



Ornamental

ABSTRACT

Four hammock species native to Florida were larger with more flowers 8 wk after transplanting into containers filled with compost or media amended with compost when compared with a Florida peat-based control. Our study indicated that compost can serve as a viable alternative substrate to peat for container production of Florida butterfly sage (*Cordia globosa* (Jacq.) Kunth [Boraginaceae]), firebush (*Hamelia patens* Jacq. [Rubiaceae]), scorpions tail (*Heliotropium angiospermum* (Murray) Britton. [Boraginaceae]), and tropical sage (*Salvia coccinea* Buc'hoz ex Etl. [Lamiaceae]). Plants transplanted to containers filled with a biosolid:yard waste compost or a formulated compost-based mix (4:5:1, compost:pine bark:sand, v:v:v) grew better than plants transplanted to a commercial peat-based mix, although initial analyses of the medium indicated that compost alone had higher pH; electrical conductivity (EC); N, P, K, Ca, Zn, Cu, Mn, Al, Fe, and B contents; and similar air-filled porosity and C contents when compared with the peat- or compost-based media.

KEY WORDS

butterfly sage, *Cordia globosa*, firebush, *Hamelia patens*, scorpions tail, *Heliotropium angiospermum*, tropical sage, *Salvia coccinea*, biosolids, container media

NOMENCLATURE

Wunderlin (1998)

Using compost for container production of

Hammock Species

native to Florida

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The nursery industry uses peat extensively as a primary component in commercial soilless potting media because of its organic composition, superior water-holding capacity, and ultimately because of its optimum production of a wide array of nursery species. Both environmental and economical implications of peat usage have resulted in the development of new substrate substitutes worldwide, most of which utilize waste by-products. Coconut coir dust, the by-product from coconut husks used in manufacturing industrial products, has been recognized as a suitable substrate alternative or partial alternative to peat with equal superior physical and chemical qualities (Meerow 1994; Evans and Stamps 1996; Pill and Ridley 1998). While comparable in appearance to that of sphagnum peat, the cost of coir is still considered high in comparison to other biowaste products such as compost. In the US, the increase of both public and private composting facilities over the past decade (Glenn 1999) has coincided with improved compost products that are acceptable in terms of quality, quantity, and economical feasibility to various horticultural enterprises. Fitzpatrick (2001) has reviewed and cited numerous investigations illustrating the beneficial growth responses of compost utilization in ornamental and nursery crop production systems including temperate woody ornamentals, bedding plants, foliage plants,

and subtropical or tropical trees. In addition, other beneficial properties of compost have been reported, such as nutrient enrichment (Hue and Sobieszcyk 1999), suppression of soil-borne diseases (Hoitink and others 1991), and improvement of physical properties (Inbar and others 1993).

In previous studies, the effects of compost-amended media on the growth of exotic perennials were investigated (Wilson and others 2001a, 2002). Several herbaceous perennial plant species, including Mexican heather (*Cuphea hyssopifolia* H.B.K. [Lythraceae]), Bolivian sunset (*Gloxinia sylvatica* H.B.K. Wiehler [Gesneriaceae]), Brazilian plume (*Justicia carnea* Lindl. [Acanthaceae]), and golden globe (*Lysimachia congestiflora* [Primulaceae]), were grown in commercial soilless mixes amended with up to 50% compost (biosolids and yard trimmings) without adversely affecting size, appearance, or flowering. Plants grown in media with higher percentages of compost (75% or 100%) were still considered marketable but were reduced in size.

While Canadian sphagnum peat is still one of the primary components of many substrate blends used by the nursery and landscape industry, up to 40% of Florida peat (sedge peat) is used by some native nurseries in Florida. As a product consisting mainly of sedges and grasses of wetland ecosystems, Florida peat is considered by some as nonrenewable at the level

in which it is harvested (Barkham 1993; Buckland 1993). Florida ranks in the top 5 states nationally in the production of horticultural peat with an annual mining industry value estimated at US\$ 8.18 million in 1999 (National Mining Association 2001). Although considered less expensive than sphagnum peat, Florida peat is reportedly inconsistent in pH and quality (Alexander 2001). The objective of this investigation was to develop a compost-based medium suitable for container production of native plants. Four species were chosen for this study because of their native origin and association to Florida hammocks (hardwood forests), popularity among consumers, and proven performance in Florida landscapes (Table 1).

MATERIALS AND METHODS

Plant Material and Media Compositions

Plugs (4 wk old from cuttings unless otherwise indicated) of butterfly sage (*Cordia globosa* (Jacq.) Kunth [Boraginaceae]), firebush (*Hamelia patens* Jacq. [Rubiaceae]), scorpions tail (*Heliotropium angiospermum* (Murray) Britton. [Boraginaceae]), and tropical sage (*Salvia coccinea* Buc'hoz ex Etl. [Lamiaceae]; 14 wk old from seeds; The Natives, Davenport, Florida) were transplanted into 3.8-l (1-gal) cylindrical, plastic pots filled with a compost-based medium formulated on-site (4:5:1, compost:pine bark:coarse sand, v:v:v) (Table 1). Addi-

TABLE 1

Botanical description, habitat, and hardiness of four native hammock species of Florida.



Botanical name	<i>Cordia globosa</i>	<i>Hamelia patens</i>	<i>Heliotropium angiospermum</i>	<i>Salvia coccinea</i>
Authority	(Jacq.) Kunth	Jacq.	(Murray) Britton.	Buc'hoz ex Etl.
Family	Boraginaceae	Rubiaceae	Boraginaceae	Lamiaceae
Common name	Butterfly sage	Firebush	Scorpions tail	Tropical sage
Florida native habitat	Hammocks	Coastal hammocks and shell middens	Hammocks, shell mounds, and disturbed sites	Hammocks and disturbed sites
USDA hardiness zone	10 to 11	8B to 11	9 to 11	8 to 10
Habit	Shrub (1.8 to 2.4 m tall [6 to 8 ft])	Shrub (1.5 to 4.6 m tall [5 to 15 ft])	Short-lived perennial or small shrub (0.3 to 0.9 m tall [1 to 3 ft])	Short-lived perennial (0.5 to 0.6 m tall [1.5 to 2 ft])
Description	Dense plant with evergreen foliage and profuse tiny white flower clusters	Attractive green foliage with red new growth and petioles; produces red, tubular flowers throughout the year followed by fruit	Semi-woody with textured evergreen leaves and white flowers resembling a scorpion's tail	Triangular leaves on long petioles with red showy bilabiate flowers

tional containers were filled with compost alone (from the same stock as that used for the compost-based mix) or 100% peat-based commercial soilless mix (4:5:1, peat:pine bark:coarse sand, v:v:v) (Atlas 3000, Atlas Peat and Soil Inc, Boynton, Florida). Compost was generated by the Solid Waste Authority of Palm Beach County, West Palm Beach, Florida, using a 1:1 ratio (w:w) of biosolids and yard trimmings (screened to 0.64 cm [0.25 in]). Materials were composted for 18 d in an agitated bed system, stockpiled, and then rescreened to 0.64 cm (0.25 in). All plants were top-dressed at a manufacturer's recommended rate of 15 g (0.53 oz) per pot of 15N:3.9P₂O₅:10K₂O Osmocote Plus® (The Scotts Co, Marysville, Ohio) and treated with a 1% granular systemic insecticide imidacloprid, (Marathon, Olympic Horticultural Products, Bradenton, Florida) at a manufacturer's recommended rate of 0.37 g/l (0.05 oz/gal) and a broad spectrum systemic fungicide etridiazole (Banrot, The Scotts Co, Marysville, Ohio) at a manufacturer's recommended rate of 12.9 g/l (1.72 oz/gal). Mean minimum and maximum temperatures in the greenhouse were 15 and 30 °C (59 and 86 °F) during the experiment.

Five replications of each medium were evaluated initially for percentage moisture, air-filled porosity, total porosity, container capacity, bulk density, and particle density. Moisture percentage was determined by oven-drying water-saturated media at 105 °C (221 °F) for 24 h and weighing before and after. The air-filled porosity was determined in 500 ml (0.13 gal) containers using the Wolverhampton submersion method of measuring the volume of drainage water in relation to the substrate volume (Bragg and Chambers 1988). Standard drying procedures were then used after volume displacement methods to determine total porosity, bulk density, particle density, and container capacity (see Niedziela and Nelson [1992] for equations).

Three samples from each medium were collected (prior to adding slow-release fertilizer) to determine chemical and nutrient composition. A 1:2 medium:deionized H₂O extract was prepared for each mixture. Electrical conductivity (EC) was measured with a YSI Model 35 conductance meter (Yellow Springs Instrument, Yellow Springs, Ohio) and pH was measured with an Orion Model 520A meter (Orion Research Inc, Boston, Massachusetts). For C and N analyses, samples of each medium were oven-dried for 2 d at 60 °C (140 °F) and ground to a powder with a ball mill prior to combustion (Nelson and Sommers 1996). Total C and N concentrations were determined by a CNS analyzer (Carlo-Erba Na-1500; BICO, Burbank, California). The US Environmental Protection Agency (EPA) method 200.7 (USEPA 1993) was used to determine total P, K, Ca, Mg, Fe, Zn, Cu, Mn, and B. An acid digestion procedure (EPA method 3050; USEPA 1995) was used to prepare the samples for analysis by Inductively Coupled Argon Plasma Spectroscopy (ICP) (Model 61E, Thermo Jarrell Ash Corp, Franklin, Massachusetts). Samples were air-dried for 2 d and ground to a powder with a ball mill grinder.



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A portion of the sample (1.0 g [0.04 oz]) was digested in nitric acid then treated with 30% hydrogen peroxide. The sample was then refluxed with nitric acid, filtered through Whatman filter paper (no. 41) (Whatman Inc, Clifton, New Jersey) and diluted to 100 ml (3.4 oz) for analyses.

Plant Growth and Development

Plant height, leaf greenness, dry weight, and flower number were measured after 8 wk. Final plant height was measured from the crown (near soil level) to the shoot apex of the primary stem. Leaf greenness was measured on the third, fourth, fifth, and sixth leaf from the apex of each plant using a SPAD-502 chlorophyll meter (Minolta Camera Co, Osaka, Japan). Flower number was recorded only for the day of harvest and represented flower buds, immature, and mature flowers. Shoots were severed at the crown, and roots were manually washed prior to oven drying for 1 wk at 70 °C (158 °F).

Experimental Design and Statistical Analysis

A randomized complete block experimental design was used for each species with treatments (the 3 media) replicated 5 times. All data within each species evaluated were subjected to an analysis of variance (ANOVA) and significant means separated by Duncan's multiple range test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Physical, Chemical, and Nutrient Characteristics of Media

At the onset of the study, compost was more basic (pH = 7.5) with higher soluble salts (EC = 4.3 dS/m) as compared with the compost-based or peat-based medium (Table 2). Biosolids are frequently stabilized and conditioned at wastewater treatment facilities using lime, resulting in elevated soluble salt levels (Fitzpatrick 2001). In previous studies, the EC of biosolid-yard waste compost ranged from 2.0 to 7.6 dS/m without adversely affecting visual quality (Wilson and others 2001a; 2002). Alexander (2001) recommended that no more than 20% of composts containing high levels of soluble salts (over 5 dS/m) should be incorporated in a soil mix for production of salt-sensitive species. Regardless of whether the medium was amended with sedge peat or compost, pH values (6.6 to 7.5) were within the preferred range for various applications under mean field conditions (6.0 to 7.5) as reported by Alexander (2001).

Initial moisture content was significantly higher for the peat-based medium than for the compost-based medium or compost alone (Table 2). Air-filled porosity was similar among media and within 5% to 30% as recommended by Poole and others (1981) (Table 2), indicating gas exchange was sufficient in the root zone (Agnew and Leonard 2003). The compost-based medium had lower total porosity and container capacity

with higher bulk and particle densities than the peat based or compost alone media (Table 2). The higher bulk and particle densities and lower container capacity in the compost-based medium were attributed to the higher portion of larger-sized particles which may improve subsequent medium drainage.

The N content was higher in compost alone than in media amended with compost or sedge peat (Table 3). The biosolid portion of the total feedstock attributed to higher N content of the compost. Organic wastes have been reported as a valuable source of N (Sims 1995). The C content was similar among media. This resulted in a low C:N (13.9) for compost alone, which is considered stable and optimal for plant growth (Davidson and others 1994; Cooperband and others 2003).

Compost alone or media amended with compost had higher P, K, Zn, Cu, Al, and Fe concentrations than the peat-based medium (Table 3). Again, biosolids are traditionally known to be a valuable source of micronutrients (He and others 2001). Levels of measured heavy metals in compost did not exceed EPA standards (USEPA 1994). For peat- and compost-based media, concentrations of Ca, Mn, and B were similar but lower than those of compost alone. Magnesium concentration was higher in the peat-based medium than in the other media.

Plant Growth and Development

Use of compost in the medium increased plant height of each species evaluated with the exception of *H. angiospermum*, which had similar plant heights among media (Table 4; Figure 1). For *H. patens* and *H. angiospermum*, compost alone produced plants that had 1.5X to 1.8X greater shoot weight than those grown in the compost-based medium and 4X to 8X greater shoot weight than those grown in the peat-based medium (Table 4). For *C. globosa* and *S. coccinea*, shoot weight was similar among compost alone or compost-based media and greater than that of plants grown in the peat-based medium. For each species grown in compost, the higher shoot weights corresponded to greater root weights, with the exception of *S. coccinea*, having root weights similar among media (Table 4). This was inconsistent with results from our previous experiments where media with more than 50% compost reduced the shoot weight of 7 out of the 10 non-native perennial species evaluated (Wilson and others 2001b). Therefore, perennial ornamental species have differential growth responses to media amended with compost. Also, differences in compost mesh (0.6 cm in this study versus 1.3 cm in previous studies) may have attributed to the differential growth responses previously reported (Wilson and others 2001b).

Investigations are limited on the use of organic amendments as a substitute for peat for native plant production. In a study using Douglas-fir (*Pseudotsuga menziesii menziesii* Mirb. Franco. [Pinaceae]) seedlings, Rose and Haase (2000) reported that plants were smaller when grown in media containing coir than in a peat moss medium or standard forestry mix. In a

TABLE 2

Mean chemical ($n = 3$) and physical ($n = 5$) properties of compost and peat based media. ^a

Medium ^b	pH	EC (dS/m)	Moisture	Air-filled porosity		Total porosity	Container capacity	Bulk density (g/cm ³)	Particle density (g/cm ³)
				(% by vol)					
Peat-based	6.55 c ^c	0.91 c	52 a	12	66 a	54 a	0.25 b	0.72 b	
Compost-based	6.91 b	2.28 b	33 c	11	57 b	46 b	0.40 a	0.92 a	
Compost	7.54 a	4.34 a	45 b	8	64 a	56 a	0.26 b	0.74 b	

^a Data measured prior to transplanting.

^b Peat-based commercial mix (4:5:1 [v:v:v] Florida peat:pine bark:coarse sand); compost-based mix (4:5:1 [v:v:v] compost:pine bark:coarse sand); compost (1:1 [v:v] yard waste:biosolids).

^c Means within columns were separated by Duncan's multiple range test at $P < 0.05$. Different letters indicate significantly different means.

TABLE 3

Mean nutrient and elemental characteristics of compost and peat based media. ^a

Medium ^b	N —(%)—	C	C-N ratio	P K Ca Mg Zn Cu Mn Al Fe B									
				(μg/g)									
Peat-based	0.90 b ^c	33.1	37.3 a	121 c	261 c	11 730 b	4324 a	15 c	6 c	53 b	1114 c	3254 c	13.0 b
Compost-based	1.12 b	31.3	27.9 b	3731 b	2256 b	26 760 b	1408 c	94 b	59 b	58 b	1578 b	5660 b	16.4 b
Compost	2.39 a	33.2	13.9 c	9973 a	6676 a	58 567 a	3280 b	228 a	159 a	126 a	3584 a	13 806 a	34.4 a

^a Data measured before transplanting.

^b Peat-based commercial mix (4:5:1 [v:v:v] Florida peat:pine bark:coarse sand); compost-based mix (4:5:1 [v:v:v] compost:pine bark:coarse sand); compost (1:1 [v:v] yard waste:biosolids).

^c Means were separated by Duncan's multiple range test at $P < 0.05$ ($n = 3$). Different letters indicate significantly different means.

study using Pigeon-plum (*Coccoloba diversifolia* Jacq. [Polygonaceae]) grown in media consisting of 80% biosolids compost and 20% sifted incinerator ash, Fitzpatrick (1985) reported growth rates comparable to the control. The responses of plants grown in a medium amended with compost vary widely depending on compost source and plant species.

SPAD readings for leaf greenness were similar among media for each species tested, except for *C. globosa*, where leaf greenness was higher when plants were grown in compost alone or the compost-based medium (Table 4). At 8 wk after transplanting, *H. angiospermum* and *S. coccinea* had almost double the amount of flowers when grown in the compost-based medium or compost alone as compared with plants grown in the peat-based medium (Table 4).

Media, especially those containing peat, are major expenses for commercial growers of container-grown ornamental

species. Our data indicate that incorporation of compost (biosolid–yard waste) in a medium had a source of macro- and micronutrients with similar physical properties to that of a peat-based commercial mix. For all species, shoot growth, root growth (except in *S. coccinea*), and plant height (except in *H. angiospermum*) were improved when compost or compost-based media were used rather than peat-based commercial media. Therefore, media amended with compost may serve as a stable, viable, and inexpensive alternative to current commercial peat-based media for the production of ornamental hammock species. Future studies will address the effect of compost on plant growth of other native species associated with flatwood, sandhill, and wetland plant communities.

TABLE 4

Mean plant growth and flowering of Florida native hammock species grown for 8 wk in media amended with compost or sedge peat.

Species	Medium ^a	Plant height (cm)	Leaf color (SPAD)	Flowers (number)	Shoot dry weight (g)	Root dry weight (g)
<i>Cordia globosa</i>	Peat-based	24.5 b ^b	39 b	6	1.8 b	0.6 b
	Compost-based	37.4 a	42 a	9	4.1 a	1.2 a
	Compost	37.0 a	43 a	9	4.2 a	1.0 a
<i>Hamelia patens</i>	Peat-based	19.6 c	42	— ^c	1.8 c	0.4 c
	Compost-based	38.4 b	42	—	4.2 b	1.2 b
	Compost	50.9 a	43	—	7.4 a	2.2 a
<i>Heliotropium angiospermum</i> ^c	Peat-based	59.0	43	20 c	1.5 c	3.1 c
	Compost-based	61.2	41	36 b	8.3 b	5.7 b
	Compost	68.3	40	55 a	12.0 a	8.2 a
<i>Salvia coccinea</i>	Peat-based	76.3 b	41	13 b	3.3 b	2.5
	Compost-based	87.8 a	43	28 a	9.6 a	3.3
	Compost	92.8 a	41	27 a	12.0 a	4.1

^a Peat-based commercial mix (4:5:1 [v:v:v] Florida peat:pine bark:coarse sand); compost-based mix (4:5:1 [v:v:v] compost:pine bark:coarse sand); compost (1:1 [v:v] yard waste:biosolids).

^b Means within each species were separated by Duncan's multiple range test at $P < 0.05$ ($n = 5$). Different letters indicate significantly different means.

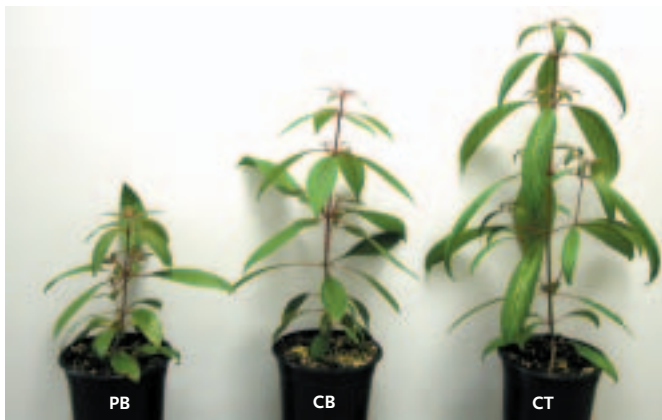
^c Plants failed to flower during the experiment.



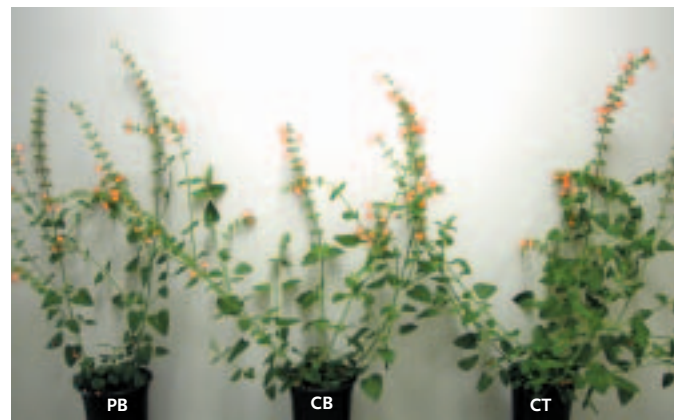
Cordia globosa



Heliotropium angiospermum



Hamelia patens



Salvia coccinea

Figure 1. Appearance of Florida native hammock species grown for 8 wk in media amended with compost. PB = peat-based commercial mix (4:5:1 Florida peat:pine bark:coarse sand); CB = compost-based mix (4:5:1 compost:pine bark:coarse sand); CT = compost (1:1 [v:v] yard waste:biosolids).

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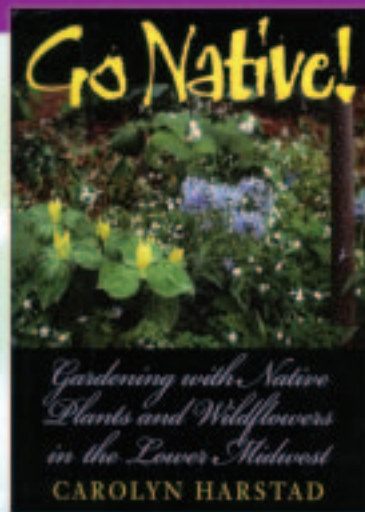
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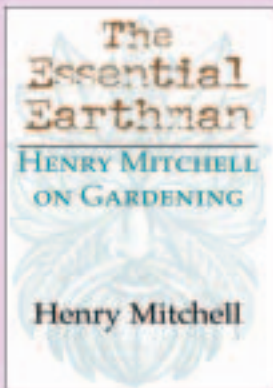
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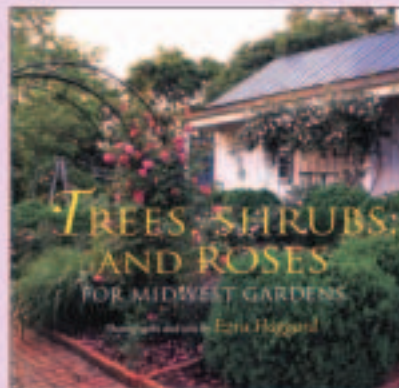
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