BY M.L. ELLIOTT, J.A. MCINROY, K. XIONG, J.H. KIM, H.D. SKIPPER AND E.A. GUERTAL

In the zone

A look at the diversity of rhizosphere bacteria in USGA putting greens

The soil environment immediately around a root frequently has a larger number of microorganisms compared to soil just a few millimeters away from a root. This zone of influence is called the rhizosphere (Rovira, 1991), which is composed of many groups of organisms that are capable of affecting plant health beneficially and deleteriously (Schippers et al., 1987).

Putting greens are artificially constructed soils, built from a predetermined mixture usually composed of sand and organic matter (USGA Green Section staff, 1993). In the Southeastern U.S., newly built putting greens are often fumigated before planted. However, previous research shows microbial populations present before fumigation rebound quickly after fumigation (Elliott and Des Jardin, 2001; Elliott et al., 2004). Additionally, as the putting greens mature, thatch, root and shoot production will cause significant increases in organic matter (Gaussoin et al., 2006), which will promote microbial growth.

Natural materials, organic materials and microbial inoculants are used by the golf course industry because there's an assumption few microbes are present in the turfgrass system or the "wrong" microbes are present. However, recent studies indicate turfgrass systems have extensive microbial populations (e.g., Bigelow et al., 2002; Elliott and Des Jardin, 1999; Elliott et al., 2004; Feng et al., 2002; Mercier, 2006) and diverse microbial communities (e.g., Mueller and Kussow, 2005; Sigler et al., 2001; Yao et al., 2006). Also, it's unclear whether introduced bacteria can influence bacterial populations in the phyllosphere, thatch, rhizosphere soil or bulk soil (Hodges et al., 1993; Lynch, 2002; Mercier, 2006; Mueller and Kussow, 2005; Sigler et al., 2001).

The emphasis of the project described herein was on culturable bacteria because it's culturable bacteria that are being exploited by the golf course industry. In other words, if you can't grow bacteria in large quantities (by a company or directly on the golf course in fermentation tanks), they aren't useful as products. While we know there's a diverse microbial community present in turfgrass root systems, it's not known which culturable fluorescent pseudomonad species or culturable bacilli species are present.

A joint project was undertaken by Auburn University, Clemson University and the University of Florida to examine bacterial populations and diversity in USGA putting greens during a three-year period after the greens were established. We've reported on the flux of the extensive bacterial populations present in putting greens (Elliott et al., 2004), the

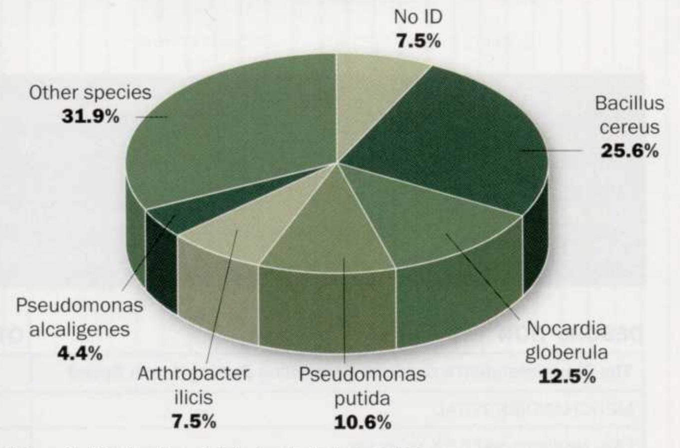

Figure 1. Distribution of rhizobacteria by species from bentgrass greens in September 2000

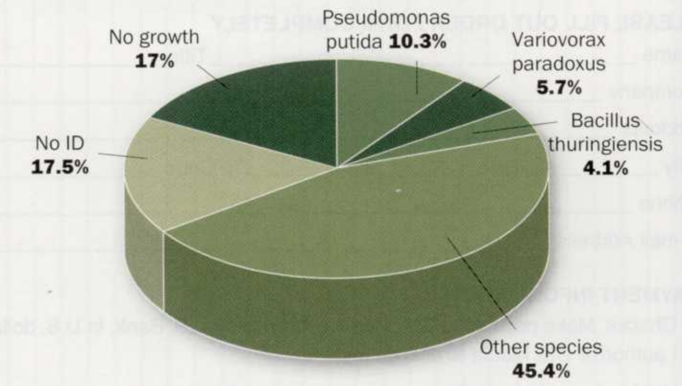

Figure 2. Distribution of rhizobacteria by species from bentgrass greens in August 2000

effect of nitrogen rate and root-zone mix on rhizosphere bacterial populations (Elliott et al., 2003), and the identification of a diverse group of denitrifying bacteria from putting greens (Wang and Skipper, 2004). This report summarizes which culturable bacterial genera and species were present and dominant in bentgrass and Bermudagrass putting greens in the Southeastern U.S. (Elliott et al., submitted).

STUDY SITES

The bentgrass (Crenshaw) putting greens are located at the Charlotte (N.C.) Country Club Golf Course and Auburn (Ala.) University. The hybrid Bermudagrass (Tifdwarf) putting greens are located at the Cougar Point Golf Course in Kiawah Island, S.C., and the University of Florida in Fort Lauderdale. All four sites were fumigated with methyl bromide before planting the turfgrass. Putting greens at university sites (Alabama and Florida) are miniature versions of those on golf courses. All greens were managed in a manner typical for the region.

RHIZOSPHERE SAMPLE

Four putting greens from each location were sampled four times a year (about every three months) for a minimum of three years in 1997 to 2000. Ten cores (0.40 inch by 4 inches)

Summary

Taxonomic diversity of bacteria associated with turfgrass roots hasn't been widely explored. The purpose of this project was to isolate and identify culturable bacteria from the rhizosphere of creeping bentgrass and hybrid Bermudagrass in the Southeastern U.S. Almost 10,000 randomly selected bacterial isolates were analyzed using gas chromatography fatty acid methyl ester (GC-FAME).

- The two dominant genera in bentgrass and Bermudagrass rhizospheres were *Bacillus* and *Pseudomonas*, with *Bacillus* dominant in Bermudagrass and *Pseudomonas* dominant or equal to *Bacillus* in bentgrass.
- Other genera that composed at least 1 percent of the isolates at all four sites were *Clavibacter*, *Flavobacterium*, and *Microbacterium*.
- *Arthrobacter* also composed a significant portion of the bacterial isolates in the bentgrass rhizosphere but not the Bermudagrass rhizosphere. Overall, there were 40 genera common to all four sites.
- At the species level, there were five that composed at least 1 percent of the isolates at each location – *B. cereus*, *B. megaterium*, *C. michiganensis*, *F. johnsoniae*, and *P. putida*.
- This project demonstrates there's considerable taxonomic diversity of bacteria present in the rhizosphere of putting greens.

South Carolina bermudagrass rhizobacteria

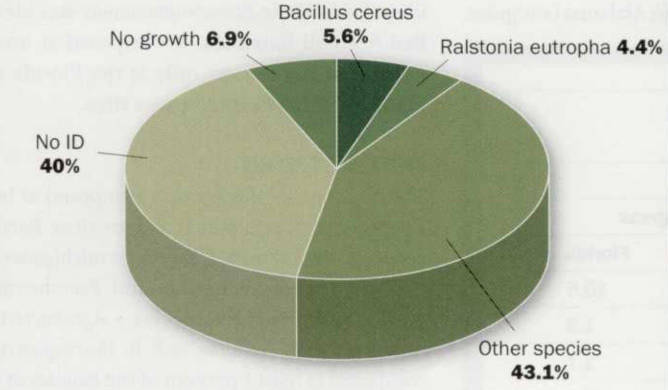

Figure 3. Distribution of rhizobacteria by species from bermudagrass greens in September 2000

Florida bermudagrass rhizobacteria

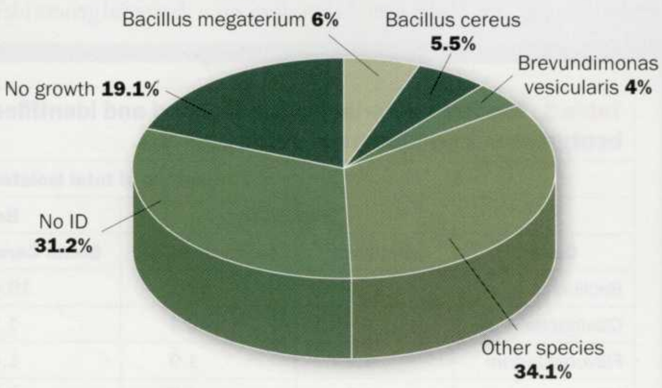

Figure 4. Distribution of rhizobacteria by species from bermudagrass greens in August 2000

Scientists' research demonstrates there's a considerable taxonomic diversity of bacteria in the rhizosphere of putting greens.

were collected per putting green to constitute a sample. Green tissue was removed from each core with a sterile razor blade. For each sample, turfgrass roots were separated from the root-zone mix, and all root material and rhizosphere soil was subjected to shaking in a sterile diluent. Aliquots of dilutions were spread plated onto duplicate plates of selective and nonselective media (Elliott et al., 2004). For enumeration of total aerobic bacteria and selection of bacteria for identification with GC-FAME, solidified 10 percent tryptic soy broth (10 percent TSBA), amended with 100 µg mL-1 cycloheximide to inhibit fungi, was used. For each sampling date, 40 bacterial isolates per green sampled were randomly selected from the 10 percent TSBA for future identification. An estimated 10,000 bacterial isolates were selected for identification during the course of this study.

ID BACTERIA ISOLATES

Analysis of the bacterial isolates was conducted using the GC-FAME/Microbial Identification System (MIDI in Newark, Del.) at Auburn University or at the Multi-user Laboratory at Clemson University. Isolates were processed according to the protocol for aerobic bacteria of environmental origin (Sasser, 2006). Fatty acid peak profiles were analyzed using the Sherlock Standard Aerobe Libraries (MIS version 4.0, Microbial ID, www.midi-inc.com). According to literature provided by MIDI, strains with a similarity index of 0.50 or greater are considered a good match at the species level, whereas strains with a similarity index between 0.30 and 0.49 are considered a good match at the species level but indicates an atypical strain (Anonymous, 2005a). Because the bacterial species present in putting greens were largely unknown when this study was initiated, a similarity index of 0.30 or greater was used as the basis for identifying bacterial isolates.

BACTERIAL GENERA

A total of 9,216 bacterial isolates were analyzed using the GC-FAME/Microbial Identification System. Overall, there were 50, 57, 64 and 64 bacterial genera identified in Alabama bentgrass, North Carolina bentgrass, Florida Bermudagrass and Sout Carolina Bermudagrass, respectively. There were 76 genera identified at both Bermudagrass sites, with 13 unique to Florida, 13 unique to South Carolina and 50 common to both. There were 59 genera identified at both bentgrass sites, with three unique to Alabama, nine unique to North Carolina and 47 common to both. Forty genera were common to all four sites.

There were five genera that composed at least 1 percent of the isolates at all four sites (*Bacillus*, *Clavibacter*, *Flavobacterium*, *Microbacterium* and *Pseudomonas*, with *Bacillus* and *Pseudomonas* the dominant bacterial genera at each location. However, the percentage of isolates identified as *Bacillus* in the Bermudagrass sites was almost twice the number of isolates identified as *Pseudomonas*. At the bentgrass sites, *Pseudomonas* was either the dominant genus (North Carolina) or was equal to *Bacillus* (Alabama). This is consistent with the previously reported enumeration data that *Bacillus* is the dominant genus over *Pseudomonas* in the Bermudagrass rhizosphere, and that significantly greater numbers of fluorescent pseudomonads are found in the bentgrass rhizosphere than in the Bermudagrass rhizosphere (Elliott et al., 2004).

Arthrobacter composed a significant portion of the bacterial isolates at the bentgrass sites (9.1 percent at Alabama and 7.5 percent at North Carolina), with only *Bacillus* and *Pseudomonas* composing a greater percentage of the isolates identified. While *Stenotrophomonas* was identified from all four sites, it composed at least 1 percent of the isolates only at the Florida and South Carolina Bermudagrass sites.

BACTERIAL SPECIES

There were five species that composed at least 1 percent of the isolates at all four sites: *Bacillus cereus*, *B. megaterium*, *Clavibacter michiganensis*, *Flavobacterium johnsoniae* and *Pseudomonas* putida. Another three species – *Agrobacterium radiobacter*, *B. pumilus* and *B. thuringiensis* – composed at least 1 percent of the isolates at the Alabama, Florida and South Carolina sites, but not the North Carolina site. A fourth species, *Comamonas acidovorans*, composed at least 1 percent of the isolates at the NC, AL and Florida sites but not the South Carolina site. One species was common at the 1-percent level only to the Bermudagrass locations: *Stenotrophomonas maltophilia*. Four species were common at the

Table 1. Top five bacterial genera isolated and identified from bentgrass or bermudagrass putting greens.

	Percentage of total isolates[y]			
	Bentgrass		Bermudagrass	
Genera	Alabama	North Carolina	South Carolina	Florida
Bacillus	13.9	12.5	19.4	10.5
Clavibacter	2.0	2.4	1.1	1.3
Flavobacterium	1.5	1.9	1.4	1.7
Microbacterium	1.2	1.7	1.1	3.1
Pseudomonas	13.6	18.7	9.1	5.8
No match[z]	34.3	32.0	38.0	50.1

[y] Total isolates analyzed is 1,896 for Alabama, 2,832 for North Carolina, 2,617 for South Carolina and 1,871 for Florida.

[z] No isolate for that site had a match to a genus in the FAME database.

1-percent level only to the bentgrass locations: *Arthrobacter ilicis*, *P. chlororaphis*, *P. fluorescens* and *P. syringae*. Figures 1 to 4 illustrate examples of species composition for single dates at each study site.

UNIDENTIFIABLE ISOLATES

The number of unidentifiable isolates (similarity index of less than 0.30) was 50.1 percent for Florida Bermudagrass, 38 percent for South Carolina Bermudagrass, 34.3 percent for Alabama bentgrass and 32 percenty for North Carolina bentgrass (Table 1). These values fall within the range of unidentifiable isolates obtained in other studies using GC-FAME for identification purposes (Germida and Siciliano, 2001; Gooden et al., 2004; Kim et al., 2001/2002; Mahaffee and Kloepper, 1997; Poonguzhali et al., 2006; Siciliano and Germida, 1999). Thus, the number of unidentified isolates in this study, obtained from an artificially constructed soil, would appear to be similar to the number from field soils in the same states using the same identification system.

Why are some bacterial isolates not identified? The MIDI aerobe bacteria library includes fatty acid profiles for 695 environmental species, with usually 20 or more strains representing each species or subspecies (Anonymous, 2005b; Sasser, 2006). Our results and those of others illustrate that a significant number of bacteria isolated from bulk or rhizosphere soils aren't part of the bacterial collection that's the basis of the MIDI environmental species library. Any database is only as good as the data – in this case, fatty acid methyl ester profiles of bacterial isolates – accumulated within it. The unidentifiable isolates aren't necessarily new species per se but simply might be species not represented in the MIDI database.

TAXONOMIC DIVERSITY

This is the first study to survey for a portion of the culturable, aerobic bacterial genera and species common to golf course putting greens in the southeastern U.S. It demonstrates there's considerable taxonomic diversity present in the rhizosphere of putting greens, despite their intense management. Obviously, while we have identified some of the bacteria genera and species present in golf course putting greens, there still are many unidentified bacteria. Even less information is known regarding what these bacteria do in the turfgrass system. GCI

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Editor's note: Literature cited for this article can be found online at www.golfcourseindustry.com posted with this article.

IMPACT ON THE BUSINESS

Back to basics

BY PAT JONES

Much of the research in the golf and turf academic community is directed to determine highly specific results. Which Bermudagrass performs the best under saline conditions? Which fungicide was most effective on *Poa annua*/bentgrass greens? Which wetting agent was best suited for highly compacted soils?

This article separates itself from the pack because it looks at a very basic question: Which tiny critters (bacteria) are hanging out in the soil of different types of putting greens? Ultimately, it gets back to the age-old question of what is the right soil ecosystem for creating greens that are viable and manageable.

WHY?

Soil microbial action has become increasingly recognized as an important indicator of turf health (or lack thereof) throughout the past decade. Yet, the presence or nonpresence of these diverse microscopic thingies raises a bunch of questions that turf scientists are just starting to answer. Those questions include:

- Which microbes are present?
- Are they beneficial or harmful?
- What is the right balance for your soils?
- How can they be promoted or eliminated to achieve that balance?

This article addresses the first question: What do you typically find in different kinds of greens structures.

WHAT'S NEXT?

The real question is how do you manage the microbial populations that inevitably live under every golf putting surface. Once again, soil testing is a big part of the answer. According to experts in the field, certain elements (calcium, potassium, etc.) probably promote a healthy microbial mix. Regular and relatively extensive soil testing offers a chance to benchmark soil mineral composition against microbial activity.

COSTS AND BENEFITS

As noted previously, soil testing costs can range from zero (the free services offered by chemical companies) to thousands of dollars annually for sophisticated testing provided by independent labs. Unfortunately, course owners and green committees sometimes fail to understand the value of independent testing and will look at this "consulting" fee as one of the first things to be axed when budgets get tight.

That short-sighted view can result in much higher costs later when the soil ecosystem gets out of balance and much more expensive cures are needed. In short, testing almost always pays for itself. GCI

BY HEATHER DAVIES

Playing rough at Oakmont

Superintendent leaves nothing to chance, even outside the fairways

I'm sure you've heard plenty about the countless hours John Zimmers and his staff put into preparing Oakmont Country Club for the 2007 U.S. Open. You've probably read about the speedy greens, the daring tree removal program, the fast-and-firm fairways and almost every other aspect of getting the famed course ready for one of the most successful Opens in recent history.

But what was going on right outside the greens and fairways – in the rough? It turns out Zimmers put almost as much thought and effort into the tall grass as he did the manicured turf.

Now that he's put the big event behind him and had a chance to catch up on his sleep, Zimmers is happy with the way things turned out.

"More importantly, the USGA and the membership were pleased with the conditions," he says.

Heading into the Open, Zimmers worried most about the weather forecast for the week.

"Weather is the biggest possible obstacle that is totally out of your control as a superintendent," he says. "It also has the largest impact on the outcome of the championship."

Fortunately, Mother Nature mostly played along, and conditions progressed perfectly throughout the week thanks to a little early moisture followed by sunny and dry conditions during play.

There's little doubt the majority of players', media's and fans' attention was – as always – on the putting surfaces. And Zimmers was prepared for that.

"You always worry the most about the putting greens," he says. "They're basically what you get judged on the most, as far as course conditioning goes, and are the most vulnerable."

In some ways, the demands of Oakmont's low-handicap membership made that part easier. Green speeds and tough pins used for the event aren't unusual in the context of regular member play at what many consider to be one of the most challenging courses in the world week in and week out.

"The Oakmont membership prides itself on playing championship conditions on a daily basis," Zimmers says. "It's also a benefit that the club has been through this several times before, as this was Oakmont's eighth U.S. Open."

One thing, however, that was different than typical Oakmont play was the newly tree-free area surrounding the greens and fairways: the rough.

"Going into the Open, I thought our rough was the weakest part of the course," Zimmers says. "I was concerned about trying to provide 5-inch-plus uniform rough without it laying over. That's difficult to achieve."

The greens usually receive all the attention and most of the babying, but the USGA historically has viewed the rough, as the part of the course that provides the most protection against unreasonable scoring, as important.

"When you think about the U.S. Open, penal rough comes to mind," Zimmers says.

In the years leading up to the event, Zimmers talked with colleagues and suppliers

Soil testing showed there were subsurface deficiencies in the rough at Oakmont before the U.S. Open, and silica was one of them. Photo: Oakmont Country Club to see what, if any, types of products and practices might be able to simultaneously strengthen the rough and create more upright growth. The goal was to be appropriately penal but not have balls that were completely unplayable because of hayfield-type rough.

During his research, Zimmers considered the option of using silicon-based products. Soil testing showed there were subsurface deficiencies in the roughs, and silica was one of them. Research from Penn State and other universities suggested silicon-enhanced products provide better cell rigidity and, therefore, more turgidity and improved upright growth. In short, the higher-mown turf in the rough tends to stand up instead of roll over.

Eventually, Zimmers found a prilled, calcium-silicate product that also contained magnesium and other micronutrients. Most importantly, the custom blend – called Excellerator from Excell Minerals – contained the soluble silicon that had been shown to bolster the upright growth that Zimmers needed in the tall grass.

"It ended up turning out just fine – it was uniform, upright, turgid and withstood the wear from the equipment wonderfully," Zimmers says. "I attribute that to the Excelerator product that we had been applying throughout the entire rough."

Application rates of Excellerator initially should be enough to correct existing silicon deficiencies. Zimmers started the program in April 2006 at an initial rate of 25 pounds per 1,000 square feet and made subsequent applications in November and April 2007 at the same rate.

For most facilities, an initial rate of 25 pounds per 1,000 square feet is standard, according to Excell Minerals. Follow-up applications should be 10 to 12 pounds per 1,000 square feet every three to four weeks, the company says. The target rate is about 50 pounds per growing season.

The bottom line for Zimmers is presenting the best-conditioned, most challenging golf course possible for Oakmont's members, guests and the pros. The rough was and will continue to be a big part of that, so Zimmers recognizes the importance of the calcium-silicate program long term. There's more to the program than just getting rough to stand up, he says.

"We use less fertilizer, and we've seen stronger, healthier turf that withstands traffic much better," he says. "It really greens up, and we think we've had some suppression of disease as well. The only thing I would've done differently was to start on the program earlier. The results speak for themselves." **GCI**

Heather Davies is a freelance writer based in Columbus, Ohio.

Research suggested silicon-enhanced products provide better cell wall rigidity and more turgidity, improving upright turfgrass growth. Photo: Oakmont Country Club

BY KATIE MORRIS

Making amends

Illinois superintendent uses natural resources as soil amendments.

Golfers prefer playing on surfaces that are green, smooth and consistent. Soil amendments helps give turf the strength and absorbance it needs to withstand daily mowing, watering and foot traffic. To keep the course looking healthy and green, Steve Diel, golf course superintendent at Quail Creek Country Club in Robinson, Ill., uses natural resources around him to amend the course's soil.

Diel has been with Quail Creek for 31 years and previously was the superintendent of Charleston (Ill.) Country Club. He has learned from being in the industry for more than 40 years what type of soil amendments work best on the course. He uses two types of amendments: pure sand and compost that consists of grass clippings and leaves.

Topdressing the greens with sand builds the soil system, allows for better drainage and restrains compaction, Diel says. His crew applies a light application six to seven times a year and a heavy application when they aerify the greens twice a year.

The second type of amendment involves his lawn division gathering grass clippings and leaves during the year and composting them to mix in the soil. Compost is mainly used for building or renovating areas such as tees or bunker surrounds, Diel says. He thought of the idea to use compost after realizing he and his staff needed to do something with the material generated from maintaining the course. He thought this would be a good way to make use of the materials.

"Adding this organic matter helps drainage, and because compost isn't as tight as clay, it helps keep soil looser," he says.

Diel's composting of grass clippings and leaves comes at a minimal cost for a course that has a $275,000 annual maintenance budget, of which about $5,000 is spent on soil amendments. The composting happens onsite, so the only expense comes from rolling the pile over during the process to keep the microbes active, he says.

Diel purchases the topdressing sand from a sand and gravel supplier located 35 miles away from the club. He purchases a blend the supplier makes specifically for golf course construction. The supplier typically hauls a couple loads to Quail Creek during spring and fall.

"We probably purchase 50 to 75 tons a year, and spend about $11 to $12 a ton," he says.

Topdressing greens lightly with sand takes

Topdressing greens with sand builds the soil system, allows for better drainage and restrains compaction. Photo: Redexim Charterhouse two crew members five to six hours. It takes them three hours to lightly dust the greens with sand, then they brush it in. When applying heavy topdressing the process takes all day because they're putting down much more material.

The composting application is only applied to new construction or areas that need to be renovated. The process involves working an area down to a grade they want with yellow clay, applying a 2-inch layer of compost, applying 4 to 6 inches of soil and then seeding the area.

"We've been doing a lot of small projects pretty frequently, but no major overhauls," Diel says.

Another part of Diel's soil amendment process includes conducting soil tests every three years. He's in a routine where he tests a third of his greens, tees and fairways every year so every third year they're all getting checked.

"It's a way for us to monitor trends of various nutrients and adjust our fertility to keep us moving where we want to go," Diel says.

Superintendents looking into soil amendments should ask themselves what kind of problem they have and what a particular product is going to do for them – not just in the short run but in the long run, Diel says.

"They should think about how this process is going to affect things in the long run because once you get in and start changing the soil, that effect is going to stay with you," he says. **GCI**

"Adding this organic matter helps drainage, and because compost isn't as tight as clay, it helps keep soil looser."
- STEVE DIEL

At Quail Creek Country Club, compost is mainly used for building or renovating areas such as tees or bunker surrounds. Photo: PICSUNV I istock.com

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TAKING THE CORRECT STEPS

Q While attending the U.S. Open Championship at Oakmont Country Club in June, I was disappointed to see the players so far forward on the teeing ground at the practice range. Why were they so far forward on the tee?

A To provide the competitors with the same practice conditions they would experience on the golf course, the USGA, in cooperation with the PGA Tour, has the players begin practicing at the back of the teeing ground on Monday. Throughout the week, they're moved forward toward the front of the tee so the turf remains free from pedestrian traffic and divots and debris, and the same height of cut and turf density as the fairways.

This method allows the grounds staff to maintain and clean the turf without old divot scars and the soil mixes damaging or dulling the mower reel blades.

Q During a championship, I watched the grounds volunteers pick up old divots from the fairways each night and fill the scar with a dark material. What's in the bottles and buckets, and why not use sand?

A Competitors have complained about playing a shot from sand-filled divots from the middle of the fairway. To them, it constitutes a penalty. So, to reduce these concerns and to provide a firmer and more reliable playing surface, the recommendation to host sites is to have the divot replacement mix be an equal combination of soil, sand and organic matter. Seed in the mixture only applies to certain turf types.

Once the mix is added, it's tamped for firmness so players will have a level, firm and predictable shot response. Divot replacement is accomplished each evening so the mix remains dry and unaffected by the morning dew. Too much moisture can cause the mix to streak on the fairways and lessen reel sharpness.

Q What's the repair strategy for a golf course after a heavy rain and an ensuing play delay during a championship?

A Repair depends on several factors: the amount of rain, the degree of damage to the course, the time it takes to recover and be ready for play, and if there's lightning in the area, which will prolong the delay. Officials also need to determine if play can return without additional rules issues.

The repair procedure primarily focuses on the putting surfaces first, followed by: greenside bunkers, fairway bunkers, fairway landing zones and teeing grounds, where any standing or casual water might be present. When repairing for play, the grounds staff must be allowed ample time to finish the work without rushing and be in constant communication with the Rules staff.

Q When starting work so early in the morning and in the dark most times, is there any way to increase light so the grounds staff can see better?

A At The PGA Championship at Southern Hills Country Club, Russ Myers, CGCS, borrowed Department of Transportation lights to illuminate the golf course. However, after conducting one of his many television interviews, he noticed how bright the studio lights were. One lamp could light up several of the fairways close to the clubhouse, allowing all fairway mowing groups to start cutting long before sunrise.

Q All we heard during the week of the FedEx Championship at East Lake Golf Club was how bad putting green conditions were and that they were virtually unplayable. However, it didn't appear to hurt Tiger Woods or the rest of the field. What was done to prepare the surfaces for play?

A First, Ralph Kepple, CGCS, his staff and the volunteers should be commended for their hard work. Second, the putting surfaces weren't unplayable. Ralph and his team took all the correct steps to encourage healthy turfgrass growth.

All member, PGA Tour player and corporate play was halted before and during the practice rounds to reduce traffic stress. A fertility plan was implemented to strengthen and grow the turf, fill in any surface voids and withstand the stress from the competition. Fans were used to move stagnant air. Subsurface ventilation was initiated, and the height of cut was raised and reestablished to meet PGA Tour requirements. Solid front rollers for walk-mowers replaced grooved rollers to reduce damage to the turf through mechanical stresses. Cutting frequency was reduced compared to other golf major operations, and hand syringing and irrigation was employed. Light and frequent hand topdressing was used to smooth any surface blemishes to allow for a consistent ball roll and tracking. All potential hole location areas were reviewed and protected.

Most importantly, the PGA Tour players understood the difficult summer conditions, including record high temperatures, humidity and too much or not enough rain. These environmental factors, combined with the club's difficult microenvironment (its close proximity to downtown Atlanta increases temperature and humidity) made growing a cool-season bentgrass turf extremely difficult. However, the end result was uniform conditions for all competitors, for which Ralph is to be commended.

This championship should help all golfers better understand that preparing a golf course to its highest level takes painstaking commitment, knowledge and dedication. Maybe they'll even understand it's the same daily routine for all golf course superintendents. **GCI**

Editor's note: If you have questions about course set-up or maintenance related to golf tournaments or events, e-mail Tim Moraghan at tmoraghan11@comcast.net.