Enhancing Biological Disease Control in Turfgrass with Composts

Research Update

The primary aim of this research is to understand how composted amendments and the microorganisms they contain, impact soil microbial communities and how these microbial changes affect turfgrass health.

The goal of our project is to establish relationships between the composition and function of microbial communities developing in soils receiving compost amendments and the evolution of disease-suppressive soil properties. By monitoring community dynamics, in conjunction with changes in organic matter quality, we hope to identify important ecological interactions that may lead to the eventual development of methods and knowledge for predicting disease-suppressive soil properties. Monitoring selected pathogens in response to community changes may clarify their behavior and specific interaction with certain suppressive microbes. The latter may well contribute to the identification of biological indicators to soil suppressiveness/biological control of plant pests and to the understanding of the mechanisms involved. The main objective of our study is to characterize microbial communities in compost-amended and non-amended soils with respect to microbial activity, biomass, functional diversity, and species composition.

Brief Methodology

Five different composts were used in the study. They included two brewery waste composts from AllGro, Inc.; municipal biosolids compost from Schenectady NY; leaf compost from Endicott, NY; and poultry litter compost from Sustane Corporation.

The experimental site was established as a randomized complete block design on a mature stand of tall fescue/perennial ryegrass at the Cornell Turfgrass Field Research Facility in Ithaca. Each treatment consisted of 980 ft^2 plots with five replicates per treatment. Except for Sustane, which is already in a granular form, composts were screened through 1/4" mesh prior to application. The application rate was 20 lb dry weight/1000 sq ft. The composts for each replicate plot were weighed and placed in individual plastic bags. Material from the bags were applied by hand evenly over the plot area (the first application was made with a drop spreader). Five applications were made at 5 week intervals, starting May 30, 1995, with the last application on October 16, 1995.

Samples were collected immediately after the first application, and subsequently, just prior to each following application, in order to assess the effects of the preceding application on various microbial activities. Samples were analyzed for microbial populations and microbial utilization of different carbon sources. Other tests included microbial biomass, fungal biomass, and microbial community diversity.

Preliminary Results and Interpretation

Preliminary results indicate that there are some general trends in microbial properties of compost-amended soils that are worth noting. One of the most obvious properties of both amended and non-amended soils is that microbial activity increases as soil temperatures increase and as cumulative applications increase. Microbial activity (as measured by the hydrolysis of fluorescein diacetate) steadily increased from levels in May to those in August and then declined thereafter (see Figure 1). The levels of microbial activity in soil amended with composted municipal biosolids were considerably greater during July and August than those in soils treated with other amendments.

These general increases in microbial activity were not completely reflected in plate count populations of bacteria, fungi, and actinomycetes

Figure 1. Microbial activity (as determined by the hydrolysis of fluorescein diacetate (FDA)) in soils receiving different compost amendments. Increased levels of FDA hydrolysis indicate higher levels of microbial activity.

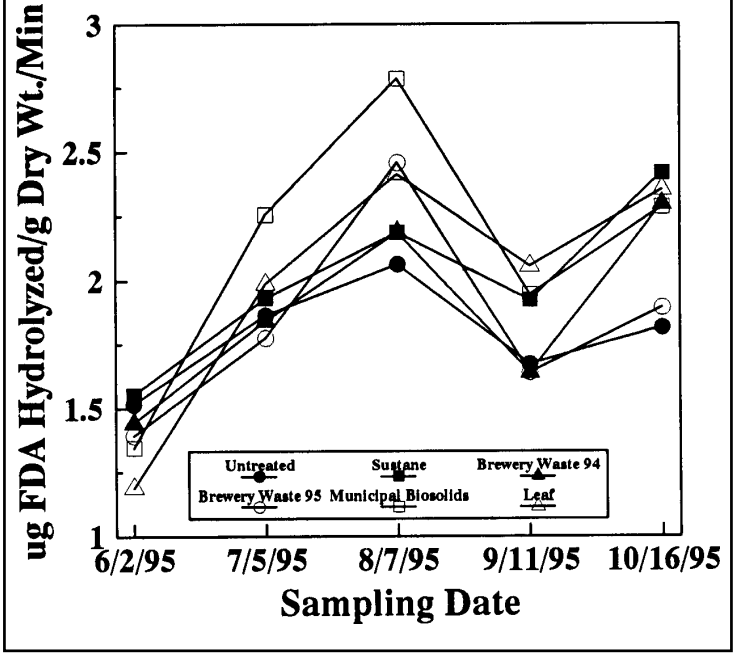
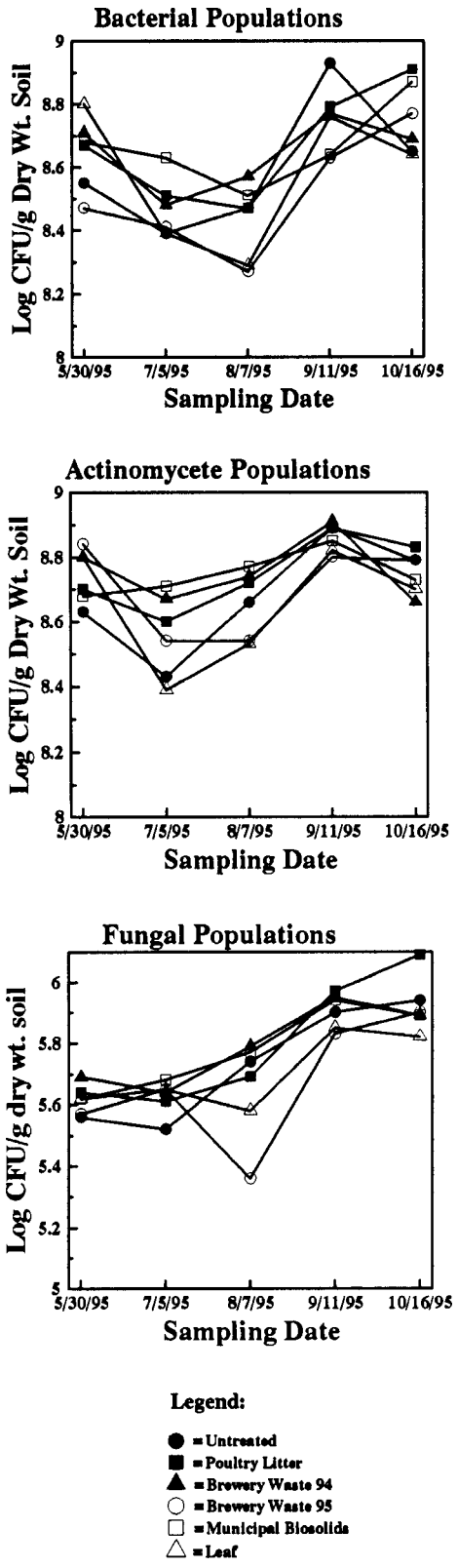


Figure 2. Populations of major microbial groups in compost-amended soils as determined by plate counting procedures.



over the course of the season (see Figure 2). The behavior of populations of each of the microbial groups differed. Populations of bacteria declined between May and August, but then increased through October. Actinomycete populations on the other hand, decreased during June and July, but steadily increased through the rest of the season. Populations of fungi increased steadily during the season, with the exception of the soil amended with the Brewery Waste 95 compost, where fungal populations took a sharp drop between the July and August sampling. This sharp drop in population corresponded to an equally sharp rise in microbial activity (see Figure 1). Other studies have shown that fungal biomass is inversely proportional to fungal plate counts. This suggests that the increase in microbial activity observed in the composted municipal biosolids treatment resulted largely from increases in fungal biomass and activity. Samples are still being analyzed for fungal biomass determinations to verify this finding.

These collective preliminary results indicate that, with the exception of the composted municipal biosolids treatment, quantitative estimates of microbial activity and biomass did not differ substantially among compost treatments. However, our results further indicate that the functional diversity of microbial communities differs with the type of compost amendment. Our evidence for this comes from results of carbon source utilization patterns of microbial communities from different compost-amended soils. Metabolic profiles of microbial communities, based on the utilization of a suite of 95 different carbon sources, revealed qualitative differences among microbial communities in soils receiving different compost treatments (see Tables 1 and 2). These profiles not only differed according to the compost amendment, but they differed temporally. Certain discriminating carbon sources could be identified that were unique to each microbial community and that could be used as signatures for each community. These results reinforce the notion that, although quantitative differences in microbial communities in compost-amended soils cannot be discerned, qualitative differences are readily apparent and are likely to be key in identifying disease-suppressive properties of certain compost-amended soils.

This study has generated a tremendous amount of data, a large part of which is still being analyzed for various microbial properties. These analyses will be completed over the remaining

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four months of the grant period. Our current work is focussing on qualitative estimates of microbial community diversity in these compost-amended soils and on correlating these characteristics with the suppression of turfgrass diseases. Based on experiments conducted prior to the initiation of this study, soils receiving applications of Brewery Waste 94 and Poultry Litter were highly suppressive whereas those soils receiving the other amendments were not suppressive. Those soils amended with immature composted amendments (such as the Brewery Waste 95) became suppressive with time. Experiments are in progress to verify these suppressive properties. It is interesting to note further that those turfgrass plots treated with the Poultry Litter compost were of higher overall quality than were those treated with any of the other composts. The reasons for this are not entirely clear at this time but likely involve increased nitrogen nutrition as a result of this amendment.

Summary

One of the greatest obstacles to the widespread use of composted amendments for turfgrass disease control has been the inconsistent performance from site to site, batch to batch, and year to year. Much of the unpredictable nature of composted amendments has come from a lack of understanding of the microbial dynamics that determine the overall properties and behavior of amendments when incorporated into soils or when applied as topdressings. Despite the fact that some types of amendments have been shown to be highly suppressive to a number of turfgrass diseases, some composts are either not suppressive or may actually enhance disease development and pathogen persistence.

The current project was designed to address questions that will advance our understanding of how composts suppress turfgrass diseases. The primary aim of this research is to understand how composted amendments and the microorganisms they contain, impact soil microbial communities and how these microbial changes affect turfgrass health.

The use of organic amendments in turfgrass management is likely to increase as the emphasis on non-chemical and environmentally-friendly production practices increases. Furthermore, with

Table 1. Metabolic profiles of microbial communities in compost-amended tall fescue/perennial ryegrass soils. (July samples, after one application.)

Carbon Source	Untreated	Municipal Biosolids 95	Brewery Waste 94	Leaf 95	Poultry Litter	Brewery Waste 95
None	0.0936	0.1076	0.0940	0.1086	0.0998	0.0914
Bromosuccinate	0.2962	0.3492	0.3412	0.3544	0.2132	0.2923
L-histidine	0.2370	0.2184	**0.4404**	0.3710	0.3374	0.2438
Hydroxy-L-proline	0.1924	0.1946	0.3206	**0.5728**	0.3614	0.1780
Inosine	0.2554	0.2172	0.1928	0.2326	0.1530	0.2144
Dextrin	0.3762	**0.4016**	0.3914	**0.5270**	**0.4476**	0.3973
Citrate	0.2386	0.3258	0.3428	**0.4614**	0.2932	0.2568
Glycogen	0.3440	**0.4220**	**0.5156**	0.3028	0.3080	0.3320
D-galactose	0.2280	0.2488	0.2398	0.3850	0.2292	0.3187
A-ketoglutarate	0.2242	0.3712	0.3298	0.3088	0.2484	0.3007
Tween-40	0.2534	0.3284	**0.4488**	0.3444	0.3256	0.2533
Tween-80	0.2452	0.2510	**0.4392**	0.3028	0.3088	0.2197
A-D-glucose	0.3386	**0.4402**	**0.4148**	**0.5300**	0.3634	0.3804
D-galacturonate	0.3440	0.2802	0.2730	0.2270	0.2440	0.2576
Putrescine	0.2202	0.2738	0.3946	0.1914	0.2470	0.2424
Sucrose	0.3076	0.3084	0.3278	**0.4940**	**0.4730**	0.3787
D-gluconate	**0.4154**	**0.4492**	**0.6026**	**0.6030**	0.3688	**0.4309**
N-acetylglucosamine	**0.4988**	0.2976	**0.4716**	**0.5108**	0.3398	**0.4252**
D-trehalose	0.3448	0.3848	**0.4268**	0.3886	0.2616	0.3548
L-asparagine	**0.5314**	**0.5846**	**0.4926**	0.3872	0.3564	**0.4408**
Quinate	0.2462	0.3070	**0.4152**	0.3268	0.2194	0.2885
L-aspartate	0.2526	**0.4152**	0.2678	0.2898	0.2418	0.2785
Maltose	0.3440	0.3204	0.3626	0.3478	0.3910	0.2461
D-saccharate	0.2256	0.2466	0.3012	0.2284	0.2020	0.2468
L-glutamate	**0.5458**	0.3972	**0.4182**	**0.5942**	0.3196	0.3253
Glucose-1-phosphate	0.2712	**0.4174**	**0.4378**	**0.5310**	0.3080	**0.4046**
Cellobiose	0.2946	0.3318	**0.4150**	0.2976	0.3110	0.3871
D-mannose	0.3026	0.3490	0.3574	0.3724	0.2824	0.3235
Succinate	0.2452	0.2542	0.3926	0.2830	0.2788	0.2820
G-Aminobutyrate	0.2440	0.2510	**0.4040**	0.3448	0.3690	0.2914

Absorbance cutoff = 0.4

Red absorbance values indicate carbon sources utilized most rapidly (absorbance values after 24-hrs exceed absorbance cutoff value). Increases in absorbance values indicate increases in microbial activity.

the increased emphasis on biological control strategies, studies with organic amendments, particularly horticultural and industrial waste materials, will undoubtedly increase. We have chosen to center our studies strictly on composted soil amendments since composted organic substrates provide a degree of uniformity and control not achievable with uncomposted soil amendments. Additionally, composted amendments are known to be biologically diverse, supporting some of the more intense biological interactions in nature. The well-documented disease-suppressive properties of composts provide an inexpensive and effective alternative to traditional chemical fungicide treatments.

Many of the properties of the composts chosen for this study are already known. The effects of mature and immature composted sludges, turkey litter compost, and yard waste compost on soil biological processes represent relative extremes in organic matter qualities, microbial activities, and disease-suppressive properties. These attributes facilitate our comparative studies on microbiological responses and, based on our preliminary results, are increasing our understanding of why composts differ in their suppressive properties. Furthermore, we feel that the results of this study will broaden the applicability of our research as well as increase our conceptual understanding of microbial interactions in turfgrass soils that impact turfgrass health. This understanding will be essential for the effective, consistent, management of disease-suppressive properties in these types of amendments.

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The well-documented disease-suppressive properties of composts provide an inexpensive and effective alternative to traditional chemical fungicide treatments.

Table 2. Metabolic profiles of microbial communities in compost-amended tall fescue/perennial ryegrass soils. (September samples, after three applications.)

Carbon Source	Untreated	Municipal Biosolids 95	Brewery Waste 94	Leaf 95	Poultry Litter	Brewery Waste 95
None	0.1204	0.1390	0.1455	0.1292	0.1388	0.1310
Bromosuccinate	0.3752	0.3403	0.3723	0.3864	0.3688	**0.4352**
L-histidine	0.3622	0.3887	0.3832	**0.4286**	0.3055	**0.4364**
B-methyl-d-glucoside	**0.4748**	**0.4340**	**0.4620**	0.3684	0.3208	**0.4312**
Hydroxy-L-proline	0.3740	0.3797	**0.4177**	0.3400	0.3653	**0.4430**
Inosine	**0.4062**	0.3973	0.3638	0.3242	0.3135	**0.4010**
Dextrin	**0.5974**	**0.5562**	**0.6307**	**0.4042**	**0.4153**	**0.5886**
Citrate	**0.4116**	**0.4158**	**0.5715**	**0.4400**	**0.4900**	**0.4922**
Glycogen	**0.5366**	**0.6205**	**0.6423**	0.3648	**0.4885**	**0.7084**
D-galactose	0.3974	**0.4522**	**0.4135**	0.3320	0.3110	**0.4146**
A-ketoglutarate	0.3406	0.3943	**0.4382**	0.3840	0.3953	**0.4368**
Tween-40	**0.5022**	**0.5328**	**0.5913**	**0.4474**	0.3853	**0.5850**
Tween-80	0.3756	**0.4110**	**0.4002**	**0.4048**	0.3400	0.3980
A-D-glucose	**0.5046**	**0.5227**	**0.5615**	**0.4222**	**0.4503**	**0.4596**
D-galacturonate	0.3452	0.3438	**0.4440**	0.3208	0.2925	**0.5672**
Putrescine	**0.4268**	0.3957	**0.4655**	**0.4270**	**0.4445**	**0.4844**
Sucrose	**0.4568**	**0.4262**	**0.4600**	**0.4610**	0.3683	**0.4540**
D-gluconate	0.3958	**0.5077**	**0.5145**	**0.4488**	**0.4650**	**0.5818**
N-acetylglucosamine	**0.4824**	**0.5195**	**0.4977**	0.3724	0.3583	**0.5766**
D-trehalose	**0.4110**	**0.4800**	0.3988	0.2956	0.3060	**0.4598**
L-asparagine	**0.5990**	**0.5853**	**0.6515**	**0.6446**	**0.4698**	**0.6614**
Quinate	**0.4740**	**0.5095**	**0.5760**	**0.5164**	**0.6195**	**0.6050**
L-aspartate	**0.5408**	**0.4312**	**0.5463**	**0.4320**	**0.4968**	**0.5332**
Maltose	**0.4244**	**0.4165**	**0.4193**	0.3380	0.3118	**0.4690**
D-saccharate	0.2902	0.3965	**0.4020**	**0.4004**	**0.4043**	**0.5338**
L-glutamate	**0.5106**	**0.5290**	**0.5262**	**0.5214**	**0.4653**	**0.6144**
Glucose-1-phosphate	**0.5318**	**0.5187**	**0.5603**	0.3966	0.3180	**0.6036**
Cellobiose	0.3380	**0.4162**	**0.4107**	0.3652	0.3335	**0.4616**
D-mannose	0.3746	**0.4007**	**0.4252**	0.3280	0.2988	0.3802
Succinate	0.3856	**0.4195**	**0.4047**	**0.4286**	0.3310	**0.5198**
G-aminobutyrate	**0.4046**	0.3807	0.3982	**0.4002**	0.3880	**0.4230**

Absorbance cutoff = 0.4
Red absorbance values indicate carbon sources utilized most rapidly (absorbance values after 24-hrs exceed absorbance cutoff value). Increases in absorbance values indicate increases in microbial activity.