Terms to know

INSECTICIDE - a chemical or other substance which is designed to kill, or otherwise control, insects.

LARVA - an immature stage of an insect which undergoes complete metamorphosis (change).

LEACHING - the vertical movement of water (or a pesticide or fertilizer dissolved in the water) through the soil profile, ultimately to ground water.

PESTICIDE - a general term referring to a chemical or other substance which is designed to kill, or otherwise control, a pest (which might be an insect, a fungus, a rodent, a weed, or a number of other organisms).

pH - a measure of the degree of acidity or alkalinity in a solution. Neutral is defined to have a pH of 7.0, while acid materials have a pH less than 7.0 and alkaline (basic) materials have a pH of more than 7.0. The more a number varies from 7.0, the more acid (or alkaline) the material is.

RUN-OFF - the horizontal movement of water (or a pesticide or fertilizer dissolved in the water), ultimately to surface water or to an area where the water begins to leach (see above).

WHITE GRUB - The larval form of several turf insect pests common in many parts of the country, the immature stage (grub) of which is cream-colored and C-shaped and feeds on roots of several turfgrasses.

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Integrated Disease Control at North Shore Country Club

by Peter L. McCormick
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While some may "talk the talk" or simply take a "wait and see" position toward biological disease control, Dan Dinelli has forged ahead with a comprehensive integrated turf disease control program in place now at North Shore Country Club in Glenview, IL.

Dinelli is taking advantage of two new products on the market as the cornerstones of his biological disease control strategy: the BioJect® system for culturing and applying *Pseudomonas aureofaceans* bacteria through his irrigation system, and Bio-Trek 22G®, a newly-registered biological fungicide that incorporates a dormant beneficial fungus (Trichoderma harzianum) in granular form. Dinelli's goal is broad spectrum natural disease suppression, thereby reducing his reliance on synthetic fungicide applications to keep turf diseases in check. His target is a 40% reduction in fungicide usage on the tees and fairways at North Shore.

The BioJect® system (from EcoSoil Systems, Inc. of San Diego, CA) was installed at North Shore Country Club early in 1995. It includes a 175 gallon bioreactor, which is a fermentation tank in which a special strain of *Pseudomonas aureofaceans* bacteria (developed by Dr. Joe Vargas at Michigan State University) is fed with simple sugars under controlled conditions so it multiplies rapidly. The bacteria slurry is then injected into the irrigation system while watering at night. When depleted, new food source material is injected into the bioreactor as it refills with water, and the *Pseudomonas* culture replenishes itself in time for the next night's scheduled irrigation.

Mode of action

Members of the genus *Pseudomonas* occur naturally in great numbers in soils and aquatic systems, particularly around the root systems of plants. Their primary food source is carbohydrates (glucose and other simple sugars) obtained from dead plant material and root secretions. These organic exudates foster microbial activity in general, including disease organisms. *Pseudomonas* can remain viable over a wide range of conditions in the soil environment but must compete with billions of other microbes to establish themselves in sufficient quantities to become an effective turf disease control agent.

Various species of *Pseudomonas* have been shown to produce anti-fungal antibiotics, which are one method by which bacteria can suppress turfgrass pathogens. Antibiotics may be loosely defined as any material produced by one organism which inhibits or kills another organism. *Pseudomonas aureofaceans*, the organism utilized in the BioJect® system, secretes a material (phenoxyzine carbolic acid) which inhibits fungal protein synthesis in pathogenic fungi. Given sufficient concentration of *P. aureofaceans* in the soil environment, pathogenic fungi are held in check due to their inability to synthesize necessary proteins.

Bacteria can also inhibit growth of patho-genic fungi by competing with the fungi for essential nutrients or growing space in the favored growth environment of the pathogen. By restricting the availability of nutrients, the bacteria may make the fungal pathogens more susceptible to the antibiotic substances they secrete. As the pathogenic fungal populations decline, the bacteria gain access to the nutrient sources once controlled by the fungi, further strengthening their position as fungal antagonists.

The caveat

While all this sounds great, the challenge has been to establish populations of these bacteria in a highly-competitive soil environment sufficient enough to achieve the desired level of disease suppression. According to Dinelli, that's where the new BioJect technology comes into play.

"There is currently more skepticism than optimism among the university professionals doing this type of research," said Dinelli. "None of the scientists dispute the disease suppressive abilities of *Pseudomonas spp.* They do, however, doubt the ability of the organism to establish itself on a long-term basis in the competitiveness of the real world soil environment," he continued. "And they're right."

The key, according to Dinelli's experience, is the constant re-inoculation of the root and crown environment with *Pseudomonas* bacteria with each irrigation application. Spoon-feeding, if you will. Before the BioJect® system became available, the only method of applying *Pseudomonas* was by mixing dormant bacteria from a bottle into a spray wagon. There were the obvious logistical challenges of applying sufficient quantities of bacterial agent at a frequency proper to maintain the desired bacterial population. Aggravating the situation was the ultraviolet sensitivity of *Pseudomonas* bacteria; they are optimally applied in the dark.

BioJect® solved these issues by incorporating into the system vastly greater quantities of bacteria, which are maintained live in the bioreactor (rather than dormant, as before). By applying them via irrigation at night, ultraviolet degradation becomes a non-issue. And, as long as you're irrigating, frequency of application concerns are also overcome.

Field trials at North Shore

"We set up some test areas last year around our golf course that were not to be sprayed with preventive fungicides," said Dinelli. "Our #8 fairway, a par 3 of creeping bentgrass and *Poa annua* approximately one acre is size, was used along with two of our bentgrass nurseries. The nurseries were maintained like putting greens. One of the nurseries, containing 7 varieties of bentgrass, was disconnected

from our irrigation water source and connected to village water, so it received no preventive fungicide applications or any *Pseudomonas* inoculant," according to Dinelli. "It was our true control."

"The second nursery had 35 varieties of creeping bentgrass, many of which are unnamed experimental varieties. This nursery received only *Pseudomonas* applications through the irrigation water. No preventive fungicides were applied. The rest of the golf course was treated as we normally would," explained Dinelli.

"In retrospect, the weather we experienced during the 1995 season here in the Chicago area created a worst-case 'acid test' of environmental extremes and disease pressure, a perfect opportunity to see what this biological control system would (or would not) do," said Dinelli.

"By the end of July, our 'bare-bones' control nursery was literally wiped-out by brown patch, Pythium and dollar spot. We actually stopped mowing it, it was so bad. During the third week in August, we had three consecutive days of rain, totalling over 2.5", with extremely high temperatures and humidity. We were obviously not irrigating during this period, so the *Pseudomonas* bacteria were not being applied, either. Four days after the rain stopped, we saw brown patch move into the #8 fairway. The next day it appeared in the second nursery. We applied Thiram to check the brown patch, which was the only fungicide application these areas received all season until snow mold control in November," Dinelli noted.

"The brown patch did not kill to the ground and grew out within two weeks. By that time," according to Dinelli, "we were back into the watering regimen, applying Pseudomonas again."

"During this period of extremely high disease pressure (aggravated by heavy rains), the apparent population of *Pseudomonas* bacteria fell under the threshold for adequate control after 4-5 days. We now know to intensify our scouting efforts after a similar period, and apply a contact fungicide as needed until we get back into a regular watering regime to re-establish the *Pseudomonas* population," advised Dinelli. "Given proper drainage, it would be possible to run through a syringe cycle even while raining. But we have old soil push-up greens here, and the overall agronomic downside of the added water outweighs any benefit from the added bacteria, in my mind," he concluded.

Enter *Trichoderma*

While the BioJect® system had a season-long trial last year at North Shore, only late in the season did Dan Dinelli load the second barrel in his biological arsenal, that with a hybridized strain of *Trichoderma harzianum* (T.h.). Available commercially on the market now under the trade name Bio-Trek 22G® (from Wilbur-Ellis Co. Fresno,CA), T.h. was developed by a trio of researchers at Cornell University (Eric Nelson, C-T Lo, and Gary Harman). Unlike the bacterium *Pseudomonas, Trichoderma* is a fungus that is applied dormant in dry granular form. T.h. is very efficient at establishing itself in the rhizosphere by colonizing roots so efficient, in fact, that the fungus continues to colonize plant roots as they grow and has been shown to overwinter on turf roots even in harsh northern climes.

Trichoderma fungi, in the form of Bio-Trek 22G®, are applied by broadcast spreader at the rate of 1.5 lbs./1000 sq. feet. The dormant fungi are activated upon contact with moisture on the soil surface or in the thatch layer. Two applications, in most instances, should give season-long control of many soil-borne fungal pathogens. It is not effective against foliar diseases.

While Dinelli's *Trichoderma* application last fall was too late to affect any disease pressure, soil samples sent to Dr. Gary Harman at Cornell for analysis show a 10-fold increase in *Trichoderma* populations since application. "This indicates an ability of *Trichoderma* to establish itself readily in the soils here," noted Dinelli. "Based upon the numbers of colony-forming units (CFUs) indicated by the soil tests, we should see positive results this season."

1+1=3D3

Given the tremendous results seen last year from the *Pseudomonas* treatments at North Shore, why would Dinelli bother with *Trichoderma?* "The two products really are complementary in their modes of action," he noted. "While *Pseudomonas* has difficulty achieving naturally self-sustaining populations in the soil here, we know for a fact (from Gary Harman's report from Cornell) that Trichoderma will colonize the roots readily. *Pseudomonas* is effective in the leaf and crown area, while *Trichoderma* is not. By using the BioJect® system to constantly renew *Pseudomonas* populations in the leaf and crown zone (and as far into the soil as it will go), and with *Trichoderma* colonizing the roots, we should have some form of biological disease control from root tip to shoot tip. The practical benefit will be increased root growth and overall plant health due to reduced stress from pathogenic fungi, and a dramatic reduction in our chemical fungicide applications."

Dollars and Sense

So what does all this cost? The BioJect® system is custom-tailored to each specific site and will vary depending on acreage to be treated. Dinelli is leasing the BioJect system at a cost of $18,000 annually. That includes the bioreactor, injection system, gallon jugs of resting *Pseuodomonas,* and the food source. "It's a complete package, with no surprises," according to Dinelli.

The granular *Trichoderma* applications cost between $10-$15/1000 sq. ft. annually, depending upon rate and number of applications.

"I am projecting an average savings of $25,000 annually from reduced fungicide applications, due to the BioJect® treatment alone," said Dinelli. "That will vary, however, depending upon the weather each particular year. In a dry year, we may save $40,000; in a wet year, maybe only $15,000. There is a potential budgetary concern with running into one of those bad years. You really need to figure a way to integrate some buffer or contingency into your budget to cover the added expense of extra fungicide applications, when needed (in the case of a rainy year)." Those estimated savings, notes Dinelli, "are strictly from pesticide expenditures alone. They don't take into account labor savings, or the ripple effects from better nutrient absorption or overall increased plant health. One of the big intangibles might be the effect on the soil microflora from reducing fungicide applications. Plus, by applying Pseudomonas through the irrigation system, we are treating areas (surrounds, tee banks, etc.) that would not normally be sprayed."

"Our goal last year was, very simply, disease suppression. We experienced very broad spectrum control, even broader than what I had hoped for initially," summarized Dinelli. "These products have brought the science of biological disease control from the laboratory to practical reality in the field. While not an end-all-be-all, they fit well into an IPM program and give us another tool from a different perspective. Hopefully, in addition to greater disease control, the healthier plants that result will be better able to deal with the other stresses they encounter throughout the growing season."

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