TB-O_02 Preplant compost application improves landscape plant establishment and sequesters carbon in compacted soil

Sullivan, D.M.[1]**; Bell, N.**[2]

[1] Dept. Crop & Soil Science, Oregon State Univ. (OSU), Corvallis, OR, 97331 USA; [2] Dept. Horticulture, OSU

Dan.Sullivan@oregonstate.edu

1. Objectives

Compost use is advocated as a component of sustainable landscape management in urban areas. Compost is often added to other soil components to provide a target level of organic matter in "topsoil" in urban projects. This study was conducted to (i) assess the potential benefit of compost application for a variety of landscape plant species, (ii) to evaluate the need for tillage following compost application, and (iii) to assess the longevity of compost effects on soil pH, nutrients, compaction, and soil carbon (C). To simulate soil compaction associated with typical urban construction activities, soil was mechanically compacted at the start of this trial. We hypothesized that preplant compost application would assist in plant establishment in compacted soil.

Composts were derived from urban sources: 1) municipal biosolids (from wastewater treatment) mixed with conifer sawdust, or 2) municipal yard debris (tree, shrub and grass trimmings from urban landscape maintenance). Although municipal composting has been common locally since the 1990s, quantitative understanding of long-term compost effects on urban landscapes is limited [1-4].

2. Methodology

Composts met environmental protection requirements for use in landscaping or gardening, and had typical chemical characteristics, reflecting differences in compost feedstocks (Table 1). The biosolids compost was made from a 3:1 v/v mix of conifer sawdust: dewatered municipal biosolids from the City of Newberg, OR. The yard debris compost was the product of a commercial composting facility (Rexius Forest Products, Eugene, OR). It was screened to remove sticks and large chunks of organic matter, and sold as a "Garden Compost" product. The biosolids compost had higher NH_4-N, P, and trace element concentration, and lower K than the yard debris compost. (Table 1). Soluble salts, as indicated by electrical conductivity were <2 dS/m, indicating suitability for a wide range of plants. Compost stability (resistance to decomposition) was high, as indicated by the respiration (CO_2 evolution) test. Both composts had typical C:N (near 20) for composts derived from woody feedstocks.

Table 1: Analysis of composts derived from municipal biosolids or municipal yard debris. Composts were applied to field plots at a depth of 7.5 cm (760 m^3/ha).

Compost source	Bulk density	C:N	Total C	Total N	NH_4-N	Total P	Total K	pH (1:5)	EC (1:5)	Stability (CO_2 evolved)
	kg DM/m^3		------	------	kg/m^3	------	------		dS/m	mg C/g OM/d
Biosolids compost	280	23	118	5.0	0.6	2.7	0.4	7.7	1.6	1.0
Yard debris compost	390	19	101	5.5	0.02	1.0	2.8	7.0	0.9	2.9

Compost analysis by Soil Control Lab, Watsonville, CA, USA using standard methods (U.S. Composting Council):

Bulk density = kg compost dry matter (DM) per cubic meter

Compost pH and electrical conductivity (EC) determined via 1:5 (compost:water; g DM/mL) method.

Stability = CO_2 evolution via 3 day incubation at 25 °C, expressed as mg C evolved per g organic matter (OM) per day.

The field trial was conducted at the OSU North Willamette Experiment Station (Aurora, OR, USA). Climate is Mediterranean, with a wet winter (Nov-Mar), and summer drought in July and August. Eight perennial plant species were installed prior to the winter rainy season (Sept 2008). No summer irrigation was applied during any year. To simulate soil compaction often present at urban sites, an agricultural soil (Willamette silt loam) was prepared by compacting with a vibrator-roller (typically used for parking lot construction) to a bulk density of 1.5 g/cm^3 (5 to 10 cm depth), as measured with a bulk density probe. Soil compaction was performed 5 days after 10 cm of overhead sprinkler irrigation. The vibrator-roller traversed the field 5X. After soil compaction, it was difficult or impossible to dig planting holes manually.

Experimental design was a 3 x 2 factorial with three compost treatments (biosolids compost, yard debris compost, no-compost control) and two compost placements (no tillage or rototilling after compost application), replicated 4X, for a total of 48 field plots. Field plots contained 3 transplants of each of 4 plant species (12 plants per plot). We installed 4 cultivars considered standard landscape plants for our area (*Nandina domestica* 'Compacta', *Vinca major* 'Bowles', *Viburnum davidii*, *Berberis thunbergii* 'Crimson Pygmy'), and 4 cultivars considered more drought-tolerant: *Rosmarinus officinalis* 'Blue Spires', *Cistus* 'Bicolor Pink', *Ceanothus gloriosus*, *Caryopteris x clandonensis* ‘First Choice’. Each field plot (3 x3 m) was surrounded by a 1.5-m border area that was seeded to turf-type tall fescue.

Prior to transplanting, compost (7.5-cm depth) was applied, followed by rototilling 5 to 10 cm depth (for tillage treatment only). Planting holes were then drilled with a 15-cm diameter screw-type power auger. Nursery transplants from 4-L pots were placed into the drilled holes, and then secured by placing a thin (<5 cm) layer of soil around transplant root cylinders. The soil used to refill planting holes contained incidental amounts of compost from the soil surface. Transplanting was performed by contract laborers who were instructed to work at a typical pace for commercial landscape operations. After transplanting, all plots were mulched with a 5-cm of Douglas-fir conifer bark, a standard practice for weed control in landscape planting beds.

Figure 1: Field trial installation, Sept 2008. Soil compaction with vibrating roller (a), tillage treatment (b), plant installation with power auger in no-till treatment (c), all plots planted and mulched with Douglas-fir bark (d).

Four of the eight plant species were harvested for dry weight determination at 13 months after installation. Plants were cut at the soil surface, and underlying soil was not disturbed. New transplants were installed to replace the harvested plants in March of 2010. Planting holes for the new (2010) transplants were offset at least 30 cm away from previous plant locations. The compost and mulch present on the soil surface was kept out of the new planting holes.

Each October, prior to heavy fall rains, mineral soil (0-20 cm) samples were collected using a 2-cm diameter soil probe. After scraping away the surface organic mulch, soil samples were collected from the area within each plot that was not disturbed by replanting in 2010. Soil testing was performed using standard procedures at Brookside Laboratories Inc. (New Bremen, OH, USA). Carbon was determined by a combustion analyzer, and organic matter was determined by loss-on-ignition (weight loss in a muffle furnace). Soil compaction determined using a recording penetrometer during the rainy season, after the soil profile reached field capacity.

3. Results and discussion

3.1 Plant response to compost

Regardless of treatment, over 90% of plants survived the first growing season. Compost increased plant growth for all plant species, including those species considered drought tolerant. Tillage did not affect plant survival or growth. Biosolids compost increased aboveground plant dry weight by 60 to 130% (average 84%) across the four plant species harvested at 13 months after installation (Oct 2009). Yard debris compost increased plant dry weight by 26 to 93%

(average = 54%). Plants that grew the most in response to compost application had high leaf N, suggesting that they were responding to the N supplied by compost. A few plant species suffered greater summer injury with compost, because they had a second flush of vegetative growth in June, and continued growth into July, when days were hot and surface soil moisture was depleted.

When compost was not incorporated by tillage, it was visible on the soil surface for several years after application. A few plant species suffered partial dessication in the dry summer because of extensive rooting at the soil surface. But, even those plants recovered, and overall, plant growth was similar with or without preplant tillage.

Plant growth in this trial was not strongly affected by preplant soil compaction. A "border plot" (adjacent to experimental area, not part of experiment) that had been treated similarly (same plants installed at same time, but soil left uncompacted) had very similar plant growth response to compost.

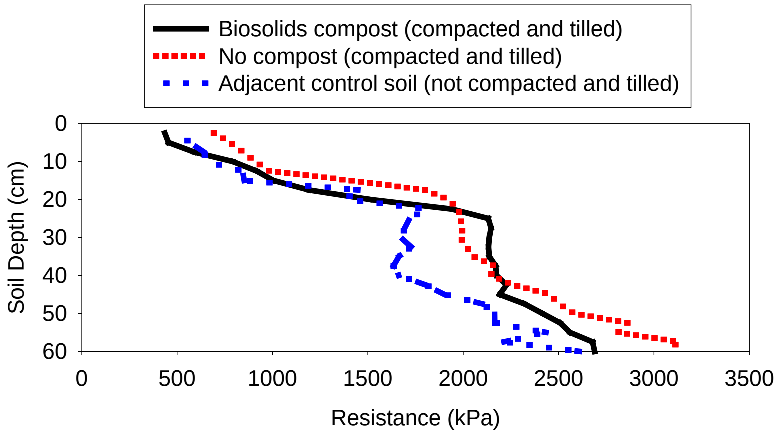

Figure 2: Resistance measured by recording penetrometer in wet soil at 16 months after preplant soil compaction (Dec 2009). Most of the residual compaction created by the vibrator-roller machine (preplant) was observed below 20 cm. Resistance was not affected by compost application.

3.2 Soil response to compost

Compost application did not alter surface soil compaction at 16 months after trial installation as measured by penetrometer (Figure 2), or by bulk density cores. Soil bulk density (0 to 15 cm) was the same with or without compost application (1.38 g/cm^3), but it was reduced by tillage from 1.38 to 1.30 g/cm^3. Penetrometer resistance readings reached 2000 kPa at 25 cm depth for all treatments. Preplant soil compaction increased soil resistance below 25 cm depth to values greater than recommended for optimal plant root growth. However, roots were confined to the top 20 to 30 cm soil for all plant species, based on visual observations made when the experiment was terminated in 2014 (plants removed with an excavator). We conclude that nutrients supplied by compost were the primary drivers of plant growth response (not compaction). When soil sampling in 2012, we noticed that soil was softer (easier to probe) and had evidence of worm activity in the compost-treated plots. The worms likely crawled from the adjacent grassy plot borders to our field plots.

Soil pH, nutrients and organic matter (C) were equivalent for both compost placements (surface or tilled-in), suggesting downward migration of surface-placed compost constituents. Biosolids compost supplied more plant-available nitrogen (N) than yard debris compost, as evidenced by higher soil nitrate-N (Figure 3). First-year N supplied by biosolids compost was excessive (2009), but it was much closer to plant needs in the second growing season (2010). Biosolids compost acidified soil, while yard debris compost increased soil pH slightly (Figure 3). Yard debris compost increased exchangeable cations: K +100%, Ca +20%, and Mg +33%, in the final soil sampling in 2012. With biosolids compost, exchangeable cations remained within 10% of values for the no-compost control.

Organic matter supplied by compost persisted throughout the four year measurement period. Fluctuation in measurements across years was probably the result of inconsistency in sample collection or laboratory analysis techniques. Organic matter (Loss-On-Ignition; LOI) or soil

C (combustion) analyses showed the same trend: yard debris compost > biosolids compost > control. Organic matter averaged 10 to 16% greater than control with biosolids compost, and 29 to 41% greater with yard debris compost. The main constituent of biosolids compost (by weight) was conifer sawdust, which was apparently decomposed more rapidly than the mixture of organic materials present in yard debris compost. .The average increase in soil C (0-20 cm depth) was 5% of compost-C applied for biosolids compost and 18% for yard debris compost (Table 2), assuming a soil bulk density of 1.3 g/cm^3.

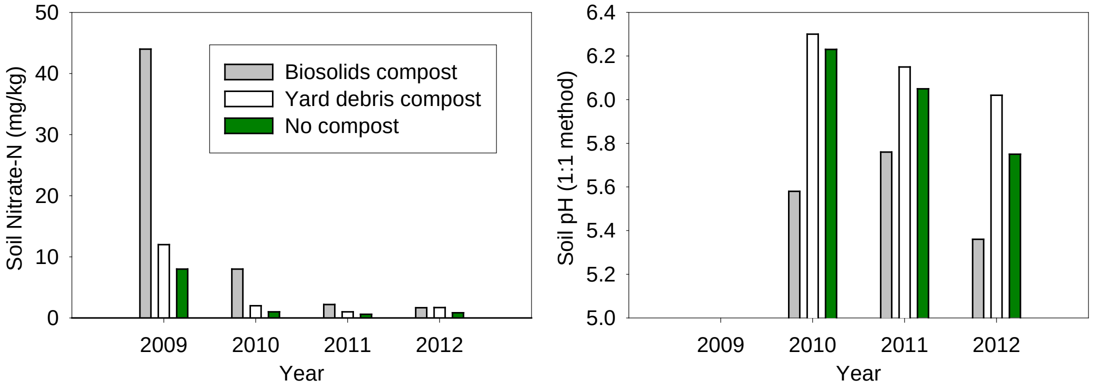

Figure 3: Soil nitrate-N and soil pH (0-20 cm depth). Samples collected in October of each year (end of dry season).

Table 2: Effect of preplant compost application on soil carbon (determined by combustion analysis) and soil organic matter (determined by Loss-On-Ignition; LOI). Compost applied Sept 2008. Soil (0-20 cm) sampled in Oct. each year.

	2009	2010	2011	2012	Average	Percent of control
			Carbon, %			
Biosolids compost	1.8	1.5	1.7	1.8	1.7	116
Yard debris compost	1.6	1.6	2.3	2.7	2.1	141
No compost	1.5	1.4	1.4	1.6	1.5	
			LOI Organic Matter %			
Biosolids compost		4.9	3.5	3.4	3.9	110
Yard debris compost		5.1	4.1	4.7	4.7	129
No compost		4.7	3.1	3.1	3.6	

4. Conclusion and outlook

Preplant compost application increased plant growth and visual appearance of a wide variety of perennial landscape plants. The positive plant growth response to compost was similar for compost left on the soil surface or compost incorporated via rototilling. Compost application did not alleviate soil compaction. Plant growth response to compost in this trial was primarily related to N supply (and perhaps other nutrients). Biosolids compost acidified soil, this characteristic improved growth of an acid-loving plant species. Carbon sequestered in soil (5 to 18% of compost-C) was at the low end of C sequestration values reported in the literature.

Acknowledgements

This project was supported by the Northwest Biosolids Management Association and the Oregon Association of Clean Water Management Agencies. The authors recognize OSU faculty and staff, including John McQueen, Judy Kowalski, Marc Anderson, and Jim Owen for their assistance.

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