Composted Turkey Litter: II. Effect on Plant Growth[1]

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Abstract

Cotoneaster dammeri C.K. Schneid. 'Skogholm' and *Hemerocallis* sp. 'Red Magic' plants were potted into a pine bark substrate amended with 0, 4, 8, 12, or 16% (by vol) composted turkey litter and were grown under 1-, 2-, or 3-day irrigation frequencies. Root dry weight of 'Red Magic' daylily plants decreased with increasing compost rate while leaf dry weight was not affected by compost addition. Photosynthesis and stomatal conductance of daylily plants were enhanced when compost was added to the substrate but were decreased by the water stress associated with the reduced irrigation frequencies. Leaf, stem, and root dry weights of 'Skogholm' cotoneaster plants decreased with decreasing irrigation frequency. Even though compost increased container capacity and available water, there was not sufficient water in the container to maintain optimal growth under reduced irrigation frequencies. 'Skogholm' cotoneaster leaf and stem dry weights increased with increasing compost rate while root dry weight decreased with increasing compost rate. Decreasing irrigation frequency increased foliar N, P, K, Cu, and Zn concentrations but decreased foliar P, K, Ca, Mg, Mn, Cu, Zn, and B contents. Increasing compost rate increased foliar N, P, Mg, Mn, Cu, Fe, and B concentrations and foliar N, P, Mg, Mn, Cu, Fe, and B contents. Based on foliar nutrient response and plant growth, it appeared that compost adequately replaced the dolomitic limestone, micronutrients, and macronutrients added to the commercial substrate.

Index words: substrate amendment, water usage, nutrient efficacy.

Species used in this study: 'Skogholm' cotoneaster (*Cotoneaster dammeri* C.K. Schneid. 'Skogholm') and 'Red Magic' daylily (*Hemerocallis* sp. 'Red Magic').

Significance to the Nursery Industry

Even though composted turkey litter (compost) increased container capacity and available water, there was not sufficient water in the container to maintain optimal growth under reduced irrigation frequencies. Based on the foliar nutrient response and plant growth, it appeared that compost substituted for the dolomitic limestone, micronutrients, and macronutrients added to the commercial substrate. Generally, plants grown in compost-amended substrates grew as well as those grown in the commercial substrate. High electrical conductivity (EC) levels as a result of compost amendment may inhibit root growth of cotoneaster and daylily plants, especially with reduced irrigation frequencies.

Introduction

Compost affects containerized plant growth by modifying the container's chemical and physical environment (7). Bilderback and Fonteno (1) reported improved plant growth of *Cotoneaster dammeri* with a substrate composed of pine bark, rockwool, and composted poultry litter compared to pine bark alone. Similarly, three perennial species performed equally or better in composted leaves and sewage sludge compared to substrate containing no compost (3). In contrast, Lumis and Johnson (10) reported that substrates containing municipal waste compost suppressed growth of two woody species compared to growth in a peat moss:sand substrate. When eight deciduous landscape woody species were grown in bark or bark:mushroom compost, shoot growth of seven of the species improved with addition of compost while shoot growth of the remaining species was suppressed (5).

Tyler *et al.* (15) reported that composted turkey litter increased container capacity, available water and bulk density while decreasing air space. In addition, composted turkey litter adequately supplied all macronutrients needed for plant growth except possibly K. The objective of this study was to determine plant growth response when grown in pine bark amended with composted turkey litter under reduced frequencies of irrigation.

Materials and Methods

The experiment, a 3 × 5 factorial in a split-plot design with eight single plant replications, was conducted on a gravel pad at North Carolina State University, Horticultural Research Unit 4, Raleigh, N.C. The two factors were three irrigation frequencies (main plots) of 1, 2, or 3 days and five compost rates (subplots) of 0, 4, 8, 12, or 16% (by vol) (compost weighed 552 kg/m^3 (933 lbs/yd^3)). Milled pine bark[(<13 mm)(0.5 in)] was amended on a m^3 (yd^3) basis with compost. For comparison to a common commercial substrate, 48 containers of milled pine bark were amended on a m^3 (yd^3) basis with 0.91 kg (2.0 lbs) dolomitic limestone and 0.9 kg (1.5 lbs) Micromax micronutrient fertilizer and incorporated into the irrigation × compost rate split plot design. These "commercial substrate" plants were top dressed with 18 g (0.63 oz) Osmocote 17-03-10 (17-7-12) per container on May 24, 1991.

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Plant growth. Uniform rooted cuttings of 'Skogholm' cotoneaster and bare root divisions of 'Red Magic' daylily were potted into 3.8 liter (#1) containers on May 13, 1991. All plants received 1400 ml (47 oz) of water daily via pressure compensated drip emitters until May 24, 1991; thereafter plants received 1400 ml (47 oz) per specified irrigation frequency. On September 11, 1991, the shoots of both species were removed and dried at 62°C (144°F) for 5 days. Roots were placed over a screen and washed with a high pressure water stream to remove substrate and dried at 62°C (144°F) for 5 days. 'Skogholm' cotoneaster leaf and root dry weights were used to calculate leaf:root ratios (leaf dry weight/root dry weight).

After drying, 'Skogholm' cotoneaster leaves were removed from the stems and ground in a Wiley mill to pass a 40 mesh (0.425 mm) screen. Each tissue sample (1.25 g) was combusted at 490°C (914°F) for 6 h. The resulting ash was dissolved in 10 ml (0.03 oz) 6 N HCl and diluted to 50 ml (1.5 oz) with distilled deionized water. Phosphorus, K, Ca, Mg, Mn, Cu, Fe, Zn, and B concentrations were determined by inductively coupled plasma emission spectroscopy. Nitrogen was determined using 10 mg (0.03 oz) samples in a Perkin Elmer 2400 CHN elemental analyzer. All tissue analyses were conducted at the Analytical Service Laboratory, Dept. of Soil Science, NCSU, Raleigh. Foliar nutrient content was based on the percentage concentration of the nutrient divided by 100 and multiplied by the leaf dry weight.

Leaf gas exchange was measured on 'Red Magic' daylily plants with a LI-COR LI-6200 (LI-COR, Lincoln, NB) closed portable infared gas exchange system between 1:00 PM and 3:00 PM on August 21, 1991, after plants receiving daily irrigation were watered, (> 1400 $\mu mol/s/m^2$) and September 3, 1991, after all plants were irrigated, (> 1700 $\mu mol/s/m^2$). Photosynthetically active radiation, air and leaf temperature, and relative humidity inside the leaf chamber were measured concurrently with gas exchange. Net photosynthetic rate (P_N), and stomatal conductance (G_S) were calculated using the LI-COR 6200 measurements. An attached leaf was placed in a 0.25 liter (165.4 cm^3) chamber for 30 sec. Measurements commenced immediately after the CO_2 concentration decreased. Ambient CO_2 concentration ranged from 310 to 400 mg/liter.

All variables were tested for differences using analysis of variance procedures and regression analysis (13). All reported means separations were performed via least significant difference (LSD) procedures at $p \leq 0.05$

Results and Discussion

'Red Magic' daylily leaf and root dry weights were affected by compost while they were not affected by irrigation frequency (Table 1). There was no interaction between irrigation frequency and compost rate. Except for the 0% compost (pine bark), leaf dry weight was not significantly affected by compost (Table 2). Only the 0% compost rate differed from the commercial substrate in leaf dry weight. In contrast, Bugbee *et al.* (3) reported increased shoot dry weight of *Aster novi-belgii* 'Peter Harrison', *Guara lindheimeri*, and *Sedum purpurem* 'Autumn Joy' with increased additions of compost (0, 30, 60, 80, and 100% v/v) containing municipal leaves, sewage sludge, and street sand compared to plants grown in loamy sand topsoil, peat, sand, and styrofoam pellets (1:5:2:2 v/v).

Table 1. Response of 'Red Magic' daylily and 'Skogholm' cotoneaster dry weight and leaf:root ratio to irrigation frequency and compost rate.

Source of variation	Dry weight (g)					
	Daylily		Cotoneaster			
	Leaf	Root	Leaf	Stem	Root	Leaf:root[z]
Irrigation (I)	NS[y]	NS	**	**	**	*
Compost (C)	**	*	**	**	**	**
I X C	NS	NS	**	**	**	*

[z]leaf:root = leaf dry weight/root dry weight.

[y]NS, **, * Nonsignificant or significant at $p \leq 0.01$ or $p \leq 0.05$, respectively.

Table 2. Effect of compost rate on leaf and root dry weights of daylily 'Red Magic.'

Compost rate (v/v)	Dry weight (g)	
	Leaf	Root
0	1.2	15.7
4	7.4	22.6
8	6.4	18.3
12	6.5	15.1
16	6.5	16.8
Comm.[z]	6.7	18.9
Significance[y]		
L[x]	NS	*
Q	NS	NS

[z]Commercial substrate data not included in the regression analysis. Comparisons of commercial substrates to compost substrate based on LSD = 1.3g, leaf and LSD = 5.3g, root.

[y]NS, * Nonsignificant or significant at $p \leq 0.05$.

[x]L = linear, Q = quadratic. Zero compost rate excluded from regression analysis.

Root dry weight decreased with increasing compost rate, excluding 0%, with the 4% compost yielding the greatest accumulation of dry matter (Table 2). Root dry weights were similar for the compost and commercial substrates. Daylily roots may have been sensitive to the higher soluble salts levels associated with higher rates of compost addition; yet, decreases in root dry weight could also result from increased fertility (2) due to increased compost addition. Marcotrigiano *et al.* (11) reported similar decreases in dry weight as a result of increasing initial EC levels with *Tradescantia fluminensis.*

Irrigation frequency and compost rate affected P_N and G_S; however, there was no irrigation frequency × compost rate interaction. When only the plants receiving daily irigation were watered (2-day and 3-day irrigation frequencies were not watered), P_N and G_S decreased linearly with decreasing irrigation frequency (Table 3). Photosynthetic rate may have decreased with possible increasing water stress due to a partial or complete stomatal closure (9). The reduction in photosynthesis depends on the amount of water deficit and the sensitivity of the plant (9). When 1-day, 2-day, and 3-day plants were irrigated, there were no discernable trends in P_N or G_S. This indicates that the plants were able to recover and continue normal photosynthetic activity once the water

Table 3. Effect of irrigation frequency and compost rate on photosynthesis (P_N) and stomatal conductance (G_S) of 'Red Magic' daylily.

Irrigation frequency (Days)	Irrigation event (days): 1 day P_N (µmol/m²/s)	1 day G_S (mol/m²/s)	1, 2, and 3 day P_N (µmol/m²/s)	1, 2, and 3 day G_S (mol/m²/s)	Compost rate (v/v)	Irrigation event (days): 1 day P_N (µmol/m²/s)	1 day G_S (mol/m²/s)	1, 2, and 3 day P_N (µmol/m²/s)	1, 2, and 3 day G_S (mol/m²/s)
1	18.8	0.44	17.2	0.40	0	10.4	0.30	12.8	0.29
2	17.5	0.39	17.3	0.38	4	16.6	0.38	17.7	0.40
3	14.3	0.31	19.7	0.42	8	18.4	0.38	19.5	0.44
Significance[z]					12	19.0	0.42	20.5	0.44
L[y]	**	**	NS	NS	16	19.9	0.41	20.0	0.43
					Significance[z]				
					L[y]	**	**	**	**
					Q	*	NS	NS	*

[z]NS, *, ** Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively.

[y]L = linear, Q = quadratic. Zero compost rate excluded from regression analysis.

stress had been alleviated. This is reenforced by the lack of significant irrigation treatment effect on leaf dry weight (Table 1).

Regardless of irrigation frequency, P_N and G_S exhibited a linear increase with increasing rate of compost (Table 3). This suggests that the increased water-holding capacity, available water, and nutrients found with the increasing rates of compost addition (15) improved P_N and G_S. However, this difference was not manifested in leaf dry weight as it did not increase nor decrease with compost rate (Table 2). Potter and Jones (12) reported the difficulties in correlating photosynthesis rate to growth.

Cotoneaster 'Skogholm' leaf, stem, and root dry weights and the leaf:root ratio were affected by irrigation frequency and compost rates (Table 1). Leaf dry weight increased with increasing rates of compost under 1-day irrigation while there were no discernable trends in leaf dry weight under the 2- and 3-day irrigation regimes (Table 4). This increase in leaf dry weight with increasing rate of compost addition is most likely due to the increased water-holding capacity and nutrient levels of these substrates (15). Ticknor and Hemphill (14) reported increased top growth of *Cotoneaster dammeri* with increased yard debris compost additions to a bark and pumice substrate. Even though compost increased available water (15), available water was insufficient in the container to maintain optimal growth under reduced irrigation frequencies. Leaf dry weight decreased with decreasing irrigation frequency for all compost rates.

Stem dry weight exhibited a linear decrease with increasing compost rates under the 3-day irrigation regime (Table 4). Similar to leaf dry weight, stem dry weight decreased with decreasing irrigation frequency for all compost rates.

Root dry weight yielded a quadratic response to increasing rate of compost addition with daily irrigation (Table 4). Maximum dry weight occurred at 12% compost. There was a linear decrease in root dry weight with increasing compost when irrigated every 3 days. This could be reflective of increasing EC with increasing compost rates. However, Hicklenton (8) working with *Cotoneaster dammeri* 'Coral Beauty' and Chong *et al.* (5) working with several woody plants reported tolerance of high EC levels. The decrease in root dry weight at the 16% compost rate could also be an artifact of the higher nutrient concentration and water content of the 16% compost amended substrates (15). Brouwer

Table 4. Effect of irrigation frequency and compost rate on dry weights of cotoneaster 'Skogholm'.

	Dry weight (g)											
	Leaf				Stem				Root			
	Irrigation frequency (days)											
Compost rate (v/v)	1	2	3	L[z] (irr)	1	2	3	L[z] (irr)	1	2	3	L[z] (irr)
0	1.1	1.2	1.0	—[y]	1.7	1.6	1.5	—	1.7	1.3	1.2	—
4	20.9	15.4	11.9	**	23.8	14.8	10.0	**	11.7	7.7	7.4	**
8	20.0	14.8	11.4	**	22.4	11.9	8.6	**	13.6	6.5	5.0	**
12	24.6	16.5	12.4	**	26.4	13.4	8.6	**	16.3	6.7	4.8	**
16	25.3	16.3	11.8	**	22.3	12.8	7.6	**	7.4	5.8	3.6	**
comm.[x]	24.8	17.4	15.6		24.6	15.9	11.7		9.7	7.7	4.4	
Significance[w]												
L[z,y]	*	NS	NS		NS	NS	**		NS	NS	**	
Q	NS	NS	NS		NS	NS	NS		**	NS	NS	

[z]NS, **, * Nonsignificant or significant at $p \leq 0.01$ or $p \leq 0.05$, respectively.

[y]Zero compost rate excluded from regression analysis.

[x]Commercial substrate data not included in the regression analysis. Comparisons of commercial substrate to compost substrates based on LSD = 3.2 g, leaf; LSD = 3.5 g, stem; LSD = 2.6 g, roots.

[w]L = linear, Q = quadratic, irr = irrigation frequency.

(2) reported that, in general, a wide range of annual and perennial plants exhibit decreased root growth with increasing water and nutrient supply.

Regardless of rate of compost addition, plants irrigated every day accumulated more dry matter followed by 2- and 3-day irrigation regimes, respectively. Hemphill *et al.* (7) suggested that adjustments in irrigation frequency are needed to accommodate substrates with substantially different water and nutrient holding capacities and air space to produce better yields. However, any reduction in irrigation frequency from a daily regime resulted in less leaf, stem, and root growth in this study. Even though the compost improved container capacity and available water, it was not sufficient to prevent growth loss with reduced irrigation frequency.

Under the 1-day irrigation regime, the 8% compost rate produced significantly greater leaf and root dry weight than the commercial substrate (Table 4). With 2-day irrigation, there were no differences between leaf dry weight of plants grown with compost and commercial substrate plants. With 3-day irrigation, the commercial substrate produced significantly greater leaf dry weight than all compost rates; however, the 4% compost rate produced significantly greater root dry weight than the commercial substrate.

Irrigation frequency affected foliar N, P, K, Cu, and Zn concentrations (Table 5). Compost affected foliar N, P, Mg, Mn, Cu, Fe, and B concentrations. Neither compost or irrigation affected foliar Ca concentration (averaged 1.68%). High levels of Ca in the irrigation water may have negated any compost treatment effects (15). In addition, only foliar K concentration had an irrigation frequency by compost rate interaction. Since compost played no role in foliar K concentration and after examining the data, this interaction appeared to arise out of a Type I error and was considered nonsignificant.

Foliar N and P concentrations increased linearly with decreasing irrigation frequency (Table 6). This occurs when tissue weight increases at a rate greater than nutrient absorption, decreasing the nutrient percentage expressed on a dry weight basis. Foliar K, Cu, and Zn concentrations responded similarly to foliar N and P (data not shown). Foliar N and P concentrations exhibited a linear increase with increasing compost (Table 6). An increase in the elemental percentage along with an increase in weight indicates that nutrients are being absorbed in increasing quantity to maintain equivalent percentage of dry weight. This suggests that the plants were able to absorb more N and P with increasing rate of compost addition. Chaney *et al.* (4) reported similar results with composted digested sewage sludge. Foliar Mg, Mn, Cu, Fe, and B concentrations responded similarly (data not shown). Several authors reported the use of compost reduced micronutrient availability due to high substrate pH levels (3, 4, 6, 16). Data herein suggests that substrate pH levels did not reduce micronutrient availability.

Irrigation frequency significantly affected foliar P, K, Ca, Mg, Mn, Cu, Zn, and B contents (Table 5). Compost significantly affected foliar N, P, Mg, Mn, Cu, Fe, and B contents. In addition, there was no interaction between irrigation frequency and compost rate for any of the nutrient contents. In contrast to foliar concentration, foliar P content decreased linearly with decreasing irrigation frequency (Table 6). Foliar K, Ca, Mg, Mn, Cu, Zn, and B contents responded similarly (data not shown). Decreased irrigation frequency possibly resulted in these nutrients being less available for plant uptake. This could be a result of the decreased water in the containers irrigated every 2 or 3 days limiting plant growth. Similar to foliar nutrient concentration, foliar nutrient content increased linearly with increasing rate of compost addition (data not shown). Increasing rate of compost addition resulted in these nutrients being more available for plant uptake. Plants grown in the commercial substrate had similar foliar N, P, Mg, Mn, Cu Fe, and B concentrations and contents as plants grown in the compost substrates. Plants grown in all compost substrates had higher foliar P concentrations than plants grown in the commercial substrate, similar to substrate P concentrations (15). Based on the foliar

Table 5. Response of cotoneaster 'Skogholm' foliar nutrient concentration and content to irrigation frequency and compost rate.

Source of variation	Nutrient Concentration (% dry weight)									
	N	P	K	Ca	Mg	Mn	Cu	Zn	Fe	B
Irrigation (I)	**[z]	**	**	NS	NS	NS	*	*	NS	NS
Compost (C)	**	**	NS	NS	**	**	*	NS	**	**
I x C	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Source of variation	**Total nutrient content (mg)**									
	N	**P**	**K**	**Ca**	**Mg**	**Mn**	**Cu**	**Zn**	**Fe**	**B**
Irrigation	NS	**	**	**	**	**	**	**	NS	**
Compost	**	**	NS	NS	**	*	*	NS	**	**
I x C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]NS, *, ** Nonsignificant or significant at $p \leq 0.05$ or $p \leq 0.01$, respectively. Zero compost rate excluded from analysis.

Table 6. Effect of compost rate and irrigation frequency on cotoneaster 'Skogholm' foliar nutrients.

Irrigation frequency (Days)	Nutrition concentration		Total nutrient content
	N	P	P
	(% dry weight)		(mg)
1	1.24	0.19	39.9
2	1.64	0.22	31.4
3	1.99	0.24	27.6
Significance[z]			
L[y]	**	**	**
Compost rate (v/v)	**Nutrient concentration**		
	N	**P**	
	(% dry weight)		
0	1.1	0.1	
4	1.4	0.2	
8	1.6	0.2	
12	1.7	0.2	
16	1.8	0.3	
Comm.[x]	1.5	0.1	
Significance[z]			
L[y]	**	**	
Q	NS	NS	

[z]NS, **, * Nonsignificant, or significant at $p \leq 0.01$ or $p \leq 0.05$, respectively.
[y]L = linear, Q = quadratic. Zero compost rate excluded from regression analysis.
[x]Commercial substrate data not included in the regression analysis. Comparisons of commercial substrate to compost substrates based on LSD = 0.3%, N; and LSD = 0.05%, P concentrations.

nutrient response and plant growth it appeared that compost adequately replaced the dolomitic limestone, micronutrients, and macronutrients added to the commercial substrate.

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Promotion of Branching in Nandina *(Nandina domestica* Thunb.) 'Harbour Dwarf' with ASC-66952[1]

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Abstract

Axillary and aerial rhizomic shoot development of *Nandina domestica* Thunb. 'Harbour Dwarf' was promoted by a single foliar application of 25-200 ppm ASC-66952. Chlorosis of immature leaflets occurred within 2 weeks of 100 or 200 ppm treatment, but was not present 4 weeks after treatment. Growth indices [(height + width in perpendicular directions) ÷ 3] of treated plants were 2–10% less than those of non-treated control plants. *Ilex* × *Meserveae* S.Y. Hu. 'Blue Girl', *Ilex* × 'Nellie R. Stevens', *Rhododendron* 'George L. Tabor', *Rhododendron* 'Trouper', *Trachelospermum asiaticum* (Siebold & Zucc.) Nakai, and *Viburnum* × *pragense* Hort. were not affected by application of ASC-66952.

Index words: growth regulator, branching.

Growth regulators used in this study: ASC-66952 (proprietary compound of ISK Biotech).

Species used in this study: Blue Girl holly (*Ilex* × *Meserveae* S.Y. Hu. 'Blue Girl'); Nellie R. Stevens holly (*Ilex* × 'Nellie R. Stevens'); Harbour Dwarf nandina (*Nandina domestica* Thunb. 'Harbour Dwarf'); George L. Tabor azalea (*Rhododendron* 'George L. Tabor'); Trouper azalea (*Rhododendron* 'Trouper'); Asiatic jasmine (*Trachelospermum asiaticum* (Siebold & Zucc.) Nakai); Prague viburnum (*Viburnum* × *pragense* Hort.).

Significance to the Nursery Industry

Harbour Dwarf nandina develops few axillary or aerial rhizomic shoots when produced in containers, a condition that limits propagation material. ASC-66952 promoted the development of axillary and aerial rhizomic shoots, providing an important source of propagation material. A temporary chlorosis of immature leaflets and a slight inhibition of overall growth with the higher rates of ASC-66952 did not adversely impact plant quality. Lack of response of 'Blue Girl' and 'Nellie R. Stevens' hollies, 'George L. Tabor' and 'Trouper' azaleas, Asiatic jasmine and Prague viburnum to ASC-66952 indicates a species-dependent response to the compound.

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