Greenhouse Production of Annuals in Aged and Fresh WholeTree Substrate©

Whitney N. Gaches, Glenn B. Fain, Donald J. Eakes, Charles H. Gilliam, and Jeff L. Sibley
Auburn University, Department of Horticulture, Auburn, Alabama 36849
Email: griffwn@auburn.edu

WholeTree (WT) is a potential new sustainable greenhouse substrate component made by milling chipped pine trees (*Pinus* spp.). This study evaluated the growth of *Petunia* Dream Series - white and *Tagetes patula* 'Little Hero Yellow' in fresh WT and peat (FWP) (1 : 1, v/v) and aged WT and peat (AWP) (1 : 1, v/v), as well as differences in physical properties of those substrates and substrate components. Plants grown in AWP resulted in larger growth indices in both species; similarly, both species had higher bloom counts when grown in AWP as compared to FWP. Aged WP had a higher container capacity than FWP, while AWP maintained a lower airspace than FWP. Aged WT as defined in this study provided a more suitable substrate component for greenhouse-grown annuals than fresh WT.

INTRODUCTION

Since the introduction of the Cornell peat-lite mixes in the 1920s, greenhouse substrates are primarily peat based. The United States imports most of its peat from Canada and the United Kingdom; however, the cost of peat continues to rise as transportation costs increase. Recently, environmental interest groups have stepped up to protect peat bogs in Europe. Great Britain has set a goal of 90% reduction in peat production by the end of 2010 (Appleby, 2009). Reduced supply and increased cost of peat continue to chip away at growers' profits.

Wright and Browder reported (2005) that chipped pine logs ground through a hammer mill showed promise as an alternative substrate for greenhouse-grown crops. The chipped pine tree substrate shows suitable physical characteristics (Saunders et al., 2006) and required additional fertilizer in the growth of greenhouse annuals (Wright et al., 2008). WholeTree (WT) is another alternative substrate component created from entire pine trees harvested at the thinning stage. All above ground portions of the tree are chipped and later ground to crop specifications; thus, WT consists of approximately wood, bark, and needles (16 : 3 : 1, by volume). Fain et al. (2008a) reported that WT substrates derived from loblolly pine (*Pinus taeda*), slash pine (*P. elliottii*), or longleaf pine (*P. palustris*) have potential as an alternative source for producing short-term horticultural crops. Studies indicate that with adequate starter nutrient charge, WT serves as an acceptable substrate component replacing the majority of peat in greenhouse production of petunia and marigold (Fain et al., 2008b). While research has been reported on the viability of chipped pine logs and WT as an alternative to peat (Fain et al., 2008a; Fain et al., 2008b; Witcher et al., 2008), there is little information on what potential benefits aging WT might have on plant growth.

For horticultural pine bark, aging substrate components refers to the stockpiling and weathering of bark after milling but prior to its use (Pokorny, 1975). In the southeast, it is common for greenhouse growers to purchase substrate components in bulk and utilize the materials throughout the growing season, so the material being used at the end of the season can have differing chemical and physical properties as a result of this aging process. As growers become more acquainted with WT and its potential in the horticultural industry, they have asked repeatedly about the effects of storing the material long-term and if aging WT is necessary. The purpose of this study is to determine growth differences in aged WT and fresh WT in order to make recommendations to growers.

MATERIALS AND METHODS

Fresh loblolly WT chips obtained from a pine plantation in Macon County, Alabama, were ground in a hammer mill to pass a 0.95-cm (3/8-in.) screen on 19 Jan. 2009 to produce fresh WT substrate. The material produced was stored in three separate 1.73 m^3 (2.3 yd^3) polypropylene bulk bags in full sun and aged thereafter. Temperature sensors were placed inside the center of each bag during filling, as well as on the outside of each bag to obtain inside bag temperature and ambient temperature for comparisons. Data loggers were attached to sensors to record temperatures at 30-min intervals. Sensors remained in place for 4 months. Figure 1 illustrates the average daily temperature inside the bulk bags. On Day 21, the average temperature inside the bags fell below the ambient temperature outside the bags and remained relatively stable for the remainder of the aging process. During this initial exothermic process sugars and other simple carbohydrates are rapidly metabolized. The material in these bulk bags were utilized as aged WT. On 22 April 2009 fresh loblolly WT chips obtained from a pine plantation in Macon County, Alabama, were ground in a hammer mill to pass a 0.95-cm (3/8-in.) screen to obtain fresh WT. On 24 April 2009, 2 days after the fresh WT was milled and 94 days after the aged WT was milled, uniform plugs of *Tagetes patula* 'Little Hero Yellow' (little hero yellow marigold) and *Petunia* Dream Series – white (dream white petunia) were transplanted from 144-plug flats into 0.95-L (1-qt) plastic pots and grown until 5 June 2009 in a twin-walled polycarbonate greenhouse under full sun. Plants were grown in a aged WT and peat medium (1 : 1, v/v) (AWP) or fresh WT and peat medium (1 : 1, v/v) (FWP). Both substrate treatments were amended with 2.97 $kg \cdot m^{-3}$ (5 lbs/yd^3) crushed dolomitic limestone, 0.89 $kg \cdot m^{-3}$ (1.5 lbs/yd^3) 7-2-10 N-P-K nutrient charge, and 154.7 $ml \cdot m^{-3}$ (4 oz/yd^3) AquaGro-L. Plants were placed on a greenhouse bench and hand watered as needed daily. Plants were liquid fed beginning on 10 DAT utilizing a 250 ppm N 20-10-20 liquid fertilizer every other watering. Greenhouse temperature daily average highs and lows were 29/21 °C (85/70 °F).

Leachates were analyzed for pH and EC at 0, 7, 14, 21, 28, 35, and 42 days after potting (DAP). Termination data at 42 DAP included final plant growth indices [(height + height + width/3)] and substrate shrinkage measured from the top of the container to the substrate surface, final bloom counts included all attached blooms and buds showing color, leaf greenness using a SPAD-502 chlorophyll meter (Minolta Camera Co., Ramsey, New Jersey), plant shoot dry weight, and a visual root rating on a 0–5 scale with 0 indicating no roots present on the substrate surface and 5 indicating roots visible at all portions of the container substrate interface.

Substrate physical properties including bulk density (BD), air space (AS), container capacity (CC), and total porosity (TP) were determined for AWP and FWP

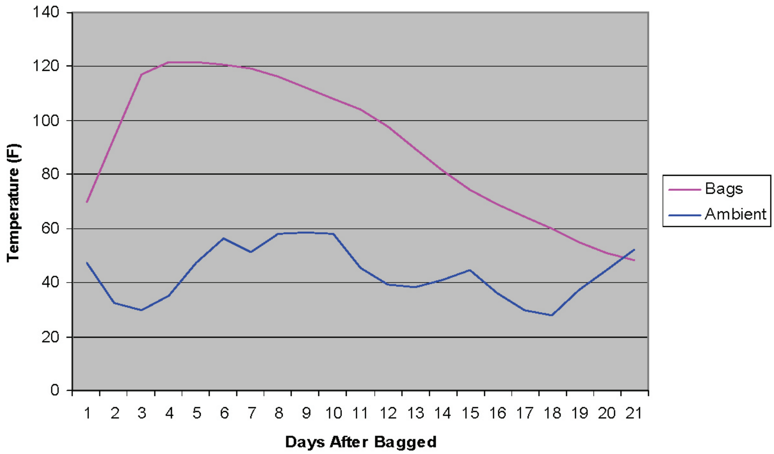

Figure 1. Evolution of ambient temperature and temperature within bulk bag during the initial stages of aging process of wholetree substrate.

and their individual components using the North Carolina State University porometer method (Fonteno et al., 1995). Plants were arranged in a randomized complete block design with 12 blocks and three samples per block per treatment. Data were subjected to analysis of variance using the general linear models procedures and multiple comparisons of means were conducted using Tukey's Honest Significant Difference test (Version 9.1; SAS Institute, Cary, North Carolina).

RESULTS

For both species, AWP pH was lower than FWP pH at 7, 14, 21, 28, and 35 DAP (Table 1). There were no differences in pH at 0 DAP or 42 DAP for either species. All the pH values were within best management production container-production range (Yeager et al., 2007). In petunia, all EC measurements were similar (Table 1). In marigold, AWP had a higher EC at 7 DAP and 14 DAP.

For both species, plants grown in AWP had higher growth indices, dry weight, and bloom counts (Table 2). Marigolds grown in FWP had more shrinkage than those grown in AWP, but there were no differences in substrate shrinkage for petunias. The SPAD readings were obtained only for the petunias, as the nature of marigold leaves prevented the SPAD meter from obtaining reliable measurements. In petunias, plants grown in AWP had higher SPAD measurements than those grown in FWP (Table 2). Subjective root ratings for petunia were the same for plants grown in AWP and FWP; however, marigolds grown in AWP had substantially higher root ratings than those grown in FWP (Table 2).

In substrate physical properties, AWP and FWP had similar TP and BD, while AWP had a higher CC (Table 3) than FWP; however, AWP had less AS than FWP. These differences were apparent in the 100% fresh WT and 100% aged WT samples

Table 1. Effects of two substrate components on pH and EC in two greenhouse grown annuals.

	Tagetes patula 'Little Hero Yellow'													
	0 DAP[z]		7 DAP		14 DAP		21 DAP		28 DAP		35 DAP		42 DAP	
Substrate	pH	EC[y]	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
AWP[x]	5.09 a[v]	1.25 a	5.57 b	1.25 a	5.88 b	1.82 a	5.92 b	1.18 a	5.70 b	0.48 a	6.29 b	0.19 a	6.39 a	0.24 a
FWP[w]	5.10 a	1.56 a	5.90 a	1.06 b	6.33 a	1.15 b	6.27 a	1.08 a	5.91 a	0.40 a	6.44 a	0.18 a	6.46 a	0.16 b
	Petunia Dream Series – white													
AWP	5.09 a	1.25 a	5.48 b	1.77 a	6.05 b	1.34 a	5.94 b	0.95 a	5.67 b	0.71 a	6.29 b	0.18 a	6.35 a	0.34 a
FWP	5.10 a	1.56 a	5.79 a	1.69 a	6.31 a	1.13 a	6.30 a	0.72 a	5.90 a	0.39 a	6.39 a	0.16 a	6.37 a	0.18 b

[z]Days after potting

[y]Electrical conductivity (dS-cm) of substrate solution using the pourthrough method (n = 12)

[x]1 : 1 (v/v) aged WholeTree : peat

[w]1 : 1 (v/v) fresh WholeTree : peat

[v]Tukey's honest significant difference ($P<0.05$)

Table 2. Effects of substrate component on growth of two greenhouse grown annuals.

Substrate	Shrinkage (mm)[z]	GI (cm)[y]	Bloom count[x]	Dry weight (g)[w]	Root R[v]	Lg[u]
			Tagetes patula 'Little Hero Yellow'			
AWP[t]	10.5b[r]	20.6a	14.5a	6.6a	3.5a	-
FWP[s]	11.9a	16.1b	9.6b	3.7b	1.9b	-
			Petunia Dream Series – white			
AWP	10.7a	30.8a	14.0a	6.3a	3.1a	30.2a
FWP	10.5a	23.2b	8.2b	3.5b	3.0a	27.5b

[z]Shrinkage in millimeters measured from the top of the container to the top of the substrate surface (n = 12)

[y]Growth index in centimeters [(height + width + perpendicular width)/3] (n = 12)

[x]Bloom counts determined by counting all attached flowers and buds showing color (n = 12)

[w]Plant shoot dry weight in grams (n = 12)

[v]Visual root rating on a 1 to 5 scale: 1 = 20% coverage; 2 = 40% coverage; 3 = 60% coverage; 4 = 80% coverage; 5 = 100% coverage (n = 12)

[u]Leaf greenness (chlorophyll content) quantified using a SPAD-502 chlorophyll meter (average of three leaves per plant) (N = 12)

[t]1 : 1 (v/v) aged WholeTree : peat

[s]1 : 1 (v/v) fresh WholeTree : peat

[r]Tukey's honest significant difference ($P<0.05$)

Table 3. Physical properties of substrates.[z]

Substrate	Air space	Container capacity (% volume)	Total porosity	Bulk density (g/cm^3)
100% AWT[y]	31.4 b[x]	55.3 c	86.7 b	0.128 b
100% Peat[w]	19.5 c	76.5 a	96.0 a	0.774 d
100% FWT[v]	45.3 a	45.9 d	91.2 ab	0.142 a
AWP[u]	17.3 c	73.2 a	90.5 ab	0.114 c
FWP[t]	28.7 b	65.7 b	94.4 a	0.116 c

[z]Analysis performed using the NCSU porometer.

[y]Processed whole pine tree ground to pass a 0.95 cm screen and aged three months.

[x]Tukey's honest significant difference (P = 0.05, n = 3)

[w]Pure sphagnum peat moss containing no nutrient charge and no wetting agent

[v]Process whole pine tree ground to pass a 0.95 screen

[u]1 : 1 (v/v) aged WholeTree : peat

[t]1 : 1 (v/v) fresh WholeTree : peat

as well. Differences in plant growth may be attributed, at least partly, to differences in substrate physical properties. Increased AS and lower CC in the FWP over the AWP could have resulted in increased nutrient leaching as well as a decrease in water availability.

DISCUSSION

Plant growth response was different in AWP as compared to FWP. Plants grown in AWP were larger, had greater dry weights, and more blooms than those grown in FWP. In general plants grown in AWP were marketable while those in FWP were not. While further studies need to be conducted to truly determine the benefits of aging it is our recommendation that WT substrates be allowed to go through this initial aging process.

LITERATURE CITED

Appleby, M. 2009. Peat: The discussion continues. Horticulture Week. 27 March 2009.

Fain, G.B., C.H. Gilliam, J.L. Sibley, and **C.R. Boyer.** 2008a. WholeTree substrates derived from three species of pine in production of annual vinca. HortTechnology 18:13–17.

Fain, G.B., C.H. Gilliam, J.L. Sibley, and **C.R. Boyer.** 2008b. Wholetree substrate and fertilizer rate in production of greenhouse-grown petunia (*Petunia ×hybrida* Vilm.) and marigold (*Tagetes patula* L.). HortScience 43:700–705.

Fain, G.B., C.H. Gilliam, and **J.L. Sibley.** 2006. Processed whole pine trees as a substrate for container-grown plants. Proc. South. Nur. Assn. Res. Conf. 51:59–61.

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.

Pokorny, F.A. 1975. A physical characterization of pine bark used in three commercial nurseries. Proc. Southern Nursery. Assn. Res. Conf. 25–27.

Saunders, T., J.F. Browder, B.E. Jackson, and **R.D. Wright.** 2006. Particle size of a pine chips substrate affects plant growth. Proc. Southern Nursery. Assn. Res. Conf. 51:46–48.

Witcher, A.L., G.B. Fain, E.K. Blythe, and **J.M. Spiers.** 2009. The effect of nitrogen form on pH and petunia growth in a WholeTree substrate. Proc. Southern Nursery Assn. Res. Conf. 54:428–433.

Wright, R.D., and **J.F. Browder.** 2005. Chipped pine logs: A potential substrate for greenhouse and nursery crops. HortScience 40:1513–1515.

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

Yeager, T., T. Bilderback, D. Fare, C.H. Gilliam, J. Lea-Cox, A. Niemiera, J. Ruter, K. Tilt, S. Warren, T. Whitwell, and **R. Wright.** 2007. Best management practices: guide for producing nursery crops. 2nd ed. Southern Nursery Assn., Atlanta, Georgia.