Processed Eucalyptus Trees as a Substrate Component for Greenhouse Crop Production©

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Fast growing eucalyptus species are selected for commercial plantings worldwide and are harvested for a variety of uses. Eucalyptus plantings in south Florida are harvested for landscape mulch production, yet this material may have potential as a container substrate for horticulture crop production. In our experiment, eucalyptus was evaluated as a substrate component for greenhouse-grown petunia and marigold. Eucalyptus (E) was blended with peatmoss (PM) at various volumetric proportions to produce three substrates [E:PM (4:1), E:PM (3:2), and E:PM (2:3)], while two standard substrates were prepared from combinations of PM, pine bark (PB), and/or perlite (P) [PM:P (4:1), and PB:PM:P (3:2:1)]. Substrate pH among all substrates ranged from 4.39 to 5.52 throughout the experiment. Petunia growth index (GI) was similar for E:PM (2:3), PM:P (4:1), and PB:PM:P (3:2:1), while marigold GI was similar among all substrates. Chlorophyll content for petunia and marigold was greater in PM:P (4:1) and PB:PM:P (3:2:1) compared to the other three substrates.

INTRODUCTION

Eucalyptus trees are grown worldwide and harvested for a variety of uses including wood products (lumber, mulch, firewood, etc.), paper products (pulpwood), renewable energy source (biomass), phytoremediation, and natural oil production. Although the genus *Eucalyptus* encompasses over 700 species, only a few species have acceptable traits for commercial production in a plantation setting. Eucalyptus selected for commercial plantings have a fast growth rate and high coppicing yield to maximize production. Most eucalyptus plantations are located in tropical and sub-tropical regions due to the low freeze tolerance of the most productive species (Rockwood et al., 2008).

In Florida, several eucalyptus species have been evaluated as short-rotation woody crops in an intensive production system for maximizing biomass yield. Most research in Florida has involved two species, *E. grandis* and *E. amplifolia*, in efforts to increase cold hardiness, productivity, and site adaptability. Although the geographic range for *E. grandis* is limited to central and south Florida due to low freeze tolerance, *E. amplifolia* can be grown throughout Florida and along the Gulf Coast to Texas (Rockwood et al., 2005). Landscape mulch is the main product of established eucalyptus plantations in Florida, but eucalyptus may have potential as a container substrate for nursery and greenhouse crop production.

Horticultural producers have expressed ongoing concerns over the increased cost of peatmoss (PM) and inconsistent quality of pine bark (PB). Wood component substrates have been evaluated in recent years for their potential to offset peatmoss and pine bark usage. Most research efforts have centered around materials obtained from pine trees, including processed whole pine trees, processed chipped pine logs, and clean chip residual (Boyer et al., 2008; Fain et al., 2008; Jackson et al., 2008). Substrates from other tree species have also been evaluated, including eastern red cedar, melaleuca, and spruce

(Gruda and Schnitzler, 2004; Ingram and Johnson, 1983; Murphy et al., 2011). Poole and Conover (1991) demonstrated that Boston fern and dwarf banana plants grown in substrates containing eucalyptus mulch were similar to plants grown in PB. Common issues associated with wood-based material are reduced nitrogen availability and less than ideal water and nutrient retention compared with traditional substrates (Fain et al., 2008; Jackson et al., 2009). Such issues have not been extensively investigated for eucalyptus substrates.

Enhanced freeze tolerance of *E. amplifolia*, coupled with increased demand for energy biomass, may result in increased eucalyptus production over a wider geographic region. As a result, chipped eucalyptus trees could be a prospective source material for producing container substrates. Eucalyptus substrates have not been widely evaluated for greenhouse crop production. The objective of our research was to examine the effectiveness of eucalyptus as a substrate component for greenhouse crop production.

MATERIALS AND METHODS

Five-year-old *Eucalyptus amplifolia* trees growing in Lowndes County, GA were harvested on April 27, 2012. On May 2, 2012, main stems were chipped with a Vermeer BC1400XL (Vermeer Co., Pella, IA) and chips were processed with a Williams GP-1518 hammer mill (Williams Patent Crusher & Pulverizer Company, Inc. , St/ Louis, MO) to pass a 0.95-cm (0.37-in.) screen. Processed eucalyptus (E) and PM were blended at various volumetric proportions resulting in three substrates [E:PM (4:1), E:PM (3:2), and E:PM (2:3)]. Two "standard" substrates composed of PM, PB, and/or perlite (P) were also prepared [PM:P (4:1) and PB:PM:P (3:2:1)]. Each substrate was amended per cubic meter (cubic yard) with the following products: 0.89 kg (1.5 lbs) Micromax (The Scott's Company LLC. Marysville, OH), 2.4 kg (4 lbs) nutrient starter charge (7N-5P-4K, Harrell's LLC, Lakeland, FL), 2.4 kg (4 lbs) controlled release fertilizer (19N-6P-13K; Harrell's LLC, Lakeland, FL), and 155 ml (4 oz) wetting agent (Aqua-Gro L; The Scott's Company LLC; Marysville, OH). Dolomitic lime was added to substrates based on PM proportion. A rate of 0.89 $kg{\cdot}m^{-3}$ (1.5 lbs/yd^3) was added for every 20% of PM contained in the substrate. Individual containers (1.3 L; Dillen Products, Middlefield, OH) were filled with substrate, completely randomized within two blocks (6 reps/block), and placed on elevated benches inside a twin-wall polycarbonate greenhouse. Two petunia (*Petunia × hybrida* 200-cell tray) or three marigold (*Tagetes patula* 'Little Hero Orange'; 288-cell tray) plugs were planted in each container and hand watered as needed.

Substrate pH and electrical conductivity were analyzed with an Accumet Excel XL50 instrument (Fisher Scientific, Pittsburgh, Pennsylvania) from samples collected using the pour-through method (Wright, 1986) at 0, 7, 14, 21, and 28 days after planting (DAP). At project termination, plant growth index (GI) [(height + width + perpendicular width)/ three], flower count (FC), and leaf chlorophyll content (LCC) (SPAD 502 Chlorophyll Meter; Minolta Camera Co., Ramsey, New Jersey) were recorded. Each plant species was treated as a separate experiment. All data were analyzed with linear models using the GLIMMIX procedure of SAS (Version 9.3; SAS Institute, Inc., Cary, North Carolina). Differences between treatment means were determined using the Shaffer-Simulated method ($P<0.05$).

RESULTS

Substrate pH at 0 DAP ranged from 4.48 to 4.76 among the five substrates for petunia (Table 1). At 28 DAP, E:PM (4:1) had the highest substrate pH (5.52), while PB:PM:P (3:2:1) had the lowest pH (4.63). Throughout most of the experiment, substrate pH for all substrates remained below the recommended range for petunia production (5.4 to 6.0) (Kessler, 1998). Eucalyptus has an inherently higher pH compared with PM and PB (data not shown), although high pH was not an issue during this experiment. Substrate EC was similar among all substrates at 0, 14, 21, and 28 DAP (Table 2).

Petunia GI was similar among the substrates containing eucalyptus, but greatest for E:PM (2:3), PM:P (4:1), and PB:PM:P (3:2:1) (Table 3). Marigold GI was similar among all substrates. Flower count was similar among all substrates for petunia, but significantly lower in PM:P (4:1) compared with all other substrates for marigold. Chlorophyll content for petunia and marigold was greater in PM:P (4:1) and PB:PM:P (3:2:1) compared to the other three substrates. Chlorophyll content for petunia decreased as eucalyptus proportion increased, while chlorophyll content was similar for marigold among substrates containing eucalyptus.

DISCUSSION

We demonstrate that substrates composed of up to 80% eucalyptus could be used for petunia and marigold production. All plants in both experiments were of marketable size and quality. The lower chlorophyll content of plants grown in eucalyptus substrates may be an indication of decreased nitrogen availability. Eucalyptus substrates could be produced from trees currently harvested for landscape mulch, although further processing would be required. More research will be required to demonstrate how other plant species perform in eucalyptus substrates.

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Table 1. Substrate pH of petunia grown in five different substrates composed of two or more of the following components at various proportions: eucalyptus[z], peatmoss, pine bark, and perlite.

Substrate	Substrate pH[y]				
	0 DAP[x]	7 DAP	14 DAP	21 DAP	28 DAP
Eucalyptus:Peatmoss (4:1)	4.64 b[w]	4.73 a	4.65 c	5.24 a	5.52 a
Eucalyptus:Peatmoss (3:2)	4.62 b	4.78 a	4.81 b	5.02 ab	5.16 b
Eucalyptus:Peatmoss (2:3)	4.76 a	4.88 a	4.96 a	4.91 bc	5.05 b
Peatmoss:Perlite (4:1)	4.75 a	4.87 a	4.99 a	5.21 a	4.97 b
Pine bark:Peatmoss:Perlite (3:2:1)	4.48 c	4.39 b	4.59 c	4.68 c	4.63 c

[w]Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method ($n=6$).
[x]Days after planting.
[y]pH of substrate solution collected using the pour-through method.
[z]Five year old *Eucalyptus amplifolia* trees, delimbed, chipped, and hammermilled to pass a 0.95-cm screen.

Table 2. Substrate electrical conductivity (EC) of petunia grown in five different substrates composed of two or more of the following components at various proportions: eucalyptus[z], peatmoss, pine bark, and perlite.

Substrate	Substrate EC[y]				
	0 DAP[x]	7 DAP	14 DAP	21 DAP	28 DAP
Eucalyptus:Peatmoss (4:1)	6.13 a[w]	8.50 a	7.18 a	2.97 a	1.95 a
Eucalyptus:Peatmoss (3:2)	6.09 a	6.79 abc	7.01 a	2.99 a	1.69 a
Eucalyptus:Peatmoss (2:3)	5.93 a	7.57 ab	5.97 a	4.04 a	2.29 a
Peatmoss:Perlite (4:1)	6.24 a	6.47 bc	7.60 a	3.46 a	2.19 a
Pine bark:Peatmoss:Perlite (3:2:1)	5.32 a	5.51 c	6.15 a	3.05 a	2.27 a

[w]Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method ($n=6$).
[x]Days after planting.
[y]Electrical conductivity ($dS \cdot m^{-1}$) of substrate solution collected using the pour-through method.
[z]Five year old *Eucalyptus amplifolia* trees, delimbed, chipped, and hammermilled to pass a 0.95-cm screen.

Table 3. Growth index, flower count, and chlorophyll content of petunia and marigold[z] grown in five different substrates composed of two or more of the following components at various proportions: eucalyptus[y], peatmoss, pine bark, and perlite.

Substrate	Growth index[x]	Flower count[w]	Chlorophyll content[v]
		Petunia	
Eucalyptus:Peatmoss (4:1)	28.8 b[u]	9.4 a	27.2 c
Eucalyptus:Peatmoss (3:2)	28.0 b	10.3 a	30.3 bc
Eucalyptus:Peatmoss (2:3)	30.7 ab	12.8 a	34.9 b
Peatmoss:Perlite (4:1)	32.1 a	11.5 a	42.8 a
Pine bark:Peatmoss:Perlite (3:2:1)	31.6 a	11.7 a	39.9 a
		Marigold	
Eucalyptus:Peatmoss (4:1)	25.1 a	3.6 a	35.4 c
Eucalyptus:Peatmoss (3:2)	25.4 a	3.6 a	35.3 c
Eucalyptus:Peatmoss (2:3)	25.4 a	3.3 a	36.9 c
Peatmoss:Perlite (4:1)	25.6 a	1.6 b	46.4 a
Pine bark:Peatmoss:Perlite (3:2:1)	25.4 a	3.1 a	41.7 b

[u]Means followed by different letters within columns indicate significant difference at $P<0.05$ using the Shaffer-Simulated method.
[v]Leaf chlorophyll content determined using a SPAD-502 chlorophyll meter (average of 4 leaves per plant); $n=12$.
[w]Flower count = number of flowers or buds showing color; $n=12$.
[x]Growth index (cm) = [(height + width + perpendicular width)/3]; $n=12$.
[y]Five year old *Eucalyptus amplifolia* trees, delimbed, chipped, and hammermilled to pass a 0.95-cm screen.
[z]Data collected at 28 (petunia) or 35 (marigold) days after planting.

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