Milled *Paulownia tomentosa* as a Substrate Component in Greenhouse Annual Production©

Tyler L. Weldon, Glenn B. Fain, Jeff L. Sibley, and Charles H. Gilliam
Dept. of Horticulture, Auburn University, 101 Funchess Hall, Auburn, Alabama 36849
Email: gfain@auburn.edu

Anthony L. Witcher
USDA-ARS Southern Horticultural Laboratory, Poplarville, Mississippi 39470
University of Southern Mississippi, Department of Biological Sciences,
Hattiesburg, Mississippi 39406

INTRODUCTION

The increase in demand for peat moss and the environmental concerns that are associated with the harvesting of peat bogs provide justification for seeking new alternatives to the industry standards. Two alternatives currently marketed for greenhouse crop substrate use are rice hulls and coconut coir. Recent research has indicated the potential of wood fiber products. WholeTree, a component made from loblolly pine (*Pinus taeda* L.) was evaluated along with starter fertilizer rate in the production of greenhouse-grown petunia (*Petunia* 'Dreams Purple') and marigold (*Tagetes patula* L. 'Hero' (Fain et al., 2008). Results of this study revealed that with the addition of an adequate starter nutrient charge, WholeTree is an acceptable substrate component replacing the majority of peat moss in production of petunia and marigold. Murphy et al. (2010) processed various hardwood trees as a peat alternative in annual production, and reported that annuals grown in up to 50% red cedar showed similar results compared to a greenhouse standard (GS) peat perlite mix, while annuals grown in sweetgum- and hickory-amended substrates had significantly less growth than the GS. A study by Wright et al. (2009) looked at the growth of mums and marigolds grown in white-pine-amended substrates. Results indicated both marigolds and mums had increased growth with addition of peat moss to the pine tree substrate at 25% or 50%. Plants were able to reach comparable growth to the control substrate with the addition of at least 50% peat moss.

Another possible wood fiber alternative to peat moss is *Paulownia tomentosa,* empress tree. *Paulownia*, a known light-weight tree could have a similar bulk density to peat moss, unlike other recently investigated wood alternative substrates which have higher bulk density. *Paulownia* is currently used in several industries including lumber for furniture and other household items. The *P. tomentosa* has very fast, vigorous growth that could prove to be beneficial to the growers. This study was conducted to determine the effects of *P. tomentosa*–amended substrates on production of greenhouse grown annuals.

MATERIALS AND METHODS

This study was conducted at the Paterson Greenhouse Complex, Auburn University, Auburn, Alabama. *Paulownia tomentosa* trees were cut, de-limbed and chipped through a Vermeer BC1400XL chipper and then milled through a $^1/_4$-in. (0.64-cm) screen in a swinging hammer-mill (No.30; C.S. Bell, Tifton, Ohio) on 13 Aug. 2010.

Paulownia tomentosa (PT) substrate component was then combined with different rates of Canadian sphagnum peatmoss (P) to achieve six different treatments. Treatments were 100% PT, PT : P (2 : 8 v/v), PT : P (4 : 6 v/v), PT : P (6 : 4 v/v), PT : P (8 : 2 v/v), compared to a standard peat-lite (PL) mix P : perlite (8 : 2 v/v). Treatments were amended with 1.36 kg• m^{-3} of dolomitic lime, 0.68 kg• m^{-3} of Micromax (The Scotts Company, Marysville, Ohio) and 120 ml• m^{-3} of Aqua-gro L wetting agent (Aquatrols, Paulsboro, Ohio). Containers of 1.96 L (Dillen Products Middlefield, Ohio) were filled to capacity, tamped and filled on 14 Aug. 2010 and two plugs (200 cell flats) of either *Petunia* 'Celebrity Rose' or *Dianthus* Telstar Series Crimson were planted in each container. Containers were placed in a twin-wall polycarbonate greenhouse on elevated benches and hand watered as needed. Containers were arranged in a random complete block design with each plant species treated as separate experiment.

Substrate pH and EC (Accumet Excel XL50; Fisher Scientific, Pittsburgh, Pennsylvania) were determined at 0, 14, 21, 28, and 35 days after potting (DAP) on petunia using the pour-through method (Wright, 1986). Initial substrates were analyzed for particle size distribution (PSD). Substrate total porosity (TP), container capacity (CC), air space (AS), and bulk density (BD) were determined using the NCSU porometer method (Fonteno and Harden, 1995). At termination all crops were measured for growth index (GI) [(height + width + perpendicular width)/three (cm)] and bloom count (BC) (open flowers and unopened buds showing color). Roots were visually inspected and rated on a scale of 0 to 5 with 0 indicating no roots present and 5 indicating roots visible at all portions of the container substrate interface. At termination shoots were removed at the substrate surface and oven dried at 70 °C for 72 h and weighed to determine shoot dry weight (SDW). Data were subjected to analysis of variance using the general linear models procedure and a multiple comparison of means was conducted using Tukey's Studentized Range Test (Version 9.2; SAS).

RESULTS

Substrates containing higher amounts of PT had greater AS than substrates containing 40% or less of PT (Table 1). Substrate CC was found to be the highest in the low percentages of PT with no difference between 40% and 20% PT compared to the PL standard. All substrates containing PT had greater TP than the PL standard. Bulk densities of the PT substrates were found to be of equal value to the peat-lite standard. Substrate BD is usually found to be higher in wood fiber substrates when compared to peat-lite mixes (Fain et al., 2006; Fain et al., 2008; Wright et al., 2008). Substrate PSD indicated substrates with 60% or better PT had higher amount of coarse and medium particles than all other substrates. The larger particle size of those substrates explains in part the greater AS and TP.

At 0 DAP substrate pH was similar for PL, and all treatments containing at least 40% P. Substrate pH at 14, 21, and 28 DAP was highest for treatments containing from 60 to 100% PT. By 35 DAP PL, and treatments containing at least 40% P were similar and lower than those containing less than 40%. Initial substrate EC was greatest for PL and 20 : 80 PT:P with the PL treatment having the greatest EC at 14, 21, and 28 DAP. However by 35 DAP substrate EC was similar among all treatments (Table 2).

Petunia GI was 63% to 400% greater for plants grown in PL compared to other treatments (Table 3). Dianthus tended to respond better to PT as a substrate component than petunia although GI followed a similar trend with GI 26% to 135% greater in the PL treatment than all others. With one exception all other growth parameters followed similar trends on both species with plants grown in PL having the greatest BC, RR, and SDW of all treatments. The exception was with dianthus in substrates containing up to 60% PT had similar RR to PL.

DISCUSSION

The data presented here indicate that PT-amended substrates would result in significant reductions in crop growth compared to the PL standard, casting doubt that PT could be a viable substrate component. In conclusion, the data presented here indicate that although PT-amended substrates showed significant difference in growth when compared to the PL standard, casting doubt that PT could be viable alternative substrate component. However, a possible explanation for reduced growth of plants in the PT-amended substrates is N-immobilization from fresh PT fibers. Similar results were seen by Fain et al. (2006) where less growth of petunia and marigold were seen with increasing rates of WholeTree as a substrate component. Fain et al. (2006) suggests one explanation was nutrient immobilization, especially nitrogen, caused by the WholeTree component. This was confirmed in a follow up study (Fain et al., 2008) where results showed that with the addition of an adequate starter nutrient charge, WholeTree is an acceptable substrate component replacing the majority of peat moss in production of petunia and marigold. Future research with *P. tomentosa* as a substrate component should address the potential problem of nutrient immobilization.

Table 1. Physical properties of *Paulownia*-amended substrates.^{Z}

Substrates	Air^{Y} Space	Container^{X} capacity	Total^{W} porosity	Bulk^{Y} density
	---------------- (% vol)		----------------	(g • cm^{-3})
80 : 20 Peat-Perlite	12.6 c^{U}	72.2 ab	84.7 b	1.33 b
100 Paulownia	45.7 a	43.8 d	89.5 a	1.33 b
80 : 20 Paulowina:Peat	43.0 a	48.2 c	91.2 a	1.38 a
60 : 40 Paulownia:Peat	23.6 b	68.6 b	92.1 a	1.33 b
40 : 60 Paulownia:Peat	17.5 bc	72.5 ab	90.6 a	1.39 a
20 : 80 Paulownia:Peat	14.1 c	75.3 a	89.4 a	1.33 b

^{Z}Analysis performed using the NCSU porometer.
^{Y}Air space is volume of water drained fromt the sample ÷ volume of sample × 100.
^{X}Container Capacity is (wet weight – oven dry weight) ÷ volume of the sample × 100.
^{W}Total porsity is container capacity + air space.
^{V}Bulk density after forced air drying at 105 °C (221.0 °F) for 48 h (g • cm^{-3} = 62.4274/ft^{3}).
^{U}Tukeys Studentized Range Test (P≤0.05, n = 3).

Table 2. Effects of Paulownia amended substrates on pH and electrical conductivity of greenhouse-grown Petunia 'Celebrity Rose'.

	0 DAP[Z]		14 DAP		21 DAP		28 DAP		35 DAP	
	pH	EC[Y]	pH	EC	pH	EC	pH	EC	pH	EC
80 : 20 Peat : Perlite	3.75 c[X]	4.11 a	4.59 d	5.07 a	4.52 c	4.56 a	4.33 d	4.03 a	5.21 b	1.56 ab
100 Paulownia	6.04 a	1.44 d	6.69 a	1.28 d	6.50 a	1.30 d	6.93 ab	1.50 b	6.82 a	0.62 b
80 : 20 Paulowina : Peat	5.16 ab	1.92 cd	6.35 ab	1.92 cd	6.40 a	1.84 cd	7.14 a	1.46 b	6.70 a	1.22 ab
60 : 40 Paulownia : Peat	4.68 bc	2.33 c	5.97 b	2.50 c	6.12 a	2.30 bc	7.09 a	1.86 b	6.24 b	1.74 a
40 : 60 Paulownia : Peat	3.88 c	3.05 b	5.19 c	2.48 c	5.18 b	3.14 b	6.66 b	1.54 b	5.43 b	1.79 a
20 : 80 Paulownia : Peat	4.07 bc	3.82 a	4.59 d	3.82 b	5.03 b	3.22 b	5.91 c	2.45 b	5.45 b	1.72 ab

[Z]Days after planting.
[Y]Electrical conductivity (dS/cm) of substrate solution using the pourthrough method.
[X]Tukeys Studentized Range Test ($P \leq 0.05$, n = 4).

Table 3. Effects of substrate on growth of greenhouse-grown *Petunia* 'Celebrity Rose,' *Dianthus* Telestar Series Crimson.

	GI[Z]	BC[Y]	RR[W]	SDW[X]
Substrates		*Petunia* 'Celebrity Rose'		
80 : 20 Peat : Perlite	32.1 a	25.6 a	5.0 a	11.1 a
20 : 80 Paulownia : Peat	19.4 b	5.8 b	3.3 b	2.6 b
40 : 60 Paulownia : Peat	10.5 c	1.1 c	2.5 c	1.0 c
60 : 40 Paulownia : Peat	7.0 d	0.0 c	2.0 cd	0.4 d
80 : 20 Paulowina : Peat	7.0 d	0.1 c	2.3 c	0.4 d
100 Paulownia	6.5 d	0.0 c	1.5 d	0.2 d
		Dianthus Telestar Series Crimson		
80 : 20 Peat : Perlite	20.7 a	17.6 a	5.0 a	7.9 a
20 : 80 Paulownia : Peat	16.4 b	4.8 b	4.5 ab	4.3 b
40 : 60 Paulownia : Peat	13.5 c	0.9 c	3.9 ab	1.5 c
60 : 40 Paulownia : Peat	11.7 cd	0.6 c	4.3 ab	2.3 c
80 : 20 Paulowina : Peat	10.3 dc	0.9 c	3.9 b	0.8 c
100 Paulownia	9.3 d	0.0 c	2.6 c	0.8 c

[Z]Growth index = [(height + width1 + width2)/3].($P \leq 0.05$, n = 12).
[Y]Bloom count = number of blooms or buds showing color at 35 days after potting.($P \leq 0.05$, n = 12).
[X]Shoot dry weight measured in grams.($P \leq 0.05$, n = 8).
[W]Root ratings 0–5 scale (0 = no visible roots and 5 = roots visible on the entire container substrate interface). ($P \leq 0.05$, n = 8)
[U]Tukeys Studentized Range Test ($P \leq 0.05$, n = 8).

LITERATURE CITED.

Fain, G.B., C.H. Gilliam, J.L. Sibley, and **C.R. Boyer.** 2006. WholeTree substrate and fertilizer rate in production of greenhouse grown petunia (*Petunia* × *hybrida* Vilm.) and marigold (*Tagetes patula*.). HortScience 43:700–705.

Fain, G.B., G.H. Gilliam, J.L. Sibley, and **C.R Boyer.** 2008. Establishment of greenhouse grown *Tagetes patula* and *Petunia* ×*hybrida* in wholetree substrates. Acta Hort. 782:387–393.

Fonteno, W.C., C.T. Hardin, and **J.P. Brewster.** 1995. Procedures for determining physical properties of horticultural substrates using the NCSU Porometer. Horticultural Substrates Laboratory, North Carolina State University, Raleigh, North Carolina.

Murphy, A.M., C.H. Gilliam, G.B. Fain, T.V. Gallagher, H.A Torbert, and **J.L. Sibley.** 2010. Hardwood amended substrates for annual plant production. Proc. South. Nurs. Assn. Res. Conf. 55:385–388.

Wright, R.D., B.E. Jackson, J.F. Browder, and **J.G. Latimer.** 2008. Growth of chrysanthemum in a pine tree substrate requires additional fertilizer. HortTechnology 18:111–115.

Wright, R.D., B.E. Jackson, and **M.C. Barnes.** 2009. White pine as a pine tree substrate. Proc. South. Nurs. Assn. Res. Conf.54:221–223.

Wright, R.D. 1986. The pour-through nutrient extraction procedure. HortScience 21:227–229.