Growth Response of *Photinia* and *Thuja* and Nutrient Concentration in Tissues and Potting Medium as Influenced by Composted Sewage Sludge, Peat, Bark and Sawdust in Potting Media[1]

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Abstract

Composted sewage sludge was blended with pumice and either bark, peat moss, or sawdust to form 6 potting media. Increasing the proportion of compost in media from 25 to 50% caused increased initial pH, electrical conductivity (EC), and air-filled pore space (AS) in all media, and increased growth of *Photinia* x *fraseri Dress.* and *Thuja occidentalis* L. 'Pyramidalis.' Sawdust-containing media had the highest pH, EC, and AS; sphagnum peat-containing media the highest water holding capacity and greatest shrinkage; bark-based media the highest bulk density. Plant growth in compost-based media containing peat or bark was equal to or better than that in two commercial media composed primarily of bark or peat.

Index words: *Photinia* x *fraseri, Thuja occidentalis* 'Pyramidalis,' peat, bark, sawdust, pumice, air-filled pore space, electrical conductivity, pH

Introduction

A wide range of components are used to produce soilless potting media for container production of woody plants. Peat-based media have been particularly successful, but their high cost has encouraged a search for substitutes.

The physical and chemical properties of media which stimulate plant growth have been widely investigated. Critical ranges for bulk density (7,13), air-filled pore space (3,12,13), organic matter (7), cation exchange capacity (7), water holding capacity (3), and particle size distribution (9,12,13) have been determined.

Composts of sewage sludge with municipal solid waste (11) or wood chips (6,14) have been used in nursery crop production. Similar composts are becoming available as more municipalities turn to composting for waste disposal. Portland, Oregon produces a sewage sludge which contains levels of plant nutrients and trace elements near or slightly lower than the national median (4). The Portland sludge is now being composted with conifer sawdust and marketed as a nursery crop potting medium.

The purpose of this study was to determine the physical and chemical characteristics of 6 compost-amended media and to measure their effects on the growth and elemental content of 2 woody nursery crops.

Materials and Methods

Polymer dewatered, anaerobically digested municipal sewage sludge from Portland, Oregon was composted with conifer sawdust in a closed vessel pilot plant (10) by the Taulman-Weiss Co. of Atlanta, GA. The compost was not screened to remove wood particles. Six potting mixes were prepared in a factorial combination of either 25 or 50% by volume compost, 50 or 25% sphagnum peat moss, conifer sawdust, or hammer-milled conifer bark, and 25% pumice amended with 1.77 kg gypsum/m^3 (3 lb/yd^3). Physical and chemical characteristics of the resulting media are shown in Table 1. Plants growing in these media were compared to plants in 2 commercial media. Commercial medium A consisted of 1.3 cm (½ in) minus conifer bark supplemented with 6.5 kg of 18N-2.6P-10K (18-6-12) Osmocote/m^3 (11 lb/yd^3), 2.0 kg concentrated superphosphate/m^3 (3.5 lb/yd^3) and 0.9 kg each of dolomite, gypsum, limestone flour, and Micro-Max trace elements/m^3 (1.5 lb/yd^3). Commercial medium B consisted of peat moss, pumice, conifer bark and sand (4:4:1:1, v/v) amended with 1.77 kg each of dolomite and limestone flour/m^3 (3.0 lb/yd^3), 0.77 kg ureaformaldehyde/m^3 (1.3 lb/yd^3), 0.6 kg conc. superphosphate/m^3 (1.0 lb/yd^3), 0.4 kg $FeSO_4$/m^3 (0.7 lb/yd^3), 0.3 kg each of KNO_3 and $Ca(NO_3)_2$/m^3 (0.5 lb/yd^3), and 75 g FTE 503/m^3 (2 oz/yd^3).

Before planting, media samples were dried and air-filled pore space (AS) (2) and total porosity (TP) (9) were measured on duplicate samples. Electrical conductivity (EC) was measured with an RD-26 Solubridge and pH by glass electrode in a 1:3 medium-water (w/w) slurry.

Rooted cuttings of *Photinia* x *fraseri* Dress. and *Thuja occidentalis* L. 'Pyramidalis,' pyramidal arborvitae, were planted into 15.0 x 17.5 cm (#1) containers of potting mixes on March 24, 1983 and placed in an unheated, clear polyethylene-covered greenhouse with 5 plants/plot and 5 replications of each treatment (media) in randomized block design. Greenhouse covers were removed on June 1.

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Table 1. Physical and chemical characteristics of potting media before planting.

Mix	Bulk density wet	Bulk density dry	EC	pH	AS	TP
	———g/cm^3———		dS/m		% of total volume	
A	0.71	0.28	2.85	4.4	25	43
B	0.92	0.37	1.45	7.2	16	54
C_1P_2 [z]	0.88	0.27	0.36	4.5	13	61
C_2P_1	0.83	0.30	0.93	4.9	19	54
C_1B_2	0.86	0.36	0.52	4.9	13	51
C_2B_1	0.85	0.37	0.95	5.1	16	48
C_1S_2	0.82	0.31	0.56	5.6	22	50
C_2S_1	0.80	0.32	1.15	5.8	23	48
LSD (0.05)	0.04	0.03	0.22	0.2	5	4
Rate of compost [y]						
25%	0.85	0.31	0.48	5.0	16	54
50%	0.83	0.33	1.01	5.2	19	50
	* [x]	*	**	*	*	*
Organic component [y]						
Peat	0.85	0.29	0.65	4.6	16	58
Bark	0.85	0.37	0.74	5.0	15	50
Sawdust	0.81	0.32	0.86	5.7	23	49
LSD (0.05)	0.03	0.04	0.06	0.3	3	4

[z] C = compost, P = peat, B = bark, S = sawdust, C_1P_2 = 25% (v/v) compost, 50% peat, 25% pumice.
[y] Main effects for compost-based mixes only.
[x] *, **: means significantly different at 1% and 5% levels, respectively.

All plants were irrigated daily by overhead sprinkler. Fertilizer was applied weekly as Peters 30N-4.3P-8.3K (30-10-10) (400 ppm N) from April 19 until June 15, when Osmocote 18N-2.6P-10K (18-6-12) was applied to all plants at 5 cc (1 tsp)/container. Leaf samples were taken at plant harvest on October 18, 1983 (*Thuja*) or October 28 (*Photinia*), washed in distilled water, and analyzed for elemental concentrations. Total N was determined by the Kjeldahl procedure. All other elements were determined by inductively-coupled argon plasma emission spectrometry (Plant Analysis Laboratory, Oregon State University) after dry ashing at 500 °C for 6 hr and extraction with 20% HNO_3. A composite sample of each medium was collected after plant harvest, dried, ground to pass a 20 mesh screen and analyzed for elemental concentrations as outlined for leaf analysis.

Results and Discussion

Increasing the proportion of compost in media from 25 to 50% increased initial dry bulk density, pH, EC, and AS but decreased TP and wet bulk density (Table 1). Compost-based media had higher bulk densities, pH and TP, and lower EC and AS than commercial medium A, but lower bulk density, pH and EC than commercial medium B. The organic component also affected media physical characteristics. Bulk densities were highest with bark; pH, EC and AS highest with sawdust; TP was highest with peat. These effects of organic component on pH, EC, AS and TP of media are consistent with the physical and chemical properties of the individual organic components (5).

After 8 months of supporting plant growth, media properties varied significantly with the type of organic amendment. Shrinkage was significantly greater with peat as the organic amendment (Table 2). Dry bulk density and EC decreased, and pH increased with time, due in part to the high Ca and Mg content of the irrigation water (1.2 meq/L or 20 ppm). The physical and chemical properties of media did not vary significantly with proportion of compost.

In media samples taken at time of plant harvest, only Cu, Ni and Zn concentration appeared to increase consistently with increasing proportion of compost (Table 2). Levels of Al, Cd, Na, Ni, and Zn appeared to be higher in compost based media than in the commercial media.

Weight, height, and number of growing points were greatest for *Photinia* grown in medium B, followed by media containing peat and compost (Table 3). *Photinia* growth in medium A was limited because of early salt phytotoxicity from preincorporated fertilizer (Table 1).

Leaf N and P levels for *Photinia* grown in compost-based media were lower than in plants grown in medium A, but similar to levels for plants grown in medium B (Table 3). Leaf B concentration was consistently lower and leaf Zn concentration higher in compost-grown plants than in plants grown in the commercial media. Plant weight was negatively correlated with leaf N content (r_{xy} = -0.70, P = 0.04) in large part because of poor growth in medium A. Except for Zn, leaf trace element content did not increase appreciably with 50% compared to 25% compost. With the exception of B, leaf elemental concentrations were higher for *Photinia* in this experiment than were found in a recent survey of container-grown *Photinia* in commercial nurseries (R.L. Ticknor, unpublished data).

Medium A and the medium containing 50% compost and 25% peat produced the heaviest *Thuja* plants (Table 4). *Thuja* fresh weight was also greater in media containing 50 rather than 25% compost. Plant height was significantly increased with 50% compost only when sawdust was part of the medium. Proportion of compost in media had little effect on leaf tissue elemental concentrations, with the higher rate resulting only in small increases in Ni and Zn, and decreases in S, Fe and Mn. Levels of Cd, Mn, Ni, and Zn were higher in the compost:peat media, presumably due to the lower initial pH. There was no correlation between height, weight, and tissue nutrient concentration of plants grown in either commercial or compost media.

In a previous study with annual bedding plants, plant growth correlated significantly with high initial AS of the media (5). In contrast, *Photinia* and *Thuja* growth did not significantly correlate with any of the initial or final physical and chemical characteristics of the media. In every case, the effects on media characteristics of increasing the proportion of compost from 25 to 50% were the opposite of those associated with peat as organic component (Table 1). However, both the higher rate of compost and presence of peat in the media favored plant growth. Better plant growth may have been more closely correlated with initial nutrient content or nutrient binding capacity of the compost (not measured). Chemical and physical characteristics of media measured before use may have little value in predicting woody plant growth, at least when AS, TP, pH, EC, etc. do not differ greatly from established ranges for acceptable growth (3,7,13). Maintaining a critical minimum As and maximum TP was found essential for adequate growth of container-grown *Rhododendron*, in a case where addition of peat to the mix depressed growth due to excessively high water holding capacity (1).

The compost-based media exhibited considerable stability over time in terms of bulk density, AS, WS, and shrinkage (Tables 1 and 2). Composts which decompose rapidly or have extremely high EC or high pH resistant to change have reduced growth of several container-grown woody ornamentals (11).

Supplemental N was needed with all media. Leaf P levels of plants grown in compost-based media were generally comparable to those grown in the phosphate-supplemented commercial media (Tables 3 and 4). Based on these results, fertilizers with only low levels of phosphate would be needed to maintain adequate phosphate in the media. Potassium levels in leaves were adequate when liquid fed with 30N-4.3P-8.3K (30-10-10) and top dressed with Osmocote 18N-2.6P-10K (18-6-12). Potassium levels in the compost-based media analyzed at the end of the growing season were lower

Table 2. Physical characteristics and elemental concentration of media after eight months of plant growth.

Mix	Bulk Density wet	Bulk Density dry	EC	pH	AS	TP	Shrink-age	N	P	K	Ca	Mg	S	Al	B	Cd	Cu	Fe	Mn	Mo	Na	Ni	Zn
	– g/cm³ –		dS/m		———	———	———	——— %	———	———	———	———	———	———	———	———	———	mg/kg	———	———	———	———	———
A	0.77	0.21	1.40	6.8	26	56	9	0.58	0.11	0.21	1.40	0.24	0.17	1549	5	1.6	46	3256	137	0.7	117	3	53
B	0.91	0.30	0.18	7.6	15	46	13	0.81	0.02	0.06	0.53	0.09	0.07	1025	3	0.6	15	1627	64	0.4	166	1	14
C_1P_2[z]	0.85	0.22	0.18	7.6	21	63	18	0.37	0.07	0.06	0.48	0.09	0.10	1629	3	1.5	29	2472	40	0.7	224	7	53
C_2P_1	0.80	0.26	0.25	7.4	26	54	13	0.30	0.20	0.07	0.49	0.09	0.11	2535	3	4.5	76	4129	96	1.1	282	17	186
C_1B_2	0.73	0.30	0.30	7.1	23	50	9	0.50	0.09	0.06	0.48	0.09	0.07	1694	3	2.0	35	2492	82	0.7	208	8	81
C_2B_1	0.79	0.27	0.25	6.9	29	50	10	0.55	0.25	0.08	0.48	0.09	0.11	3051	4	5.7	73	3480	98	1.5	320	13	159
C_1S_2	0.81	0.26	0.38	7.3	30	51	11	0.52	0.22	0.07	0.40	0.09	0.13	2449	3	3.6	48	2864	118	1.0	357	8	137
C_2S_1	0.81	0.26	0.33	7.4	23	64	11	0.38	0.19	0.06	0.32	0.06	0.10	1985	3	3.6	53	2655	88	0.9	286	11	147
LSD (0.05)	0.05	0.05	0.30	0.4	6	7	2																
Rate of compost[y]																							
25%	0.80	0.26	0.29	7.3	25	55	13	0.46	0.13	0.06	0.45	0.09	0.10	1924	3	2.4	37	2609	80	0.8	263	8	90
50%	0.83	0.26	0.28	7.3	26	56	11	0.41	0.21	0.07	0.43	0.08	0.11	2524	3	4.6	67	3421	94	1.2	296	14	164
	NS[x]	NS	NS	NS	NS	NS	NS																
Organic component[y]																							
Peat	0.83	0.24	0.21	7.5	23	59	15	0.34	0.13	0.07	0.49	0.09	0.10	2082	3	3.0	53	3300	68	0.9	253	12	120
Bark	0.76	0.29	0.27	7.0	26	50	10	0.52	0.17	0.07	0.48	0.09	0.09	2372	3	3.8	54	2986	90	1.1	164	11	120
Sawdust	0.81	0.26	0.35	7.4	26	58	11	0.45	0.21	0.07	0.36	0.08	0.12	2217	3	3.6	51	2760	103	1.0	322	10	142
LSD (0.05)	0.03	0.04	0.10	0.2	NS	6	3																

[z]C = compost, P = peat, B = bark, S = sawdust; C_1P_2 = 25% (v/v) compost, 50%, 25% pumice.
[y]Main effects for compost-based mixes only.
[x]NS: means not significantly different at 5% level.

Table 3. Growth and leaf elemental concentration of *Photinia* grown in compost-based and commercial media.

Mix	Weight	Height	No. of growing points	Leaf elemental concentrations												
				N	P	K	Ca	Mg	S	B	Cd	Cu	Fe	Mn	Ni	Zn
	(g)	(cm)		——————%——————						——————mg/kg——————						
A	88	44	20	2.13	0.40	1.6	1.1	0.23	0.20	21	0.14	5.8	258	43	1.0	45
B	157	51	45	1.82	0.23	1.4	1.2	0.28	0.15	29	0.08	3.2	276	32	0.7	26
C_1P_2[z]	129	50	23	1.72	0.23	1.4	1.0	0.23	0.17	13	0.12	5.2	248	34	1.6	46
C_2P_1	150	55	29	1.59	0.29	1.4	1.1	0.24	0.17	15	0.15	5.6	226	38	2.4	74
C_1B_2	90	41	24	1.91	0.32	1.6	1.1	0.24	0.16	17	0.13	4.4	245	33	1.5	60
C_2B_1	122	50	30	1.73	0.31	1.5	1.1	0.23	0.16	17	0.18	5.8	274	35	1.9	87
C_1S_2	86	43	23	1.92	0.27	1.6	1.0	0.23	0.21	15	0.19	4.4	210	39	1.2	70
C_2S_1	101	47	23	1.89	0.30	1.7	1.2	0.24	0.19	17	0.19	4.2	240	41	1.2	90
LSD (0.05)	39	8	11	0.10	0.05	0.2	0.2	0.03	0.04	7	0.07	1.1	NS	NS	0.4	12
Rate of compost[y]																
25%	102	45	23	1.85	0.27	1.5	1.0	0.23	0.18	15	0.15	4.7	234	35	1.4	59
50%	124	51	27	1.74	0.30	1.5	1.1	0.24	0.17	16	0.17	5.2	247	38	1.8	84
	**[x]	**	*	*	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	**
Organic component[y]																
Peat	140	53	26	1.66	0.26	1.4	1.1	0.24	0.17	14	0.14	5.4	237	36	2.0	60
Bark	106	46	27	1.82	0.32	1.6	1.1	0.24	0.16	17	0.16	5.1	260	34	1.7	68
Sawdust	94	45	23	1.91	0.29	1.7	1.1	0.24	0.20	16	0.19	4.3	225	40	1.2	80
LSD (0.05)	10	4	3	0.11	0.04	0.2	NS	NS	0.03	NS	0.04	0.8	NS	NS	0.7	6

[z]C = compost, P = peat, B = bark, S = sawdust, C_1P_2 = 25% (v/v) compost, 50% peat, 25% pumice.
[y]Main effects for compost-based mixes only.
[x]**, *, NS: mean significantly different at 1% and 5% levels, and nonsignificant, respectively.

than in the commercial media, indicating possible need for a K-containing fertilizer after potting. It may be necessary to add Ca and Mg at locations where the irrigation water contains low levels of these elements.

Addition of minor elements to compost-based media does not appear necessary, with some possible exceptions. Compost-based media tended to have low B concentration and leaves of *Photinia* grown in these media had lower B concentration than did plants in the commercial media. A spray application of B during the growing season might be necessary to prevent a deficiency with low-B composts. However, some composts contain high B levels (8).

Significance to the Nursery Industry

Sewage sludge composted with conifer sawdust in a closed vessel system is a suitable weed free component of media for growing container nursery stock. Plant growth in media containing 50% compost was equal to or better than that in two commercial media. One pound of slow release nitrogen per cubic yard would be the only fertilizer required initially with a 50% compost medium. If compost is priced competitively with other possible components, total costs for media and fertilizers would be reduced. Successful production requires maintaining appropriate nutrient, aeration, and moisture levels in the chosen medium. Irrigation and fertilizer applications will need to be altered when making changes in media components.

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Table 4. Growth and leaf elemental concentration of *Thuja* grown in compost-based and commercial media.

			Leaf elemental concentrations												
Mix	Weight	Height	N	P	K	Ca	Mg	S	B	Cd	Cu	Fe	Mn	Ni	Zn
	g	cm	%						mg/kg						
A	98	69	2.25	0.39	0.95	1.8	0.39	0.16	20	0.11	6.0	250	213	1.0	55
B	81	62	2.18	0.36	0.89	1.8	0.34	0.18	27	0.09	3.2	202	203	0.5	33
C_1P_2[z]	82	67	2.31	0.35	0.89	1.8	0.34	0.19	19	0.22	5.6	266	179	2.2	89
C_2P_1	95	65	2.06	0.33	0.86	1.7	0.35	0.17	18	0.20	5.7	254	122	3.2	119
C_1B_2	69	64	2.22	0.35	0.91	1.7	0.35	0.18	22	0.13	5.9	320	113	2.0	83
C_2B_1	76	65	2.36	0.37	0.91	1.7	0.33	0.17	22	0.12	6.3	243	109	2.5	97
C_1S_2	55	57	2.37	0.35	0.87	1.7	0.31	0.18	21	0.16	5.7	309	139	1.7	75
C_2S_1	75	63	2.24	0.36	0.88	1.8	0.32	0.16	21	0.16	6.3	273	130	2.3	89
LSD (0.05)	13	5	0.16	0.03	0.04	0.1	0.02	NS	2	0.06	0.9	NS	38	0.5	15
Rate of compost[y]															
25%	69	63	2.30	0.35	0.89	1.7	0.33	0.18	21	0.17	5.7	299	144	2.0	82
50%	82	64	2.22	0.35	0.89	1.7	0.33	0.17	20	0.16	6.0	257	120	2.6	102
	**[x]	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	*	*	*	*
Organic component[y]															
Peat	89	66	2.18	0.34	0.89	1.7	0.35	0.18	19	0.21	5.7	260	150	2.6	104
Bark	73	65	2.29	0.36	0.91	1.7	0.34	0.18	22	0.13	6.1	281	112	2.2	90
Sawdust	65	60	2.31	0.36	0.88	1.7	0.32	0.17	21	0.16	6.0	292	135	2.0	82
LSD (0.05)	10	NS	NS	NS	NS	NS	0.02	NS	NS	0.06	NS	NS	26	0.4	6

[z]C = compost, P = peat, B = bark, S = sawdust; C_1P_2 = 25% (v/v) compost, 50% peat, 25% pumice.
[y]Main effects for compost-based mixes only.
[x]**, *, NS: means significantly different at 1% and 5% levels, and non-significant, respectively.