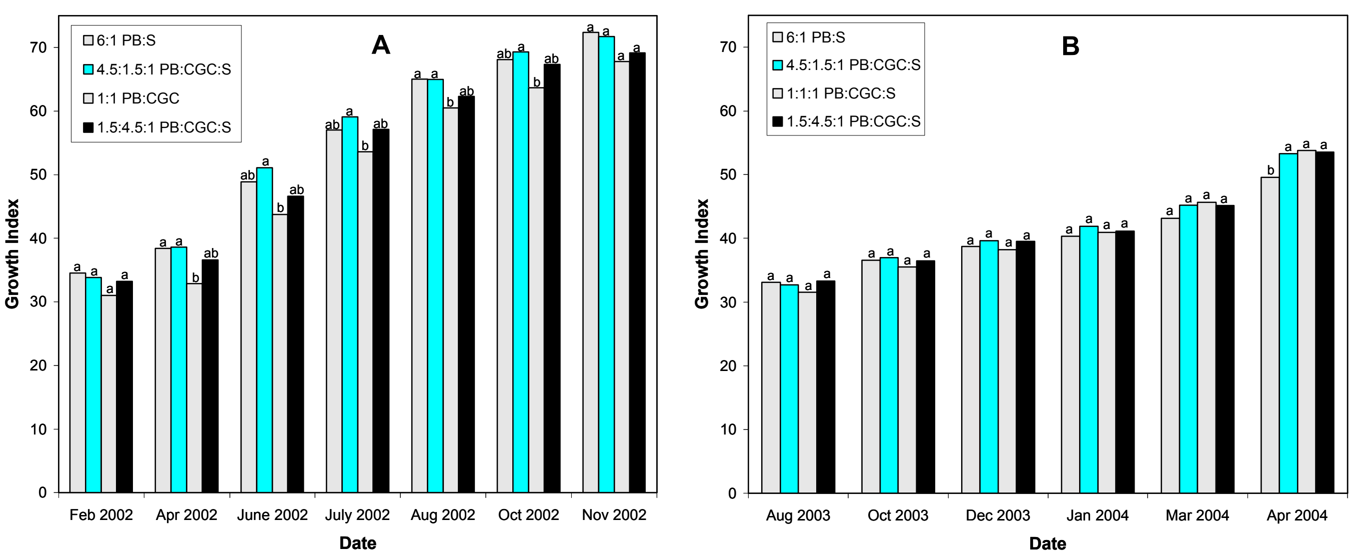

Fig. 3. Growth index (GI) [(height + widest width + perpendicular width) / 3] of (A) 'Midnight Flare' azalea in 2002 and (B) 'Renee Mitchell' azalea in 2004 grown in four substrates with linear (L) trends for all substrates at $P < 0.001$ (***). With in date, bars with the same letter are not significantly different ($P < 0.05$) using Fisher's LSD.

Table 1. Initial physical properties of four substrate blends.

Substrate[z]	Water holding capacity (%)	Air space (%)	Total porosity (%)	Bulk density (g/cm³)
6:1 PB:S	33d[y]	41a	74b	0.28c
4.5:1.5:1 PB:CGC:S	42c	32b	73b	0.31b
1:1 PB:CGC	53b	24c	78a	0.23d
1.5:4.5:1 PB:CGC:S	57a	13d	70c	0.44a
BMP guidelines[x]	45–65	10–30	50–85	0.19–0.70

[z]PB = pine bark, S = sand, CGC = cotton gin compost.

[y]Means separation within columns by Fisher's LSD at $P = 0.05$.

[x]BMP = Best Management Practices recommended ranges for substrates used in general nursery production (Yeager et al., 2000).

Physical properties. Initial AS was highest in 6:1 PB:S (41%) as expected for a PB based substrate (Table 1), but not desirable based on recommendations by *The Best Management Practices Guide for Producing Container-Grown Plants* (BMP) for physical properties of container substrates (16). Although the final AS decreased from the initial evaluation, it still was slightly above guidelines (Table 2). In all cases 6:1 PB:S had the highest AS.

Initially, 1.5:4.5:1 PB:CGC:S had the highest WHC (57%) of all the substrates (Table 1). BMP guidelines suggest a WHC between 45 and 65% volume. Both 6:1 PB:S and 4.5:1.5:1 PB:CGC:S were below this range (Table 1). In general, final WHC increased from the initial in all substrates for all cultivars and were within BMP recommendations (Table 2).

Initial TP was highest in 1:1 PB:CGC (78%), but all substrates were within BMP guidelines of 50 to 80% (Table 1).

Table 2. Final physical properties for substrate blends for three cultivars.

Species	Substrate[z]	Water holding capacity (%)	Air space (%)	Total porosity (%)	Bulk density (g/cm³)
Buxus microphylla 'Winter Gem'	6:1 PB:S	49c[y]	32a	81a	0.23c
	4.5:1.5:1 PB:CGC:S	57b	22b	79ab	0.27b
	1:1 PB:CGC	59ab	21b	80ab	0.24bc
	1.5:4.5:1 PB:CGC:S	62a	14c	76b	0.35a
Nandina domestica 'Atropurpurea Nana'	6:1 PB:S	49c	36a	85a	0.22b
	4.5:1.5:1 PB:CGC:S	54b	29b	83a	0.24b
	1:1 PB:CGC	54a	21c	85a	0.19c
	1.5:4.5:1 PB:CGC:S	65a	14d	80b	0.31a
Rhododendron indicum 'Midnight Flare'	6:1 PB:S	44c	35a	79a	0.23c
	4.5:1.5:1 PB:CGC:S	51b	25b	76a	0.27b
	1:1 PB:CGC	52b	23b	75ab	0.26b
	1.5:4.5:1 PB:CGC:S	59a	12c	71b	0.37a
BMP guidelines[x]	Desirable range	45–65	10–30	50–85	0.19–0.70

[z]PB = pine bark, S = sand, CGC = cotton gin compost.

[y]Means separated by species and within columns by Fisher's LSD at $P = 0.05$.

[x]BMP = Best Management Practices recommended rages for substrates used in general nursery production (Yeager et al., 2000).

Table 3. Initial and final leachate pH and electrical conductivity (EC) of container substrates.

Species	Substrate[z]	EC (dS/m) Initial	EC (dS/m) Final	pH Initial	pH Final
Buxus microphylla 'Winter Gem'	6:1 PB:S	2.2c[y]	0.7a	5.38b	6.23a
	4.5:1.5:1 PB:CGC:S	6.2b	0.9a	5.50ab	6.25a
	1:1 PB:CGC	6.9b	0.8a	5.73a	6.32a
	1.5:4.5:1 PB:CGC:S	9.1a	0.9a	5.55ab	6.38a
Nandina domestica 'Atropurpurea Nana'	6:1 PB:S	2.2c	0.7b	5.38b	5.67b
	4.5:1.5:1 PB:CGC:S	6.2b	0.6b	5.50ab	5.86ab
	1:1 PB:CGC	6.9b	0.7b	5.73a	5.86ab
	1.5:4.5:1 PB:CGC:S	9.1a	1.1a	5.55ab	6.07a
Rhododendron indicum 'Renee Mitchell'	6:1 PB:S	2.2c	0.7a	5.38b	6.15b
	4.5:1.5:1 PB:CGC:S	6.2b	0.8a	5.50ab	6.13b
	1:1 PB:CGC	6.9b	0.7a	5.73a	6.23a
	1.5:4.5:1 PB:CGC:S	9.1a	0.9a	5.55ab	6.27a
BMP guidelines[x]	Desirable range	0.8–1.0		5.0–6.0	

[z]PB = pine bark, S = sand, CGC = cotton gin compost.

[y]Mean separation by species and within columns by Fisher's LSD at $P = 0.05$.

[x]BMP = Best Management Practices recommended ranges for substrates used in general nursery production (Yeager et al., 2000).

Final TP increased in all substrates for all cultivars and were within recommendations (Table 2).

Initially, 1.5:4.5:1 PB:CGC:S had the greatest BD (0.44 g/ cm^3), but all substrates were within a range of 0.19 to 0.70 g/ cm^3 recommended by BMP guidelines (Table 1). Final BD was generally high in 1.5:4.5:1 PB:CGC:S, and all substrates were within BMP suggestions for BD (Table 2).

The differences in the final physical properties among all substrates were similar regardless of the plant species grown in them (Table 2). Physical characteristics of substrates among species were alike even though root systems of the different species ranged from coarse (boxwood) to fine (azalea), suggesting that various root systems will not alter the physical properties of the substrates when used in production systems.

Chemical properties. Initial pH values were high in all substrates containing CGC (Table 3), but differences were of little statistical significance compared to the PB:S substrate. Final pH levels were in upper to high values across all substrates compared to BMP guidelines (Table 3). EC was initially high (>6 dS/m) in substrates containing CGC (Table 3), but was suitable following initial irrigation to the point of leaching. Final EC levels across all substrates were low to adequate according to BMP guidelines (Table 3). The low EC in all substrates at the end of the study is attributed to using an eight to nine month control release fertilizer.

At the conclusion of both studies, GI's of all four cultivars grown in the CGC blended substrates were equal to or larger than those in the PB:S control, suggesting that CGC can be used to replace part of the PB fraction in container substrates. The incorporation of CGC can enhance the physical properties of a PB substrate and thereby produce quality plants. Data for WHC suggest that CGC substrates may hold more water than PB over the course of the growing season, potentially providing optimal growing conditions for species that perform well in wetter soils. High WHC may also suggest that substrates containing CGC may require less frequent irrigation than a PB substrate with much lower WHC, thereby saving water. Incorporation of CGC can also increase initial EC levels of a PB substrate which could be desirable for many commonly grown nursery crops. Based on the guidelines for nursery production, a standard PB substrate can be amended with CGC without sacrificing the growing conditions recommended for suitable plant production.

A renewed interest for PB substitutes in the nursery industry has spawned much research on new substrates and substrate blends for horticultural crop production. Despite previous research on CGC, and its potential as a quality substrate amendment, the current industry standards do not reflect its utilization in production systems. With increasing demands on PB supply and concern over its availability, growers who operate in the southeast should consider taking advantage of CGC as a resource that is available, inexpensive, and underused.

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