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Container and Field Evaluation of Three Native Shrubs Grown in Compost-Based Media

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Three shrubs native to Florida, pineland privet [*Forestiera segregata* var. *pinetorum* (Small) M.C. Johnst.], Simpson's stopper [*Myrcianthes fragrans* (Sw.) McVaugh], and Walter's viburnum (*Viburnum obovatum* Walter), were container grown in a peat- or compost-based medium for 18 weeks. The formulated compost-based medium had lower initial moisture, pH, total porosity, and container capacity; and higher bulk and particle density than the other media. The compost-based medium and unamended compost both had higher levels of N, P, K, Zn, Cu, Mn, and Fe than the peat-based medium. Regardless of species, incorporation of compost in the medium did not affect plant height or shoot dry weight. Although growth indices of Walter's viburnum and pineland privet were similar among media, compost-grown Simpson's stopper had 24% greater growth index than plants grown in peat-based media. Root dry weights of Walter's viburnum grown in peat or compost-based media were 30 to 50% greater than that of plants grown in unamended compost. Regardless of species, when grown out in the landscape for an additional 32 weeks, initial container medium did not affect subsequent plant height, growth index, stem caliper, or visual quality.

Introduction

There is an abundant supply of commercially available, horticultural-grade composting material in the U.S. Twenty-one states have banned the dumping of at least some forms of yard trimmings in their landfills (Kaufman *et al.* 2004). In efforts to use organic waste materials, compost has been utilized to successfully grow a wide range of crops including bedding annuals (Klock-Moore 1999), perennials (Wilson *et al.* 2002), sod (O'Brien and Barker 1995) vegetables (Roe *et al.* 1997), woody shrubs and trees (Fitzpatrick *et al.* 1998), and foliage plants (Fitzpatrick 1986). While the varying types of feedstocks, degree of sophistication of composting facilities, and varying levels of maturity prevent over generalizations of its recommended use (Raviv 2005), utilization of urban waste compost products for containerized media has been well reviewed for ornamental production (Moore 2005; Fitzpatrick 2001). Compost-related ornamental research also has addressed various factors such as plant nutrition (Wilson *et al.* 2003), species specificity (Wilson *et al.* 2002), salinity (Klock 1997), and irrigation (Wilson *et al.* 2003). However, few studies have addressed the use of yard waste/biosolid compost for containerized native shrub production.

Plants are considered native if they were present at the time of European contact in the early sixteenth century (1513). Florida has over 2,400 native species of plants (Wunderlin and Hansen 2003) that have long-term survival rates because of their early adaptation to our soils, temperature, and rainfall patterns. Due to the natural beauty, wildlife benefits, and low maintenance requirements characteristic of many natives, interests and applications of their use in the landscape are increasing. About 25 percent of the native flora of Florida is in commercial production (AFNN 2005). Subsequently, containerized media compositions are being continually modified to optimize native plant production. Since native species were originally associated with natural plant communities or ecosystems such as the coastal strand, sand scrub, sandhills, hammocks, flatwoods and swamps, media composition can significantly impact containerized production and subsequent landscape performance. The objectives of this investigation were to develop a compost-based medium suitable for container production of native shrubs, and to evaluate their subsequent field establishment. Three species were chosen for this study based on their ornamental value, tolerance of a wide range of growing conditions, and consumer availability.

Materials and Methods

Plant Material and Media Composition

Pineland privet [*Forestiera segregata* var. *pinetorum* (Small) M.C. Johnst.], Simpson's stopper [*Myrcianthes fragrans* (Sw.) McVaugh], and Walter's viburnum (*Viburnum obovatum* Walter) were propagated by seed at a commercial nursery (D.R. Bates Nursery, Loxahatchee, FL). Plant specifications prior to use in the study were as follows: pineland privet (5-7 seeds/cell, 3 months old, 12.8 cm tall), Simpson's stopper (20 seeds/cell, 3 months old, 6.7 cm tall), and Walter's viburnum (3 selected seedlings per cell, 12 months old, 16.9 cm tall). For each species, a single uniform liner was selected and transplanted into a 3.8 L plastic pot filled with a compost-based medium formulated on site with 50% pine bark, 40% compost, and 10% coarse sand (v:v:v). Additional plants were transplanted into pots filled with compost (100%) or a peat-based commercial soilless mix (50% pine bark, 40% Florida peat, and 10% coarse sand) (v:v:v) (Atlas 3000, Atlas Peat and Soil Inc., Boynton, Florida). Compost was generated by the Palm Beach County Solid Waste Authority (West Palm Beach, Florida) using a 1:1 ratio (w:w) of biosolids and yard trimmings (screened to 0.64 cm). For each species, five pots of each media were utilized for the greenhouse experiment and an additional nine pots of each media were used for the subsequent field experiment. All plants were top-dressed at a standard rate of 18 g per pot of 15N-9P-12K Osmocote Plus " and treated with a 1 percent granular systemic insecticide imidacloprid, (Marathon‰, Olympic Horticultural Products, Bradenton, Florida) at a manufacturer recommended rate of 0.37 $g \cdot L^{-1}$ and a broad spectrum systemic fungicide etridiazole (Banrot, The Scotts Co., Marysville, OH) at a manufacturer recommended rate of 0.9 $g \cdot L^{-1}$. Plants were drip irrigated (960 mL/min) two to three times per week. Mean minimum and maximum temperatures during the experiment were 18.6 and 37.2°C in the greenhouse.

Percent moisture, air-filled porosity (AFP), total porosity (TP), container capacity (CC), bulk density (BD), and particle density (PD) were determined on five samples from each medium. Percent moisture was determined by drying a known weight of media at 105°C for 24 h and weighing before and after drying. The AFP was determined in 500 mL 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 TP, CC, BD, and PD (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 H_2O extract was prepared for each mixture. Electrical conductivity (EC) was measured with an 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 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, MA). Samples were air-dried for 2 d and ground to a powder with a ball mill grinder. A portion of the sample (1.0 g) 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 for analyses.

Plant Growth and Development

Plant height, growth index, and shoot and root dry weights were measured 18 weeks after transplanting. Plant height was measured from the soil level to the shoot apex of the primary stem. Growth index was calculated by taking the average of plant height, width 1 (north-south) and width 2 (east-west). Shoots were severed at the crown, and roots were manually washed prior to oven drying each at 70°C for 1 week.

For subsequent field evaluations, a subset of plants were removed from pots and transplanted (21 June 2004) 0.91 m on-center in raised beds covered with landscape fabric (Synthetic Industries Inc., Alto, GA). Plants were top-dressed with 18 g of 15N-9P-12K Osmocote Plus " per plant and watered twice a week by drip irrigation (3.4 L/plant). Field conditions were as follows: 1.2% organic matter, pH 6.3, average monthly rainfall 12.2 cm, mean minimum and maximum temperatures 13.6 and 32.1°C, respectively, and relative humidity 78.0%. Plant height, growth index, caliper, percent survival and visual quality of plants were evaluated 32 weeks after transplanting in the field. Stem caliper was measured for the largest primary stem (pineland privet and Walter's viburnum) or the entire stem bunch (Simpson's stopper) approximately 5 cm above the soil

line for each plant. Visual quality was performed by three individuals based on a scale of 1 (very poor quality) to 5 (excellent quality) and averaged.

Statistical Analysis

For the greenhouse study, a randomized complete block experimental design was used for each species with media treatments replicated five times. All data within each experiment were subjected to an analysis of variance (ANOVA) and significant media means separated by Duncan's multiple range test at $P \leq 0.05$. For each species, the field study utilized a randomized complete block experimental design with 3 replications (3 single plant samples per media and within each replication).

Results and Discussion

Media Nutrient Composition and Chemical Characteristics

The formulated compost-based medium had lower initial moisture, pH, total porosity, and container capacity than the other media, with higher bulk and particle density (Table 1). Higher bulk density generally corresponds to a lower porosity (Poole et al., 1981). Air filled porosity (6.7%) and container capacity (44.0%) were within the optimal range reported as suitable for use as a substrate for container-grown plants (Rynk, 1992). Inbar et al. (1993) have reviewed physical, chemical, and biological properties of compost used as a containerized media. More recently, Raviv (2005) reviewed the criteria necessary to produce high quality commercial composts for horticultural purposes and suggested that N content be greater than 1.8%, with sufficient hydraulic conductivity, air porosity, and available water.

While it is typical for composts to have pH values slightly above the desirable range (Nappi and Barberis 1993), the compost used in this study had a pH value (6.53) similar to that of the peat-based commercial mix (6.58). The EC of the compost-based medium, however, was 3.5 times higher than that of the peat-based medium. High EC values have been reported for other biosolids:yardwaste composts (Vavrina 1994), and often limit the exclusive use of compost without amendments, particularly for salt sensitive species. Since the species used in this study (Walter's viburnum, Simpson's stopper, and pineland privet) are native to coastal areas and tolerant of a variety of conditions, this was of minimal concern.

Compost had higher N content than the compost-based or peat-based media (Table 2). Organic wastes have been reported as a valuable source of N (Sims 1995). Composts with C:N ratios less than 20 are con-

TABLE 1.
Chemical and physical properties of compost and peat-based media[1].

Medium[2]	Initial Moisture (%)	pH	EC (mmho/cm)	Air Filled Porosity	Total Porosity	Container Capacity	Bulk Density	Particle Density
				(% by vol)			(g/cm^3)	
Peat-based	53.3 a[3]	6.58 a	1.63 c	5.08	48.0 a	43.0 a	0.23 b	0.46 b
Compost-based	36.2 c	5.97 b	5.73 b	4.06	41.6 b	38.0 b	0.33 a	0.57 a
Compost	52.8 b	6.53 a	11.2 a	6.67	50.8 a	44.0 a	0.20 c	0.42 b

[1]Data measured prior to transplanting. [2]Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v). Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v). Compost consists of 1:1 yard waste:biosolids (w:w). [3]Mean separation by Duncan's multiple range test, 5% level.

TABLE 2.
Elemental contents of compost and peat-based media[1].

Medium[2]	N	C	C/N Ratio	P	K	Ca	Mg
	(%)			Concentration ($mg \cdot kg^{-1}$)			
Peat-based	0.52 c[3]	31.8 a	60.7 a	103 c	267 c	13300 b	3660 a
Compost-based	0.84 b	24.3 b	28.9 b	3540 b	1937 b	13940 b	1105 c
Compost	2.43 a	30.7 a	12.7 c	10410 a	7150 a	47143 a	3096 b

Medium	Zn	Cu	Mn	Al	Fe	B
	Concentration ($mg \cdot kg^{-1}$)					
Peat-based	5.4 c	3.6 c	20.1 c	1326 c	1174 c	11.0 b
Compost-based	40.9 b	58.0 b	48.4 b	1703 b	4162 b	15.6 b
Compost	102.3 a	166.4 a	115.6 a	3749 a	10557 a	34.8 a

[1]Data measured prior to transplanting. [2]Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v). Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v). Compost consists of 1:1 yard waste:biosolids (w:w). [3]Mean separation by Duncan's multiple range test, 5% level.

sidered stable and optimum for plant growth (Davidson *et al.* 1994), while those with ratios greater than 30 may result in plant phytotoxicity (depending on plant species) and N immobilization (Zucconi *et al.* 1981). Compost and the compost-based medium had substantially more P and K than the peat-based medium (Table 2). Phosphorus and K are often present at higher levels in compost media (McLachlan *et al.* 2004). In addition, both the compost and compost-based medium had higher levels of Zn, Cu, Mn, Al, and Fe than the peat-based media. However, heavy metal contents did not exceed the Environmental Protection Agency (EPA) levels for biosolids application standards (USEPA 1994), for any substrate.

Plant Growth and Development

Regardless of species, incorporation of compost in the medium did not affect plant height or shoot dry weight (Table 3). Although non-significant, pineland privet grown in compost appeared shorter than those grown in peat or compost based media (Figure 1). Similar growth indices and shoot dry weights among media suggest, however, that plant growth and development were indeed not affected by compost. Although growth indices of Walter's viburnum and pineland privet were similar among media, Simpson's stopper had a 24% greater growth index when grown in compost or compost-based media than plants grown in the peat-based medium. Root dry weights of Walter's viburnum grown in peat or compost-based media were 30 to 50% greater than that of plants grown in compost. This contributed to the significantly greater shoot to root ratios of Walter's viburnum grown in compost as compared to other media. Few other investigations have used organic amendments as a partial or complete substitute for peat for native plant production. In a study using Douglas-fir

TABLE 3.
Mean plant growth and dry weight of three native shrubs container grown in peat- and compost-based media for 18 weeks under greenhouse conditions.

Species[1]	Medium[2]	Plant Height (cm)	Growth Index (cm)	Shoot Dry Weight (g)	Root Dry Weight (g)	Shoot: Root Ratio
Walter's viburnum	Peat-based	30.2	44.2	13.8	4.5 a	3.0 c
	Compost-based	34.8	50.4	15.5	3.9 a	4.0 b
	Compost	33.2	51.8	15.1	3.0 b	5.1 a
Pineland privet	Peat-based	75.2	62.1	28.4	6.1	4.8
	Compost-based	71.0	64.7	34.4	8.0	4.7
	Compost	50.2	61.9	28.7	5.7	5.5
Simpson's stopper	Peat-based	33.4	26.8 b	7.7	2.5	3.2
	Compost-based	41.8	31.4 ab	10.9	3.0	3.8
	Compost	41.6	33.3 a	9.6	2.7	3.7

[1]Means within each species were separated by Duncan's multiple range test at P>0.05. [2]Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v). Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v). Compost consists of 1:1 yard waste:biosolids (w:w).

TABLE 4.
Landscape growth, visual quality, and survival of three native shrubs that were container grown in peat- and compost-based media. Data was recorded after 32 weeks in the landscape[1].

Species[2]	Medium	Plant Height (cm)	Growth Index (cm)	Stem Caliper (cm)	Visual Quality[3]	Survival (%)
Walter's viburnum	Peat-based	24.7	38.9	15.2	2.2	67
	Compost-based	24.6	36.9	13.8	2.6	78
	Compost	20.4	38.5	17.6	2.6	89
Pineland privet	Peat-based	86.7	89.7	66.5	4.7	100
	Compost-based	103.9	96.2	67.0	4.4	100
	Compost	91.6	96.9	56.2	4.6	100
Simpson's stopper	Peat-based	46.3	41.4	32.8	4.4	100
	Compost-based	46.6	42.0	35.5	4.8	100
	Compost	48.7	41.8	34.1	4.8	100

[1]Each measured parameter within each species was nonsignificant among media. [2]Peat-based commercial mix consists of 4:5:1 peat:pine bark:coarse sand (v:v:v). Compost-based mix consists of 4:5:1 compost:pine bark:coarse sand (v:v:v). Compost consists of 1:1 yard waste:biosolids (w:w). [3]Assessed on a visual scale from 1 (very poor) to 5 (excellent).

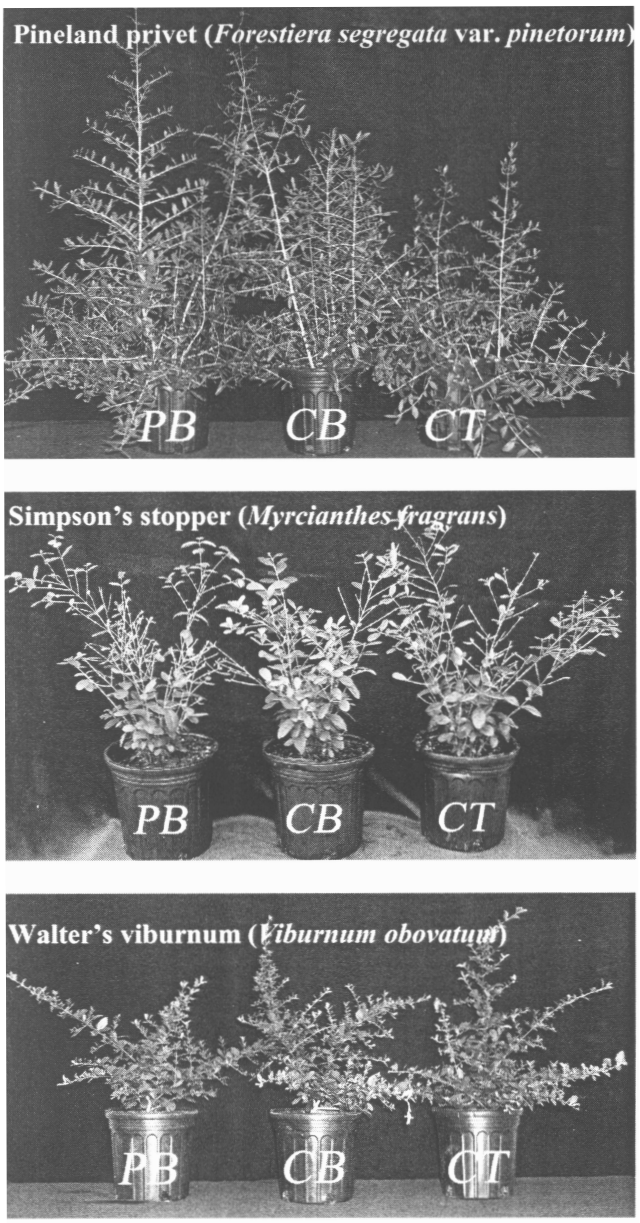

FIGURE 1. Performance of three native shrubs container grown in peat- or compost-based media for 18 weeks. PB= peat-based commercial mix (4:5:1 v:v:v Florida peat: pine bark: coarse sand); CB=compost-based mix (4:5:1 v:v:v compost: pine bark: coarse sand); CT=compost (1:1 w:w yard waste:biosolids).

(*Pseudotsuga menziesii* Mirb. Franco.) 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 study growing the Florida native pigeon-plum (*Coccoloba diversifolia* Jacq.) in media consisting of 80% biosolids compost and 20% sifted incinerator ash, Fitzpatrick (1985) reported growth rates comparable to the control. Again, the responses of plants grown in a medium amended with compost vary widely depending on compost feedstock(s) and plant species.

Regardless of species, when grown out in the landscape for 32 weeks, the initial container medium did not affect subsequent plant survival, height, growth index, or stem caliper (Table 4). This is significant since compost substrates often compact after extended time in a container. Wilson *et al.* (2001) observed that roots of golden shrimp plant (*Pachystachys lutea* Nees.) grown in 75% or 100% compost were distributed abnormally along the sides of the containers with minimal root growth in the center. In this study, visual inspection of Simpson's stopper revealed an uneven distribution of roots that were brownish in color (regardless of media), whereas roots of Walter's viburnum and pineland privet were whiter and completely embedded throughout the medium. With herbaceous bedding plants, documentation of longer term field establishment is not necessary. Verifying field establishment of Florida native woody shrubs, however, is particularly warranted since they are not native to soils with high organic matter. In a study exploring nursery and field establishment techniques to improve seedling growth of three Costa Rican hardwoods, Wightman *et al.* (2001) reported varying results among ecologically distinct species. Pilon (*Hyeronima alchorneoides* Fr. Allemao), grown initially in compost, retained its size advantage after a year in the field, however container use of compost did not affect subsequent field growth of Spanish elm [*Cordia alliodora* (R.P.) Cham] and santa maria (*Calophyllum brasiliense* Cambess).

In summary, each native species grown in compost or compost-based media grew as well as or better than those in peat-based media. More importantly, the media composition did not affect subsequent field establishment or landscape performance. As the cost of peat continues to rise due to increases in transportation and mining expenses, utilization of horticultural grade compost is commercially warranted. These results suggest that compost can serve as a viable alternative to peat for containerized production of three popular native shrub species.

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