All That Glitters Is Not Gold

Continued from page 50

New golfers are not making golf a game for a lifetime. Even in the face of the best widespread course conditioning the game has had, 3 million people per year drop out because the game is too expensive, takes too long and is too difficult. The National Golf Foundation has reminded industry people of this for years, but we keep seeing new courses constructed that are longer, tougher and more expensive. We keep watching as maintenance and design teams create novelties, whether it's the course with the lily-whitest bunkers or the one with the most intricate fairway-striping patterns.

That's not what attracts and keeps golfers. The traditional values and simple themes of nature have always been and will continue to be the features that enamor golfers while keeping the game affordable and economically healthy — and that's what we have to grasp.

Golf is a brilliant game, and it's our job to figure out how to keep it that way. The values of the game will be strengthened for years to come if we can cast off the fast-food, mass-production, brand-name addiction it has attracted. It's time to create mom-and-pop style operations and embrace the artistic side of the game as much as we currently embrace the scientific.

By actively encouraging creativity with a big-picture view of architecture, maintenance and operations, golf could play an integral role in rejuvenating America's spirit of community. ■

GEOFF SHACKELFORD

Easthampton GC on Long Island, a new Bill Coore and Ben Crenshaw design, feature hazards with a natural look.

Shackelford, Golfdom's contributing editor, can be reached at geoffshackelford@aol.com.

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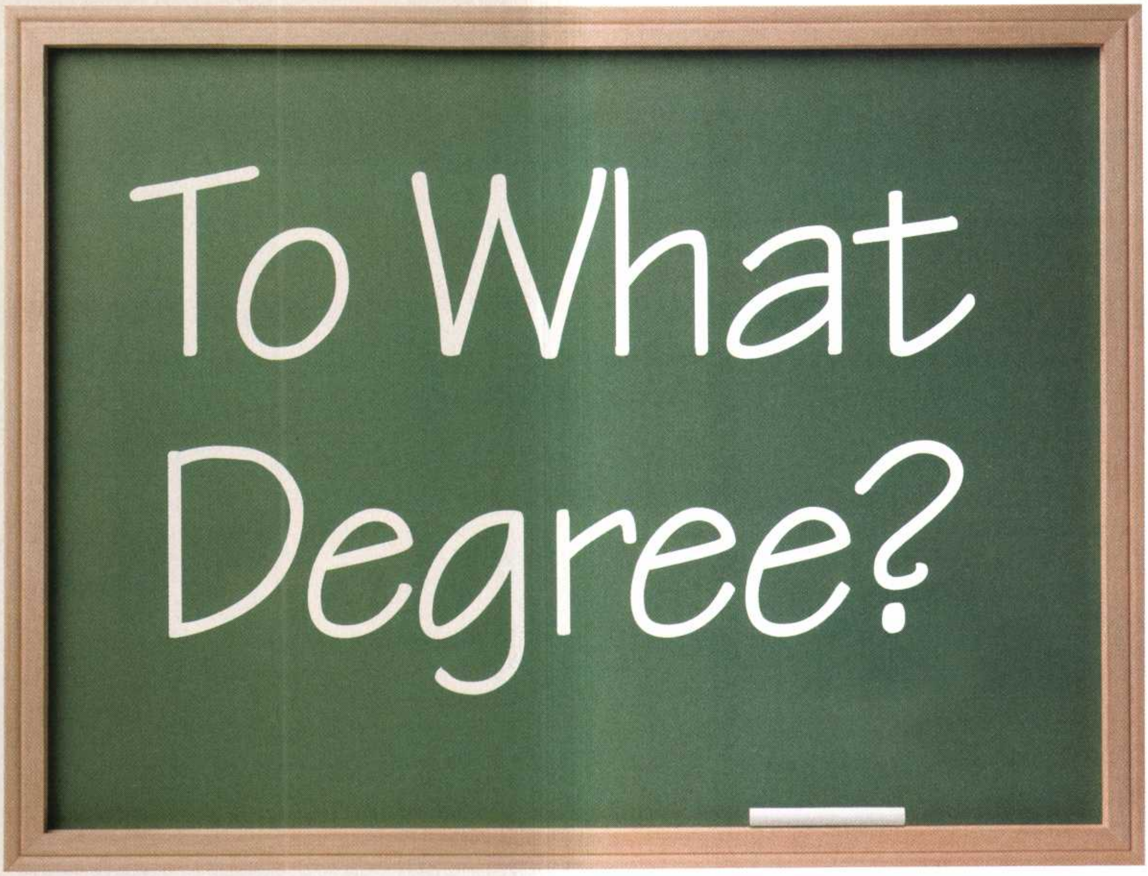

What does time spent behind a school desk have to do with being a capable superintendent?

BY RON FURLONG

I stand before you — my esteemed colleagues — to announce that I'm coming out of the closet. I'm opening the door and stepping into the light — shedding my dead, mottled skin. I'm ready to make a confession. But let me shout it — not whisper it — because we're all adults and my declaration must be proclaimed. So here I go:

I HAVE A TWO-YEAR DEGREE!

I said it! Gosh, I feel better. What a weight off my shoulders. Let me say it again.

I HAVE A TWO-YEAR DEGREE!

I feel so unburdened that I could walk on water (or at least a shallow wetland). For too long, I've let this fester inside me, eating away at me like an incipient patch disease.

To be honest, I've never been ashamed or embarrassed of the degree. I'm just being a little dramatic for shock effect. I have, however, encountered others who have tried to diminish it, and that bothers me.

My degree bears the symbol of Anoka-Hennepin Technical College (quite a mouthful when someone tells me they're from Penn State or Lake City and then asks where I went to school), which is near Minneapolis. It's not hidden away in a box in the closet or in the bottom drawer of the desk. (You know the drawer I'm talking about — that big sucker that's stuffed with items you'll never need again but can't bring yourself to throw out.) No, my degree hangs proudly above my desk and receives a good bimonthly dusting and even a quarterly Windexing.

At this point you may ask: If I'm so proud of my two-year degree, and everything is hunky-dory, then why even mention it? Good question. My answer has something to do with the mindset of several industry people who put as much emphasis on four-year degrees for superintendents as they do on health care for their children.

Anoka-Hennepin Technical College offers a good, no-frills "Two-Year Golf Course Management Program" that consists of a lot of meat and potatoes, but not much veggies and bread. (Unfortunately, I didn't learn at school which

PHOTODISC

side of the plate to place my salad fork. Thank God my Mom told me this.) Anoka-Hennepin offers useful — dare I even say comprehensive — hands-on teaching by quality instructors. It offers all you ever wanted to know about turf but were afraid to ask, and it has served me well. Is it Penn State? No. Is it Michigan State? No. Does it claim to be? No.

I've been in this business more than 13 years. My degree came somewhere in the middle of that time when I decided to get off my lazy butt and make something of myself. Without listing my résumé, let me say I've been at five clubs, three exclusive private clubs and one upscale high-end grow-in near Minneapolis. I also have a couple of years under my belt as superintendent at a public course. The last four years have been spent as first assistant under certified superintendent Randy White at Everett Golf and CC, just north of Seattle. It's an old private club with a history of excellence in the area. I like to think I've paid my dues and even excelled in my field. I've been involved in some cutting-edge management techniques, especially in the last few years at the club.

I know golf course management, and I like to think I know it well. I don't know corporate business or what it takes to make a dot-com work. I have no knowledge of managing a thriving restaurant or running a lumberyard. But I feel compelled to state that I'm fairly certain that golf course management is as unique a field that you can find in respect to gaining hands-on experience and learning from a mentor.

I'm not trying to diminish school or what I learned or didn't learn. But perhaps — just perhaps — golf course management is that one industry where a two-year degree may serve an individual as well as a four-year degree. It's all in getting on at the right course under the right superintendent and learning as much as you can. I'm the only person that can limit my knowledge and my managerial abilities. I've been fortunate to work under some great superintendents, including White, and the experience has been invaluable.

I realize I'm treading a thin and delicate line here. I don't wish to denigrate the importance of a four-year education. Truth told, I nearly did take the plunge myself a few years ago to finish my last two years, but I decided against it. Besides, I go to school every day: A green 100-acre fir-lined classroom with some great views of the Cascade Mountains. Class starts at 5:30 a.m. every morning.

Of course, there are other ways to continue one's education without sitting in a classroom. I consider this pivotal today because you're apt to get passed by without so much as a second glance if you don't keep learning. This can be done through many venues, including attending GCSAA seminars, chapter meetings of your local associations, turf shows and conferences (both local and national). Even the annual course visit from your regional USGA agronomist can be educational. In addition, you can take courses through GCSAA's Environmental Management Program, as well as correspondence courses from various turf schools.

But perhaps – just perhaps – golf course management is that one industry where a two-year degree may serve an individual as well as a four-year degree.

OK, so what's my real beef? Well, let's address this group of individuals I mentioned earlier — this growing faction that insists on having four-year degreed superintendents. The growing number of green chairmen, general managers, owners and directors of golf requiring four-year degrees for new superintendents amazes me. (Although this is not as amazing to me as the ones that require — yes, *require* — a certified superintendent for their positions.)

I know a director of golf that's been quoted as stating he'll never hire a superintendent on any of his courses who doesn't hold a four-year degree — no exceptions. I guess it doesn't matter how good or experienced individuals are. Even if they're the most perfect people for the jobs, they don't have a chance for them.

Is it just me, or does this seem narrow-minded? Is this fellow not limiting himself on some truly wonderful individuals who are

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going to make great superintendents? Isn't it possible that there may be an individual with a two-year degree who's more experienced and better suited for a particular job than an individual with a four-year degree? Isn't it *possible*?

I'd like to think that right now I'm better suited to run an 18-hole private club than a 22-year-old kid with a four-year degree who has interned on two golf courses for a total of nine months. If you owned the golf course, whom would you trust? Yet, according to some people's logic, I wouldn't even be considered.

I know from experience that I've not been interviewed for certain positions I've applied for because my 8 x 11 certificate above my desk says two-year degree — not four. It gets a bit frustrating, you know?

On the other hand, I know I have come close to landing positions with clubs who had no problem at all with the length of time I spent behind a classroom desk. They actually concentrated on the candidates' experience and what they could bring to their clubs. Imagine that. My hat is off to these brave folks.

Let me throw out this analogy to end this rant. Some may think it's farfetched, but then again, maybe not. I consider Kevin Garnett the best all-around player in the NBA, and Kobe Bryant is a distant second. I would hate to think we'd be cheated the enjoyment of watching these two great stars play because neither one attended college. The fact is, they were ready for the NBA and, as it turned out, the NBA was ready for them. I know the analogy from NBA player to superintendent may seem a stretch, but why not give us a chance? May the best man (or woman) win.

OK, I'm out of the closet. It's bright out here — and cold. Better get myself some sunglasses and a jacket. ■

Ron Furlong, first assistant superintendent at Everett Golf & CC in Mukilteo, Wash., can be reached at rf7500@aol.com.

Featuring Flexibility

New York municipal complex replaced outdated pump stations with more flexible ones to increase irrigation coverage

BY FRANK H. ANDORKA JR., MANAGING EDITOR

Thanks to sufficient pump stations, New York's municipal golf fairways finally receive irrigation.

Problem

Outdated irrigation systems with insufficient pump stations plagued New York's 12 municipal golf courses. Any new system needed to combine flexibility with cost-efficiency.

Solution

Flowtronex's pump stations allowed each of the 12 courses to customize their pump stations, which helped meet their individual needs.

John Dillon, superintendent at the 36-hole Pelham/Split Rock GC in New York, says summers routinely proved brutal to the city's 12 municipal golf courses before 1999. The city last installed new irrigation systems on its courses in the 1940s and 1950s, consisting of a motley collection of mainlines and quick couplers that only covered tees and greens. Consequently, the pump stations were designed for a low water flow. When the systems needed minor upgrades, the superintendents could only patch repairs to the old systems.

"During hot summers, the fairways turned brown because they weren't getting water," Dillon says. "The courses wouldn't necessarily lose turf, but the grass would creep into dormancy. It wasn't pretty."

Sol Cohen, partner in Wesler-Cohen Associates, a landscape architecture and design firm, says the systems were completely inadequate because the city never had enough money to upgrade the golf courses — until 1999. "[That's when] New York received a $12 million grant from the state's Department of Environmental Protection, and Mayor Rudolph Giuliani decided to upgrade the city's golf courses," Cohen says.

The problem

Diagnosing the problem of inadequate and horribly outdated irrigation systems was easy. Finding equipment flexible enough to adapt to each individual course's water sources was difficult.

"We weren't working with an unlimited budget," says Cohen, whose firm designed and oversaw the installation of the new systems. "If you break down the grant over the 12 courses they wanted to remodel, it's about $1 million per course. We had to find new systems that would meet the city's specifications, but wouldn't break the bank."

The challenge for Cohen lay in the city's specifications for the standard flow rate and the variety of water sources.

On the golf courses, superintendents have some combination of three potential water sources, Dillon says. The courses can either receive water from the city, dig irrigation lakes to hold water or dig wells to provide irrigation, Dillon says. At Pelham/Split Rock, for example, the soil is too rocky to drill wells, so Dillon depends on a combination of city water and irrigation lakes.

"Since you frequently have two or more sources, you need a variety of pumps to get the water from point A to point B," Dillon says. "It can get fairly complicated, and you need a system to handle the complexity."

Cohen says the irrigation pumps at the golf courses needed to boost the normal flow from the city water to a flow rate of 800 gallons per minute, far faster than the city's pumps could manage.

The solution

As he designed the irrigation systems, Cohen decided to go with a specific pipe system and software package, but he still wasn't sure which pump stations to specify because of the high volumes they had to handle.

Cohen investigated pump station manufacturers to determine which would work most effectively with the pipe system he chose. When he consulted with the system manufacturer, it recommended Flowtronex PSI, a Dallas-based irrigation pump station manufacturer. Cohen says the ability of Flowtronex to adjust to the project's special requirements impressed him.

Dave Talboo, golf sales director for Flowtronex, says the company developed a reputation for flexibility by installing irrigation pump stations at desert courses in the West and Southwest.

"The variety of topography and geography in those areas always presents you with challenges to overcome," Talboo says. "When Cohen called about his challenges in New York, we thought we could overcome them based on our previous experience."

In all, Cohen installed 26 pump stations, including four prefabricated FloBoy systems, on 12 courses. Cohen designed pump stations that housed three 40 horsepower motors and three pumps. Two pumps work anytime the system is on, with the third pump idle in case of a breakdown. Each course's system, however, included subtle changes adapted to its individual needs.

For some courses Cohen installed lake-lift pumps to move water from irrigation lakes through the system. For others, a reliable link to the city water supply or a well was more important. All the courses required Cohen to combine these technologies in some form, and the Flowtronex system allowed him to do it easily and effectively.

"The pumps can pull the water from wells one day, and the next day you can pull the water from the city supply, depending on what will suit your purposes most effectively," Cohen says. "The superintendents liked that feature in particular because it put them in control."

New York's 12 municipal golf courses have a choice of three different water sources: city water, irrigation lakes and wells.

Cohen says superintendents also liked the simplicity of the pump station's Web-based operating system, the PumpLog 2000. Its interface allows superintendents to control the pump stations from anywhere they have access to the Web. "Superintendents don't have to crawl out of bed and go to the course to turn on their pump stations because they can do it from their computers at home," Cohen says.

The technology can also tell a pump station to lower water pressure if no programs are operating, which saves time, energy and maintenance costs, Talboo says.

"We understand the need to keep the system simple to operate and simple to fix," Talboo says. "After all, you don't want to spend huge sums of money to fix them because they're breaking down all the time. That's not cost-efficient."

Outcome

Dillon, for one, is thrilled with his system. His course installed four new pump stations that allow him to combine city water and lake use. He says the system is easy to use and it performed well this past summer, although he didn't get a chance to put it through its paces because the summer was cool and wet.

"The system will really get a workout when we experience a drought," Dillon says. "Based on what I've seen, I'm convinced that everything will work well. It's going to radically change the way I'm able to maintain my course." ■

Read another Real-Life Solutions on page 75

A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

Section II • Volume 11, Issue 1 • **January 2002**

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WEED CONTROL

Nutsedge by any other name is still a sedge

By Tim R. Murphy

You know you can call a weed any name you wish. As long as the management strategy controls the weed, there is no problem. Sometimes an improper common name, however, can lead to a control failure.

Consider this — the Cyperaceae, the sedge family, has about 4,000 species around the world (Correll and Johnston, 1979). Numerous members of this family are found in turfgrass, and many of these species look like grass. After repeated attempts to control these grass "look-alikes," however, with the postemergent turfgrass graminicides such as sethoxydim (Vantage), fenoxaprop (Acclaim Extra) and fenoxaprop (Fusilade II), some of us may realize that maybe this isn't grass after all.

> The essential factor to sedge control is persistence. We do not have a herbicide that can be applied one time to eradicate nutsedge.

Sedges are not grasses and respond differently to most herbicides. In general, sedges are yellow-green to dark-green, with triangular stems and three-ranked leaves, unlike the two-ranked leaves of the grass family (Table 1). The leaf sheath of sedges is closed and encircles the stem.

Several sedges (Cyperus spp.) are major problem weeds in turfgrass. Of these species, only two — purple (C. rotundus) and yellow nutsedge (C. esculentus) — form tubers.

Other problem species of the Cyperaceae family include annual or water sedge (C. compressus), green (Kyllinga brevifolia) and fragrant kyllinga (Kyllinga sesquiflorus), globe sedge (C. croceus), Texas sedge (C. polystachyos) and cylindric sedge (C. retrorsus).

Yellow and purple nutsedge are low-growing perennials that, at first glance, resemble a grass. In fact, some people call these species "nut-grass." Seedhead color is often used to distinguish between the two major nutsedges.

Yellow nutsedge has a yellowish- to straw-colored inflorescence, while purple nutsedge has a reddish to purplish inflorescence. Leaf tip shape is another distinguishing characteristic, but that difference is difficult to see in regularly mowed turfgrasses. Leaf tips of purple nutsedge are generally wider and gradually taper to a sharp point.

Conversely, yellow nutsedge leaves become constricted near the narrow, needle-like tip. Yellow and purple nutsedge are not believed to produce viable seed, but due to their underground tubers and rhizomes, these species have tremendous reproductive capacity. Excellent color photographs and descriptions of these and other sedges may be found in *Weeds of Southern Turfgrasses* (Murphy et al. 1992), *Color Atlas of Turfgrass Weeds* (McCarty et al. 2001), and at the University of Georgia Turfgrass

IN THIS ISSUE

TABLE 1

Distinguishing characteristics of grasses and sedges.

CHARACTERISTIC	GRASSES	SEDGES
Stem	hollow, round or flattened	usually triangular, pithy, rarely hollow
Nodes	easily seen	indistinct
Leaf arrangement	two-ranked	three-ranked
Leaf sheath	usually split	usually closed
Leaf blade	flat, often folded, hairy or smooth	flat, usually smooth
Leaf margin	smooth, hairy or sharp to touch	usually rough
Collar	distinct	indistinct
Auricles	present or absent	absent
Ligule	present, rarely absent	absent, or only weakly developed

Web site (*www.georgiaturf.com*).

Most sedges thrive in soils that remain wet for extended periods. The first step to controlling them is to dry up the soils. Do not overirrigate an area, and if necessary, provide surface and subsurface drainage.

The overwhelming majority of turfgrass pre-emergent herbicides do not control sedges. Triazine herbicides (e.g., atrazine, simazine) provide fair pre-emergent control of some annual sedges, but generally are ineffective on perennial species.

Metolachlor (Pennant) provides pre-emergent control of most annual sedges and yellow nutsedge. However, purple nutsedge is not controlled by metolachlor. Pre-emergence control of purple nutsedge is currently unavailable.

Historically, postemergent chemical control of most sedges was attempted with repeat applications of 2,4-D, the organic arsenicals (MSMA, DSMA) or a combination of the two.

Although organic arsenicals were effective, numerous applications over a period of years generally were necessary. Extensive damage also resulted with certain turf species, such as centipedegrass and St. Augustinegrass.

In the past 10 to 15 years, several postemergent herbicides have been registered for sedge control in turfgrasses (Table 2). Bentazon (Basagran T/O) will control yellow nutsedges and several annual sedges in all species of turfgrass. Two applications, at an interval of 10 to 14 days, are necessary for control with bentazon.

Purple and yellow nutsedge, annual sedges and kyllinga species can be controlled with imazaquin (Image). Tank-mixing recommended rates of MSMA with imazaquin in MSMA-tolerant turfgrasses generally increases sedge control. For optimum results with imazaquin, apply two treatments during the late spring and summer months. The first application should be made after full spring green-up of warm-season turfgrasses and when sedges are visible in the turfgrass canopy. Apply the second treatment six to eight weeks later when sedges re-emerge. Image is not labeled for use in cool-season turfgrasses.

Another excellent herbicide for sedge control is halosulfuron (Manage). This herbicide provides good to excellent control of both purple and yellow nutsedge, annual sedges and fair control of the kyllinga species. Similar to imazaquin, a repeat application six to eight weeks after the initial application will be necessary for season-long sedge control. The various turfgrass species have excellent tolerance to halosulfuron.

The essential factor to sedge control is persistence. We do not have an herbicide that can

TABLE 2

Sedge control ratings for selected turfgrass herbicides[1]

Herbicide[2]	Annual Sedge	Purple Nutsedge	Yellow Nutsedge	Annual Kyllinga	Perennial Kyllinga
Metolachlor	G	P	G	F-G	P
Oxadiazon	G	P	P	F	P
Bentazon	G	P	G	F-G	F-G
Imazaquin	G	G	F	G	G
Halosulfuron	G	G-E	G-E	G	F-G
MSMA/DSMA	G	P-F	F	G	G
Imazaquin + MSMA/DSMA	G	G-E	G	G	G

[1] FROM MCCARTY, L. B. 2000 PEST CONTROL RECOMMENDATIONS FOR PROFESSIONAL TURFGRASS MANAGERS. CLEMSON UNIVERSITY EC 699.

[2] FOLLOW DIRECTIONS ON HERBICIDE LABEL FOR REPEAT APPLICATIONS.

be applied one time to eradicate nutsedge. Repeat applications at prescribed intervals that are shown on the herbicide label will be required for acceptable control within a given year. It will also be necessary to think of nutsedge control as a multi-year project.

Research conducted in Georgia showed that imazaquin + MSMA applied for three consecutive years eliminated purple nutsedge from a turfgrass site (Johnson and Murphy 1992).

A South Carolina study investigated the effect of multiyear herbicide applications on yellow nutsedge control and tuber populations (Lowe et al. 2000). Control was more than 90% and tuber populations were reduced 92% for the best herbicide combination at the end of this four-year study. However, 200,000 tubers per acre were present after four years of 90% yellow nutsedge control.

Nutsedge is indeed a formidable weed in turfgrasses. While new chemistry has been registered to control nutsedge, control programs still need to be annual events.

Another factor in getting good control with nutsedge herbicides is to treat when nutsedge is active and there is good soil moisture.

Nutsedge, annual sedges and kyllinga species are aggravating turfgrass weeds. We have made progress in controlling them, however, and we can effectively manage nutsedge and related sedge species if we maintain turfgrasses with a proper control program for several years.

Tim R. Murphy is an extension weed scientist in the Crop and Soils Sciences department at The Griffin Campus of the University of Georgia.

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A primer on microbial products, bacteria and their relationship with nitrogen

By Monica L. Elliott, Ph.D.

An increasing number of microbial-based products claim to increase plant growth or protect plants from various pests. Products that claim to directly control plant pests are referred to as biological pesticides or biopesticides. These products are regulated by the Biopesticides and Pollution Prevention Division of the U.S. Environmental Protection Agency (EPA).

There are three types of biopesticides — biochemical, plant and microbial. The latter contain a naturally occurring or genetically altered microorganism or its product as the active ingredient. For more detailed information about biopesticides in general or about specific products, please refer to the EPA Web site at *www.epa.gov/pesticides/biopesticides*. Every registered "active ingredient" is listed on this site. As with chemical pesticides, biopesticides may be formulated in a number of different ways, and so any single registered "active ingredient" may have numerous product trade names.

If microbial products only claim to improve plant health in general, without mentioning direct control of specific pests, the product does not have to be registered by EPA. This group of products is often referred to as "inoculants." Root-associated (rhizosphere) bacteria that benefit plant growth are called plant-growth-promoting rhizobacteria (PGPR). However, that term can be misleading. For example, PGPR that promote the growth of one plant species may be detrimental to another plant species. In addition, the PGPR are only beneficial to plants under specific environmental situations, such as high disease pressure or low nutrient levels.

Some products contain only a single microorganism, whereas others contain a mixture of microorganisms. The latter approach is probably more useful because at least one of the microbes in the mixture may benefit the targeted host plant. Many microbial products claim to reduce fertilizer use because they include bacteria that fix nitrogen nonsymbiotically or liberate phosphates and micronutrients from the soil.

As with chemical products, microbial products are formulated with various carrier compounds, both inorganic and organic. Carrier compounds may include small amounts of plant nutrients (N, P, K), sugars, amino acids, plant hormones — compounds that may also affect plant growth. Because evaluation of microbial-inoculant products normally includes only plant growth responses, without examining the microbial responses, it is difficult to determine if the plant responses observed may result from the microbes added.

Why are there so many microbial products available today? First, in most cases, the only data that is published in refereed scientific journals is positive data — experiments in which a positive response was observed. Even then, the data is associated with only one microbe or a mixture containing less than five microbes. Unfortunately, negative data is seldom published. Thus, it does appear that wondrous things happen when specific bacteria are applied in a specific manner in a specific environmental situation.

Furthermore, studies have primarily been conducted on field crops, where yield (and not aesthetics) is the measure of success or failure. The bottom line is these are living microbes. We do not know how adaptable they are to different crops, different environments, different formulations, different application methods and so on.

Second, turfgrass managers, especially golf course superintendents, are looking for anything that will give them an edge in the stressful situations in which they grow grass. What do they have to lose but a couple thousand dollars when buying microbial products? In most cases, the products are harmless. They may not help, but at least they will not hurt the grass.

I do have a word of caution, however: Never apply a product to an entire golf course, lawn, athletic field without first trying it on a practice green, sideline or small side yard. While the microbes in a product probably will not hurt the turfgrass, the product the microbes are mixed with may damage grass.

This brings me to my old stand-by statement of "do your own experiments." All it takes is a piece of plywood. Put the plywood down in the middle of the area to be treated. Apply the product over the area and remove the plywood. Then wait to see what happens. That plywood-covered area is your control that received no product. Remember, as long as you are willing to buy a microbial product, someone will make it available to you.

But what are microbes? What do all the terms used in the product literature and labels mean? In this article, I will discuss only one group of microbes, bacteria, as they are the primary components found in non-EPA registered microbial products. I will follow with a discussion on bacteria associated with the driving force of turfgrass growth — nitrogen.

Bacteria background

Biologists divide the world into two groups of organisms based on the types of living cells that compose each organism. Humans, and the turfgrass we manage, are eukaryotes, composed of cells that have a nucleus bound by a membrane. These cells divide through mitosis. The nucleus is where the chromosomes that contain DNA are located. Other eukaryotes in the turfgrass world are fungi, nematodes, insects — virtually everything else.

However, two important groups of organisms, bacteria and archaea, are not eukaryotes; they are prokaryotes. This means their cells have no nucleus. Instead, they have a single, circular DNA molecule (chromosome) that is not bound by a membrane. Prokaryote cells divide by binary division instead of mitosis.

Archaea microbes are not likely to be found in turfgrass because they prefer extreme environments, such as high temperatures (thermal springs) or high salts (ocean).

Bacteria can be divided into three basic groups, based on differences in cell walls. One group has no cell wall (mycoplasmas and phytoplasmas) and are not normally found living freely in the soil.

The remaining two groups are separated based on the composition of their cell wall, which is reflected in a simple test called the Gram stain. Bacteria are either Gram-positive or Gram-negative. It is simply one method used to classify bacteria into groups.

The only turfgrass systems that will likely benefit from the addition of diazotrophs in terms of supplying nitrogen are those grown without nitrogen fertilizer inputs.

Bacteria are also classified according to cell shape — rods (bacilli), spheres (cocci), spiral-shaped rods (spirilla) or branching filaments (actinomycetes). We further classify bacteria based on their need for oxygen for growth — aerobic (need oxygen), anaerobic (don't need oxygen), facultative anaerobic (sometimes they do and sometimes they don't need oxygen).

Just like humans or turfgrass, bacteria also need nutrients. Carbon, nitrogen, phosphorus and sulfur are the elements needed in the greatest quantities and obtained from the environment in which the bacteria are growing.

Bacteria also need hydrogen and oxygen, but obtain those elements from water. Bacteria take these elements and then either assimilate them into cellular components or transform them into energy.

The source of the carbon — and how a bacterium obtains its energy — are other means of classifying bacteria.

The majority of soil and plant-associated bacteria are chemoheterotrophs. They use organic carbon compounds to obtain carbon and energy. The energy is obtained by the biodegradation of organic compounds, including carbohydrates and proteins. Saprophytic bacteria feed on dead organic com-


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pounds (plant or animal residues). Pathogenic bacteria feed on living organic compounds and thus harm their host.

Fortunately, plant pathogenic bacteria in the turfgrass system are rare. Symbiotic bacteria feed on living organic compounds, but do so in a manner that benefits the host. Turfgrass species are not known to have symbiotic relationships with bacteria.

The remaining soil bacteria are autotrophs, either chemoautotrophs or photoautotrophs. Autotrophic bacteria obtain carbon from inorganic carbon compounds, such as carbon dioxide or methane. Chemoautotrophs obtain their energy from light-independent chemical reactions. These bacteria include nitrifying and sulfur-oxidizing bacteria. Photoautotrophs obtain their energy from light-dependent chemical reactions. These bacteria include cyanobacteria, often referred to as blue-green algae.

Bacteria and nitrogen

Now I will examine these bacteria relative to one element in the turfgrass system — nitrogen. Many different sources of nitrogen are used on turfgrass. These range from inorganic sources, such as ammonium nitrate, to organic sources that include synthetic organic materials formulated from urea and natural organic materials.

For inorganic sources, the nitrogen is in a form already available to the plant. No microbes are required. For organic sources, microbes are required to turn the nitrogen into a form that can be used by the plant. The biological process that transforms organic, synthetic or natural nitrogen to ammonium is called ammonification.

Synthetic organic nitrogen fertilizers include ureaformaldehydes (UF), sulfur-coated urea (SCU), isobutylidenediurea (IBDU) and resin-coated urea (RCU). IBDU and RCU are not dependent on microbes for urea release. Urea from SCU can be released by microbial decomposition of the sulfur coating or by water entering through cracks in the coating.

Ureaformaldehydes (also referred to as methyleneureas) are dependent on biodegradation by microbes (bacteria and fungi) for release of the nitrogen. Some bacteria release nitrogen from UF as ammonia and urea; the formaldehyde released is immediately oxidized to carbon dioxide. Once urea, which is not normally taken up by plant roots, is released by any of these processes, it is hydrolyzed in the presence of the enzyme urease to carbon dioxide and ammonia/ammonium. The urease enzyme itself probably comes from soil microbes.

There is no single bacterial species that is capable of oxidizing ammonia directly to nitrate.

Examples of components in natural organic fertilizers include proteinaceous materials, such as animal manures, poultry litter, crop residues, sewage sludge, hoof and horn materials, and blood meal. These fertilizers are completely dependent on microbial decomposition for release of ammonia/ammonium from the proteinaceous materials. The microbes associated with the processes that release ammonia from synthetic and natural organic fertilizers are not well-defined, but certainly will include a range of chemoheterotrophic bacteria that produce, for example, extracellular enzymes required to break down urea, proteins, amino acids (building blocks of proteins), or aminopolysaccharides (sugars combined with amino acids).

No matter whether you apply a synthetic organic or natural organic nitrogen fertilizer, ammonia/ammonium is the nitrogen compound released from either the urea or proteinaceous materials. Ammonia can volatilize because it is a gas.

Ammonium can be taken up by the plant, but more often the nitrogen is made available to the plant as nitrate. The ammonia is oxidized to form nitrate, a process referred to as nitrification. This process cannot occur without microbes. Nitrification is usually discussed in terms of autotrophic nitrification. Chemoheterotrophic bacteria and fungi can also oxidize ammonium to nitrate, however. The importance of this type of nitrification is still unknown. In pure cultures, it is of minor importance, but the verdict is still out in regard to its importance in soils.

The bacteria associated with autotrophic nitrification are well defined and are all members of the bacterial family, Nitrobacteraceae. Since this process produces energy for these bacteria, the bacteria would be classified as chemoautotrophs.

Two steps are involved in autrotrophic nitrification: 1) ammonia is oxidized to nitrite by ammonia-oxidizing bacteria, which is the rate-determining step; and 2) nitrite is oxidized to nitrate by nitrite-oxidizing bacteria.

There is no single bacterial species that is capable of oxidizing ammonia directly to nitrate. All known terrestrial ammonia-oxidizing bacteria are strict autotrophs. They are members of the "b" subdivision of the Proteobacteria class and primarily belong to the genera nitrosomonas, nitrosospira or nitrosolobus. All nitrite-oxidizing bacteria are members of the "a" subdivision of the proteobacteria, with nitrobacter normally considered the primary genus of terrestrial nitrite-oxidizing bacteria. Nitrobacter is capable of heterotrophic growth, but growth is much slower under those conditions.

All members of the nitrobacteraceae are extremely difficult to isolate from their respective environments. To obtain pure cultures requires an enrichment technique and can easily require six to 12 months. This is why these bacteria will not be found in the microbial products on the market, despite what the literature might claim.

The slow growth also eliminates using a culturable plate count method to monitor or identify Nitrobacteraceae populations in the soil. While probable number techniques have been developed for quantifying ammonia-oxidizing bacteria and nitrite-oxidizing bacteria, these techniques do not allow for identification of the members of the population and are probably biased for the strains most amenable to these techniques. Molecular techniques are the best tools for working with this group of bacteria.

Once the nitrate is released, it can be taken up directly by the plant, or another group of soil microbes can assimilate the nitrate and convert it to ammonium to make amino acids. This process is one form of denitrification and is sometimes referred to as nitrate immobilization. Another form of denitrification occurs under anaerobic conditions. The resulting products are dinitrogen (N_2) and the greenhouse gas nitrous oxide (N_2O).

Another process by which plants obtain nitrogen is through biological nitrogen fixation. In this process, bacteria reduce one molecule of atmospheric nitrogen (N_2, so it is really dinitrogen) to two molecules of ammonia. Bacteria that use atmospheric dinitrogen as their only source of nitrogen for growth are called diazotrophs. All nitrogen-fixing microbes are free-living bacteria. Those which form a symbiotic association with legumes belong to a group of bacteria commonly referred to as rhizobia (e.g., rhizobium, bradyrhizobium). Another bacterium, frankia, forms symbiotic associations with non-legumes, primarily forestry plants. frankia belongs to the general group of bacteria called actinomycetes, which look like fungi but are really bacteria.

Never apply a product to an entire golf course, lawn or athletic field without first trying it on a practice green, sideline or small side yard.

However, bacteria do not have to form symbiotic associations with plants to biologically fix nitrogen. These nonsymbiotic diazotrophs are represented by numerous genera of bacteria. Common ones found in the soil are azotobacter, beijerinckia, acetobacter, azospirillum, xanthobacter, pseudomonas, alcaligenes, bacillus, klebsiella, enterobacter and numerous cyanobacteria genera. If these names look familiar, it is because these are the common bacteria associated with microbial products used on turfgrass.

Azospirillum is a genus of gram-negative bacteria that has been examined the most, both genetically and in laboratory or field studies, in regard to promoting plant growth by nitrogen fixation. However, the contribution of biological nitrogen fixation to the positive plant responses sometimes observed are still often questioned by scientists.

Three important factors limit biological nitrogen fixation in these nonsymbiotic diazotrophs. Except for photoautotrophs like the cyanobacteria, all diazotrophs require an organic or inorganic energy source — and lots of it. The biological fixing of nitrogen requires a considerable amount of energy.

It takes 16 ATPs (adenosine triphosphate, a biological compound that provides the energy to make biochemical reactions possible) to make the two molecules of ammonia from one dinitrogen. Therefore, the first limiting factor is carbon sources needed to produce the massive amounts of energy required.

The second limiting factor is the level of nitrogen (ammonium, nitrate, and organic nitrogen) already present in the environment. As with symbiotic nitrogen fixation, the enzyme complex called nitrogenase mediates the fixing process. It takes very small quantities of nitrogen (think micro, as in virtually undetectable) to limit the nitrogenase enzyme complex.

The third limiting factor is oxygen. Nitrogenase is extremely sensitive to oxygen. Some bacteria have devised unique ways in solving this problem. Rhizobia do this by having the plant produce nodules. The nitrogen fixation occurs inside these nodules, where a compound called leghemoglobin binds the oxygen, thus protecting the nitrogenase enzyme from oxygen. Most of the diazotrophs do not have such an efficient mechanism of binding oxygen.

It is important to understand that the nonsymbiotic diazotrophs probably do not function in most soils and root systems as biological nitrogen fixers. It is only when the environmental conditions meet all of the exacting criteria that the nitrogenase enzyme complex requires that atmospheric dinitrogen is converted to ammonia.

For more detailed information about biopesticides in general or about specific products, please refer to the EPA web site at *www.epa.gov/pesticides/biopesticides.*

Research regarding Klebsiella pneumoniae has shown that at least 21 genes are involved in controlling and supporting the nitrogenase complex.

Does the turfgrass benefit from adding nitrogen-fixing bacteria?

Realistically, the only turfgrass systems that will likely benefit from the addition of diazotrophs in terms of supplying nitrogen are those grown without nitrogen fertilizer inputs — low-maintenance situations or roadside vegetation. If this describes your turfgrass system, then maybe it is worthwhile to experiment with these microbial products. Otherwise, it is highly unlikely that you will receive a positive effect from these bacteria due to their fixing of nitrogen for plant growth.

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Use corn gluten meal as a natural pre-emergent weed control

By Nick Christians

There was a time when pesticides were widely used on turf with little concern about their effects on the environment and human health. This has changed dramatically, and there is now a growing interest in reducing the use of synthetic pesticides and in finding natural products to replace them.

Considerable progress has been made in the development of alternative insect controls. These include things like insecticidal soaps, bacteria that kill insects selectively, pheromone traps and predatory insects. Weed control has been more difficult, however, and standard herbicides have generally been the only solution for weedy turf.

A material that has received a lot of attention in recent years is a byproduct from corn milling called "corn gluten meal." This material is being widely marketed in the United States and Canada as a naturally occurring pre-emergent herbicide and nitrogen source.

Where did the idea originate?

The concept of using corn gluten meal as a natural herbicide originated at Iowa State University in the 1980s. The idea began as a secondary observation from a totally unrelated research project. The original study involved the use of corn meal as a growing medium for pythium, a fungal organism that causes a serious turf disease. The pythium was cultured on corn meal for several weeks and then incorporated into a seed bed before grass was seeded. In adjacent plots, raw corn meal directly from the bag was also incorporated into the soil before seeding. The objective of the study was to observe the effects of the fungal organism on the grass.

The secondary observation came when the germination of the grass was inhibited by the raw corn meal, whereas the grass seed in the plots that received the same amount of corn meal with pythium germinated normally. This indicated there was some type of organic substance in the corn meal that was destroyed when it was cultured with fungal organism.

It was suspected that this substance had some type of inhibitory effect on the germination of grasses. The next step involved the screening of several components of corn meal. These included things like corn starch, corn germ and corn protein (corn gluten meal). This study demonstrated that there was something in the corn gluten meal that had an inhibitory effect on the root formation of germinating seeds.

This led to other studies that demonstrated that corn gluten meal was an effective nitrogen fertilizer on mature grasses and that it could also inhibit the establishment of annual weeds like crabgrass. Eventually, this led to the idea that corn gluten meal could be used as a natural pre-emergent herbicide for turf, as well as gardens and crop production areas.

What is corn gluten meal?

Corn gluten meal is a byproduct of the wet-milling process of corn grain. This process separates the components of the grain to obtain starch and other valuable materials. The corn gluten meal is the protein fraction of the corn.

Corn gluten meal contains 60 percent protein and 10 percent nitrogen (N) by weight and makes an excellent fertilizer for plants that have well-established root systems. The inhibitory substance it contains prevents the formation of roots on germinating seedlings of a variety of grass and broadleaf plants. This includes germinating lawn grasses. Therefore, the product should not be used within six weeks before desirable grasses are seeded.

It is used as a pre-emergent material by applying it to mature stands of grass with well-developed root systems before weeds germinate. Weed establishment is prevented by inhibiting root growth at germination. It is a pre-emergent material only.

How is it used?

Timing is everything with corn gluten meal. It must be applied before weed germination.

TABLE 1

Companies that market corn gluten meal under license with Iowa State University

Alternative Earth Products Corp.
1976 Jericho Tpke.
E. Northport, N.Y. 11731
Ph: 866-765-9654/631-659-1099
Fax: 631-499-4824
Web site: *www.alternativeearth-products.com*

Bioscape
4381 Bodega Ave.
Petaluma, Calif. 94952
Ph: 877-246-7227
Fax: 707-781-9234
Web site: *www.bioscape.com*

Central Garden & Pet
26200 SW 95th Ave., Suite 302
Wilsonville, Ore. 97070
Ph: 503-582-9114

Cereal Byproducts Co.
P.O. Box 575
55 E. Euclid Ave, Ste 410
Mt. Prospect, Ill. 60056
Ph: 800-369-1550
Fax: 847-818-1659
Web site:
www.cerealbyproducts.com

Colorado Sweet Gold
8714 State Hwy. 60
Johnston, Colo. 80534
Ph: 970-587-6500
Fax: 970-587-6515

Down To Earth Distributors
345 Lincoln St. Alley
Eugene, Ore. 97401
Ph: 800-234-5932
Fax: 541-485-7141
Web site: *www.down-to-earth.com*

Fertrell
Box 265
Bainbridge, Pa. 17502
Ph: 717-367-1566
Fax: 717-367-9319
Web site: *www.fertrell.com*

Gardens Alive!
5100 Schenley Place
Lawrenceburg, Ind. 47025
Ph: 812-537-8650
Fax: 812-537-5108
Website: *www.gardensalive.com*

Grain Processing Co.
1600 Oregon St.
Muscatine, Iowa 52761
Ph: 563-264-4265
Fax: 563-264-4289
Web site: *www.grainprocessing.com*

IntAgra
8906 Wentworth Ave. S.
Bloomington, Minn. 55420
Ph: 800-468-2472
Fax: 952-881-7002
Web site: *www.intagra.com*

Manning Agricultural Center
619 Julia Street
Manning, Iowa 51455
Ph: 800-248-4409/712-653-3411
Fax: 712-653-2981
Web site: *www.pionet.net/~macinc*

Pure Barnyard Co.
P.O. Box 1011
Raymond, N.H. 03077-1011
Ph: 888-707-8802
Fax: 603-895-6592
Webs ite: *www.purebarnyard.com*

Renaissance Fertilizers
2300 Totem Trail
Minnetonka, Minn. 55305
Ph: 800-395-4769
Fax: 612-546-0565
Web site:
www.organicfertilizer.com

Safe Earth Lawn & Garden
900 52nd St.
West De Moines, Iowa 50265
Ph: 515-222-1997
Fax: 515-223-1669
Web site: *www.safe-earth.com*

Soil Technologies Corp.
2103 185th St.
Fairfield, Iowa 52556
Ph: 800-221-7645
Fax: 641-472-6189
Web site: *www.soiltechcorp.com*

Walt's Organic Fertilizer Co.
P.O. Box 31580
1528 NW Leary Way
Seattle 98107
Ph: 206-783-6685
Fax: 206-297-9092
Web site: *www.waltsorganic.com*

Wilbur-Ellis Co.
1200 N.W. Naito Pkwy.
Portland, Ore. 97209
Ph: 503-227-2661
Fax: 503-274-2518

The standard recommendation for its use includes the application of 20 pounds of product (2 pounds N) per 1,000 square feet in the spring in a two-to-four week period before the germination of summer annuals like crabgrass. This time will vary by location.

Crabgrass will germinate when soil temperatures reach 55 degrees F. The two pounds of nitrogen releases slowly and provides uniform greening and growth through the summer. The second application of 20 pounds nitrogen per 1,000 square feet on cool-season turf is made around August 15. This helps control some of the perennial broadleaves that germinate in late summer and provides another 2 pounds of nitrogen through the fall. These two applications provide 4 pounds nitrogen per 1000 square feet per year, which is sufficient for most cool-season lawns.

Tests performed on areas with high populations of crabgrass indicate that the crabgrass will be reduced by about 60 percent in the first year of application, in the 80 percent or better range in year two and over 90 percent reduction by year three. This cumulative effect is likely due to an ecological effect of a thickening of the turf due to the nitrogen and to a reduction of weed seed from year to year. There is no carryover of the inhibitory material. Its effect generally dissipates in five to six weeks after application.

There are many other rates and methods of applications being recommended for corn gluten meal. Some individuals are claiming good results with applications of 10 pounds product per 1,000 square feet. Others are combining corn gluten meal with turkey manure and other natural organic products in effective, all-organic programs that appear to be working well.

On warm-season turf like bermudagrass, it can be repeat applied through the weed germination period and through the summer in at amounts equivalent to approximately one pound N per 1,000 square feet per growing month.

What makes it work?

Once it was determined that corn gluten meal contained a natural compound or compounds that could inhibit weed establishment, the next logical step was to determine the nature of that compound. Graduate student Dianna Liu began this work in 1989.

Liu eventually determined that five individual dipeptides (combinations of two amino acids) had the ability to inhibit root formation of germinating seedlings. These dipeptides were glutaminyl-glutamine, glycinyl-alanine, alaninyl-glutamine, alaninyl-asparagine and alaninyl-alanine.

Nick Christians is a professor of horticulture at Iowa State University. He teaches undergraduate and graduate turfgrass science courses and is involved in research projects on turfgrass weed control, nutrition and management.

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TURFGRASS TRENDS

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