Evaluation of Various Industrial, Construction, and Municipal Wastes as Pine Bark Amendments in Container Nursery Plant Production

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Nature of Work: Pressures to properly dispose of wastes are increasing in all areas of society. Composting and combining various waste residues provide an opportunity for development of useful products in the multi-billion dollar horticultural and floriculture industries as substrates, top-soils, mulches, fertilizers, soil conditioners, and biofilters. Research is needed to determine suitable or optimal combinations of various organic wastes, such as poultry wastes and processing residues, industrial and forestry byproducts, residential trimmer trash, and biosolids from sewage effluent for use as substrate components. Interest in the use of various composted waste materials for container substrates has increased over the last 20 years as a way to utilize and recycle material that would otherwise be disposed of in landfills. Lawn clippings, leaves, vegetable refuse, etc. represent approximately 150 million tons of municipal solid wastes (MSW) produced in the U.S. annually. Nationally, about 70 % of the daily waste total is organic matter. In excess of 75% of MSW in the U.S. consists of recyclable materials, about 40% of which is paper and paper products - much of which could be extracted from the MSW stream and composted for nursery substrates.

Peat moss and softwood bark have provided the primary components for most greenhouse and nursery substrates over the last 30 years. However, availability of softwood bark of consistent quality can be a problem due to the variety of methods used to harvest, process, and store bark. In addition, potential movement of the lumber and paper industries to other countries or the practice of burning bark for energy will likely limit future bark supplies. Many studies have investigated the use of various wastes as substitutes for bark and peat moss including animal wastes, cotton gin waste, wood by-products, municipal leaf and sewage sludge and rice hulls. While suitable for plant growth, regional availability and a limited supply of uniform and consistent quality product reduces widespread use of most alternative substrate components. For successful container nursery crop production, growers require substrates that are readily available, easy to mix and handle, economical, and have consistent and appropriate physical and chemical properties. Therefore, there continues to be a need to identify readily available, low-cost and renewable substrate components with consistent quality.

Research with composted MSW (MSWC) has been conducted in multiple locations with a wide range of nursery crops. Studies at Auburn University in 2003 evaluated five MSWC and pine bark blends in three container nursery crops and three greenhouse-grown bedding plants (Data not shown). All MSWC (referred to as "Fluff") was obtained from the WastAway Sciences Co., in McMinnville, TN. No attempt was made to standardize the species, irrigation, fertilizer, or other cultural practices. Plant growth measurements were determined by a growth index (GI) ((height + width at widest point + width perpendicular to width at widest point)/3). Leachates were collected by the Virginia Tech Extraction Method for analysis of pH and electrical conductivity (EC). Following the standard practices of commercial nursery production, field trials were in 2004 conducted to evaluate MSWC as a pine bark substitute for a total of 16 nursery crops at Greene Hill Nursery in Waverly, Ala, Martin's Nursery, Semmes, AL, PDSI, Loxley, AL, and S & S Nurseries, Athens, AL. Those field trials replaced pine bark with MSWC from 25% to 100% (in volume).

Research has been conducted continuously since 2004 at the Center for Applied Nursery Research (CANR), Dearing, GA to evaluate MSWC ("Fluff") obtained from WastAway as an amendment to composted pine bark for use as a growing substrate in container plant production (Tables 1-3). In 2004, five substrate treatments were mixed to grow three nursery crops: 'Pink Ruffle' azalea, dwarf yaupon holly, and cleyera (*Ternstroemia gymnanthera*). Five treatments were (same as the Auburn University "Fluff" study): 100% MSWC, 75%: 25% (in volume) MSWC:pine bark (PB), 50%:50% MSWC:PB, 25%:75% MSWC:PB, and 100% PB as control (Table 1). In 2005, MSWC was used to grow to four nursery crops: azalea ‘Pink Gumpo’, ‘Compact’ holly, cleyera, and wax leaf ligustrum (*Ligustrum*) using the same five substrate treatment as in 2004. Four species were separated into four replications for the study and grown outdoors under standard overhead irrigation (Table 2). In September, 2005, the same four crops were potted again using the same experiment design for a third consecutive year (Table 1 and Table 3). Above-ground plant growth was measured in the same manner as the Auburn “Fluff” study for determination of growth index. The Virginia Tech Pour-Through Extraction Method was used to collect leachates for determination of substrate pH and EC.

In 2005, studies in Auburn, Alabama evaluated potential substrate components of composted poultry litter (Ala. Agric. Expt. Stat., Crossville, AL), or municipal biosolid saturated newsprint crumbles (Tascon Inc., Houston, TX) blended with either ground pine chips or composted pine bark. Ten plants per treatment for each of three species were grown in trade gallon containers in a greenhouse. Pour-through extractions were conducted at 2, 4, 6, and 8 weeks after planting to determine pH and EC. At the end of the growing season plant quality was assessed using a SPAD-502 Leaf Greenness Meter (Minolta, Inc.), as well as measurements for size and dry weight (Table 4).

Results and Significance to the Industry: Understandably, everything that goes in the kitchen trash cannot be sorted and removed at garbage processing centers. When household garbage is processed with a hammer mill or similar equipment, composted, and flushed with abundant water, many of the potential hazards from handling these materials are minimized. In the MSWC studies of 2003 and 2004 at Auburn University, physical properties were comparable to pine bark and with the exception of initial high EC, which fell within the recommended desirable range for substrates within one month under conventional overhead irrigation. Replacing about one-third of pine bark with MSWC could be effectively used to grow a wide variety of container plants or flowers. Grower opinions of “Fluff” from field trials were generally positive at the rates used. The “Fluff” we evaluated in different locations is a substrate component that is compatible with automated production systems and common methods of container plant production.

In the 2004 CANR research, plant growth was similar, with the exception of less growth in the blend containing 50% bark and 50% MSW compost. In 2005, there were few differences in growth across all blends for all species. Where different, the best growth occurred for the standard pine bark:sand mix and the blend containing 75% bark with 25% composted MSW. In the latest 2006 study, all plants grown in blends with up to 50% MSWC had the same growth over a whole year period. Growth of cleyera and ligustrum was as good as the standard pine bark up to 75% MSWC in the substrate blends. Leachate pH was general higher in blends with incorporation of MSWC than 100% PB blend, but all within recommended pH range. Also, similar to previous years, EC values were initially high in blends containing MSWC but fell quickly following about two weeks at standard overhead irrigation. Once the MSWC blends EC was within acceptable ranges, it remained similar to the standard pine bark:sand mix through the growing season. Studies at CANR for three years again proved that one-third of MSW compost in substrate is a reliable and safe ratio to grow container crops.

For the 2005 Auburn studies, as a general observation, for all species, the largest plants across all treatments were those in which poultry litter was a component of the substrate. Also, as a general rule, plants grown in substrate blends containing pine bark as the primary component were larger than those grown with ground pine chips as the primary component. In many cases, dry weight of plants from pine bark based substrates was more than double the size of those from ground pine chips. However, plant quality, based on SPAD-502 values was not different among treatments for ageratum, and only one treatment difference was detectable for vinca.

The materials evaluated in the Auburn studies are plentiful nationwide and typically at a cost lower than that of pine bark. Even with the added cost of additional grinding, chip-mill material may still be competitive with pine bark prices, and much lower in price than peat, which could lead to reduced production costs. Our studies indicate that ground pine chips may be have potential as a substrate component, but more work is needed on particle size and optimization of nutrition when combined with other materials. Also, additional attention to possible toxins in fresh wood from a variety of sources is needed.

Table 1. Growth[z] of container plants in blends of Composted Municipal Solid Waste (MSWC) and pine bark (PB) at Center for Applied Nursery Research (CANR), Dearing, GA.

Year	Species	100% MSWC	75:25 MSWC:PB	50:50 MSWC:PB	25:75 MSWC:PB	100% PB
2004	'Pink Ruffle' Azalea	19.6 ab	20.9 a	17.9 b	21.1 a	21.4 a
	Dwarf Yaupon Holly	17.7 ab	19.5 a	14.8 b	17.7 ab	18.0 ab
	Cleyera (*Ternstroemia*)	26.4 ab	30.2 a	24.1 b	30.2 a	31.0 a
2006	Azalea 'Pink Gumpo'	13.7 b	15.1 b	15.7 ab	16.1 ab	17.8 a
	'Compacta' Holly	22.1 b	22.1 b	24.4 ab	26.2 ab	27.7 a
	Cleyera (*Ternstroemia*)	26.1 b	28.5 ab	31.0 a	30.3 a	27.9 ab
	Wax leaf ligustrum (*Ligustrum*)	27.4 b	34.1 ab	35.1 a	- [x]	36.8 a

[z] Growth index (GI) determined by (height + width at widest point + width perpendicular to width at widest point)/3.
[y] Means within rows followed by different letters are significantly different according to Tukey's Studentized Range (HSD) Test ($p = 0.05$).
[x] - indicates no data available for this ratio due to plant deaths. Notice that the death was not caused reasons other than incorporation of MSWC in the substrate mix.

Table 2. Leachate analysis of container plants in blends of Composted Municipal Solid Waste (MSWC) and pine bark (PB) at CANR in 2005.

Measurements	Species	100% MSWC	75:25 MSWC:PB	50:50 MSWC:PB	25:75 MSWC:PB	100% PB
pH	Azalea 'Pink Gumpo'	6.6 / 6.4	6.4 / 6.1	6.3 / 6.1	6.1 / 5.9	5.4 / 4.9
	'Compacta' Holly	6.4 / 5.9	6.3 / 5.8	6.1 / 5.8	6.0 / 5.7	5.6 / 4.5
	Cleyera (*Ternstroemia*)	6.5 / 6.2	6.3 / 6.0	6.1 / 5.8	6.0 / 5.5	5.4 / 4.4
	Wax leaf ligustrum (*Ligustrum*)	6.3 / 5.8	6.3 / 5.7	6.2 / 5.7	5.9 / 5.6	5.7 / 4.9
Electrical Conductivity (mS cm^{-1}) [y]	Azalea 'Pink Gumpo'	0.20 / 0.16	0.40 / 0.13	0.32 / 0.23	0.31 / 0.20	0.59 / 0.31
	'Compacta' Holly	0.17 / 0.12	0.12 / 0.18	0.24 / 0.25	0.52 / 0.28	0.38 / 0.22
	Cleyera (*Ternstroemia*)	0.39 / 0.23	0.43 / 0.22	0.37 / 0.21	0.40 / 0.21	0.62 / 0.40
	Wax leaf ligustrum (*Ligustrum*)	0.21 / 0.13	0.15 / 0.12	0.29 / 0.18	0.95 / 0.22	0.25 / 0.31

[z] Within each column and row, the first value represents initial pH following potting and the second value represents pH one-month after potting.
[y] EC for leachates collected from plants grown in all blends containing composted MSW (MSWC) fell below 0.8 within one month under conventional overhead irrigation.

Table 3. Leachate analysis of container plants in blends of Composted Municipal Solid Waste (MSWC) and pine bark (PB) at CANR in 2006.

Measurements	Species	100% MSWC	75:25 MSWC:PB	50:50 MSWC:PB	25:75 MSWC:PB	100% PB
pH	Azalea 'Pink Gumpo'	6.30 / 6.50 / 6.40	6.30 / 6.20 / 6.30	6.50 / 6.40 / 6.30	5.80 / 5.60 / 5.30	4.40 / 4.20 / 3.80
	'Compacta' Holly	6.20 / 6.40 / 6.50	6.10 / 6.10 / 6.40	6.00 / 5.60 / 6.00	5.30 / 5.60 / 5.40	4.30 / 3.60 / 3.80
	Cleyera (*Ternstroemia*)	6.30 / 6.10 / 6.50	6.00 / 5.80 / 6.10	6.00 / 5.80 / 6.00	5.80 / 5.50 / 4.90	4.20 / 4.10 / 3.50
	Ligustrum	6.90 / 6.10 / 6.40	6.60 / 5.80 / 6.30	6.00 / 5.80 / 6.00	5.40 / 5.20 / 5.40	5.10 / 3.70 / 3.90
Electrical Conductivity (mS cm^{-1})	Azalea 'Pink Gumpo'	0.1 / 0.10 / 0.21	0.14 / 0.11 / 0.22	0.16 / 0.11 / 0.11	0.41 / 0.15 / 0.48	0.59 / 0.17 / 0.45
	'Compacta' Holly	0.06 / 0.08 / 0.27	0.18 / 0.06 / 0.10	0.2 / 0.24 / 0.18	0.66 / 0.26 / 0.19	0.45 / 0.49 / 0.13
	Cleyera (*Ternstroemia*)	0.08 / 0.06 / 0.26	0.19 / 0.07 / 0.35	0.21 / 0.07 / 0.20	0.47 / 0.11 / 0.29	0.48 / 0.19 / 0.25
	Ligustrum	0.05 / 0.05 / 0.09	0.08 / 0.07 / 0.12	0.07 / 0.07 / 0.12	0.18 / 0.13 / 0.16	0.28 / 0.52 / 0.25

[z] Within each column and row, the first value represents pH or electrical conductivity in January, 2006 (four months after potting, MAP), May, 2006 (8 MAP), and September, 2006 (12 MAP).

Table 4. Evaluation of various substrate component blends for container production of summer annuals at Auburn, AL in 2005.

Treatment [z]	*Ageratum* 'Hawaii Blue'		*Salvia* 'Vista Red'		*Vinca* 'Rose Cooler'	
	Dry weight (g) [y]	SPAD-502 Values	Dry weight (g)	SPAD-502 Values	Dry weight (g)	SPAD-502 Values
100 GW: 0 PL	3.6 e	33.5 a	8.0 d	53.4 cd	2.0 e	43.7 ab
87.5 GW:12.5 PL	6.9 cd	34.5 a	14.9 b	54.9 bcd	2.8 cde	46.7 a
75 GW:25 PL	10.7 a	34.1 a	12.3 bc	52.2 cd	2.1 e	40.0 ab
87.5 GW:12.5 BIO	5.8 cde	33.2 a	7.3 d	51.7 d	1.8 e	42.5 ab
75 GW:25 BIO	4.5 de	33.1 a	9.7 cd	51.2 d	2.0 e	37.6 b
100 PB: 0 PL	6.0 cde	33.0 a	7.9 d	53.7 cd	2.6 de	42.9 ab
87.5 PB: 12.5 PL	10.2 ab	32.0 a	20.4 a	57.5 abc	4.9 a	44.0 ab
75 PB:25 PL	10.3 ab	31.3 a	19.2 a	60.0 ab	4.6 ab	44.5 ab
87.5 PB:12.5 BIO	7.9 bc	33.0 a	13.8 b	59.6 ab	3.4 bcd	43.2 ab
75 PB:25 BIO	9.5 ab	35.8 a	15.3 b	61.4 a	4.0 abc	44.6 ab

[z] Treatments were percentage of substrate component where GW = pine chips ground to pass a 3/8 inch screen; PL = poultry litter; PB = Pine bark; and BIO = Municipal biosolid saturated newsprint crumbles.

[y] Means within rows followed by a different letter are statistically different according to Tukey's Studentized Range (HSD) Test (p = 0.05).