PLACEMENT AND VISIBILITY. In my opinion, it is critical that bunkers and, for that matter, all hazards be visible. I think that the golf holes which are the most memorable are the ones where the golfer can see everything unfold in front of them. We want the golfer to be able to see the entire hole or landing area when preparing to hit his shot so that he can make an informed decision on how to play it. For that reason, we would generally not put bunkers on the back side of a hill or behind a green where they can't be seen. However, with that said, there are times where we might propose a "catch" bunker or a "savior" bunker in that location. For instance, if there is water behind the green, we may put a bunker behind the green to gather a shot that might trickle off the green, rather than penalizing a player a full stroke for only slightly miss-clubbing.

In the fairway, we use cross bunkers, directional bunkers or framing bunkers to frame the hole, define the landing areas and to create strategy. Around the green, we use bunkers to guard the green and to create preferred angles of approach. Generally, greenside bunkers are a little deeper and a little more dramatic than fairway bunkers. How far we place the bunker from the putting surface is dependent in part upon the length of the hole, the size of the green, how difficult we want the hole to play and, again, the type of course we are working on.

DRAINAGE AND EROSION CONTROL. There are a lot of ways to build bunkers but the one thing they all must have in order to function properly is drainage. Often times, if a course is contemplating a bunker renovation project it is because their sand no longer drains properly and because the playability is inconsistent. It doesn't really matter whether you want more traditional bunkering with flat sand and grass faces or whether you want elaborate capes and bays with the sand flashed up high on the faces. All bunkers need good internal drainage. This includes drainage in the bottom of the bunker to evacuate water as well as paying attention to how much water actually runs into the bunker from the surrounding area. Generally, what tends to happen over time is that bunker sand gets contaminated with silt which either washes in from the surrounding area or washes in from the exposed faces of the bunker. In time, that silt then tends to plug up the pores in the sand and the sand loses its ability to drain quickly. To minimize this, it is important that the area surrounding the bunker complex be designed so that a minimal amount of water is actually running into the bunker. In part, we do this by adding small mounds and features which help direct the water or by creating swales around the bunker.

How we finalize the grassing of the bunker complex to control erosion and to get the project back into play is again dependent on the budget and the overall character or style of the course. Generally, we would either try to sod the bunker surrounds or we would use seed and an

Hole 10 fairway and greenside bunkers at The Preserve on Lake Rathbun, Moravia, Iowa.

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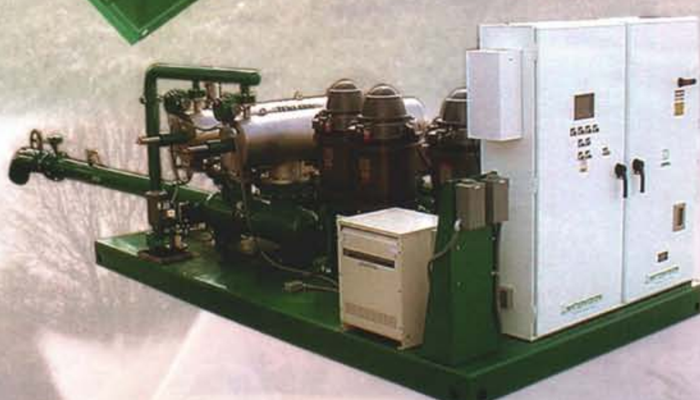

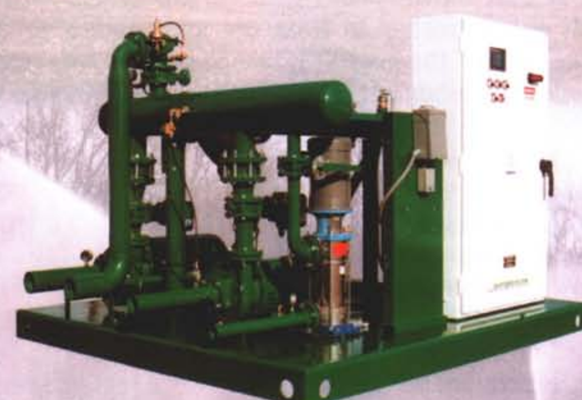

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erosion control blanket. Sod is a bit more expensive than seed but gives us an almost immediate look of completion. If the bunker faces and capes are going to be maintained at 2 or 2 1/2" height then sod is probably the best solution. However, if the club is looking to maintain the capes in fescue or at a taller cutting height then seed and blanket might be the best choice so that we can be more selective about the turf grass varieties.

SAND. To some degree, which sand we choose for a bunker renovation project is a function of budget and, again, the type of course which we are working for. What is important is that the sand drains quickly and that it sets up firm enough that balls don't plug. A little bit coarser sand with some particles that are more angular rather than round is generally best. Depending on where you are in the country, there are some very good local bunker sands where you might spend only $13 to $15 a ton. You also usually have the option of bringing in a USGA sand for $30 to $40 per ton. If the club has the money, we might look at bringing in a premium white sand which usually cost somewhere in the $90 to $110 per ton range.

DISRUPTION TO PLAY. One of the most important issues to consider is how to minimize the potential for disruption to play during your renovation project. In most cases, we prepare a bunker renovation plan and then work with the club officials to determine how to complete the project over a 3 to 5 year period of time. We may decide to do a few holes each year or we may decide to do all the holes at one time. Fortunately, bunker renovations are generally not so disruptive that we can't continue play during construction. In the Midwest, the best time for a bunker renovation project is usually in July and August since the chances of weather delays which might prolong the project are reduced. However, with tournament schedules and with fewer golfers in the fall, most clubs seem to opt for a September project schedule. With a well defined project scope and a good contractor, we can make the necessary changes and have the disturbed areas re-grassed quite quickly and be ready for play by spring. The key is to start with an overall plan on how to complete the project and then use an experienced golf architect and an experienced golf course contractor to insure that the project is completed properly and on time.

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Nutrient Profile: Iron

By Dr. Doug Soldat, *Department of Soil Science, University of Wisconsin-Madison*

Of all the nutrients in the soil, iron is found in the greatest abundance. In fact, soils are largely made of iron-containing compounds. Think of Wisconsin's eastern red clays and the red earth in the southern US. The red color in those soils comes from iron oxide - more commonly known as rust. Iron is present in the soil because it is not very soluble and has persisted despite tens of thousands of years of rainfall and leaching. Therefore, it should come as little surprise to learn that iron is found in miniscule quantities in the soil solution, which is where the plants directly obtain nutrients. Even though total soil iron content is typically high, the *available* iron content may be very low, and iron deficiency symptoms can appear. Luckily, plants require only small amounts of iron to grow properly and actual iron deficiencies in turfgrass are extremely rare. This is not true for many other ornamental and native plants that cannot thrive or even live on high pH soils because of iron deficiency problems.

Iron is also one of the most complex nutrients in soils and plants. Researchers have found that the total amount of iron in the plant is not necessarily related to whether or not an iron deficiency appears. For example, you could find two of the same species of plant, both with 150 ppm Fe in the tissue and only one of the plants might show severe iron deficiency problems, while the other would be completely healthy. This is called the iron paradox and is a current topic of several research studies across the nation. Soil testing for Iron is not very simple either, as extractable iron in the soil is not well correlated with the iron in the plant. Some (like me) wonder about the sanity of using a soil test to predict tissue concentrations, if tissue concentrations are already known to be misleading. To summarize, there are known knowns about iron, and there are known unknowns. We will stick to the known knowns for the rest of the article (my apologies to the former Defense Secretary).

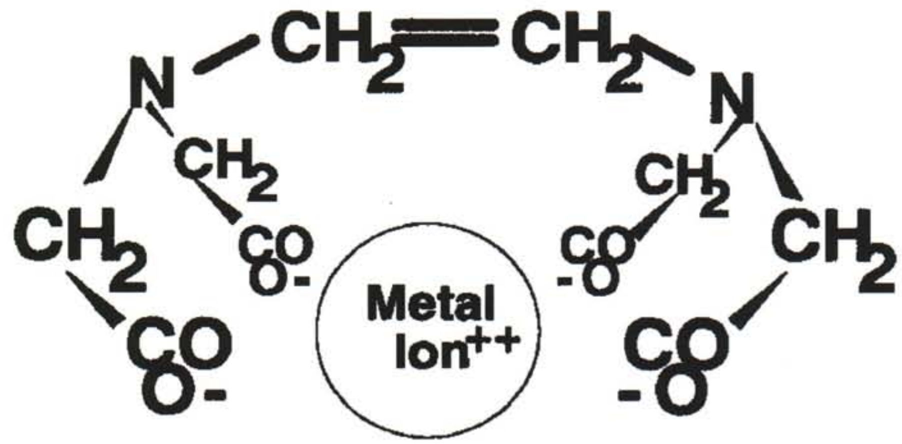


Figure 1. A conceptual representation of the chelation process, where a large organic molecule (in this case EDTA) binds with a metal ion like iron (Fe3+) like a hand gripping a ball. Notice how the negatively charged "fingers" of the EDTA molecule surround the positively charged, smaller metal ion. Look on your soda can, chances are EDTA was added to remove complex with the metal from the can to remove the metallic taste that would otherwise exist.

Foliar or Soil Application?

Iron availability is very sensitive to soil pH, and iron becomes less available as soil pH increases. Therefore, most iron deficiencies are seen in calcareous (high pH) soils, especially calcareous sands, which have very low total iron, compared with mineral soils to begin with. Because soil pH adjustment is impractical for large areas, periodic iron fertilizer applications are the solution to increasing iron availability. In the turf industry, iron is applied predominantly by foliar sprays. Soil applications are rare, or incidental (as when applying Milorganite, or another iron-rich material). There are many iron products available, and the two most important factors related to efficacy of the application are the form of iron (chelated or not) and the type of adjuvant used in the formulation.

Iron Chelation

Chelate (pronounced KEY-late), is derived from the Greek word for claw. This turns out to be a very descriptive name, because chelating molecules look similar to a hand closing in on another smaller atom or molecule, like iron (see Figure 1). Several natural and synthetic chelating (KEY-lay-ting) agents exist. These agents "grab" iron and other metals and keep them in the soil solution at much higher concentrations than would normally occur if the chelating agents were absent. Natural chelating agents are formed when soil organic matter decomposes and grasses secrete their own iron-specific chelating agents called phytosiderophores into the root zone. Sometimes these natural chelating agents are insufficient for increasing the iron solubility to achieve optimum growth or plant health, and iron fertilization is required. Chelated forms of iron are recommended for soil and foliar applications of iron. This is because (as mentioned earlier) iron is very insoluble in the soil, and chelating agents can substantially increase the solubility of iron for a few weeks. If using a soil-based application, the most effective chelating agents in high-pH are EDDHA and DTPA. EDTA and glucoheptonate are common chelating agents that will not be effective in high pH soils.

Figure 2. The typical patchy, mottled look of Kentucky bluegrass suffering from iron deficiency.

Photo Credit: Dennis Robinson

Figure 3. Close up picture of creeping bentgrass blades with no iron applied.

Photo credit: Wayne Kussow, Todd Fregien

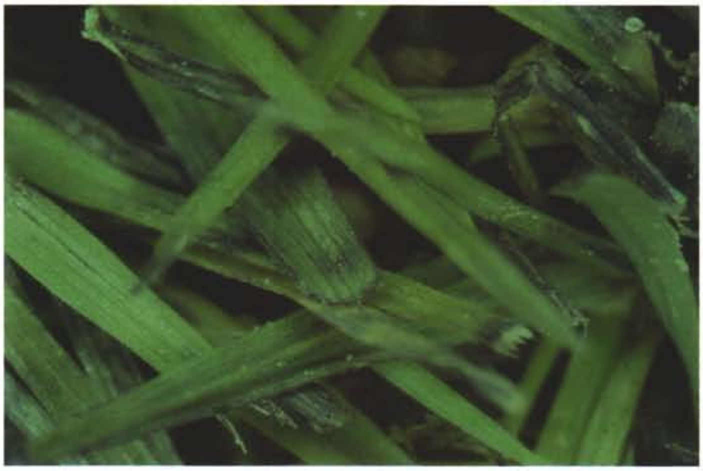


Figure 4. Close-up picture of creeping bentgrass blades following iron application.

Photo credit: Wayne Kussow, Todd Fregien

Iron can also form insoluble compounds on the leaf surface. The degree of solubility is related to the chemistry of the spray tank solution. Because the tank mixtures for golf turf management tend to be complex, chelated sources of iron are probably a wise decision. If you add Fe-EDTA or Fe-glucoheptonate to a spray tank filled with hard water (pH=8.2, high in calcium), those chelating agents will rapidly drop the iron and complex with the calcium in the water. For this situation, an iron fertilizer containing EDDHA or DTPA would be a better choice. *In summary, know the pH of your soil and spray solution and soil to choose a product with a chelating agent that is effective with iron at that pH.*

Breaking the Barrier

To penetrate the plant's waxy leaf surface, a chemical must be relatively small and preferably non-charged. (This is why urea is a good candidate for foliar uptake). Large molecules have trouble working their way through the tiny pores and cracks of the leaf, and charged molecules can be bound or repelled by the positively charged surfaces that line the pores in the plant. Most chelating agents meet the requirement of being relatively small and uncharged. The other important factor for foliar uptake is a low surface tension of the spray solution.

Adjuvants (or surfactants) are substances added to a product to decrease the surface tension of the spray solution and increase the foliar uptake of the active ingredient. A low surface tension allows the spray solution to spread out and cover more of the plant surface. More coverage by the spray solution increases the chance for penetration. There is a very large industry built around the research and development of surfactants for improving the efficiency of fertilizers and pesticides, attesting to the importance of these additives.

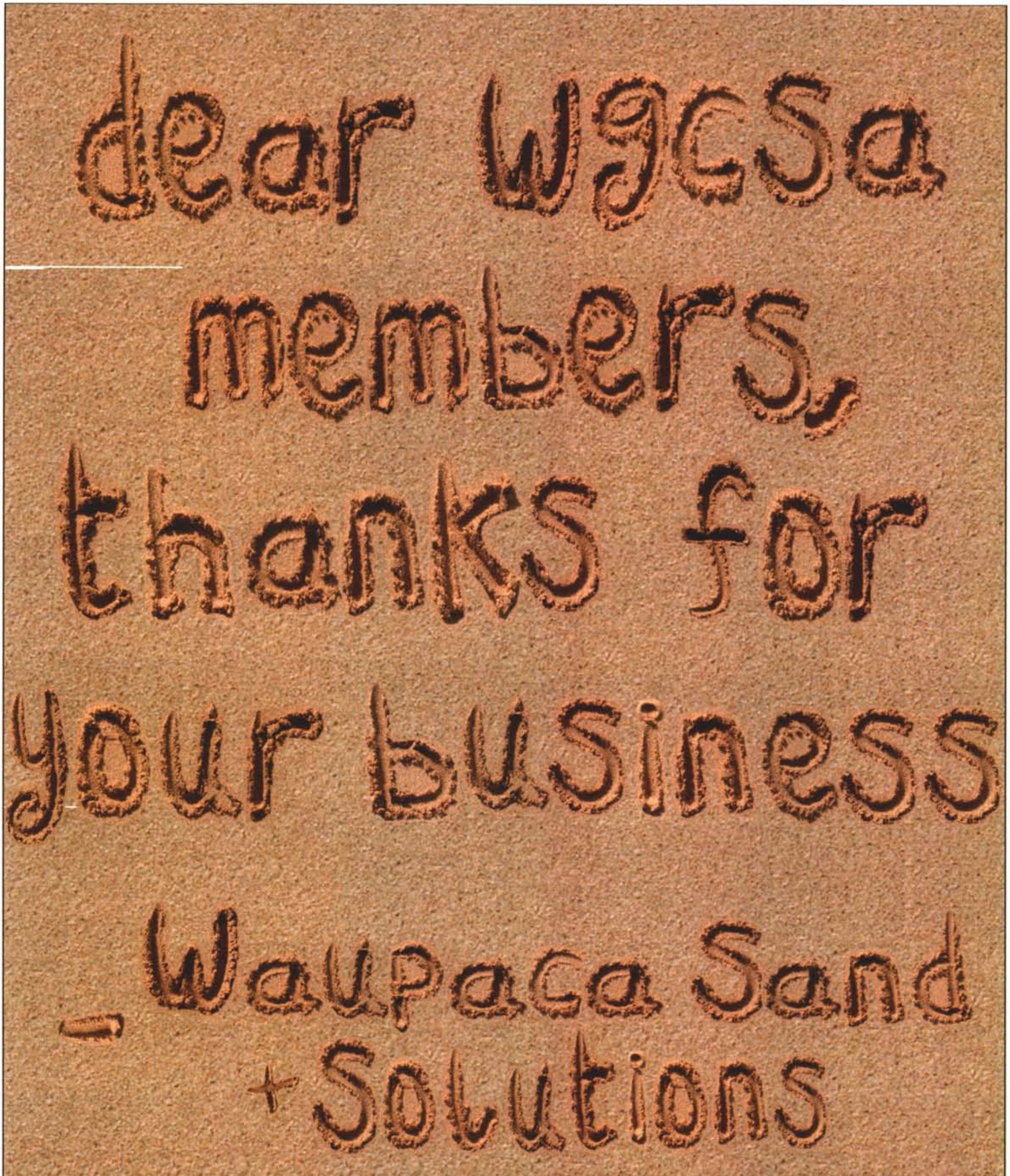
A True Deficiency or Aesthetic Response?

Insufficient Fe is not very common, but can occur in specific situations like high pH soils, or when nutrient uptake (including iron) is limited by low or excessive temperatures. The primary visual symptom of iron deficiency is a general yellowing or chlorosis of newer leaves. When viewed from afar, this yellowing, or chlorosis, tends to show up in a mottled or patchy pattern, unlike chlorosis due to N deficiency, which tends to be fairly uniform in nature (see Figure 2). Also, nitrogen deficiencies show up in older leaves first, as the plant is able to move N from older tissue to newer tissue. Because of its mottled appearance, iron deficiency is often mistaken for a water or drainage issue.

Probably less than 1% of all iron applications are made to turf truly deficient in iron. The other 99% are meant to enhance the color of the turf, or to get by with less N without sacrificing color. When the iron is intended only as "paint," chelation of the iron source becomes less important because precipitation of iron on the surface of the leaf will provide the desired greening or darkening effect.

The darkening effect is shown clearly in the two classic images taken by Dr. Wayne Kussow and former student Todd Fregien (Figures 3 and 4). When viewed up close, the foliar iron application left dark spots on the leaves. When viewed from a distance, the grass would appear a darker shade of green. This temporary staining disappears as the grass grows and the leaves are mowed off, usually lasting no longer than 10-14 days. Try spraying different rates of your foliar iron product to identify the rate that gives the best darkening color without turning the turf entirely black or brown (which is very possible). The optimum rate will not always be the rate suggested on the label.

In summary, iron is a complex nutrient in the soil, plant, and in the spray solution. If you are dealing with a true iron deficiency, consider relatively high rates of chelated iron to the soil and to the plant tissue. Most iron chelating agents are effective for low pH soils and spray solutions, but only a few (EDDHA and DPTA) have been shown to be effective in high pH soils and spray solutions. There is little doubt that iron applications can have beneficial aesthetic effects on turfgrass color when applied frequently by foliar application. However, the darker green color associated with iron-treated plants is not indicative of better physiological plant health. Frequent foliar applications of iron may be one solution for dealing with cuts in fertilizer budgets due to high fertilizer prices.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My Summer Vacation - A 2008 TDL Year in Review

By, **Paul Koch,** Turfgrass Diagnostic Lab Manager, **Dr. Jim Kerns,** Department of Plant Pathology - University of Wisconsin-Madison

As the gloomy economic numbers are being analyzed from the 2008 golfing season, one item in the budget that nearly every superintendent spent significantly less on this year was fungicides. Mild temperatures and low humidity for much of the summer kept most diseases in check. In fact, at the O.J. Noer Turfgrass Center we had a difficult time getting dollar spot to even appear, which was evident to any attendee at the WTA Summer Field Day who watched Dr. Kerns and myself talk about this wonderful new bio-control product for dollar spot called "Untreated Control." However, despite the title of this article, grass did still die and we still found ourselves with plenty to do. The breakdown of sample submissions to the TDL in 2008 can be seen in Table 1, as well as the comparison to 2007.

With over 100 inches of snow across much of the area, the winter of 2007-2008 was one for the record books. Much of the talk as we headed towards spring was how bad the snow mold would be, and once the snow finally did melt, the answer was in most cases, "well that's not so bad." Snow mold was most severe on unsprayed areas of the golf course and areas that were nitrogen-heavy going into the winter. If you think back all the way to the fall of 2007, there were several dollar spot outbreaks in October and even November. Some superintendents attempted to fertilize to recover from the dollar spot before dormancy hit, but with the winter's early and permanent arrival, the stage was set for some severe snow mold breakthrough. Breakthrough was even observed at some courses that used three-way mixtures that had held up well under heavy disease pressure in our northern snow mold trials, which should remind everyone just how important a role late-season fertility plays in snow mold.

Later in the spring brought the usual disease suspects; leaf spots, red thread, and Micodochoum patch, albeit in lower numbers than we had observed in previous years. The big stories of the spring were the cold temperatures and the heavy rainfall. Any place that had experienced damage from ice cover or snow mold seemed to take until July to recover, and the only thing more frustrating than winter damage is having to wait weeks and months for it to fully recover. Maybe the biggest newsmaker of the summer in southern Wisconsin was the heavy rains that inundated the state and caused record flooding. This not only wiped out revenue from potential golfers, but also diverted funds away from other areas of course maintenance towards flood cleanup.

Following the floods, conditions dried out and humidity stayed low for most of the year. While this was not conducive for diseases such as dollar spot, brown patch, or Pythium blight it did seem to cause a problem with rooting depth of annual bluegrass. I also observed this abnormally shallow rooting of annual bluegrass in August of 2006, when southern Wisconsin was hit by 12 inches of rain over a couple day period, and rooting depth seemed to decrease significantly on many courses.

2008 TDL Diagnoses

Diagnosis	Professional*		Homeowner*	
Take-All Patch	7	(8)	0	(0)
Abiotic	29	(22)	30	(29)
Microdochium Patch	1	(0)	0	(0)
Leaf Spots	9	(10)	2	(5)
Insects	1	(2)	1	(2)
Anthracnose (Foliar and Basal Rot)	2	(6)	0	(0)
Fairy Rings	2	(1)	1	(1)
Necrotic Ring Spot	3	(2)	20	(11)
Summer Patch	3	(5)	1	(5)
Rhizoctonia Brown Patch	1	(6)	2	(3)
Brown Ring Patch	3	(0)	0	(0)
Rough Bluegrass (*Poa trivialis*)	0	(1)	8	(8)
Typhula Blight	2	(2)	5	(0)
Weed ID	5	(1)	10	(12)
Dollar Spot	0	(4)	0	(0)
Pythium foliar blight or root rot	5	(2)	1	(3)
Fungicide Resistance Assays	0	(6)	0	(0)
Other	3	(2)	4	(6)
TOTAL	76	(80)	85	(85)

Table 1. *Numbers in parentheses are diagnoses in 2007

While there is other possible causes for the decrease in rooting depth, what is clear is that a higher number of samples were diagnosed as "abiotic" than in past years and many of those were related to annual bluegrass.

One disease that actually saw an increase in diagnoses across the state and the region in 2008 was brown ring patch (*Waitea circinata* var *circinata*). As Dr. Kerns talked about in a previous Grass Roots article (Kerns 2008), brown ring patch has never been officially reported in Wisconsin but has been reported as close as Chicago. Much of the work on this pathogen to date has been done by Dr. Frank Wong at the University of California - Riverside, and though we are in the initial stages of researching this disease expect much more information as research from our lab and others becomes available. Dr. Kerns and I are currently testing the isolates we have in the lab to get a definitive diagnosis of the pathogen.

Another disease that seemed to be more severe than normal in 2008 was fairy ring. Possibly a result of the wet spring and dry summer, fairy ring seemed to be very severe in places it had never been observed before while at the same time never showing up in places where it had been a problem in the past. In a particularly extreme case of Type I fairy ring, Dennis Robinson of Horst Distributing brought in a sample that came from a perfectly round circle of dead grass (Figure 1). While it looked like fairy ring, the sample was incubated in a moist chamber for 3 days and the amount of hyphae produced was incredible, nearly enveloping the entire sample (Figure 2). To have such prolific fungal development is thought to be rare with fairy ring, but little is known about the multiple species of fungi that cause the disease. Lee Miller from North Carolina State University is working to gain more insight into this frustrating disease, and we submitted fairy ring samples from around the state to aid in his research.

Figure 1: This type I fairy ring appeared in early September, and apparently did not previously have the darker green ring that most fairy rings have in their initial development. This picture was provided by Dennis Robinson of Horst Distributing.

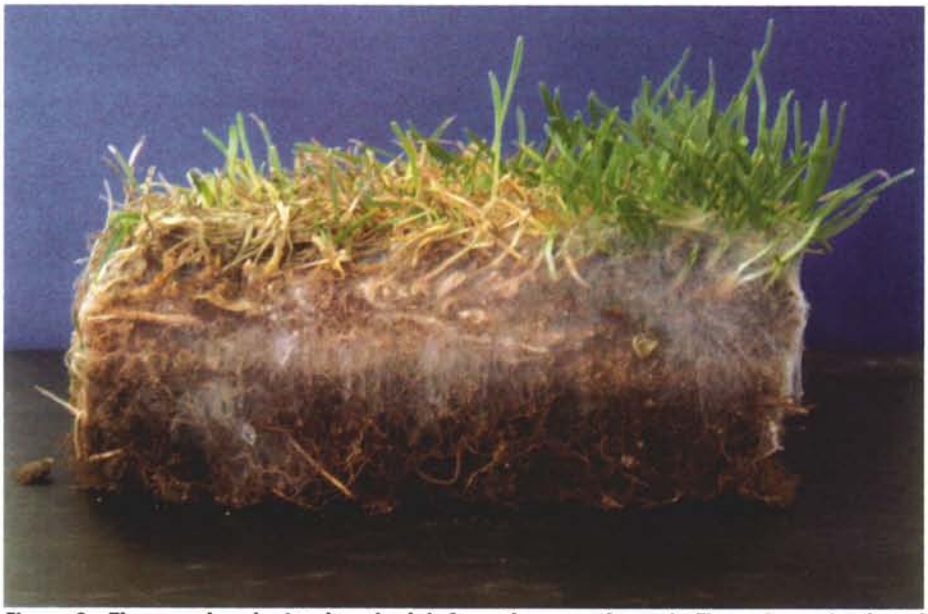

Figure 2: The sample submitted to the lab from the area shown in Figure 1 was incubated for 3 days in a moist chamber and produced a tremendous amount of fungal mycelium.

Looking at the table of samples submitted to the TDL shows it matches up pretty well with 2007. The number of samples submitted was close to the same, the breakdown between homeowner and professional was similar, and aside from the numbers of abiotic samples, the breakdown within diagnoses was also similar. It just goes to show you, no matter the weather the grass will still find some way to die.

TDL Contract Memberships

Speaking of turf death, if your course has had turf decline for unknown reasons in the past, or