Managing Shaded Turf, Part II: Better Success Through Research

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In the last issue of *The Grass Roots*, I discussed why turf on shaded putting greens struggles to survive, particularly during summer. In this issue, I cover the tried and true methods for managing shaded turf, and introduce some newer concepts that have been achieved through research. These management strategies make the most sense when viewed with an understanding of the issues associated with shade, so let's do a quick review.

Grass dies in the shade because a lack of sufficient light quality and quantity prevents the grass from producing enough photosynthate (sugars). The altered light quality (excessive amounts of red, insufficient blue light) causes the plants to grow spindly and weakly due to excessive production of the hormone gibberellic acid (GA). Root growth is decreased, and thin cell walls make it easier for fungal pathogens to enter turf plants. The moderated temperatures and reduced wind provide more favorable climate for fungal pathogens. Tree roots in some cases can steal enough water from the turf that desiccation occurs, but this is a relatively rare phenomenon on putting greens due to the raised soil profile, especially on sand based putting greens where a liner is used around the root zone. Keeping traffic off the turf can really help reduce the need for the plant to produce sugars to replace traffic-killed tissue, but unfortunately traffic is kind of desired on golf courses because golfers help pay the bills. So what can be done to help the turf?

The Basics we've known for a long time

Managing grass under shade stress requires different techniques than managing grass that is not under shade stress. It's that simple! Or is it? Most of us have a fair idea of at least the minimal things that can be done to help turf in the shade. Sometimes they're not done, though, because we're not sure if they're really helpful, or, if they are, why they work and how to explain it to golfers.

One of the simplest ways to maximize photosynthesis is to maximize the leaf tissue area. Most putting greens have a leaf area index (LAI) of about 1: that is, 1 square inch of leaf material to 1 square inch of ground. As mowing height increases, the LAI increases too, at least to a point. Doubling the mowing height can double the LAI. Thus, if the grass is struggling at 0.1 inch height, raising it to 0.156 inch could improve the LAI by about 50%. Will the greater mowing height slow play? Will the golfers notice? Maybe, but if such a change saves the grass (and your job), is it worth it? Of course, mowing shaded greens at a higher height of cut might mean different mowers have to be used for these greens, which could require more labor and equipment. But if money is that tight, why are greens being mowed as short as they are even in full sun? After all, its common knowledge that the lower the mowing height, the more it costs to maintain turf, regardless if it is in the shade or not. So why are greens mowed so short these days compared to 20 years ago? As always, communication is key. Read on to learn more, then be able to explain to your green committee why things need to be done differently.

As pointed out in the last issue, those fungi that attack creeping bentgrass just love to grow in the consistently moist, temperature-buffered environments provided by shading. Fungicides are a must: under certain conditions, I've seen fungicides fail within days after application because the growing conditions for the fungi were so ideal. Don't count on contact fungicides lasting 14 days, and don't count on systemic lasting 21 to 28 days. One of the projects Paul Koch is working on for his Ph.D. is to determine the feasibility of an on-site testing kit for fungicide residues, so superintendents would know when fungicides need to be re-applied.

Sufficient wind movement can help dry the turf surface and keep fungal diseases under control. Unless trees/shrubs are moved out of the way (usually a Western exposure will help), though, nature won't provide enough air movement in many shaded conditions. People have known this for years, and courses like Trappers Turn use fans on greens that need more air movement. The wind movement can even help turf grow better as evapotranspiration (ET) rates will increase. The increased ET helps keep water moving through the plant, making the plants more turgid (stiff), which adds to traffic tolerance and makes for a cleaner cut when mowing. The wind movement will also bring fresh air over the turf canopy to ensure that a sufficient amount of CO_2 exists for photosynthesis.

One practical item to control is the irrigation system. Every golf course should have one or more weather stations to monitor climate and calculate ET for the area. The ET data can and should provide the basis for irrigation. A single weather station for a golf course is better than nothing, but many golf courses have several unique microclimates. When we were developing forecasting models for *Pythium* blight at the Scarlet course of The Ohio State University back in the 1990s, there was one hole that always got *Pythium* blight before any place else on the golf course. Having a weather station 2,000 yards away didn't help predict those occurrences. Back then, a decent weather station cost between $15,000 and $20,000, and was relatively complex to program. These days, weather stations can be purchased for about $1,500 and can be programmed using Windows-like software. The great thing about using ET rates as an irrigation guide is that rainfall additions can be taken into account. Thus, if the weather station calculated an ET of 0.75 inches over a 3 day period, but it rained 0.25 inch on day 2, then the actual amount of water to be replaced is only 0.5 inches.

Back to the point. The amount of sunlight is a critical factor driving ET rates. Wind and temperature are important too, but both are driven by sunlight at some level. ET rates in the shade are low, so the grass isn't using much water. How much is low? At the O.J. Noer, we typically water soil-based greens enough to replace 100% ET three days weekly. In our shaded putting green project (80% shade), we started at 50% ET in the spring and have been at 30% ET replacement all of August, and its still too much water! In addition, the lack of sunlight means leaf surfaces don't dry very fast. I've seen heavily shaded greens sopping wet at 5 pm after just a brief shower early in the morning. As the grass dies, algae invades, even if the shade is caused by just one tree affecting a small portion of the green (Fig. 1). The bottom line: water infrequently, then make sure enough moisture is applied to moisten the root zone. Then don't water again until the root zone approaches dryness. If you can't afford a weather station, opt for a $30 soil probe and check the soil moisture every couple of days.

Fig. 1. Shade from a single tree eliminates turf and encourages algae on the edge of this putting green.

Fig. 2. The owners didn't want to remove any trees at first on this putting green until after we had a discussion on the golf course. If there is this much shade in early spring before the trees are fully leafed out, can you imagine how shaded it is later in the summer?

Often the easiest ticket to shade-stress-free turf starts with a chain saw. That's if the membership can be convinced to remove one or more offending trees. Superintendents usually know which trees, or at least large limbs, should be removed to provide enough sunlight. One fact that many non-plant people don't realize, and that turf managers take for granted, is that in Wisconsin anything that blocks the southern view is a shade threat, because that's the primary direction of the sun from the Northern hemisphere. We had a dickens of a time getting the Stadium Authority who oversaw the construction of Miller Park in Milwaukee to realize that windows needed to face south, and they still kind of missed the boat on that one.

It is typical that a green committee or golf course owner wants a second opinion on tree removal (Fig. 2).

I've been called out on so many of these I've lost count. Other options exist, too, if someone wants high-tech. Arbor Com, Inc., is one example of a company that uses measuring devices and computer simulations to gauge the effect of removal of any given tree or group of trees. Eventually, in the process of tree removal, an older member of the club will come up and say something like "We didn't use to have these problems on the putting greens 30 years ago". Of course, the trees were a lot smaller then; it is up to the superintendent to find a tactful way to remind them of that fact. Sometimes people can be convinced that yes, it is the trees causing excessive shade, but then they question if the limbs can't just be pruned back a bit. Pruning is like a haircut: looks good for now, but it soon grows back and needs more cutting. Add up the expense of hiring a certified arborist to routinely prune: shouldn't be too long before the membership is racing to the maintenance shop to get the chainsaw for you.

Research brings wonderful things

In the early 1990s I was hired by Michigan State University to help develop a turfgrass sports field for the dimly lit Pontiac Silverdome in time for them to host the 1994 World Cup (soccer, that is). I was brought in partly because of my pathology background, and had to work hard to get up to speed on turfgrass physiology. One of the ideas I started working from was something a couple of the professors had started just a few months earlier: if shade caused the turf to produce excessive levels of GA that caused all these undesirable side effects, why not try to stop the plants from producing GA? At the time, the Scotts Co. was successfully marketing a GA inhibitor known as Scotts TGR®. It was sold primarily to reduce growth and mowing costs. At about the same time, Dow Chemical developed another GA inhibitor known as flurprimidol, and sold as Cutless®. The two had similar chemical structures, and accomplished the same thing: less turf clippings because GA production was inhibited. We began a series of studies at low light levels, on several species of both warm and cool-season grasses, to determine the effects of GA inhibitors on turf under low light. The results of GA inhibitors on keeping turf alive and dense at low light levels were amazing (Stier et al., 1999). Ciba-Geigy (now Syngenta) came out with a foliar-applied GA inhibitor in 1993 (now sold as Primo®): it worked pretty good, too (Stier and Rogers, 2001). By the late 1990s, superintendents were starting to use GA inhibitors to increase turf quality as much as for clipping yield reduction. The reason it works this way is that GA causes cell elongation in plants but doesn't affect cell division and other growth. Instead, turf plants funnel their energy into producing roots, more tillers, and more leaves (just shorter). Overall, the turf density appears thicker. Cell walls get thicker, and LAI is increased, both of which leads to better traffic tolerance.

Shortly afterwards, Goss et al. (2002) showed that creeping bentgrass in shaded conditions benefitted from lower N rates (2.8-3.6 lb N/1000 ft^2) compared to higher N rates (4.1-4.6 lb N/1000 ft^2). By then I was at the University of Wisconsin-Madison. One day, shortly after discussing turf management with the Miller Park crew, I was eating lunch in the stadium and watched a lawn company vehicle pull up to the field. The employee got out of the truck and started spraying what turned out to be a liquid fertilizer. That one observation got me thinking "what do we really know about the best method of nitrogen application"? This question led me to my next shaded turf research project, my first at UW-Madison.

The WGCSA, the GCSAA, and privately-owned seed companies in the U.S. and Europe funded a two-year study at the O.J. Noer Turfgrass Research and Educational Facility to study the best management practices for golf course turf under shaded conditions. Using 80% shade, we compared liquid versus granular applications of nitrogen on creeping bentgrass, supina bluegrass, and Kentucky bluegrass mowed at 0.5 inch height. Half of each plot was treated with Primo. As it turned out, bentgrass much preferred to be fertilized with liquid applications, while Kentucky bluegrass turf looked much better when granular fertilizer was applied (Steinke and Stier, 2003). Supina bluegrass performed well with both types of fertilizer. All turf species looked and functioned best with monthly Primo applications, followed by bimonthly applications. No Primo at all led to the worst-looking turf. It cost us $80,000 to find these answers, but the project helped to form my recommendations for managing putting greens in shade. Of course, we found other neat stuff too, such as the fact that the Primo applications allowed the turf to store more sugars going into the winter, making the turf less likely to winterkill, a relatively important issue in Wisconsin (Steinke and Stier, 2004).

Only a small portion of the energy from sunlight, known as photosynthetically active radiation (PAR), is used by plants for photosynthesis. In Wisconsin, the maximum amount of PAR we get occurs during the summer solstice (about July 20), which is about 55 mol PAR per square meter per day. The term mol is a unit of measurement, just like a gallon is a unit of measurement for liquids. Photosynthetically active radiation declines as daylength gets shorter and the angle of the sun decreases after the summer solstice. Sunlight begins increasing again after the winter solstice in December.

One of the things we needed to do in order to figure how to grow grass indoors for the 1994 World Cup was quantify the amount of PAR the turf needed every day. We set up several studies using different types of lamps (e.g., high pressure sodium, metal halide) to determine the lighting requirement for several turf species used on sports fields. The idea was not totally new: Dr. James Beard had done a short term study at the Louisiana Superdome a couple years earlier but the results were not widely publicized. Our studies were longer term, some lasting several years, with various amounts and types of lighting sources. Eventually we were able to calculate a Daily Light Integral of 7 to 8 mol PAR per day for 2 inch tall Kentucky bluegrass if GA inhibitors were used and fungi were controlled. We also found that leaving lamps on 24 hours a day, seven days a week provided dense, stiff turf, but it was discolored a sickly yellow-orange green (Rogers et al., 1996). Bunnell et al. (2005) calculated a Daily Light Integral for bermudagrass greens, but no one has yet done so for creeping bentgrass greens. Existing information can give us an estimate. Our data for sports turf doesn't work directly because the higher cutting height gives a different LAI than putting greens and the grass species are different. Bunnell et al's. (2005) work on bermudagrass is even less relevant as bermudagrass has a much higher requirement for light than bentgrass (Stier and Gardner, 2008). The closest we have to a Daily Light Integral for bentgrass is work done by Bell and Danneberger (1999). They showed creeping bentgrass was able to maintain desirable turf quality at putting green height when it received full sun for 40% of the day. The information isn't perfect, though, as 40% of the day means different things depending on the time of day. While five hours of light in the morning may provide as much PAR as five hours of light in the afternoon, the five hour period centering at 12 pm will provide much more light than either of the other two scenarios. In addition, the use of GA inhibitors and other practices can dramatically reduce the amount of light required.

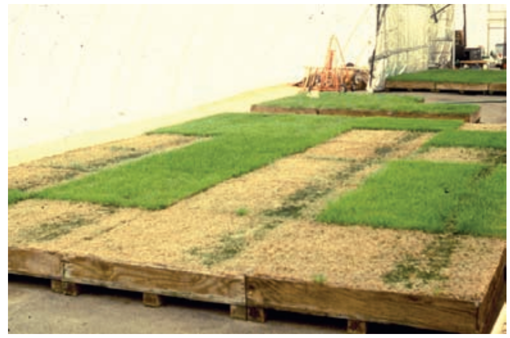

Fig. 3. Supina bluegrass survives at 10% sunlight while Kentucky bluegrass dies.

Knowing the Daily Light Integral would help superintendents determine if their putting green was indeed getting enough light or if the grass was struggling for other reasons. This isn't a far-fetched idea: quantum sensors to measure PAR can now be purchased for a few hundred dollars. We've used them to calculate the amount of sunlight in shaded situations to determine the amount of light on various types of turf areas in order to prescribe grass species and management practices at places like indoor animal exhibits at zoos, the Great Lawn in Kentucky, and parks in New York City. Though we don't know the true Daily Light Integral needed for bentgrass greens, let's use full sunlight for 40% of the day as a guide, and imagine the turf receives full sun for the first five hours of the day. We measure sunlight at various places around the green each hour, 6 am through 11 am. The readings, in order of time, are 100, 300, 700, 1200, 1800, and 2000 micromols PAR per square meter. Multiply each number by 3600, then divide by 1,000,000, to convert micromols to mols. Summarize the mols for each hour and you'll get almost 22 mol PAR per square meter for the day. That should be plenty of light. My best guess as to the amount of PAR needed for bentgrass putting greens is on the order of 10-12 mol PAR per square meter for the day.

One of the ways to reduce the amount of PAR needed is to plant a grass species that grows more efficiently at lower light levels. Better disease tolerance helps, too. We found supina bluegrass (*Poa supina*) to be much more capable of growing at 10% sunlight than Kentucky bluegrass; the Kentucky bluegrass died after six months while the supina bluegrass survived throughout the year-long study (Fig. 3). Supina bluegrass does a good job at fairway and tee height and is used on some sites in Wisconsin, including University Ridge golf course. I'd be hesitant about relying on it for putting greens, however, even though I've seen supina bluegrass as putting green turf in its native habitat of the sub-alpine regions of Germany and Austria. One of the things we're exploring at the O.J. Noer Facility currently is the potential for velvet bentgrass to provide better shaded putting green turf than creeping bentgrass. We'll finish our first year of data collection this autumn, and begin to present results this winter. Information published in trade journals indicates it is more shade tolerant than creeping bentgrass (Brilman and Meyer, 2000), but at UW we'll need verification before we start recommending it.

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