Environmental Institute for Golf

The Environmental Institute for Golf provided part of the funding for this research.

Effects of microbial and organic products on putting green performance

Although the effectiveness of microbial and organic treatments is not substantially different from that of traditional fertilizer programs, some important qualifications are in order.

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WEB exclusive:

Several tables that provide additional data resulting from Frank Rossi's research on microbial and organic products for turf are available as this month's ***GCM*** **Web exclusive** on GCSAA's Web site at www.gcsaa.org\gcm. These tables are referenced in the magazine article but are labeled with the letters from A to R to distinguish them from the tables published in the magazine article.

Photos courtesy of F. Rossi

Figure 1. The study area was a sand-based California green located at Cornell's Turfgrass and Landscape Research Center in Ithaca, N.Y.

Pressure on superintendents to provide fast greens, reduce pesticide use and improve stress tolerance requires precise management regimes, which often substantially increase turfgrass stress. To compensate for the increased stress on turf, many superintendents have turned to organic, microbial and nutritional products.

Organic and microbial products — sometimes referred to as biostimulants, biological control products, etc. — are a burgeoning sector of the turfgrass industry, but advances in this market have outpaced researchers' ability to properly evaluate the agronomic contributions of these products. A few studies have found small benefits from using specific organic products such as humates (1) and cytokinins (4) under controlled laboratory conditions, but field studies with similar products have shown limited benefits (6).

Microbial inoculants used for biological control of fungal disease have shown promise in field studies (5). However, these products are rarely evaluated in integrated management programs and often fail when disease pressure is high. Therefore, studies that investigate integrated organic, microbial and nutritional programs under field conditions are needed.

The objective of this study is to critically evaluate the response of putting green turf to microbial and organic products compared to traditional nutrient sources and management.

Methodology

Product applications

Products from a variety of companies were applied in a programmatic fashion and compared to a traditional nutrient management

PROGRAMS AND PRODUCTS, 2003-2005

Program	Products
Traditional fertilizer program	urea or ammonium sulfate monoammonium phosphate potassium sulfate iron sulfate
Novozymes program + traditional fertilizer	EcoGuard Turf Vigor Agriplex KCS
Helena programs	Coron Renova N-Turf 0-28-26 Saponyn
Plant Food programs	Green-T Micro Mix AdamsEarth Sugar Cal Flo Thru 28-0-0 MKP
Nutramax programs + traditional fertilizer	Macro-Sorb foliar Quelant-Ca Quelant-Minors 18-3-4 + amino acids
Grigg Bros. programs	Gary's Green Sili-Kal B Tuff Turf Ultraplex
Emerald Isle programs	SeaBlend 12-4-5 19-1-6 3-0-10 2-0-16 4-0-1 16-12-6
Suståne program	10-2-10 Bolster Bio Grounds Keeper
Floratine programs	Knife Carbon N Astron Renaissance Perk-Up PK Fight ProteSyn Turgor Oxyflor Pervade Phlex-Man TriCal-35 Sp Floradox Pro Maxiplex

Table 1. Cooperating manufacturers' programs and products, 2003-2005.

program from 2003 through 2005. The traditional nutrient program consisted of a total of 3.5 pounds nitrogen, 1.5 pounds phosphorus, 3 pounds potassium and 2 pounds iron sulfate/1,000 square feet/year (17.1 grams nitrogen, 7.3 grams phosphorus, 14.6 grams potassium and 1.2 grams iron sulfate/square meter/year). Nitrogen, phosphorus, potassium and iron sulfate were applied every seven to 10 days. We requested programmatic approaches from cooperating companies that often included a variety of products applied at different rates and frequencies (Table 1). Specific annual treatment programs and nutrient rates may have been altered over the study, but most treatment programs were applied to the same plots for three years. (Details of the treatment programs are shown in Tables A-D on the Internet at www.gcsaa.org.)

Treatments were replicated four times and arranged in a completely randomized design on a mixed stand of Penn G-2 creeping bentgrass (*Agrostis palustris*) and annual bluegrass (*Poa annua*). The treatment area was growing on a sand-based California green with a pH of 8.2 (Figure 1).

Applications were made from June through September from 2003 through 2005 with a hand-held CO_2 sprayer fitted with TeeJet XR8015 nozzles calibrated to deliver either 2 gallons or 1 gallon of water per 1,000 square feet (81.5 or 40.7 milliliters/square meter) at 40 pounds/square inch (276 kilopascals).

Plot maintenance

Plots were maintained to championship conditions, including mowing seven days a week at 0.100 inch (2.5 millimeters) with a Toro Flex 21 fitted with a grooved roller. Supplemental irrigation was applied as needed to maintain a championship-quality putting surface.

Light frequent sand topdressing was applied every two to three weeks depending on growth and performance. Pest management was conducted on a curative basis depending on incidence and severity. For example, if several plots were at very high levels of disease, then the entire area was treated curatively after data were collected.

Golf traffic was simulated daily during the season using a modified traffic device with two rollers, each 0.5-meter (about 19.7 inches) in diameter, that spin at different speeds to create slipping. The rollers were fitted with Softspikes cleats. The number of spikes and passes used were designed to simulate 30,000 rounds of golf.

Weather

In 2003, average daily temperatures from June through September ranged from a low of 57 F (14 C) to a high of 80 F (27 C). During this period, temperatures averaged 3.0 F (1.6 C) warmer than normal, among the top 10 warmest such periods on record. Precipitation was below normal: 22% of normal for July, 50% for August and 40% for September.

During the 15 weeks of the study (June through September) 2004, precipitation was nearly twice normal, approximately 20.3 inches (51.5 centimeters). Therefore, no supplemental irrigation was applied. Average daily temperatures ranged from a low of 55.8 F (13 C) to a high of 76.3 F (24 C).

In 2005, average daily temperatures from June through September ranged from a low of 60 F (13 C) to a high of 84 F (24 C). During this period, temperatures averaged 4.2 F (2.3 C) warmer than normal, again, among the warmest such periods on record. Precipitation was below normal: 38% of normal for July, 83% for August and 55% for September. Supplemental irrigation was applied as needed.

Figure 2. A greener turf color is sometimes associated with higher rates of nitrogen or iron.

Product analysis

Products were sampled in 2003 and analyzed by the Cornell University Analytical Laboratory to determine accurate product mineral ingredients. Some of the sampled products are no longer available or their labels have been changed. The products were analyzed according to the Infant Formula Protocol (2).

Processing products for analysis with the Infant Formula Protocol is more sensitive than would be required for standard product labeling mandated by law. As a result, in many cases, we found significantly more nutrients than the manufacturers have reported. However, with this process, it is not possible to assess the level of available nutrients or additional chelating agents such as amino acids, humates, carbohydrates, etc.

The product analysis results revealed the variety and levels of nutrients found in the products. (Data are available online in Tables E-H.) The nitrogen levels are mostly consistent with those reported by manufacturers. However, the levels reported in this study are significantly different from those on current product labels.

Potassium, iron and calcium tended to be exceedingly high in many products, most likely because of the benefits these nutrients are reported to afford for color and stress tolerance (Figure 2). Of particular concern are several products with very high levels of sodium. Several of these products are produced from ocean-derived materials such as seaweed and fish waste.

Data collection and analysis

Data were collected for turfgrass quality, rooting, clipping production, tissue nutrient content, ball roll distance, algae infestation, anthracnose activity and soil nutrient levels.

Data analysis was conducted to assess overall treatment effects when repeated measurements were made on the same experimental unit over time. Treatment differences at individual measurement dates were evaluated.

Results and discussion

Turf quality

There were stark differences in growing seasons during the three-year study, with 2003 and 2005 having above-normal temperatures and below-normal rainfall and 2004 having twice the normal rainfall. Although these variable environmental conditions made combining the data over the three years difficult, there are some key trends.

In general, most treatments provided turf of acceptable quality during the study. Turf quality was highest for all treatments in 2003 and lowest in 2005. The 2003 season was warm but not unusually dry, whereas 2005 had record warm temperatures and record dry weather in Ithaca. In spite of adequate irrigation, the high evening temperatures in 2005 produced intense environmental stress that resulted in many treatments providing less than acceptable quality for 25% of the season. (For turf quality data, see Tables I-K online.)

A closer look at treatment performance by year reveals a consistent relationship between nitrogen level and turfgrass quality. However, higher nitrogen treatments did not always provide the highest turf quality. The traditional fertilizer + EcoGuard treatment provided higher turfgrass quality than the traditional fertilizer alone on almost 50% of the rating dates over three years (Table 2). In 2003, the Plant Food, Grigg and Soil Life treatments provided higher turfgrass quality ratings than the traditional fertilizer on more than 50% of the rating dates.

The 2004 and 2005 seasons showed a downward trend in turfgrass quality for all treatments. In fact, the traditional fertilizer treatment (average rating of 7.3) had significantly higher turf quality ratings than most of the other treatments when averaged across all dates. The only exception was for the Emerald Isle treatment, which had an average rating of 6.9.

Did organic and microbial products perform better than traditional fertilizer nutrients supplied as unformulated salts? Overall, the answer was a clear "it depends." The variable environmental conditions during the study demonstrate the variable performance of many of these programs. However, the traditional fertilizer treatment rarely (one rating date in three years) provided unacceptable quality ratings over three years.

Growth

Clipping production and root growth are used as quantitative measures of plant growth and vigor. In 2003 and 2004, there were few to no significant differences among treatments. However, in 2005, there were clear differences in clipping production. The Emerald Isle and EcoGuard treatments produced 50% to 100% more clippings than the traditional fertilizer treatment as well as most of the other treatments. (The 2005 dry weight clipping production is in Table L online.) These treatments also provided as much as 25% more nitrogen.

Certainly, clipping collection can be prone to experimental error. However, for all three years, the largest clipping amounts were not always associated with the highest nitrogen rate. For example, in 2004, the Floratine + traditional fertility treatment supplied more than 5 pounds (2.3 kilograms) of nitrogen and the Grigg program supplied 4 pounds (1.8 kilograms), yet neither produced clippings significantly different from the 2004 Emerald Isle treatments, which had 20% of the nitrogen supplied in the traditional treatment or around 1 pound (0.5 kilogram).

There were few significant differences among the treatments for root growth over the three years of the study. There also did not appear to be a statistical relationship between nitrogen rate and rooting. The absence of a consistent nitrogen effect conflicts with claims made that many products enhance rooting. (The 2005 root weight data are online in Table M.)

Ball roll

During the 2003-2005 trials, ball roll distances were measured four hours after mowing once each week for 10 weeks. The most consistent effect between years was the lack of significant differences for ball roll distance as a result of treatments. Ball roll distances were significantly greater in 2004 than in 2005 and 2003. (The 2004 and 2005 data are available online in Tables N and O.)

In 2004, except on July 29, there were no significant differences in ball roll distance among the treatments. Averaged across all rating dates in 2003 and 2004, no significant differences were evident. However, in 2005, significant differences among treatments were found on seven of the 10 rating dates. When averaged across all rating dates in 2005, the differences were caused primarily by the lower ball roll distances for EcoGuard and Emerald Isle, which had the highest nitrogen rates (average distance of 9.7 feet for both).

Green speed, as measured by ball roll distance, is an important functional aspect of putting green management. Previous research on fertility and ball roll has suggested the "4-inch rule" (7), which states that green speed is reduced 4 inches for every 1-pound (0.45-kilogram) increase in nitrogen. More than 24 studies have supported this theory, but this study does not. For example, in 2003 and 2004, the half-rate traditional fertilizer + Nutramax program supplied less than half the amount of nitrogen of most of the other treatments, yet ball roll distances were not significantly different and did not adhere to the 4-inch rule.

Disease

No disease pressure was observed in 2003 in spite of the warm and wet season and little pressure in 2005. However, 2004 was marked with substantial pest problems, notably anthracnose and significant algae infestation. (Data for treatment effects on algae and anthracnose are available online in Tables P, Q and R.)

Anthracnose infestation in 2004 was initially high on Emerald Isle treatments, which had lower nitrogen rates, and, to a lesser extent, on the traditional + Trichoderma treatment and the Helena I program. However, by mid-July, infestation levels were substantial for all treatments except the Traditional + EcoGuard treatment.

By mid-August, most treatments had little to no infestation except for the Emerald Isle programs, Trichoderma and Sustâne.

% TURF QUALITY RATINGS > OR < TRADITIONAL FERTILIZER RATINGS

Treatment	2003		2004		2005	
	Greater than	Less than	Greater than	Less than	Greater than	Less than
Traditional + EcoGuard	77	0	50	0	12	12
Plant Food	62	0	8	0	0	12
Grigg	54	0	0	0	0	25
Emerald Isle	0	0	0	10	0	
Traditional + Soil Life	77	0	0	0	0	
Helena	0	0	0	0	0	38
Sustâne	0	0	0	8	0	25

Table 2. Percentage of turfgrass quality ratings for treatments greater than or less than turfgrass quality ratings for traditional fertilizer.

Anthracnose infestation was not strongly correlated with nitrogen rate in 2004. This conflicts with recent research at Rutgers University suggesting increased nitrogen rates reduce anthracnose (3). However, the nitrogen rates used in this study were higher than those used in the Rutgers work.

One significant anthracnose outbreak occurred in 2005. The traditional treatment as well as the EcoGuard, Grigg, Emerald Isle and Helena treatments had significantly lower levels of anthracnose when compared with other treatments. There does not appear to be any consistent aspect of these treatments that would explain this response.

Summary

The results of three years of evaluation of organic and microbial products (also known as biostimulants) have offered insight into various aspects of product performance. In general, the results of this study show that the performance of most of these products is not consistently or substantially different from traditional fertilizer applications.

However, a few product lines appear to offer nitrogen use reductions. Yet, in years of high disease pressure, some of these treatments break down and allow increased disease levels.

Much more needs to be to learned about these products and programs. This study has shown that, although there are some differences, in general, traditional fertilizer applications provide acceptable putting green turf. Nonetheless, where resources allow, there might be circumstances in which incorporating certain products and programs would be beneficial.

THE RESEARCH says . . .

- **The traditional fertilizer** treatment provided only one unacceptable turf quality rating over three years and produced significantly higher quality ratings than all but one of the other treatments in 2004 and 2005.
- **In general, most** of the organic and microbial products did not consistently perform substantially better than the traditional fertilizer applications.
- **However, simple nutritional** aspects cannot explain the few differences in quality, growth and performance that resulted from using some of the products tested.
- **More research needs** to be done on microbial and organic turf products.

Funding

The Environmental Institute for Golf, TriState Turfgrass Research Foundation, Adirondack GCSA and New York State Turfgrass Association provided funding for this research.

Acknowledgments

I would like to acknowledge the cooperation of the companies who make the products tested in this research for making this project a success.

Literature cited

1. Cooper, R.J., C. Liu and D.S. Fisher. 1998. Influence of humic substances on rooting and nutrient content of creeping bentgrass. *Crop Science* 38(6):1639-1644.
2. Hilrich, K., ed. 1990. Official methods of analysis. Association of Official Analytical Chemists. Washington, D.C., p. 1106-1107.
3. Inguagiato, J.C., J.A. Murphy, B.S. Park, T.J. Lawson and B.B. Clarke. 2005. Anthracnose on annual bluegrass affected by nitrogen, plant growth regulators, and verticutting. p. 26-27. *In:* D. Giménez and B. Fitzgerald, eds. Proceedings of the 14th annual Rutgers Turfgrass Symposium, New Brunswick, N.J. Jan. 13-14, 2005. Cook College, Rutgers, The State University of New Jersey, New Brunswick, N.J.
4. Liu, X., and B. Huang. 2002. Cytokinin effects on creeping bentgrass response to heat stress: II. Leaf senescence and antioxidant metabolism. *Crop Science* 42(2):466-472.
5. Lo, C.T., E.B. Nelson and G. E. Harman. 1997. Improved biocontrol efficacy of *Trichoderma harzianum* 1295- 22 for foliar phases of turf diseases by use of spray applications. *Plant Disease* 81(10):1132-1138.
6. Schmidt, R.E., E.H. Ervin and X. Zhang. 2003. Questions and answers about biostimulants: Superintendents are often in the dark about the best ways to use biostimulants and what types of results to expect. *Golf Course Management* 71(6):91-94.
7. Throssell, C.S. 1981. Management factors affecting putting green speed. M.S. thesis. Pennsylvania State University, University Park.

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