A USGA-SPONSORED RESEARCH PROJECT

Biological Control of Diseases on Golf Course Turf

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ONE OF THE more exciting alternative strategies being developed for turfgrass disease management is the use of biological controls. Individual or mixtures of microorganisms are deployed to reduce the pathogens' activities or enhance the disease tolerance of plants. This approach to disease control has been used successfully on an experimental and commercial basis for the control of plant pathogens on several crop species, but only recently has it gained interest as an alternative pest management strategy for use on turf.

The microbiology of disease-suppressive composts has not been extensively studied. A USGA-funded study entitled "Microbial Basis of Disease Suppression in Composts Applied to Golf Course Turf" is currently being conducted at Cornell University. The goal of this project is to understand the microbiology of composts in order to predict disease-suppressive properties and assemble microbial antagonists useful as inoculants or biological fungicides for turfgrass disease control.

In addition to disease-causing microorganisms, turfgrass soils harbor a variety of non-pathogenic microorganisms that actually improve plant health. These soil bacteria and fungi are responsible for increasing the availability of plant nutrients, producing substances stimulatory to plant growth, and protecting plants against infection from diseases. The practice of biological control attempts to take advantage of these beneficial microbial attributes in order to minimize damage from plant pathogens. Biological control may be achieved either through the application of introduced microbial antagonists or through the manipulation of native antagonists present in soils, composts, or on plant parts. In either case, the goal is to reduce or eliminate pathogen activity by reducing pathogen inoculum in the soil, protecting plant surfaces from infection, or inducing natural defense mechanisms within the plant.

The Use of Composts for Biological Disease Control

Although few in-depth studies on the biological control of turfgrass diseases have been conducted, promising results have been obtained using complex mixtures of microorganisms and individual antagonists as tools for managing fungal diseases of golf course turf (Table 1). While individual organisms isolated from many different environments can be suitable for use as biological control agents, compost-based organic fertilizers are perhaps the best sources of complex mixtures of antagonistic microorganisms.

Composting has been defined as the biological decomposition of organic constituents in wastes under controlled conditions. Since composting relies exclusively on microorganisms to decompose the organic matter, the process has biological, as well as physical, limitations. During composting, the environmental parameters (i.e., moisture, temperature, and aeration) must be stringently controlled. This is necessary to maintain adequate rates of decomposition and to avoid the production of decomposition by-products that may be harmful to plant growth. In order to maintain proper temperatures, the composting mass must be large enough to be self-insulating, but not so large that compaction results in reduced air exchange. The composting mass must be moist enough to support microbial activity, but not so moist that air exchange is limited. The particle size

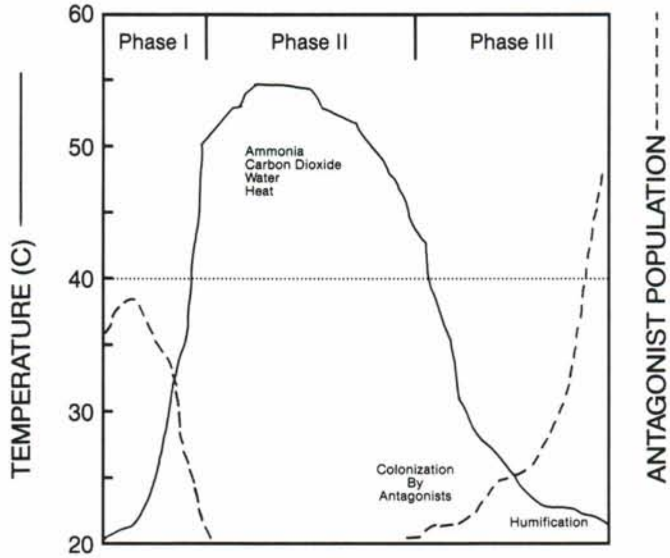


Figure 1. During Phase I of the composting process, initial heating takes place and readily soluble components are degraded. During Phase II, cellulose and hemicellulose are degraded under high temperature (thermophilic) conditions. This is accompanied by the release of water, carbon dioxide, ammonia and heat. Finally, during Phase III, curing and stabilization are accompanied by a drop in temperatures and increased humification of the material. Recolonization of the compost by mesophilic microorganisms occurs during Phase III. Included in these microbial communities are populations of antagonists.

Table 1. Known Examples of Turfgrass Disease Biological Control

Disease *(pathogen)*	Antagonists	Location
Brown Patch *(Rhizoctonia solani)*	*Rhizoctonia* spp.	Ontario, Canada
	Laetisaria spp.	N. Carolina
	Complex mixtures	New York, Maryland
Dollar Spot *(Sclerotinia homeocarpa)*	*Enterobacter cloacae*	New York
	Fusarium heterosporum	Ontario, Canada
	Gliocladium virens	South Carolina
	Complex mixtures	New York
Pythium Blight *(Pythium aphanidermatum)*	*Pseudomonas* spp.	Illinois, Ohio
	Trichoderma spp.	Ohio
	Trichoderma hamatum	Colorado
	Enterobacter cloacae	New York
	Various bacteria	New York, Pennsylvania
	Complex mixtures	Pennsylvania
Pythium Root Rot *(Pythium graminicola)*	*Enterobacter cloacae*	New York
	Complex mixtures	New York
Red Thread *(Laetisaria fuciformis)*	Complex mixtures	New York
Southern Blight *(Sclerotium rolfsii)*	*Trichoderma harzianum*	N. Carolina
Take-All Patch *(Gaeumannomyces graminis var. avenae)*	*Pseudomonas* spp.	Colorado
	Gaeumannomyces spp.	Australia
	Phialophora radicicola	Australia
	Complex mixtures	Australia
Typhula Blight *(Typhula spp.)*	*Typhula phacorrhiza*	Ontario, Canada
	Trichoderma spp.	Massachusetts
	Complex mixtures	New York

Table 2. Turfgrass Diseases for which Composts have been Suppressive

Disease *(pathogen)*	Mode of Application	Turfgrasses
Brown Patch *(Rhizoctonia solani)*	Topdressings	Creeping Bentgrass/ Annual Bluegrass
Dollar Spot *(Sclerotinia homoeocarpa)*	Topdressings	Creeping Bentgrass/ Annual Bluegrass
Necrotic Ringspot *(Leptosphaeria korrae)*	Topdressings	Kentucky Bluegrass
Pythium Blight *(Pythium aphanidermatum)*	Topdressings[1]	Perennial Ryegrass
Pythium Root Rot *(Pythium graminicola)*	Topdressings and heavy fall applications	Creeping Bentgrass/ Annual Bluegrass
Red Thread *(Laetisaria fuciformis)*	Topdressings	Perennial Ryegrass
Summer Patch *(Magneporthe poae)*	Topdressings	Kentucky Bluegrass
Typhula Blight *(Typhula spp.)*	Heavy fall applications[2]	Creeping Bentgrass/ Annual Bluegrass

[1]Applied at the rate of approximately 10 pounds per 1,000 square feet

[2]Applied at the rate of approximately 200 pounds per 1,000 square feet

of the material must be small enough to provide proper insulation, but not so small that it limits air exchange.

When all of the environmental and physical conditions are optimized, composting should proceed through three distinct phases (Figure 1) involving (1) a rapid rise in temperature, (2) a prolonged high-temperature decomposition phase, and (3) a curing phase where temperatures and decomposition rate decrease. These three phases of decomposition are accompanied by successions of both mesophilic (moderate-temperature) and thermophilic (high-temperature) microflora. Each of these microbial communities makes an important contribution to the nature of the composted material. Failure to maintain environmental conditions favorable for adequate microbial activity could jeopardize the quality of the final product.

In general, the longer the curing period, the more diverse the colonizing mesophilic microflora. These microflora are the most important in suppressing turfgrass diseases. At the present time, unfortunately, there is no reliable way to predict the disease-suppressive properties of composts, since the nature of these colonizing microbial antagonists is left to chance and determined largely by the microflora present at the composting site.

Applications of composted material can suppress turfgrass diseases (Table 2). Monthly applications of topdressing containing as little as 10 pounds of suppressive compost per 1,000 square feet were effective in suppressing diseases such as dollar spot, brown patch, *Pythium* root rot, *Typhula* blight, and red thread. Reductions in severity of *Pythium* blight, summer patch, and necrotic ringspot also have been observed in sites receiving periodic applications of composts. Of particular benefit is the impact of long-term compost applications on root-rotting pathogens in soil. Populations of soil-borne *Pythium* species are generally not suppressed following traditional chemical fungicide applications, but can be reduced on putting greens receiving continuous compost applications in the absence of any chemical fungicide applications. Also, heavy applications of compost (approximately 200 pounds per 1,000 square feet) to putting greens in late fall are effective not only in suppressing winter diseases, such as *Typhula* blight, but also in protecting putting surfaces from winter ice and freezing damage.

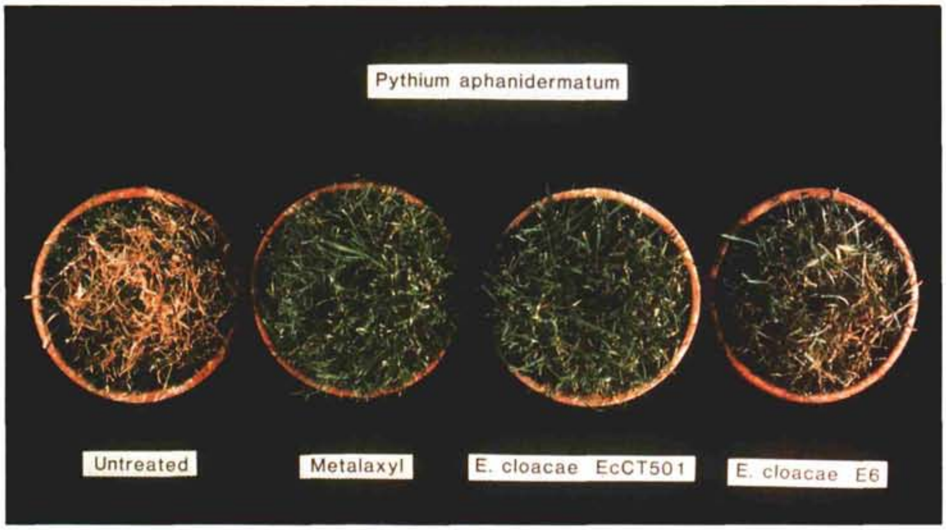
(Left) Figure 2. Field research plots immediately after applying topdressings amended with various composts and organic fertilizers.

Biological suppression of dollar spot on a creeping bentgrass/annual bluegrass putting green 32 days after application of selected composts and organic fertilizers. (Left photo) The plot on the left was untreated, while the one on the right was treated with approximately 10 pounds per 1,000 square feet of an organic fertilizer. (Right photo) The plot on the bottom was left untreated, while the one on the top was treated with a poultry litter/cow manure compost mixture at the rate of approximately 10 pounds per 1,000 square feet.

Composts prepared from different starting materials, as well as those at different stages of decomposition, vary in the level of disease-suppression and in the spectrum of diseases that are controlled. This is primarily a result of the microbial variability among different composts and differences in the quality of organic matter present in a compost at various stages of decomposition. Although microbial activity is necessary for disease-suppressive properties to be expressed in most composts, the specific nature of disease suppressiveness is, in general, unknown.

In our research, several aspects of the ecology of key compost-inhabiting antagonists are being investigated. For example, the ability of microbial antagonists to establish and survive in turfgrass ecosystems is necessary for biological control to occur. The interactions of antagonists with other soil organisms, and the soil or plant factors affecting optimum biological control activity, will be important in developing strategies with compost-based materials. In addition, these organisms may serve as indicators of how long to compost a material before it can be certified to be disease-suppressive. Research aimed at understanding the fate of antagonistic organisms in soils and on plants following compost applications will aid in understanding why composts fail at certain times and locations. This research also should help predict the compatibility of composts and their resident antagonists with other pesticides and cultural practices commonly used in turf management.

Individual microbial antagonists found in soils, composts, or in association with plants can, in many cases, suppress disease at levels typically achieved with composts or from use of fungicides (Figure 4). Due to the extremely close link between their function and performance, however, one cannot readily predict antagonistic



Effect of various strains of Enterobacter cloacae *and the fungicide metalaxyl on the suppression of* Pythium *blight of perennial ryegrass in growth chamber experiments. Disease severity was rated on a scale of 1 to 5, for which 1 equals no foliar blight and 5 equals 100 percent foliar blight. A — Nontreated; B — Drenched with metalaxyl (750 μg a.i./ml); C — Treated with* E. cloacae *strain EcCT-501; and D — Treated with* E. cloacae strain E6. (From Nelson & Craft, 1991).

behavior without an understanding of the microbial traits important in pathogen or disease suppression. It also follows that the performance of antagonists could be effectively enhanced if their function was clearly understood.

The traits necessary for an antagonist to suppress turfgrass disease are unknown; however, a number of traits are currently being investigated. For example, these traits include the ability of antagonists to produce fungicidal compounds or compounds that make nutrients unavailable to pathogens. Other traits include the ability of antagonists to parasitize pathogens, colonize plant parts, and compete with pathogens for resources in soil and on plants.

The use of topdressing materials amended with disease-suppressive composts or organic fertilizers has received some acceptance by turfgrass managers as an attractive disease-control alternative. Many composted materials and organic fertilizers are commercially available from distributors or municipal waste treatment facilities. Preliminary research has shown that use of composts and organic fertilizers for turfgrass disease control is economically and technologically practical and, in some instances, can provide reasonable levels of disease control. In the few cases that have been examined with some of these materials, a reduction in fungicide use has accompanied the adoption of this biological control strategy.

Before disease-suppressive composts become widely accepted and used for disease control, the principal problem of a compost not being consistently suppressive from year to year, batch to batch, or from one site to the next must be solved. Turfgrass managers and compost producers agree that the future success of these materials in commercial turfgrass management depends upon the ability of producers to provide materials with predictable levels of disease control. Gross variation in disease-suppressive qualities of composts cannot be tolerated because end-users need to be assured that every batch of compost used specifically for disease control will work every time.

Unfortunately, we do not yet know how to predict the suppressive activity of certain composts without actually testing them in field situations. A number of tests have been developed to determine compost maturity and degree of stabilization for the purpose of reducing the variability in physical and chemical properties. Very little of the research, however, has been designed to directly assess microbiological aspects of maturity and disease suppressiveness. Currently, predictive tests based on levels of microbial activity and organic matter quality are being explored through this research project as potential tools for predicting composts' disease-suppressive properties.

Back to the Basics for Golf and the Environment

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LOOKING ahead into this decade of environmental concerns, it is a distinct possibility that superintendents throughout the country will experience restrictions in the application or availability of pesticides. To prepare for these future reductions, there is a need to search for alternatives to make grasses healthier and less chemically dependent. The successful superintendent in the 1990s will be one who is able to combine proven agronomic practices of the past with some of today's technology. A "back to basics" approach will help you meet the environmental challenges at your doorstep.

Three of the most important factors in maintaining healthy turf are proper nutrition, reasonable cutting heights, and regular aeration. In order to prepare a fertilization program, the soil from a portion of the greens, tees, and fairways should be tested annually. For best results, it is preferable to continue with the same testing laboratory to achieve a consistent evaluation year after year.

When test results are received, they should be examined closely and compared to the previous year's analysis. Adjustments can then be made to provide optimum growing conditions for the turf. In particular, potassium and phosphorous levels should be closely monitored. Soil potassium can be depleted due to rapid uptake by the turf as well as its tendency to be leached through the soil profile. This results in