Composted Biosolids Incorporation Improves Turfgrass Establishment on Disturbed Urban Soil and Reduces Leaf Rust Severity

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Abstract. The effects of incorporation of compost to a disturbed urban soil on turfgrass establishment, growth, and rust severity were assessed in a replicated field study. A blend of two locally available composted biosolids (sewage sludge) was incorporated into a nutrient-deficient subsoil at a rate of 130 m³·ha⁻¹, adding NO₃-N, P, and K at 126, 546, and 182 kg·ha⁻¹, respectively, to each compost-amended plot. Kentucky bluegrass (Poa pratensis L.), perennial ryegrass (Lolium perenne L.), and a mixture of these two species were seeded into both compost-amended and nonamended plots and observed for 1 year. Turfgrass establishment estimated from visual assessments of percentage cover and growth measured by clipping yields were significantly (P < 0.05) enhanced by the incorporation of the composted biosolids. These effects were first observed and most pronounced on plots seeded with perennial ryegrass and were apparent for the duration of the study. The severity of leaf rust caused by Puccinia sp. was significantly (P < 0.05) less on perennial ryegrass seeded on the compost-amended plots. This study demonstrates the feasibility and potential benefits of amending disturbed urban soils with composted biosolids to enhance turfgrass establishment and is the first report of the suppression of a foliar turfgrass disease through the incorporation of compost into soil.

Establishing lawns following construction of new homes is frequently difficult. During construction the topsoil is often removed or covered with basement fill, construction debris is buried, and heavy equipment compacts the remaining subsoil. New homeowners face the challenge of growing a lawn on these disturbed soils. Early in the 20th century, homeowners were advised to grow cover crops for one or more seasons to improve soil tilth and fertility before seeding turfgrass (Barron, 1923). Current recommendations based on agronomic research include amending the soil prior to seeding with organic materials (Pound and Street, 1991). Manures and other organic agricultural wastes sometimes are used for this purpose in field soils (Larney and Janzen, 1996), but transportation costs and availability of these materials limit their use in urban settings. Urban sources of organic matter such as sewage sludge and yard wastes, which until recently posed waste disposal problems, are increasingly composted today and used as soil conditioners.

Incorporation of composted urban wastes into soil reduces the bulk density and increases the moisture holding capacity of amended soils (Darmody et al., 1983; Hornick and Parr, 1987), improves aggregate stability and cation exchange capacity (Aggelides and Londra, 1999), and may also increase the depth of the Ap horizon (Darmody et al., 1983). The effects of various composted materials on soil fertility and plant nutrition have been documented extensively (Darmody et al., 1983; O’Keefe et al., 1986; Pascual et al., 1997; Sikora and Yakovchenko, 1996). Composts also have been shown to reduce the incidence and severity of diseases caused by soilborne plant pathogens, such as Pythium root rot and damping off of ornamental and nursery crops (Hoitink and Boehm, 1999), Fusarium wilt of flax (Serra-Wittling et al., 1996), and Phythophthora crown rot of citrus and avocado (Lumsden et al., 1983).

Research on turfgrass also has demonstrated beneficial effects of compost amendments and topdressings. Most of this research, however, was conducted on golf course turf or was based on greenhouse or laboratory studies using sand or topsoil. For example, establishment rates and color of creeping bentgrass (Agrostis palustris Huds.) were enhanced by the incorporation of composted biosolids to a sand-based putting green rootzone mix (Markham, 1998). Composts have also been used to replenish or even substitute for soil in sod production (Logsden, 1991; Murray, 1982). Topdressings consisting of composted biosolids have been used to supplement or replace urea-based fertilizers on putting greens and fairways (Eguiza et al., 1991; Garling and Boehm, 2001).

Composts also have been shown to reduce the severity of both root and foliar diseases of turf. Thurn (1993) in a field study and Craft and Nelson (1996) in a laboratory bioassay documented the suppression of Pythium root rot of creeping bentgrass seeded into composted biosolids-amended, sand-based rootzone mixes. There are numerous reports of compost topdressings reducing the severity of dollar spot caused by Sclerotinia homoecarpa Bennett (Boulter et al., 1999; Garling, 2000; Nelson and Craft, 1992a), brown patch caused by Rhizoctonia solani Kühn (Nelson and Craft, 1991a), Typhula blight caused by Typhula sp. (Nelson and Craft, 1992b), and red thread caused by Laetissia fusiformis McAlpine (Nelson and Craft, 1991b).

There is little information, however, in the scientific or the popular literature on the use of composts for the establishment of lawns on disturbed urban soils and no previous reports on the suppression of a foliar turf disease, such as leaf rust, through the incorporation of compost to the soil. The objectives of this research were to evaluate the effects of the incorporation of composted biosolids (sewage sludge) into a nutrient-deficient, structureless subsoil typical of new housing developments on the establishment of Kentucky bluegrass and perennial ryegrass and on the development of leaf rust caused by Puccinia species.

Materials and Methods

Field plot. A 390-m² field plot was established at The Ohio State Univ. Ohio Turfgrass Foundation Research and Education Facility in Columbus in July 1998. To simulate typical construction disturbance, existing topsoil was removed to a depth of 20 cm and replaced with a nutrient-deficient subsoil. Three blocks, each consisting of nine 3 × 3-m plots separated by 0.6-m alleys, were delineated. A 1.3-cm layer of compost (130 m³·ha⁻¹) was incorporated to a depth of 10–15 cm on one randomly assigned half of each plot. A mixture (1:1; v/v) of two different composted biosolids was used. One source (ComTil™) was obtained from the city of Columbus, Ohio, where it was prepared from sewage sludge mixed with wood chips by the static aerated pile method (Finstein et al., 1983). The other compost (TechnaGro™), received from the city of Akron, Ohio, was prepared from sewage sludge mixed with tree trimmings in an in-vessel system (Kuter et al., 1985).

The compost mixture added NO₃-N, P, and K at 126, 546, and 182 kg·ha⁻¹, respectively, to each compost-amended plot. Tables 1 and 2 list the nutrient properties and heavy metal content of the subsoil and the composted biosolids used in this study. Total N was

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Table 1. Properties of the subsoil and the composted biosolids used in this study and the loading rate for each nutrient supplied by the incorporation of 130 m³·ha⁻¹ composted biosolids into the subsoil.

| Property | Subsoil | Composted biosolids | Nutrient loading rate |
|----------|---------|---------------------|-----------------------|
| pH       | 8       | 5.4                 |                       |
| NO₃⁻-N   | 800     | 27,300              | 1,014                 |
| P        | 4'      | 3,400               | 126                   |
| K        | 2'      | 14,700              | 546                   |
| Ca       | 3,4900  | 33,700              | 1,252                 |
| Mg       | 199°    | 6,700               | 249                   |
| Fe       | Not tested | 16,100         | 598                   |
| Mn       | Not tested | 1,000              | 37                    |
| B        | Not tested | 41°              | 2                     |
| Zn       | 82      | 1,400               | 8                     |
| Cu       | 25      | 214                 | 8                     |
| Mo       | 8       | 17                  | <1                    |

¹Determined by the Dumas (combustion) method.
²Determined by the electrode method.
³Determined by the saturated paste method.
⁴Determined by the Bray and Kurtz P-1 method.
⁵Determined by the inductively coupled plasma (ICP) method after extraction procedure.
⁶Determined by the Dumas (combustion) method.

Table 2. Concentrations of heavy metals in the composted biosolids and the subsoil used in this research relative to average background concentrations in Ohio soils and maximum EPA allowable levels.

| Element | Subsoil | Composted biosolids | Avg background in Ohio soils | Maximum EPA allowable level |
|---------|---------|---------------------|-----------------------------|-----------------------------|
| Se      | <1      | 1                   | <1                          | 100                         |
| Zn      | 82      | 1400                | 93                          | 7500                        |
| Cu      | 25      | 214                 | 24                          | 4300                        |
| Cd      | <1      | 2                   | <1                          | 85                          |
| Ni      | 26      | 152                 | 27                          | 420                         |
| As      | 19      | 25                  | 30                          | 75                          |
| Hg      | <1      | <3                  | <1                          | 57                          |
| Mo      | 8       | 17                  | 153                         | 75                          |
| Pb      | 12      | 69                  | 24                          | 840                         |
| Cr      | 15      | 167                 | 28                          | ---                         |

¹Determined by microwave-assisted acid digestion.
²U.S. Environmental Protection Agency, 1997.

The incorporation of composted biosolids into the nutrient-deficient subsoil used in this study significantly ($P < 0.05$) enhanced turfgrass establishment and growth. These effects were first observed and most pronounced on plots seeded with perennial ryegrass due to its shorter germination time and faster growth rate. By the 5th week after seeding in Exp. 1, all treatments showed significantly ($P < 0.05$) greater turfgrass establishment in the compost-amended compared to the nonamended plots (Table 3). Turfgrass growth as measured by clipping dry weight also was significantly ($P < 0.05$) greater for the compost-amended plots (Table 4). Similar trends in turfgrass establishment (Table 5) and growth (Table 4) were observed in Exp. 2. These compost-induced effects were apparent for the duration of the study.

Results and Discussion

The incorporation of composted biosolids into the nutrient-deficient subsoil used in this study significantly ($P < 0.05$) enhanced turfgrass establishment and growth. These effects were first observed and most pronounced on plots seeded with perennial ryegrass due to its shorter germination time and faster growth rate. By the 5th week after seeding in Exp. 1, all treatments showed significantly ($P < 0.05$) greater turfgrass establishment in the compost-amended compared to the nonamended plots (Table 3). Turfgrass growth as measured by clipping dry weight also was significantly ($P < 0.05$) greater for the compost-amended plots (Table 4). Similar trends in turfgrass establishment (Table 5) and growth (Table 4) were observed in Exp. 2. These compost-induced effects were apparent for the duration of the study.

The enhanced turfgrass establishment and growth observed on the compost-amended plots are most likely a result of the plant-available nitrogen and phosphorus introduced into the seedbed with the compost (Table 1). This conclusion is supported by previous reports by Sikora et al. (1980), who attributed a similar increase in the growth of greenhouse-grown fescue (*Festuca arundinacea* Schreb.) to the N supplied to the soil by composted biosolids amendment. Chen (1997) found a positive linear relationship ($r^2 = 0.992$) between the amount of N supplied by a composted biosolids amendment and the yield of greenhouse-grown perennial ryegrass. Most re-
Table 4. Growth of turfgrass seeded on compost-amended and nonamended subsoil.

| Treatment          | Kentucky bluegrass | Perennial ryegrass |
|--------------------|--------------------|--------------------|
|                    | Dry wt of clippings (g·m⁻²) |                    |
|                    | Weeks after seeding |                    |
|                    | 2   | 4   | 5   | 7   | 8   | 38  | 39  | 41  | 43  | 45  | 46  | 48  | 50  | 52  | 54  |
| Compost¹            | 3   | 18  | 33  | 57  | 69  | 76   | 81  | 81  | 85  | 82  | 90   | 92  | 97   | 96  | 97  |
| No compost          | 3   | 14  | 18  | 26  | 42  | 45   | 45  | 57  | 69  | 72  | 77   | 77  | 86   | 84  | 86  | 89  |
| SE                 | 0.7 | 2.9 | 6.2 | 7.4 | 9.6 | 4.8   | 2.2 | 3.6 | 3.8 | 5.2 | 1.5   | 2.9 | 2.1   | 1.8 | 2.2 |
| K. bluegrass/P. ryegrass mix |
| Compost²            | 10² | 20² | 41² | 72² | 75² | 73    | 87  | 86  | 82  | 84  | 87²   | 89² | 92²   | 92² | 96² |
| No compost          | 6   | 13  | 27  | 43  | 48  | 54    | 68  | 72  | 74  | 77  | 77    | 80  | 80    | 83  | 87  |
| SE                 | 1.5 | 2.5 | 4.9 | 5.8 | 5.1 | 4.6    | 5.5 | 4.5 | 3.5 | 3.2 | 2.2    | 5.3 | 1.8   | 2.4 | 2.7 |

¹Growth was measured by collecting clippings from each plot with a rotary mower followed by drying at 50°C for 2 d.
²Composted biosolids (130 m³·ha⁻¹) incorporated to a depth of 10–15 cm. The compost amendment of NO₃-N, P, and K supplied at 126, 546, and 182 kg·ha⁻¹, respectively, to each compost-amended subplot.
*, **, ***Significant at ≤0.05, 0.01, and 0.001, respectively, by ANOVA.
cently, Markham (1998) attributed enhanced establishment of creeping bentgrass on a composted biosolids-amended putting green rootzone mix to the N and P introduced by the incorporation of the composted biosolids to the rootzone mix.

The year-long enhancement of turf establishment and growth observed in this study is also consistent with previous reports in other cropping systems of prolonged effects of nutrients introduced into soil through the incorporation of composted biosolids. For example, O’Keefe et al. (1986) reported an extended availability of N to maize (Zea mays L.) planted in soil with incorporated composted biosolids, with a rapid rate of N mineralization for the first 28 weeks and a slow but sustained rate for the next 45 weeks. Darmody et al. (1983) reported high residual levels of Ca, P, and K 3 years after incorporation of composted biosolids into soil. They also reported a decrease in bulk density and an increase in the moisture-holding capacity 4 years after composted biosolids were incorporated into a silt loam. It is highly likely that similar changes, although not measured, took place in the heavy clay subsoil used in this study.

The severity of leaf rust was significantly (P < 0.05) lower on perennial ryegrass seeded on the compost-amended plots at 6 weeks after seeding in Expt. 1 and for up to 9 weeks after seeding in Expt. 2 (Table 6). Although it has been reported that applications of compost topdressing can suppress foliar turf diseases and that the incorporation of compost into soil can suppress soil-borne diseases, this is the first report of a foliar turf disease being suppressed by the incorporation of compost into soil. Since it is well-documented that the development of rust in turfgrass is greatly reduced by increased N fertility (Smiley et al., 1992), the lower rust severity observed in the compost-amended ryegrass plots was most likely due to an increase in plant-available N supplied by the compost (Table 1). Garling (2000) attributed suppression of dollar spot on creeping bentgrass to the plant-available N provided by composted biosolids and yardwastes topdressings. Although increased growth rates and removal of symptomatic turf via mowing are usually cited as the mechanisms of how increased N fertility results in decreased disease, the exact mechanism(s) have yet to be documented experimentally. Given the spatial separation between the location of the compost and the site of pathogen activity, however, it is possible that the suppression of rust observed in this study was due to the induction of systemic resistance by microorganisms present in the compost. Zhang et al. (1996) demonstrated compost-induced systemic acquired resistance in cucumber to Pythium root rot and anthracnose. Most recently, Enbak and Carey (2000) showed that such a mechanism was responsible for resistance to fusiform rust (Cronartium quercuum f. sp. fusiforme Burds. et Snow) of loblolly pine (Pinus taeda L.) seedlings treated with plant growth promoting rhizobacteria (PGPR).

These results clearly demonstrate that composted biosolids can be used to enhance the establishment and growth of turfgrass on disturbed urban soils. This is of particular benefit for the installation of new lawns on nutrient-deficient, structureless urban soils where erosion is likely when turf is slow to establish. These results also present the first evidence of a foliar turf disease being suppressed by the incorporation of composted biosolids into the soil profile. Future research focusing on the mechanisms of compost-induced improvements of turf will help in the development of practical guidelines for the use of composted urban wastes to improve the quality of urban soils and the establishment, growth, and overall vigor of turf.

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## Table 6. Severity of rust (Puccinia sp.) on turfgrass seeded on compost-amended and nonamended subsoil.

| Treatment       | Expt. 1 | Expt. 2 |
|-----------------|---------|---------|
|                 | No compost | Compost  |
|                 | 6.1      | 6.0     |
|                  | 8.0      | 6.0     |
|                  | 6.0      | 6.0     |
|                 | 8.0      | 8.0     |
|                 | 8.0      | 8.0     |
|                  | 2.2      | 2.5     |
|                  | 1.2      | 2.3     |

Rust severity (%) *Significant at ≤0.05, 0.01, and 0.001, respectively, by ANOVA.

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