From Forest Nursery Notes, Winter 2013

226. Post-distilled cedar as an alternative substrate in the production of greenhouse grown annuals. Vandiver, T. A., Fain, G. B., Gilliam, C. H., and Sibley, J. L. International Plant Propagators' Society, combined proceedings 2011, 61:420-424. 2012.

Post-Distilled Cedar as an Alternative Substrate in the Production of Greenhouse Grown Annuals©[1]

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INTRODUCTION

Peat moss is the main component found in soilless greenhouse substrates today and is thus in high demand commercially. Due to the increasing demand for peat moss; the issue of peat bog preservation has been brought to light. Another concern associated with peat moss production is the cost of shipping from Canada or Europe and the economic strain it puts on growers. Perlite, another common media component, is also experiencing increased demand. Perlite is not only expensive to produce; there are also high amounts of energy required for both the production and shipping processes. Perlite is considered a nuisance, causing lung and eye irritation in cases involving over-exposure (Du et al., 2010). Due to these concerns, growers have been engrossed in finding replacement substrate options for both peat moss and perlite. In recent years research regarding alternative substrates has steadily increased; with an emphasis on local and regional sources of materials which are considered to be more sustainable. Numerous types of alternative substrates have been tested in greenhouse crops. Recent examples include the research initiatives on Clean Chip Residual (CCR), WholeTree (WT), and Pine tree substrate (Boyer et al., 2008; Fain et al., 2008; Wright et al., 2008).

Clean chip residual is a by-product of thinning pine plantations composed of about 50% wood, 40% bark, and 10% needles. In a study by Boyer et al. (2008), two CCR particle sizes were used alone or in combination with varying peatmoss rates and planted with three annual species. The study demonstrated that CCR is a viable alternative substrate in greenhouse production of ageratum, salvia, and impatiens.

WholeTree is a biomass derived from processed whole pine trees (above-ground portions). WholeTree substrates were compared to a standard peat-lite (PL) mix (Fain et al., 2008). A WholeTree and peat-lite mix [WT : PL (1 : 1, v/v)] was found to have similar growing qualities when compared to the standard mix. Also, a WT ratio of 8 : 2 [WT : PL (8 : 2 v/v)] was found to be similar to the standard mix when amended with 0.907 $kg \cdot m^{-3}$ 7N-3P-10K fertilizer.

Pine tree substrate (PTS) is made from loblolly pine logs. A 100% PTS substrate was compared to a treatment containing a standard peat, perlite, vermiculite, and pine bark industry mix (9 : 3 : 3 : 5, by vol.). Nitrogen was applied at an increasing ppm for each substrate. The PTS substrate required a 100 ppm rate of nitrogen to be comparable to the standard mix (Wright et al., 2008).

In recent years an interest in using *Juniperus virginiana* (L.) as an alternative substrate component for peat moss has risen. Research has shown that plants grown in substrates amended with cedar tended to be equivalent to those grown in a traditional PL mix. Murphy et al. (2011) indicated greenhouse producers could amend standard greenhouse substrates with up to 50% cedar with little to no difference in plant growth. Starr et al. (2011) indicated that *J. virginiana* chips could be used as a substrate for container-grown *Rudbeckia,* with chips at 0.476 cm screen

[1]First Place – Graduate Student Research Paper Competition

size performing the best when compared to a pine bark substrate. In addition to the replacement of peat moss, the physical nature of cedar tends to add substrate porosity normally achieved with the addition of perlite. Therefore, we believe a reduction or elimination in the need for perlite might also be realized with the use of cedar as a substrate component.

The cedar used in this study was obtained from CedarSafe, a company located in Huntsville, Alabama. It is unlike cedar found in other substrate research projects. This cedar is a by-product of cedar oil production at the CedarSafe facilities. The cedar logs (*J. virginiana*) are first shaved and then sent through a hammer mill. It is then conveyed to a set of boilers, where the material undergoes a steam distillation process, which extracts a percentage of the cedar oil. CedarSafe currently has no market for the post-distilled cedar biomass. Our project was to incorporate this cedar into a substrate to determine if it had suitable properties for use as a greenhouse substrate component.

MATERIALS AND METHODS

Cedar (C) was used alone or in a volumetric combination with an industry standard peat-lite base mix (80% peat : 20% perlite). There were six treatments implemented (Table 1).

Table 1. Treatments implemented in experiment.

Treatment	Substrate
1	Industry standard peat-lite (PL)
2	C:PL (1 : 4, v/v)
3	C:PL (2 : 3, v/v)
4	C:PL (3 : 2, v/v)
5	C:PL (1 : 4, v/v)
6	Cedar (C)

The varying cedar treatments were compared to a 100% PL base mix. Substrate treatments had the following amendments added per cubic meter at mixing: 2.26 kg lime (added only to PL base); 0.907 kg starter nutrient charge (7N-3P-10K, Greencare Fertilizers Inc. Kankakee, Illinois), 0.45 kg Micromax (The Scott's Company LLC. Marysville, Ohio), 0.45 kg gypsum (added only to 100% cedar), and 2.72 kg slow-release fertilizer (13N-6P-16K, Harrell's LLC. Lakeland, Florida). Aqua-Gro L was added at 118.3 $mL\cdot m^{-3}$. Containers (1.8 L) (Dillen Products Middlefield, Ohio) were filled with the substrates and two plugs (200 cell flats) of either *Impatiens walleriana* 'Extreme Violet' or *Petunia* Celebrity Series Blue were planted into each container. Containers were placed in a twin-wall polycarbonate greenhouse on elevated benches and hand watered as needed. Containers were arranged in a randomized complete block with 12 blocks per treatment. Species were arranged as separate experiments.

Data collected included pH and EC using the pour-through method (Wright, 1986). At termination all plants were measured for growth index (GI) and bloom count (BC). Roots were visually inspected and rated on a scale of 0 to 5 (RR). At termination shoots were removed at substrate surface, oven dried, and weighed to determine shoot dry weight (SDW). Initial substrate airspace (AS), container capacity (CC), total porosity (TP), and bulk density (BD) were determined using the NCSU Porometer method, as well as particle size distribution (PSD) (Fonteno Harden, 1995). Data was analyzed using Tukey's Studentized Range Test ($P \leq 0.05$) (SAS Institute version 9.1, Cary, North Carolina).

RESULTS

Substrates containing higher amounts of cedar had greater AS and a lower substrate CC (Table 2). Starr et al. (2011) concluded that substrates containing cedar tended to have a higher AS and lower CC than PBS. Substrate TP was similar amongst all the treatments. Substrate PSD (data not shown) showed that cedar substrates contained a higher amount of medium and coarse particles and fewer fine particles. The larger particle size of these treatments explains, in part, the greater AS and lower CC.

At 0 days after planting (DAP) pH and EC were similar amongst all the treatments. Substrate EC at 14 and 28 DAP showed that substrates containing higher amounts of cedar had a lower EC than those containing higher amounts of peatlite. At 14, 28, and 35 DAP substrates containing higher amounts of cedar had a higher pH than the PL substrates. At 35 DAP the EC of all the substrates was similar (Table 3). It can be determined that, as we have seen from other experiments, substrates containing cedar had higher AS and therefore the leaching of nutrients would be greater in those substrates. This would result in a lower EC overtime for those substrates.

Petunia GI and SDW were similar among Treatments 1, 2, and 3. Petunia BC was also comparable among Treatments 1, 2, and 3. Similarly, the GI, BC, and SDW of the impatiens were similar between Treatments 1, 2, and 3 (Table 4). The weakest treatment was that of the 100% cedar. From this data we can conclude that the lower water holding capacity along with lower cation exchange capacity (data not shown) of cedar resulted in poor nutrient retention and thus reduced growth.

Table 2. Physical properties of cedar-amended substrates.[Z]

	Air	Container	Total	Bulk
	space[Y]	capacity[X]	porosity[W]	density[V]
Substrates	(% vol)			(g/cm^3)
100% Peatlite	8.1 dc[u]	76.1 a	84.2 ab	0.11 b
20:80 Cedar : Peatlite	4.4 d	76.1 a	80.5 b	0.15 a
40:60 Cedar : Peatlite	12.7 c	70.1 b	82.7 ab	0.15 a
60:40 Cedar : Peatlite	20.3 b	65.0 c	85.4 a	0.15 a
80:20 Cedar : Peatlite	23.9 b	60.3 d	84.2 ab	0.16 a
100% Cedar	35.9 a	50.1 e	85.9 a	0.16 a

[Z]Analysis performed using the NCSU porometer.
[Y]Air space is volume of water drained from the sample ÷ volume of the sample.
[X]Container capacity is (wet weight – oven dry weight) ÷ volume of the sample.
[W]Total porosity is container capacity ÷ air space.
[V]Bulk density after forced-air drying at 105 °C (221 °F) for 48 h ($1\ g \cdot cm^{-3} = 62.4274\ lb/ft^3$).
[U]Tukeys Studentized Range Test ($P \leq 0.05$, $n = 3$).

Table 3. Effects of substrate on pH and electrical conductivity of greenhouse grown *Impatiens walleriana*.

	0 DAP[Z]		14 DAP		28 DAP		35 DAP	
Substrates	pH	EC[Y]	pH	EC	pH	EC	pH	EC
100% Peatlite	4.98 ab[X]	2.27 a	5.12 bc	9.79 a	5.10 d	2.21 a	5.09 bc	0.94 a
20:80 Cedar : Peatlite	4.99 ab	2.55 a	5.01 c	8.30 ab	4.98 d	2.51 a	4.73 d	0.89 a
40:60 Cedar : Peatlite	4.83 ab	2.40 a	5.31 b	4.58 cd	5.21 cd	2.69 a	4.83 cd	0.82 a
60:40 Cedar : Peatlite	4.65 b	2.29 a	4.99 c	5.31 cd	5.44 bc	2.19 ab	4.89 cd	0.84 a
80:20 Cedar : Peatlite	4.73 ab	2.03 a	4.90 c	5.89 bc	5.63 b	1.39 ab	5.40 b	0.54 a
100% Cedar	5.10 a	1.98 a	5.62 a	2.99 d	6.19 a	0.59 b	5.82 a	0.34 a

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

Table 4. Use of cedar as an alternative substrate component.[Z]

Substrates	Growth index[Y]	Bloom counts[X]	Root rating[W]	Shoot dry weight[V]
		Petunia		
100% Peatlite	35.8 a	60.1 b	4.1 a	12.2 ab
20:80 Cedar : Peatlite	35.4 a	69.7 a	4.1 a	12.9 a
40:60 Cedar : Peatlite	33.6 ab	63.6 ab	3.8 a	10.6 b
60:40 Cedar : Peatlite	30.9 bc	49.5 c	2.6 b	8.3 c
80:20 Cedar : Peatlite	29.2 cd	42.0 cd	2.8 b	7.1 cd
100% Cedar	27.6 d	36.9 d	1.3 c	5.7 d
		Impatiens walleriana		
100% Peatlite	28.3 a	68.3 a	4.5 a	13.3 a
20:80 Cedar : Peatlite	28.6 a	68.0 a	4.9 a	12.9 a
40:60 Cedar : Peatlite	28.0 a	63.9 a	5.0 a	11.8 a
60:40 Cedar : Peatlite	26.9 a	49.0 b	4.9 a	9.2 b
80:20 Cedar : Peatlite	24.1 b	41.7 b	3.9 b	6.5 c
100% Cedar	22.1 c	28.8 c	3.4 b	4.6 d

[Z]Experiment installed at the Paterson Greenhouse Complex on 15 April 2011.
[Y]Growth index = [(height + width1 + width2)/3] (P≤0.05, n = 12).
[X]Bloom count = number of blooms or buds showing color at 35 days (P≤0.05, n = 12).
[W]Root ratings 0–5 scale (0 = no visible roots and 5 = roots visible on the entire container substrate interface) (P≤0.05, n = 8).
[V]Shoot dry weight measured in grams (P≤0.05, n = 8).
[U]Tukeys Studentized Range Test (P≤0.05, n = 12).

DISCUSSION

The data provided indicates that both petunias and impatiens grown in substrates containing 20% and 40% cedar were of equal, if not greater, marketable value than that of those grown in the standard peat-lite mix. The cedar provided by CedarSafe would be a sustainable alternative component for greenhouse substrates replacing portions of peat and perlite.

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