Biostimulant Effects on the Microbial Community and Turfgrass Quality of a Sand Putting Green

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INTRODUCTION

Golf course superintendents are constantly being exposed to the idea that the quality of sand putting greens suffers for lack of soil microbial activity that can readily be corrected with applications of a wide array of commercial products commonly referred to as biostimulants. Some of these products contain soil microorganisms, while others claim that their products constituents stimulate native microbe activity. The purposes of this research were to characterize the microbial community in a putting green, to observe how a select group of biostimulants affect that community, and to determine if and how the characteristics of the soil microbial community relate to the quality of the bentgrass on the putting green.

Soil ecologists maintain that a "healthy" soil is one that sustains a large, very active, and diverse population of microorganisms. Through their metabolic processes, the microbes convert plant nutrients from organic to inorganic forms, produce organic polymers that stabilize soil structure, possibly excrete hormones that stimulate plant growth, and regulate plant root pathogen populations. The presumed result is healthy, vigorous plant growth.

Researchers are faced with a daunting challenge when it comes to characterization of soil microbial communities. Merely counting microbe numbers via classical techniques provides very little useful information. Not only are the numbers obtained grossly inaccurate, but no one knows what constitutes an optimal population for plant growth.

In the present research, the microbial community of a sand putting green was characterized in three ways bi-weekly levels of activity as indicated by assays for four enzymes produced by microorganisms and monthly measures of the range of organic substances the microbes are able to employ as energy sources and the diversity of the microbe population. Repeated measures over time revealed the dynamic nature of the microbial community.

The site for the study was a 3-year-old putting green constructed at the O.J. Noer Turfgrass Research and Education Facility according to USGA standards. Five commercial biostimulants (Table 1) were applied bi-weekly to replicated plots at rates recommended by the manufacturers. The biostimulant applications were in addition to bi-weekly applications of 0.25 lb N/M in the form of Isotek 18-3-16 fertilizer. The control treatment in the study received just the fertilizer.

Soil samples were collected every 2 weeks for characterizations of the microbial community. At the same time, the SR1119 creeping bentgrass on the putting green was visually rated for color, stand uniformity, and the degree of development of localized dry spot (LDS).

OBSERVATIONS

Over the season, 720 assays were conducted for each of four soil enzymes associated with the microbial decomposition of a range of organic compounds. The concentrations of these enzymes provided an index of the level of soil microbial activity.

Data in Table 2 illustrate what was observed with respect to biostimulant effects on soil microbial activity. The data indicate two things: First is that the bios-

Table 1. Biostimulants tested.

Product name	Manufacturer	Major components
Experimental A	Ocean Organics	Seaweed extract & dextrose
Experimental B	Ocean Organics	Seaweed extract & dextrose
Flexx-Plus	Plant Health Care, Inc.	Micronutrients, bacteria, yucca extract
Colonize T&O	Plant Health Care, Inc.	Mycorrhizae inoculum
Raiz-Mor	Jay-Mar, Inc.	Seaweed, plant extracts & surfactant

timulants had only minimal and inconsistent influences on microbial activity; second is the fact that microbial activity declined noticeably as the season progressed.

Biolog plates were used to characterize the soil microbial community in terms of the range of organic compounds it was capable of using as energy sources. This provides information on what is known as the "functional" or "metabolic" diversity of the community. Since different microorganisms decompose different types of organic compounds, knowing how many different compounds the microbial community can decompose also indicates something about the diversity of the kinds of microorganisms in the community.

The Biolog plates contain 95 organic compounds ranging from simple sugars to complex polymers. Color changes in the plates indicate which compounds were degraded and at what rate. Over 37,000 color readings were taken and analyzed using three techniques commonly employed by soil microbial ecologists. The results of the Biolog assays indicated that (1) the metabolic diversity of the microbial community in the sand putting green was no different than that reported for natural soils in agricultural fields; (2) the metabolic diversity of the putting green declined as the season progressed; and (3) the biostimulants applied had essentially no effect on the metabolic diversity of the microbe community.

The third and final technique used to characterize the microbe community was phospholipid fatty acid

Table 2. Biostimulant effects on soil enzyme concentrations on four sampling dates.

Biostimulant	Enzyme concentration 5 June	10 July	1 Aug.	12 Sept.	Full-season mean
	$\mu mol\ g^{-1} soil\ 24\ hr^{-1}$				
Experimental A	5.65	5.25	3.43	4.14	4.31
Experimental B	6.41	6.21	4.71	3.78	4.57
Flexx-Plus	6.51	4.92	4.55	3.44	4.50
Colonize T&O	5.93	4.96	3.86	3.56	4.46
Raiz-Mor	5.80	5.99	3.46	3.78	4.36
None (control)	5.84	5.61	3.49	3.36	4.40

Table 3. Biostimulant influences on visual estimates of putting green quality.

Biostimulant	Means of visual ratings: Color	Uniformity	LDS†	Frequency of quality improvement
				% time
Experimental A	6.68‡	7.45	7.92‡	41
Experimental B	6.67‡	7.50	8.09‡	44
Flexx-Plus	6.62‡	7.51	7.84‡	37
Colonize T&O	6.47	7.25	7.52	11
Raiz-Mor	6.66‡	7.58‡	8.25‡	55
None (control)	6.35	6.87	7.12	--

† LDS, localized dry spot.

‡ Significantly better than the control treatment.

(PLFA) analysis. This technique is based on the fact that the kinds of fatty acids in soil microbe cell membranes are unique to different organisms or groups of microorganisms. This allows for characterization of microbial population diversity.

Due to several technical difficulties, the PLFA did not provide as comprehensive a set of information as anticipated. The data collected did indicate that the numbers and kinds of microorganisms in the putting green were stable over time and were not influenced by biostimulant application.

The influences of the biostimulants on putting green quality are summarized in Table 3. These data show that statistically significant effects were never great, were inconsistent for the majority of the biostimulants, and significant responses occurred only 11 to 55% of the time. Furthermore, virtually all of the significant effects on putting green quality were observed during the first half of the growing season.

When the improvements in turfgrass quality were examined in relation to soil microbial community activity, functional diversity and population diversity, the results were inconclusive. As an example, enhancement of turfgrass color by the biostimulants was significantly and positively related to concentrations of one of the four enzymes assayed, but negatively related to concentration of the other three enzymes. There were no notable relationships between the turfgrass quality ratings and the microbial community functional or population diversity.

The early season improvements in turfgrass color suggest that the biostimulants influenced biocycling or plant uptake of N, or both. Analysis of bentgrass clippings collected on 19 June did, in fact, reveal higher tissue N concentrations when the biostimulants were applied. Clippings collected later in the season indicated no influence on the N status of the turfgrass. At no time did clipping concentrations of the other essential nutrients vary significantly among the six treatments and all nutrient concentrations were well within their sufficiency ranges.

CONCLUSIONS

Enzyme concentrations measured in the putting green were considerably lower than those reported for natural soils in agroecosystems treated with large doses of organic materials such as manure or compost. These observations provide evidence that sand putting green microbial activity is relatively low and the most likely reason is severe limitations in the supply of organic substrates that serve as energy sources for the microorganisms.

As the season progressed, microbial activity and functional diversity consistently decreased. Our explanation for this derives from the speculation that in this relatively immature putting green where organic matter levels have yet to stabilize, the primary energy sources for the microorganisms are dead root tissues and root exudates. Coupling this idea with the well-documented fact that when bentgrass is subjected to heat stress in mid- to late- summer, net photosynthate declines and partitioning of this dwindling carbohydrate supply to roots also declines. The net result, then, could well be paralleling reductions in the amounts of root exudates that constitute the major energy source for soil microorganisms. We believe that this accounts for the declines seen in microbe activity as indicated by the enzyme assays.

With this scenario, explanations arise for the failure of the biostimulants applied to have greater and more consistent influences on turfgrass quality and the microbial community. In essence, the biostimulants simply do not provide sufficient amounts of carbon substrates to significantly alter the naturally existing microbe activity limiting supply of substrates in the putting green. With carbon substrate supply being so limiting regarding microbial activity, it is little wonder that adding more microorganisms via the biostimulants had little to no impact on soil microbial activity or functional diversity.

Clearly, there is a great deal yet to be learned about the microbe community in sand putting greens. Until we have a much better understanding of what controls microbe community activity and diversity and how these vary with putting green composition and age, we have no basis for predicting when application of a biostimulant stands a reasonable chance of having a significant influence on putting green quality.

This article is abstracted from Sabrina Mueller's Master's degree research. She completed her M.S. degree in Soil Science in August 2001 and is now working on a Ph.D. in Environmental Biology at the University of Cincinnati.

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