Pine Wood Chips as an Alternative to Perlite: Cultural Parameters to Consider©[1]

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INTRODUCTION

Soilless growing media became popular in the 1960s when Cornell University introduced their new peat-lite mixes as an alternative to topsoil for growing plants in containers. Since the transition to soilless growing media (substrates), the basic components have been peat, coir, vermiculite, and perlite. Perlite is a light weight, non-renewable, inorganic, silicaceous aggregate that allows aeration and gas exchange in substrates. The cost of perlite has increased significantly in recent years due to increased transportation costs, especially since the majority of perlite has to be shipped from overseas. In recent years, alternative substrate components have been investigated to decrease costs and utilize more renewable and local/regional products. Specific alternatives to perlite that have been investigated include parboiled rice hulls, growstones and processed corncobs (Evans and Gachukia, 2004; Evans, 2011; Weldon et al., 2012).

In addition to these alternative aggregates, many researchers have reported the effectiveness of using fresh pine wood in greenhouse substrates as both a peat and perlite replacement (Fain et al., 2008; Wright and Browder, 2005).

While it has been hypothesized that perlite is not needed in greenhouse substrates that contain fresh pine wood as a component, little work has actually been conducted to support this claim. The potential of using pine wood chips (PWC), produced from loblolly pine trees (*Pinus taeda* L.) as an aggregate is significant because of loblolly pines' fast growth rate, regional availability and abundance throughout the Southeastern USA. Therefore, objectives of this work were; (1) determine physical properties of substrates containing PWC, (2) determine lime requirements for plant growth in PWC substrates, (3) evaluate plant growth regulator (PGR) efficacy in PWC substrates, and (4) determine if PWC age effects plant growth.

MATERIALS AND METHODS

Acquisition of Pine Wood Chips

On 3 January 2012 8-year-old loblolly pine trees were harvested at ground level, de-limbed and chipped in a DR Chipper (18 HP DR Power Equipment, model 356447; Vergennes, Vermont) resulting in small PWC. Pine wood chips were then hammer-milled through a 6.35 mm screen [(¼ L x ¼ W x $^{3}/_{16}$ H –inch); C550 – CHP Meadows Mills, North Wilkesboro, North Carolina]. Pine wood chips were stored in a large bulk bag (under covered shelter) and used to make substrate blends for the experiments conducted in the spring of 2012. For all experiments conducted in the spring of 2012, two substrates were chosen for comparison; 8 peat and perlite (80:20, v/v) or peat:PWC (80:20, v/v).

Physical Properties of Pine Wood Chip Substrates

The objective of this study was to determine physical properties of substrates containing PWC. Physical properties including air-filled space (AS), total porosity (TP), container capacity (CC), and bulk density (BD) were determined for both substrates using the NCSU Porometer procedure. Data were subjected to Duncan's Multiple Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, North Carolina).

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[1] First Place – Graduate Student Research Paper Competition.

Lime Requirements of Pine Wood Chip Substrates

The objective of this study was to determine lime requirements for crop growth in a PWC substrate. Dolomitic limestone was incorporated in both 20% perlite and 20% PWC substrates at the following rates: 0, 1.78, 3.56, 5.34, 7.12, or 8.90 $kg \cdot m^{-3}$ (0, 3, 6, 9, 12, or 15 lbs/yd^3). On 21 June, 'Moonsong Deep Orange' French marigolds (*Tagetes erecta*) were potted in 12.7-cm (5-in) diameter plastic containers filled with each substrate. Plants were fertilized at each watering with 200 ppm nitrogen (N) with Peters Professional® 20N-10P-20K Peat-Lite Special® containing 8.1% ammonium (NH_4-N) and 11.9% nitrate (NO_3-N). Substrate solution was extracted one day after planting (DAP) and 28 DAP using the pour-through method (Wright, 1986) and was analyzed for pH and electrical conductivity (EC) using a Hanna HI 9813-6 instrument (Hanna® Instruments, Woonsocket, Rhode Island). On 18 July, growth index (GI) [(height + widest width + perpendicular width) ÷ 3] was determined on all plants and on 19 July, shoots were severed at the substrate surface and roots were washed, dried at 70°C for one week, and weighed. The experimental design was completely randomized with six single-plant replications of two substrates x six lime rates for a total of 72 plants. Data were subjected to analysis of variance using the general linear models procedure and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, North Carolina).

Paclobutrazol Efficacy in Pine Wood Chip Substrates

The objective of this study was to evaluate plant growth regulator (PGR) efficacy in substrates containing PWC. The same substrates used previously were mixed on 17 Jan. 2012 and amended with dolomitic limestone at 5.3 $kg \cdot m^{-3}$ (9 lbs/yd^3) and Aquatrols 2000G wetting agent at 26 $kg \cdot m^{-3}$ [(202.8 g/yd^3); Aquatrols, Paulsboro, New Jersey]. On 20 Jan. 2012, 'Pacino Gold' sunflower were potted in 12.7-cm (6-in), diameter plastics containers filled with each substrate. The seedlings were grown in a polyhouse in Raleigh, NC and grown at 23°C day/ 17°C night temperatures. Plants in each substrate were watered by drip emitters at the same time and were fertilized at each watering with 200-ppm N with Ultrasol 13N-0.9P-10.8K Water Soluble Seedling Plus (SQM North America, Atlanta, GA) containing 0.3% ammonium (NH_4-N) and 12.7% nitrate (NO_3-N). Fifth-teen days after potting, 0.00, 1.25, 2.50, and 5.00 ml of solution containing 0, 1, 2, 4 $mg \cdot L^{-1}$ (a.i.) paclobutrazol [(Piccolo 10XC), Fines Americas, Walnut Creek, California] was beaker applied to each container. Growth indices (GI) [(height + widest width + perpendicular width) ÷ 3] were determined on all plants at the first sign of flower anthesis. Shoots were severed at the substrate surface, dried at 70°C for one week, and weighed. The experimental design was completely randomized with eight single-plant replications of two substrates x four PGR treatment combinations. Data were subjected to analysis of variance by the general linear model procedures and regression and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, North Carolina).

Pine Wood Chips: Effect of Aged versus Fresh

The objective of this study was to determine if PWC age effects plant growth. On 17 June, 8-year-old loblolly pine trees were harvested and processed as previously described. PWC processed in January (aged) and June (fresh) in addition to the 80:20 perlite control were formulated. Substrates were amended with dolomitic limestone at 4.4 $kg \cdot m^{-3}$ (7.5 lbs/yd^3). On 26 June, 'Moonsong Deep Orange' French marigolds were potted in 12.7-cm (5-in), diameter plastic containers filled with each substrate. Substrate solution was extracted at 7 and 28 DAP using the pour-through method and was analyzed for pH and EC. On 22 July, GI [(height + widest width + perpendicular width) ÷ 3] was determined on all plants. Data were subjected to Duncan's Multiple Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, North Carolina).

RESULTS

Physical Properties of Pine Wood Chip Substrates

Air space, CC and TP were similar for both substrates (Table 1). Bulk density was higher in the PWC substrate, but to such a minor degree (0.01 g·cm^{-3}) it is unlikely that any practical difference would be seen in shipping or handling PWC versus perlite substrates.

Lime Requirements of Pine Wood Chip Substrates

As lime rate increased, pH levels increased at 1 DAP and 28 DAP for both perlite and PWC substrates, however lime rate had no effect on EC (Table 2). Similarly, as lime rate increased, GI, shoot and root dry weight increased in both substrates. pH levels of perlite and PWC substrates were similar at both 1 and 28 DAP and at all lime rates with the exception of the 5.34 kg·m^{-3} (9 lbs/yd^3) rate where pH was lower in PWC. Electrical conductivity was similar between substrates at both measurement dates with only one exception [1.78 kg·m^{-3} (3 lbs/yd^3) in PWC; Table 2]. Maximum GI and highest shoot and root dry weight of marigolds were achieved at that 3.56 kg·m^{-3} (6 lbs/yd^3) in the PWC substrate in contrast to marigolds grown in perlite which did not achieve maximum growth until the 7.12 kg·m^{-3} (12 lbs/yd^3) lime rate.

Table 1. Physical properties of substrates containing 80:20 (v:v) perlite or pine wood chips (PWC).[z]

Substrates	Air space	Container capacity	Total porosity	Bulk density
		(% vol)		(g·cm^{-3})
Peat:perlite (80:20, v/v)	16.3 a[y]	68.9 a	85.2 a	0.10 b
Peat:PWC (80:20, v/v)	18.8 a	70.1 a	89.0 a	0.11 a

[z]Analysis performed using the NCSU porometer.
[y]Means separated using Duncan's multiple range test within column at $P \leq 0.05$.

Paclobutrazol Efficacy in Pine Wood Chip Substrates

As paclobutrazol rate increased, plant growth decreased similarly in both substrates (Fig. 1). There was no difference in plant growth at any of the individual PGR rates. It's worth noting that at the zero rate, plant growth was similar indicating no effect of substrate physical or chemical properties, fertility or pH management in the growth of sunflowers in this experiment. The similar plant growth response seen in both substrates at all PGR rates suggest that there is no efficacy issues with paclobutrazol control of sunflower growth.

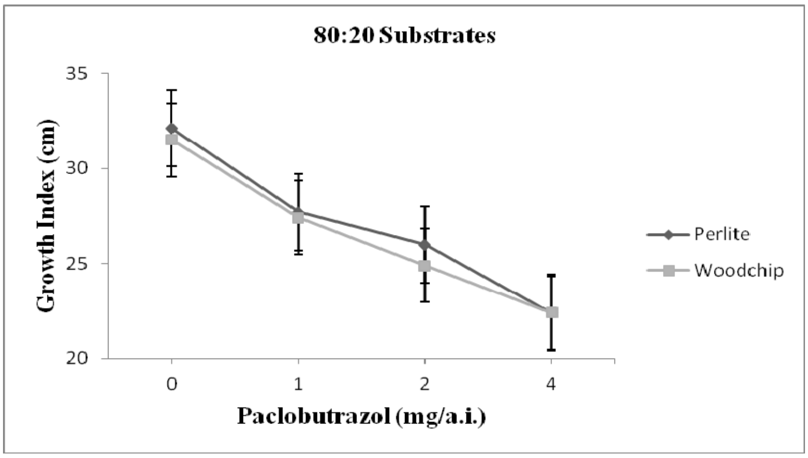

Fig. 1. Paclobutrazol drench activity on 'Pacino Gold' potted sunflower growth grown in substrates containing perlite or pine wood chip aggregates.

Table 2. Effects of lime rate on substrate pH, electrical conductivity (EC), plant growth index (GI), shoot and root dry weights of 'Moonsong Deep Orange' French marigolds.

Lime rate ($kg\cdot m^{-3}$)	1 DAP[z] pH	1 DAP[z] EC ($dS\cdot m^{-1}$)	28 DAP pH	28 DAP EC ($dS\cdot m^{-1}$)	Growth index (cm)[y]	Shoot dry wt (g)	Root dry wt (g)
Peat:perlite (80:20, v/v)							
0	3.6 f[x]	0.90 ab	4.0 g	1.30 a	18.08 g	1.89 c	0.93 bc
1.78	4.4 de	1.10 a	4.2 f	1.50 a	20.11 cdef	2.34 c	0.58 cd
3.56	4.8 cd	0.60 c	5.0 de	1.50 a	19.28 efg	2.34 c	0.78 bcd
5.34	5.7 b	1.00 ab	5.6 c	1.50 a	20.97 abcd	3.10 b	0.48 d
7.12	6.0 ab	0.80 abc	6.3 a	1.40 a	20.72 bcde	3.54 ab	1.43 a
8.9	6.3 a	1.00 a	6.4 a	1.40 a	21.39 abc	3.74 a	1.35 a
Significance[w]	L***	NS	L***	L*	L**	L***	L*
Peat:pine wood chips (80:20, v/v)							
0	3.6 f	0.90 abc	4.0 g	1.30 a	19.08 fg	1.95 c	0.88 bc
1.78	4.1 e	0.70 bc	4.3 f	1.30 a	19.75 def	2.23 c	0.63 cd
3.56	4.7 d	0.70 bc	4.9 e	1.40 a	22.22 ab	3.39 ab	1.65 a
5.34	5.2 c	0.80 abc	5.2 d	1.40 a	22.28 a	3.35 ab	1.03 b
7.12	5.7 b	0.90 abc	5.9 b	1.60 a	21.42 abc	3.62 a	1.48 a
8.9	6.1 ab	0.90 abc	6.4 a	1.40 a	20.94 abcd	3.54 ab	1.58 a
Significance	L***	NS	L**	L*	L*	L***	L**

[z]Days after planting.

[y]Growth index = [(height + widest width + perpendicular width) ÷ 3].

[x]Means separated using Duncan's Multiple Range Test within column at $P \leq 0.05$.

[w]Linear (L) response at $P \leq 0.05$ (*), 0.01 (**), or 0.001 (***).

Pine Wood Chip: Effect of Aged versus Fresh

There was no difference in substrate solution pH or EC at 7 DAP and 28 DAP across all substrates (Table 3). Growth index of marigolds grown in the perlite substrate was higher than marigolds grown in PWC aged and PWC fresh. It is unclear why growth differences occurred, but further investigation of multiple species and higher PWC rates compared to perlite are needed.

Table 3. Effects of aged and fresh pine wood chips (PWC) on pH, EC, and plant growth of 'Moonsong Deep Orange' French marigolds.[z]

Substrate	7 DAP[y]		28 DAP		Growth index
	pH	EC ($dS \cdot m^{-1}$)	pH	EC ($dS \cdot m^{-1}$)	(cm)[x]
Perlite (80:20, v/v)	5.2 a[w]	1.40 a	5.4 a	1.50 a	21.56 a
PWC (80:20, v/v) (aged)	4.9 a	1.50 a	5.3 a	1.40 a	19.06 b
PWC (80:20, v/v) (fresh)	5.1 a	1.20 a	5.3 a	1.30 a	19.78 ab

[z]Loblolly pine trees harvested January 2012 (aged) and loblolly pine trees harvested June 2012 (fresh).
[y]Days after planting.
[x]Growth index = [(height + widest width + perpendicular width) ÷ 3].
[w]Means separated using Duncan's Multiple Range Test within column at $P \leq 0.05$.

DISCUSSION

In conclusion, the data presented here demonstrates PWC aggregates can replace perlite and be utilized in greenhouse substrates without greatly altering cultural parameters of plant production. There were no differences between AS, CC, and TP of perlite or PWC substrates which suggests no change in irrigation practices is expected. Maximum plant growth in PWC substrates was achieved at a lower lime rate 3.56 $kg \cdot m^{-3}$ (6 lbs/yd^3) compared to perlite substrates. Root growth was also observed to be larger in PWC-grown plants at lower lime rates compared to plants grown in perlite. Pine wood chips do not appear to affect the efficacy of paclobutrazol drench activity on plant growth which has been a concern of many growers. Based on these results PWC can be a substitute for perlite with no major concerns or significant changes to cultural practices.

Literature Cited

Evans, M.R. 2011. Physical properties of and plant growth in peat-based root substrates containing glass-based aggregates, perlite, and parboiled fresh rice hulls. HortTech. 21:30-34.

Evans, M.R. and Gachukia, M. 2004. Fresh parboiled rice hulls serve as an alternative to perlite in greenhouse crop substrates. HortScience 39:232-235.

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

Jackson, B.E., Wright, R.D. and Barnes, M.C. 2010. Methods of constructing a pine tree substrate from various wood particle sizes, organic amendments, and sand for desirable physical properties and plant growth. HortScience 45:103-112.

Weldon, T.L., Fain, G.B., Sibley, J.L. and Gilliam, C.H. 2011. Processed corncob as an alternative to perlite in the production of greenhouse grown annuals. Comb. Proc. Intl. Plant Prop. Soc. 60:531-534.

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

Wright, R.D. 2004. Chipped pine logs: a potential substrate for greenhouse and nursery crops. HortScience 40:1513-1515.