



Biological pest control: a realistic outlook

Having a completely organic course may not be possible, but superintendents can incorporate many environmentally friendly products and practices into their regular golf course management practices.

Turfgrass is the ultimate “green” crop, isn’t it? And biological pest control is as green as you can get, is it not? Which leads to the obvious question: How much is biological pest control used in golf course turf, and why isn’t it used more?

In this article, we look at some recent efforts to incorporate biological pest control into turfgrass management programs and give you our opinion on what kind of progress we can realistically expect in the near future.

But first a disclaimer of sorts. Before we founded PACE Turf in 1988, both of us started our scientific careers as biological pesticide researchers for the (now defunct) agricultural biotechnology company Mycogen. Larry headed up an effort to develop mycoherbicides (herbicides based on fungal diseases of weeds), and Wendy directed development efforts for biopesticides, including those based on the bacterium *Bacillus thuringiensis*, as well as on insecticidal and herbicidal “soaps” (including Scythe, a product mentioned later in this article). Our combined 15 years in this industry were exciting and scientifically challenging but also, at times, disappointing because for every moderately successful product that the company developed, there were many others whose early promise led nowhere.

It is from this vantage point, of excitement about the potential of biologicals for pest control, combined with practical experience of both their up- and down-sides, that we approach the important questions of if and how biological approaches can be integrated into golf course turfgrass management programs.

Definitions

Sustainable turfgrass, reduced-risk and organic

turfgrass. Biological pest control and integrated pest management. Biopesticides, parasites and predators. Best management practices, precision management and environmental stewardship.

As confusing as this profusion of concepts and phrases can be, they all represent facets of the same goal — of making pest control as safe for humans and the environment as possible. For the purposes of this article, we use the term “biological pest control” to refer to all methods — whether they are cultural practices, management strategies or products — that attempt to achieve this goal.

Biological pest control in everyday life

Many superintendents are already practicing biological pest control, but may not be aware of it. As you’ve no doubt heard and seen countless times, healthy turfgrass is the first line of defense against pest invasion. Good soil fertility and water management, aerification programs, sand topdressing, traffic management and other strategies are the backbone of any biologically oriented program.

Some recently generated data on the role of cultural practices in disease prevention have been particularly stunning, as described below.

Soil moisture and disease. Can you control turfgrass diseases by withholding water? Many people think so. But new research shows why keeping turfgrass dry frequently hurts more than it helps. We came across this counterintuitive phenomenon while studying gray leaf spot, a disease caused by the fungus *Magnaporthe grisea*. This is the first example that we encountered where dry conditions increased disease damage rather than



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Gray leaf spot

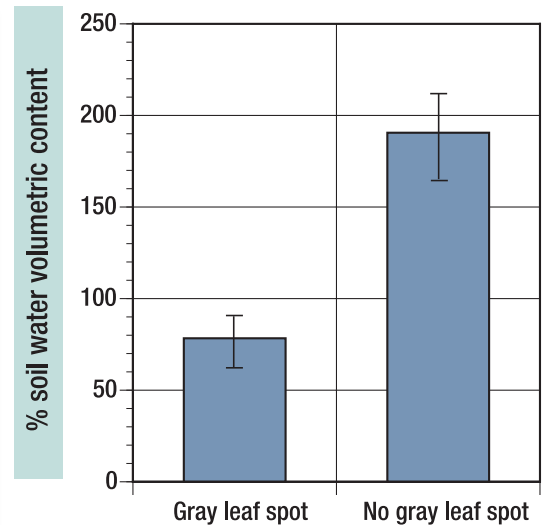
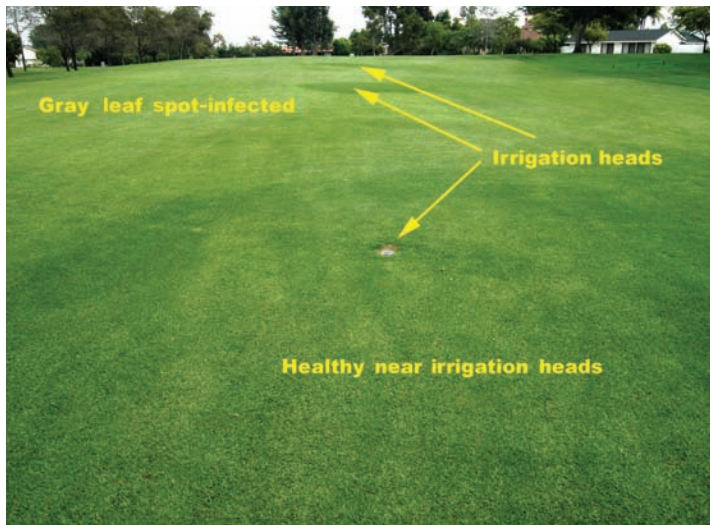


Figure 1. Poor irrigation uniformity resulted in moist and dry areas on this kikuyugrass fairway. The only areas attacked by gray leaf spot were those with low moisture levels (see graph). Photos by L. Stowell

decreasing it (Figure 1).

Brown ring patch, caused by *Waitea circinata*, is another example of a disease that causes more trouble when soils are dry. In trials sponsored by The Environmental Institute for Golf and conducted in spring and summer 2008 in conjunction with Frank Wong, Ph.D., and graduate student Chi-men Chen (University of California–Riverside), we looked at the locations where brown ring patch occurred versus the number of heads irrigating that area. We found that brown ring patch was most common in areas irrigated with two heads. In contrast, the disease was much less common in moister areas that were irrigated with three and four heads (see Figure 2).

Bruce Clarke and colleagues from Rutgers University have found similar patterns with anthracnose as well. (3). In other words, the relationship between dry conditions and heavy disease pressure may be more common than we think.

Nitrogen and disease. Recent results on both brown ring patch and anthracnose show that application of nitrogen (0.2-0.5 pound nitrogen/1,000 square feet [0.98-2.4 grams/square meter]) every two weeks during the disease threat period can cause dramatic reductions in disease damage, as shown in Figure 3.

Sand and disease. In multiyear studies (3), researchers at Rutgers University showed that light, frequent (as much as one time per week) sand topdressing is a great practice for preventing anthracnose. The researchers believe that the sand

raises the height of cut, protects the crown of the plant and supports the weight of the mower, all benefits that help the plant fight off anthracnose attack.

Selection of turfgrass species and variety type

Almost no single decision has more impact on the number of pesticides you apply or on the amount of pest damage that you deal with than your choice of turfgrass species and cultivar. Here are just a few examples of how selecting the right turfgrass species and cultivar can reduce pesticide inputs.

Density and vigor. Excellent data show that creeping bentgrass (*Agrostis palustris*) varieties that produce the densest, most vigorous stand of turfgrass in your location will also be least susceptible to *Poa annua* invasion and moss infestations.

Endophytes. Using endophyte-enhanced perennial ryegrass (*Lolium perenne*) and fine fescue (*Festuca rubra* and *F. rubra* subspecies) and tall fescue (*F. arundinacea*) seed for biocontrol of insects and diseases and for stress and drought tolerance is probably the most widely adopted and yet little recognized use of biocontrol agents in turfgrass. Endophytes are beneficial fungi that grow inside the vascular system of cool-season grasses. As they grow, the fungi produce chemicals such as alkaloids, indole diterpenes and peramine, which are toxic to insects such as billbugs, chinch bugs, sod webworms, fall armyworms and greenbugs (1).



Brown ring patch and soil moisture

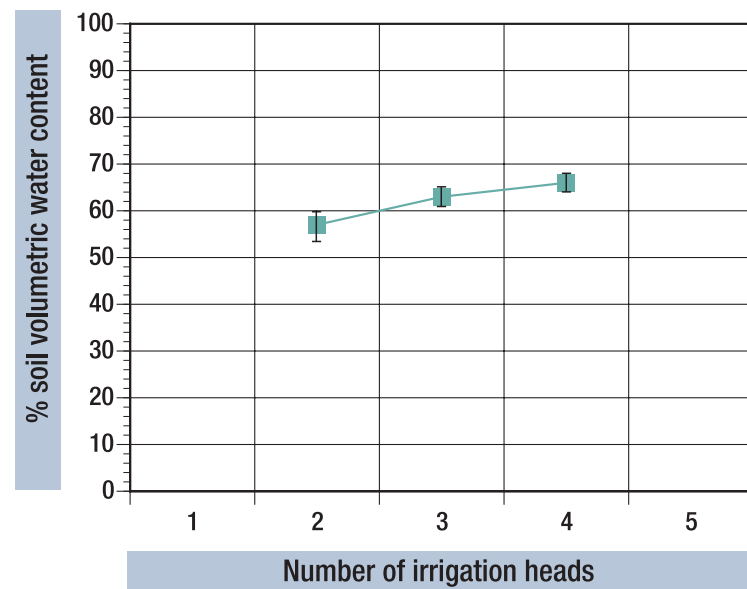
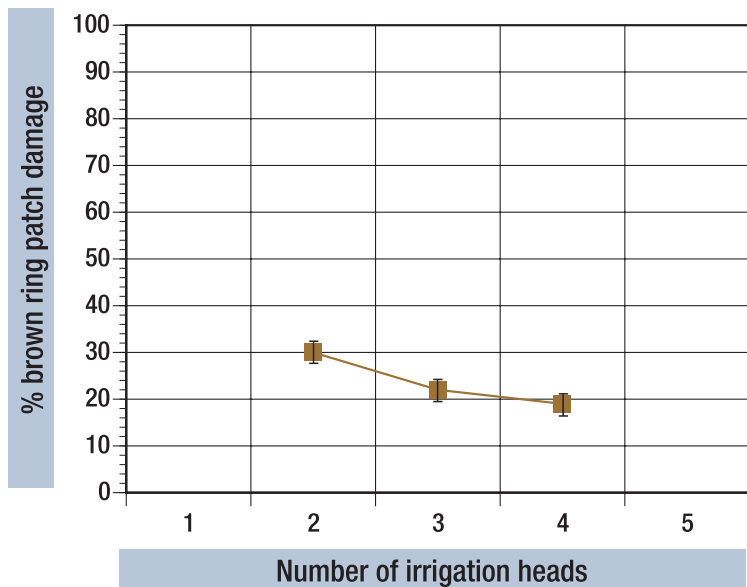


Figure 2. Top: Percent brown ring patch damage in areas receiving irrigation from two, three and four irrigation heads. Results represent the average of eight greens, with vertical bars illustrating the standard error of the mean. **Bottom:** Disease was heaviest in areas covered by the fewest number of heads; these areas were the driest areas on the green. High levels of soil organic matter caused the TDR 300 soil moisture meter to give an artificially high volumetric water content reading. As a result, readings for volumetric water content should be viewed on a relative basis only.

Endophyte-enhanced seed has been available since the 1980s and is an easy-to-use, biological technology well worth investigating. Just look for the “endophyte-enhanced” designation for tall or fine fescue or perennial ryegrass seed (other turfgrass types have not yet been successfully infected with endophytic fungi); a plus sign (+) is sometimes also used on the bag to indicate the presence of endophytic fungi.

Disease resistance. Selection of disease-resistant turfgrass varieties is one of the main fronts in the battle against diseases, with excellent choices available ranging from dollar spot-resistant creeping bentgrass, to gray leaf spot-resistant perennial ryegrass (Figure 4), to leaf spot-resistant Kentucky bluegrass. Although using these varieties does not guarantee turfgrass will be completely disease-free, many can make a significant impact on pesticide inputs and turfgrass quality. For the best source of information on the performance of disease-resistant turfgrass varieties, see the Web site of the National Turf Evaluation Program (www.ntep.org).

Precision turfgrass management

Every time you spot-treat rather than make broadcast applications of pesticides, you are doing it. Every time you map areas of pest infestation so that you can easily return to monitor and track progress, you are doing it too. And every time you double-check to make sure that you have correctly identified the pest you are trying to control and have finessed the timing of application, you are doing it as well. By “it,” we mean *precision turfgrass management*, the steps you take every day to carefully observe, document, map and manage golf courses on the smallest reasonable scale to provide optimal performance with the minimum of human, natural, mechanical and chemical resources (4).

The many benefits of more accuracy in turfgrass management include reduced pesticide inputs and increased preservation of the beneficial organisms (insects, fungi, bacteria, viruses) that help to keep pest populations under control.

New biological control products

Pesticides are for those times when pest populations pierce through the barriers of natural control, cultural protection and turfgrass health that you have constructed.

Luckily, the past five years have seen an explosion of new biological pest control products for turfgrass. And some of them perform exceptionally well. This is good news, but a small piece of bad news goes with it — the confusion that

Brown ring patch and nitrogen

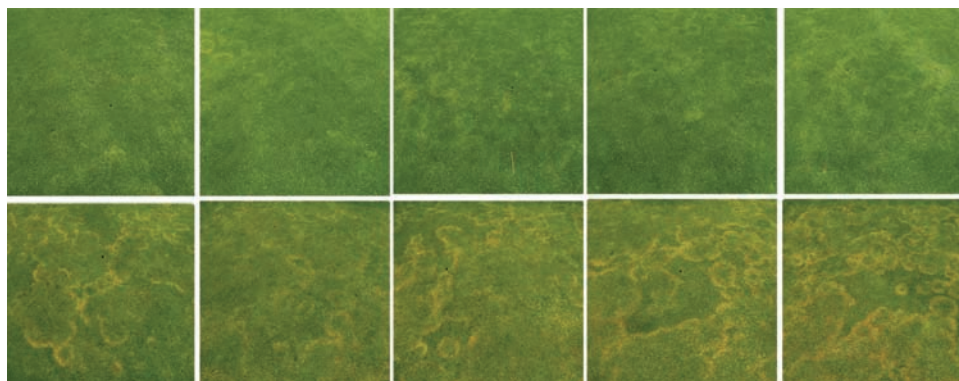


Figure 3. Sections of a *Poa annua* green treated with ammonium sulfate (1 pound nitrogen/1,000 square feet/month) (**top row**) did not suffer from brown ring patch as much as areas of the same green that were not treated with nitrogen (**bottom row**). No fungicides were applied.

results from so many products with so many performance claims. How can you tell which will work and which won't? Or which product's claims for turfgrass, human or environmental safety are valid and which aren't?

The guidelines below can help you to make decisions that are as informed as possible.

Look for the data

Replicated research trials, preferably carried out in several (at least three) different locations, are the gold standard when it comes to backing up product performance claims. Data can come from university researchers, extension agents and independent consultants. Or you can look for it in publications and on Web sites such as *Golf Course Management*, *Fungicide and Nematicide Tests*, *Arthropod Management Tests* and the *PACE Turf Information Service*.

Superintendents are also increasingly doing their own testing, a practice that we strongly support. For detailed guidelines on how to conduct your own research, the "Guide to testing products and practices" is available at www.paceturf.org. If you are interested in sharing your research results with others, the Super Journal, an electronic venue for publication of superintendent-generated research, is also available at www.paceturf.org.

Data provided by companies can also be very useful, but it is important to recognize that there is a possibility that the company may be presenting only the data that show their product to its best advantage. For this reason, it is always best to have the company's data supplemented with one or more of the data sources listed above.

Getting a warm, fuzzy feeling

When reviewing data on performance of bio-

logical pest control products, we like to see the following:

- at least 80% pest control (compared to the untreated turfgrass), consistently, across all locations
- the rates and application frequencies tested are consistent with the product label
- if the intention is to use the product by itself, then the product should be tested by itself, and not in combination with other pesticides or fertilizers
- confirmation that the product is not phytotoxic to turfgrass

We have scoured all of the data available to us and have identified some of the products that meet these criteria (see Table 1), but this list is far from comprehensive. Many other biological pest control products — some of them perhaps favorites of yours — are available but are not on this list. In some cases, efficacy data on their performance were not available. But in other cases, the products *have* been tested, but their performance was unacceptable. As more data become available, we look forward to seeing this list grow.

Environmental credentials

We have been surprised and somewhat distressed over the years at how hard it is to find out which products have the safest environmental and health profiles. With all of the desire for safer products by the industry, the public and government agencies, this seems like a big unmet need.

By combing through a variety of sources, we have come up with some suggestions for identifying products with good biological profiles, that is, they have low toxicity to humans and other non-target organisms, and they have minimal impact on the environment as well.

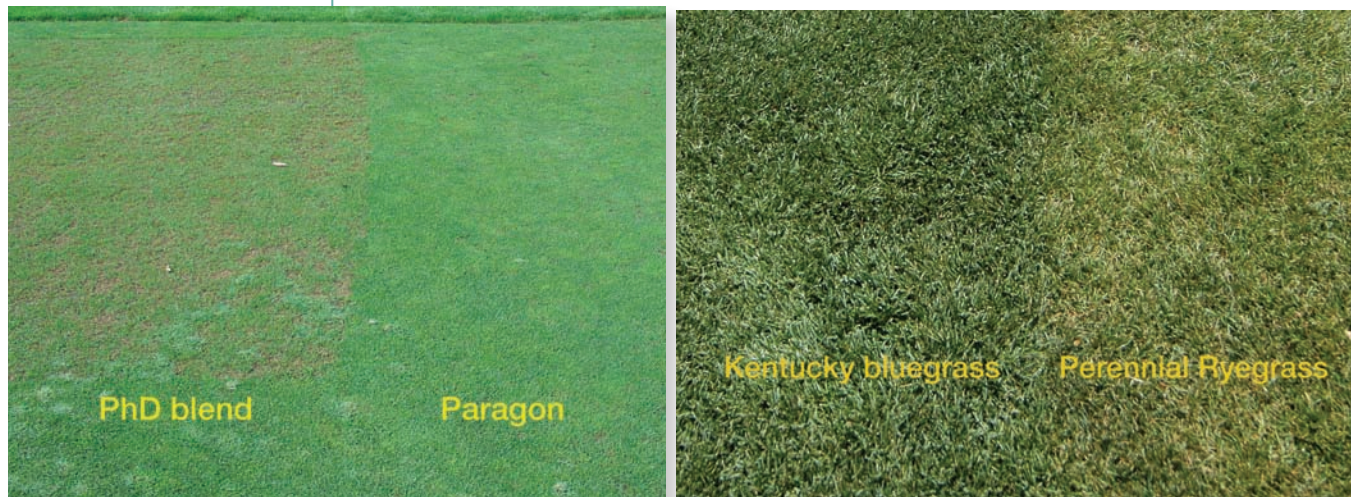


Figure 4. Left, Gray leaf spot heavily damaged the susceptible PhD blend of perennial ryegrass, while the disease-resistant Paragon cultivar escaped relatively unscathed. Right, the natural tolerance of Kentucky bluegrass to gray leaf spot was illustrated dramatically when compared side-by-side with susceptible perennial ryegrass. Photo on the left by F. Wong.



The research says

→ Good soil fertility and water management, aerification programs, sand topdressing, traffic management and other strategies are the basis of any biologically oriented program.

→ Selecting the right turfgrass species and cultivar can reduce pesticide inputs.

→ Follow practices of precision turfgrass management.

→ When searching for biological pest control products, look for results from replicated research trials, do your own testing, focus on biopesticides and reduced-risk products, look for signal words on labels and read the MSDS.

→ Although not every course is ready for 100% biological pest control, superintendents should not hesitate to incorporate these new practices and products into their management programs.

Focus on biopesticides and reduced-risk products. Our first step was to locate products that the U.S. Environmental Protection Agency defines either as biopesticides (low-toxicity products based on natural materials such as animals, plants, bacteria and certain minerals) or as reduced-risk products (products with “low impact on human health, low toxicity to nontarget organisms, low potential for groundwater contamination, lower use rates, low pest resistance potential”). Although these two categories encompass some products that are based on biological as well as conventional chemical technologies, they are all products with low environmental toxicities (see Table 1 for a listing of biopesticides and reduced risk products that have shown good efficacy against key turfgrass pests).

Look to the label for clues. The signal word on the product label, which appears in bold letters at the top, can tell you a lot about the product’s environmental and worker safety profile. “CAUTION” indicates low toxicity and relatively good worker safety, but the words “WARNING” or “DANGER” indicate increasing levels of risk. The term “Restricted Use Pesticide” also indicates some health or environmental risk.

The MSDS also helps. Go to section 11 of the MSDS (material safety data sheet) for detailed information about the product’s toxicity to mammals, nontarget animals (like fish and bees) and the environment. Don’t be distressed by the dense listing of numbers that sprawl out before you; the information is relatively easy to decipher. First, look at the numbers associated with what are vari-

ously labeled “LD₅₀” or “acute” doses. These refer to the doses that have been tested against a variety of animals and plants to see what dosages will kill 50% of the test organisms. A high dose indicates that the product is relatively safe. Even better, the use of the “greater than” sign (for example, >5,000 mg/kg) means that even the highest dose tested did not kill 50% of the test group.

Searching for biological pest control products should be easier than this, but the hints above are at least a start.

Getting from here to there

The decision to go completely green on a golf course, long thought to be an impossibility, has grown much closer to reality, thanks to the efforts of forward-thinking superintendents, innovative biological-control companies and dedicated researchers, but we are not there yet. Products address many pest control needs but still do not target all of the key pests that plague golf courses, and they still, for the most part, do not perform with the consistency of conventional pesticides. Cultural practices that help to stave off pest damage have decreased pesticide inputs, but we still do not know enough about many pests to understand how to defeat them through management strategies alone. The additional costs of scouting, monitoring, record keeping and niche products can exceed many budgets. And the expectations of golfers and managers for turfgrass that is simultaneously the lushest, fastest and greenest is at odds with the desire for reduced inputs and costs.

Biological and reduced-risk products

Active ingredient (product, company)	Insects and related pests									
	Japanese beetle	Masked chafer	Black cutworm	Sod webworm	Billbugs	Crane flies				
Chlorantraniliprole (Acelepryn, DuPont)										
Endophyte-enhanced turf varieties										
Diseases										
	Dollar spot	Pythium	Brown patch	Anthracnose	Snow molds	Fairy ring	Gray leaf spot			
Azoxystrobin (Heritage, Syngenta)				*			*			
Boscalid (Emerald, BASF)										
Fludioxinil (Medallion, Syngenta)										
Phosphites, phosphonates (Agri-Fos, Agrichem; Alude, Cleary; K-Phite, Plant Food Systems; Magellan, Nufarm Americas; Resyst, Regal; Vital, Luxembourg-Pamol)										
Polyoxin-D (Endorse, Cleary)										
Trifloxystrobin (Compass, Bayer)				*			*			
Weeds										
	Timing	<i>Poa annua</i>	Crabgrass	Goosegrass	Moss	Dallisgrass	Clover	Sedges	Broadleaf weeds	
Penoxsulam (Sapphire, Dow AgroSciences)	post-emergent									
Pelargonic acid (Scythe, Dow AgroSciences)	nonselective burn-down									
Mesotrione (Tenacity, Syngenta)	pre- & post-emergent									
Carfentrazone (Quicksilver, FMC Corp.)	post-emergent									
Bispyribac sodium (Velocity, Valent)	post-emergent									
Corn gluten meal	pre-emergent									

Note. Reduced-risk products are shown in blue, biopesticide products in green and products not considered pesticides in black. No effective biological controls are currently available for fire ants, mole crickets, nematodes and algae. Refer to each product's label for specifics on spectrum of pest control and turfgrass safety.

*Disease has developed resistance to these products in some locations.

Table 1. Biological and reduced-risk pest-control products that have shown good efficacy (consistently more than 80% control) in field research trials against the key pests shown.

Those few superintendents who have successfully implemented wholly organic or biological turfgrass regimes are clear that their remarkable achievements are due, at least in part, to unique circumstances — such as permissive budgets, extremely supportive memberships, weather patterns that discourage high pest populations or highly restrictive legislation that bans the use of pesticides — that make biologicals a necessity, rather than a luxury. In other words, the shift to 100% biological pest control is not yet ready for prime time. But this should not inhibit you from experimenting and incorporating these new and sometimes very valuable practices and products into your regimes today.

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