Techno-Turf Management

By Dr. John Stier, *University of Wisconsin-Madison, Department of Horticulture*

This July I was invited along with several other researchers to give presentations on the latest methods for measuring turfgrass stress responses at the American Society for Horticultural Science annual conference. The stresses of interest were water, compaction, herbicide, and low temperatures. While the presentations were intended for researchers, I thought several items might have practical interest for golf course superintendents.

Dr. Bernd Leinauer (New Mexico State University) gave a presentation on water conservation. Since much of the area in the Western states exists in a perpetual drought, water supply and quality have been an issue for as long as the area has been inhabited. This year Phoenix, AZ became the country's fifth largest city, and claims to have the country's largest per capita number of golf courses, yet the area is one of the driest in the country. The day I left for the conference, July 16, USA Today ran an article on the benefits of replacing turf in lawns with rocks, cacti and other water-thrifty plants.

The two main issues of water for turf irrigation in the West are quantity and salinity. Superintendents know irrigation is needed to ensure a sufficient water supply to the turf in order to keep the grass green and growing. In the past most superintendents have been able to irrigate with as much water they deemed necessary, whenever the time seemed appropriate. As an expanding population increases demand for potable water supplies, the turf industry will have to become smarter water users. Temporary irrigation bans are already common throughout the West and southeastern regions of the U.S. Wisconsin is likely to begin seeing at least localized restrictions on golf course irrigation in the future as public water supplies diminish and state and federal water laws regulate access. Both ground and surface sources will be affected. One of the ways superintendents will deal with reduced water supplies will be monitoring of the soil moisture content to justify irrigation events and to accurately determine the correct amount of water for each area of the golf course at each irrigation event.

Historically superintendents have watched for changes in leaf color from green to a bluish-green and/or "footprinting" to know when the turf was in need of water. Many superintendents even have a good idea of the irrigation time needed to supply a given amount of water to the turf, e.g., one-half inch. However, such an approach is costly in terms of labor, and since usually only the superintendent and/or an assistant can judge and decide on irrigation needs, some areas may not get the appropriate amount of irrigation. Differences in soil type between areas of the golf course, compaction, and changes in nozzles or even wind effects on irrigation can reduce the likelihood of maintaining sufficient soil moisture.

Researchers have long used a variety of techniques to monitor soil moisture in various experiments. Pulling a soil core with a probe and feeling the soil is undoubtedly the simplest method of monitoring soil moisture, but for most people this technique provides no more information than simply "This soil is dry" or "This soil is moist". A more labor-intensive but accurate method is the use of monolith lysimeters. A monolith lysimeter is nothing more than a tube, usually PVC, pushed into the ground. The tube is then pulled from the ground, complete with turf and its intact root and soil structure, then saturated and weighed. The lysimeter is pulled each day and reweighed. The lysimeter becomes lighter each day as water is transpired or evaporated from the system, providing an accurate measure of the amount of water needed to be replaced by irrigation (or rainfall). Since this method could easily occupy a person's time every day on a golf course, more advanced technologies have to be considered.

One of the tried and true methods for measuring soil moisture without removing samples is to install a tensiometer in the soil. Anyone who completed an introductory soils course in college will remember these gauges-they consist of a cylindrical or oval-shaped water-filled rod with a porous ceramic cup at one end and a gauge at the other end which displays a soil moisture reading. A sufficiently deep hole is made in the ground, sized to ensure a snug fit between the ceramic cup and the soil. After about 10 minutes, sufficient water has exited from the ceramic cup to establish an equilibrium with the soil moisture. At this point the gauge displays the soil moisture within some percentage range depending on the quality of the tensiometer. Unfortunately these don't provide a quick measurement, and depending on the size, the hole left may be an inch or more in diameter which means they aren't conducive to monitoring moisture on several places on each green on a daily basis. Neutron probes have been used by some researchers in the past to accurately measure soil moisture. Probes are placed into the ground, and radioactivity is used to measure soil moisture but these are expensive and one needs a license to operate them!

Dr. Leinauer has conducted extensive research on methods to monitor soil moisture and salinity for over 15 years. In fact, for the past few years one of his Ph.D. students has been Casey Johnson, a graduate of the UW-Madison turf program and a Wisconsin native. Most of their work has relied on instrumentation that measures the dielectric constant of the soil. As most people know, water is a fairly good conductor of electricity. Since the early 1990s researchers have used technology called time domain reflectometry (TDR) to very accurately measure soil moisture very quickly and with a minimum of surface disturbance. The first TDR systems were bulky and expensive-Dr. Kussow had one. One I used in the mid-1990s was similar to Dr. Kussow's and cost over $10,000. It was so large and heavy we pulled the system in a child's wagon across the turf plots while using the device. However, the ease of use and accuracy were outstanding. Two or more steel rods called "waveguides" are embedded in a resin block which is wired to a device which generates and measures electrical pulses. The waveguides, usually less than one-quarter inch diameter, are inserted into the turf either vertically or diagonally depending on the soil profile of interest. The push of a button sends an electrical pulse down the waveguides, and the speed of the pulse is used by the TDR to calculate the amount of soil moisture. A measurement can literally be collected in less than 10 seconds.

As with most technology, advancements have occurred rapidly since initial development while costs have decreased. The expensive, bulky devices have given way to hand-held units selling for $1,000 and less. Bernd has tested a number of these devices for accuracy, ease of use, etc. He showed this information in his presentation and two items stood out for me: First, all types provided good to excellent accuracy and second, longer waveguides were a bit more reliable than shorter waveguides. Trime and Turf-Tech manufacture some of the more user-friendly units and both have waveguide lengths suitable for turf measurements (e.g., three to six inches). Dr. Soldat at UW-Madison has been using one of the devices at the OJ Noer Facility this summer for some of his experiments. The long handle allows measurements to be collected from a standing position, and multiple measurements can be taken from a putting green in just a few minutes. It's so easy one of the cavemen from the Geico commercial could do it!

Dr. John Sorochan (University of Tennessee) spoke about compaction. Some of you heard him speak at the Wisconsin Turfgrass Association winter conference this year. He has been using what's called ground-penetrating radar to measure soil compaction. This technology involves a radar unit mounted to or behind a vehicle. As the vehicle is driven across the ground, radar data are collected in a computer and used to generate a 3-dimensional map of the soil underground. The depth of interest can be set by the user. Colors are used in addition to peaks and valleys to denote different levels of compaction on the map. One map he showed was from the University of Tennessee football field at the end of last year's season. In this map, green indicated little compaction while orange showed areas of high compaction. As one would expect, green color dominated the sides and end zones with only minor peaks randomly occurring, and the center of the field showing some moderate-sized orange peaks. At first the audience was puzzled when the largest orange peaks were shown in a small area near the 50 yd line of the sideline, until John explained that last year was a losing season for the usually stellar football team and the orange area was where the coach paced and stomped during the games!

Dr. Brian Horgan at the University of Minnesota has been working with the Toro Co. to develop similar technology for golf courses, while UW-Madison engineers have recently tried their own design on the putting greens at the OJ Noer Turfgrass Facility. John has also used the technology to compare compaction from conventional golf carts to the Segway transporter. Although the wheels on the two-wheeled Segway are narrower than those on golf carts, the enormous difference in weight generates dramatically less compaction than golf carts. In addition to measuring compaction, ground-penetrating radar can be used to locate pipes and other buried objects. Such information is helpful when renovating an older golf course in order to find buried items such as irrigation lines.

A third speaker, Dr. Doug Karcher (University of Arkansas) has gained a national reputation for his development of digital image analysis for turf. Some of the Wisconsin and Northern Michigan superintendents will remember him from the Northern Great Lakes Golf Course Superintendents conference several years ago when he spoke about internet resources for turf management. For the past several years Doug has been interested in trying to quantify turf characteristics such as color and groundcover using digital imaging as a replacement for our conventional methods of simply "rating" the turf. Turf ratings require a trained investigator to achieve consistent evaluations, and many people simply are not suited to conducting consistent evaluations. Even trained evaluators can rate the same turf differently depending on the day, amount of cloud cover, personal fatigue, etc.

Doug has now developed a system using easily obtained components that allows rapid and repeatable (thus reliable) collection of turf color and cover data. The system uses a digital camera (a medium-level camera is sufficient), either a desktop or laptop computer, and SigmaScan software. A suitable camera will cost from $500 to $1000 and the SigmaScan software about $1000. With this system, the user takes a digital photograph of the turf then downloads the image into the SigmaScan software. The software is used to compute the angle, hue, and saturation (brightness) of the turf as a quantitative unit of color, similar to how paint manufacturers and photographers specify their colors. Alternatively, the user can assign one color (e.g., red) to the turf in the photo and a contrasting color (e.g., blue) to the ground or soil in the photograph, and SigmaScan will compute the percent ground actually covered by turf. Historically this has been a laborious, time-consuming process with the user having to complete several functions for each analysis. However, Doug has developed a "macro" command which users can get from him free of charge that frees the user from having to complete multiple functions for each analysis, allowing hundreds of pictures to be quickly analyzed. This work is important before it's practical to use digital imagery on golf courses to measure disease, nutrient response, drought stress, and other aspects of turf for decision-making purposes. We are starting to use the technology in some of our work to quantify the establishment rate of different grass varieties. At some point I expect the system will be sensitive enough to distinguish weeds from desirable grasses, giving superintendents accurate data to justify use of an herbicide.

Dr. Scott McElroy is a weed scientist from the University of Tennessee. While his presentation was especially geared to researchers, I thought it contained some information of interest to superintendents. He has been interested in why some turfgrasses tolerate herbicides better than others: mesotrione herbicide, for example, bleaches the color from creeping bentgrass but doesn't harm Kentucky bluegrass. In sensitive plants, mesotrione causes the loss of chlorophyll and subsequent use of the sun's energy in photosynthesis: the excessive solar radiation results in the formation of free radicals which disrupt cell membranes and kill the plant. Carotenoids are orange pigments in plants which help funnel the energy from sunlight into the photosynthetic process and also "quench" free radicals such as singlet oxygen, preventing them from damaging cells. Compounds which can prevent damage from free radicals are known as antioxidants. People are often encouraged to eat more fruits and vegetables such as spinach because of their antioxidant content. Scott has used high pressure liquid chromatography to identify and quantify carotenoids in turfgrasses. Some warm-season grasses will be bleached by an initial application of mesotrione, but are not killed. When new tissue is treated with mesotrione, it does not seem to be harmed. Scott's research shows that this new tissue contains higher levels of carotenoids which appear to prevent mesotrione from damaging the grass. This type of information is useful to breeders who can then identify genes responsible for the response and breed them into desirable grasses. While I doubt people will start eating creeping bentgrass anytime soon, Scott showed that turfgrasses can have a carotenoid content as high as spinach!

My own presentation was on ways to measure low temperature tolerance and injury to turfgrasses. With the routine loss of turf, particularly *Poa annua*, each winter we are fortunate enough to have newer technologies such as video thermography and chlorophyll fluorometers to measure turf response to low temperatures. Video thermography is a system we've used in the past to show how turfgrass plants freeze. An infrared camera is connected to a video recorder, and used to "watch" grass plants freeze when they are placed in a freezing chamber. Our work has shown that small roots freeze first, after which freezing progresses rapidly through the root system then into the lower crown which is the site of new root formation. The upper crown where shoots form, and the shoots and leaves themselves, are the last tissues to freeze. This work has shown why we occasionally will have green grass emerging from winter, only to see it die several weeks into spring as late winter freezes have killed the root systems while leaving the shoots and upper crowns undamaged (Stier and Filault, 2000; Stier et al., 2003).

Determining the actual cold tolerance of a grass is time-consuming as the grasses have to be properly cold-acclimated, frozen, then regrown. A single experiment can take 4-12 months. Fluorometers are sophisticated machines that allow us to measure the efficiency of photosynthesis, and identify potentially harmful agents such as low and high temperatures. A burst of light is used to saturate a leaf or leaves. Since not all of the light energy can be used in photosynthesis, some of the energy is "fluoresced" just as fluorescent paint works on a watch in the dark. Fluorescence levels rise as stress increases and photosynthetic efficiency decreases. We are finding that cold tolerant grasses such as Kentucky bluegrass have photosystems that are more responsive to low temperatures than grasses with poor cold tolerance such as perennial ryegrass. Fluoroemetry may allow us to rapidly identify annual bluegrass ecotypes with superior cold tolerance which can then be used in breeding programs, providing a grass which is just as competitive with the weedy type of annual bluegrass but with much better cold tolerance.

I don't expect that all of these techniques will necessarily become common tools for golf course superintendents. Devices like the fluorometer, which currently cost $15,000-$20,000 depending on options, are unlikely to have a routine use for golf course maintenance. However, technology such as ground-penetrating radar will likely become a contracted service by which superintendents may have their fairways "mapped" to reveal problem areas which can then be properly handled to improve course conditions. Devices such as the soil moisture probes and digital analysis are available now. At least one superintendent in the Madison area has started using the soil moisture probe on a daily basis to monitor moisture levels in each putting green. Stay tuned for future techno-advances!

REFERENCES

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