FEATURE ARTICLE I

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Tree Shade Exacerbates Physiological Decline of Greens during a Chicago Summer

Physiological Decline History.

During midsummer, physiological decline of cool-season or C-3 turfgrasses is common in the Midwest region. Previously, the malady had been blamed on various biotic pathogens. Of diseases, root pathogens were in the spotlight beginning in the 1980s when their initial discovery by plant pathologists began within the field of turfgrass science. In the mid-1990s researchers began to investigate the hypothesis that decline was more than just disease-related. Perhaps there was a physiological component that had not yet been quantified. At about the time I began my M.S. at Kansas State University new miniaturized gizmos to measure plant health began to be utilized by researchers. For example, Dr. Bingru Huang and her team of students, post-docs, and visiting scientists at K-State began to measure CO_2 gases by using a portable infrared analyzer easily toted onto a green. By taking measurements, both above and below the ground across a growing season, they found midsummer physiological decline was independent of disease. It was most likely due to "supraoptimal temperatures." In other words, summer itself can be too dang hot for a cool-season turfgrass (e.g., creeping bentgrass). Their investigations showed soil temperatures were most important. They alone could compromise plant health. The amount of the effect was linked to the duration of supra-optimal temperatures (Xu et al., 2002).

Heat can cause starvation.

By 2000 Huang's group at K-State published results of field, growth chamber, and greenhouse experiments. They had extensively investigated, through generous funding by the USGA, the effects of high temperature stress on both shoot and roots. Aboveground they showed that the photosynthetic rate of creeping bentgrass faltered at midsummer. At the same time, plant utilization of carbohydrates or respiration continued to climb. The result was an imbalance, and stored energy reserves were used faster than could be replaced. With time, starvation of a bentgrass green was unavoidable. The canopy thins, as wear exceeds plant biomass production, and golfers notice. The study was important because it found high soil temperature (abiotic factor) was the primary contributor to root mortality (Huang, B. and X. Liu. 2003). Root number and length were decreasing when water demand (evapotranspiration) and carbohydrates (stored in roots) were at peak levels – midsummer.

Applied turfgrass science and physiology.

These physiological studies on bentgrass broke new ground – golf greens to be exact. They showed that a golf course superintendent could not apply "plant protectants" and expect to avoid physiological decline. Instead, the key to alleviating or delaying physiological decline was pretty straight forward. Increase the mowing height, or use a newer, denser bentgrass variety rather than Penncross. With respect to considering a newer bentgrass variety, Fry and Huang explained it using 'layman's terms' in their 2004 book called *Applied Turfgrass Science and Physiology*. "…new cultivars have higher tiller density and narrower leaves than Penncross. High tiller density is associated with high canopy photosynthetic rate by providing more leaves available for light interception." Nevertheless, renovating greens with newer bentgrass cultivars is not generally feasible midseason, whereas raising the mowing height is – though education for golfers is required. The reality is that you can't disregard Mother Nature. Each summer we expect a two-to-four-week period of "supraoptimal temperature" for cool-season turfgrass in the Midwest. The historical period for physiological decline of Chicago greens begins about the end of July and then typically peaks sometime in August. If cultural practices are not adjusted, significant thinning can occur. A dynamic, living surface requires dynamic decisions to maximize plant health. Midsummer is demanding from a multitude of perspectives, and one we previously ignored too much in turfgrass science was physiology. In the yin and yang of putting green health, a man known as 'Golf Course Superintendent' must find balance.

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Concept of the Chicago shade study.

A study was conducted during summer 2007 to determine the effect of shade on putting green health in Chicago. Shade is a known contributor to poor turfgrass health and represents Turfgrass Science 101 (**Figure 1**). The research objective was to understand if tree shade contributes to physiological decline of greens, an abiotic disorder of creeping bentgrass and *Poa annua*. The question might be thought of in another way . . . Can improving light levels on greens also be a cultural practice that helps avoid midsummer physiological decline? We already know raising the mowing height or using newer bentgrass varieties works. The research was summarized for the international Crop Science meeting held in New Orleans the fall of 2007 (November 4-8). The poster began . . . *Light is essential for maintaining healthy bentgrass. However, landscape features can lead to light deficiencies on golf courses, especially on greens . . .*

Anatomy	Morphology	Physiology
Thinner cuticle layer	Thinner, narrower blades	Higher chloropyll content
Lower stomatal density	Longer leaves & internodes	Lower respiration rate
Fewer chloroplasts	Lower shoot density	Lower photosynthetic rate
	Fewer tillers	Lower transpiration rate
	Thinner stems	Greater succulence
	More upright growth	Lower carbohydrate reserves

*Figure 1. Anatomical, morphological, and physiological effects of shade on turfgrasses (*from Fry and Huang, 2004*).*

A miniature device.

Once again a miniaturized device has made it possible to collect data (light levels) in new ways (next to a green). The CDGA collaborated with Spectrum Technologies, of Plainfield, Illinois, www.specmeters.com in the current study. This time a miniature weather station made it possible. The size of a shoebox, it is called the WatchDog® Model 2475 Plant Growth Station (**Figure 2**). During July and August of 2007, air temperature, soil temperature, relative humidity, and photosynthetically active radiation (PAR) were measured at 15-minute intervals on putting greens at 15 Chicago area golf courses.

Figure 2. Close-up of the mini weather station with a light sensor used in this study.

A range of light levels desired.

At each course, the superintendent allowed the deployment of a mini-weather station, mounted one ft. high, on the green collar edge (**Figure 3**). Whenever possible, a shaded location was selected (**Figure 4**), but a range of light levels would exist from deep shade to full sun. This range was necessary and allowed for correlations between plant health and light levels. The 15 golf greens in this study were in use at the time: three sites as a course green in play (**Figure 5**), four sites as a nursery green (**Figure 6**), and eight sites as a practice green (**Figure 7**). Plant health was assessed by visual quality ratings and by an electronic method called normalized difference vegetative index (NDVI). At each site, measurements were averaged from three 6x6' plots taken on the green nearest the weather station. Composition of turfgrass species (creeping bentgrass : *Poa annua*) on each green was estimated at study start. Correlations were made between turf health indicators (e.g., visual quality) and measured environmental data (e.g., shade or daily light integral).

Figure 3. The weather station was located as close to each green as possible.

Figure 4. A range of light levels was needed, and three 6x6' plots were measured on each green nearest the weather station.

Figure 5. Golf green in play: Medinah Country Club's 6th green on number one course.

Figure 6. Practice putting green: Bryn Mawr Country Club location.

Figure 7. Nursery green: Chicago Golf Club location.

And the research says – effect of shade on a golf green environment.

One aspect is that shade will influence weather conditions. For example, we found temperature is lowered in shaded conditions on a green (**Figure 8**). Makes sense, shade in the summer allows animals (including humans) to avoid heat-stress outdoors. Overall, air temperature moderation did not outweigh shade's reduction of necessary light levels. Instead, we found the composition and health of golf greens in Chicago were negatively affected by increasing shade.

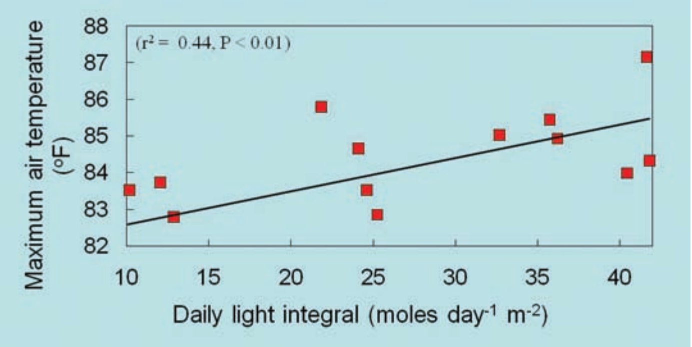

Figure 8. Shade (low daily light integral values) has a minor cooling effect on a golf green environment when averaged over a month period across 15 different Chicago sites.

By estimating *Poa annua* presence at study start and then comparing with the daily light integral through the study period we found Poa annua out-competes creeping bentgrass in shade (**Figure 9**). It makes sense. Genetically, *Poa annua* is more shade tolerant than creeping bentgrass. We can easily find that information in our turfgrass textbooks and this fact is a common observation by superintendents and golfers alike. Now with science we have demonstrated it is indeed fact, not just academic nonsense or superintendent lore. In summer 2007 we showed *Poa annua* likes an environment of shade, this time across the many varied golf courses of Chicago (this study included: five north suburb courses, five south suburb courses, and five west suburb courses). Big problem: *Poa annua* lacks heat tolerance when compared to creeping bentgrass. It suggests that shaded greens will be vulnerable to midsummer decline . . . because greater levels of heat-intolerant *Poa annua* are present compared to a green that receives full sun.

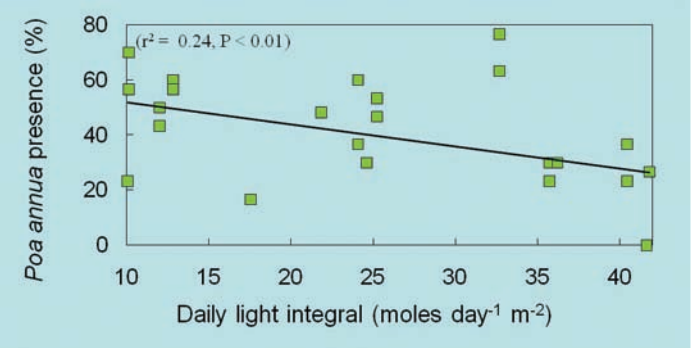

Figure 9. Increased shade was related to greater presence of Poa annua *when rated on 15 individual golf greens at select sites across Chicago on July 23, 2007.*

And the research says – effect of shade on golf green health.

Within the environment of a green, we found shade had a significant influence on visual quality during a stressful month-long period that began in late July in 2007. Visual quality decreased more on shaded greens than those in full sun. The difference in visual quality from study start on July 23 to study end on August 23 was greatest at lowest light levels (**Figure 10**). Best solution: reduce shade near greens and increase creeping bentgrass whenever possible. It suggests using seed of a newer variety which has a finer texture and greater density than that of an older bentgrass variety such as Penncross. This will maximize photosynthesis at the low mowing heights necessary for greens.

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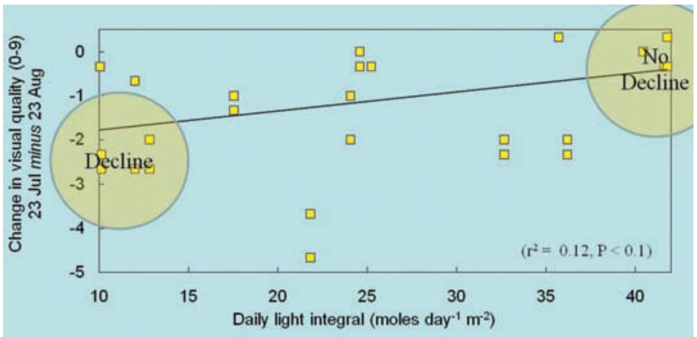

Figure 10. Increased shade (low daily light integral values) was related to greater midsummer physiological decline (initial rating subtracted from final rating) of greens across 15 Chicago Golf Courses.

Future research.

More research is needed to investigate whether shade itself is the main contributor to decline of putting green health at midsummer. When it comes to managing roots, an Oklahoma study found shade was responsible for the greatest loss in biomass of sand-based creeping bentgrass greens (Koh et al., 2003). So, it returns us to the beginning of this story – midsummer decline associated with root loss and not disease in Kansas. In this Chicago study, shade's greatest fault may be that it increases the *Poa annua* component of bentgrass greens. Bentgrass greens without a *Poa annua* component may avoid midsummer physiological decline entirely, as long as golf course superintendents adjust cultural practices in their dynamic attempts to maximize photosynthesis (i.e., a timely raise in mowing heights and/or a reduction of other mechanical injury to leaf blades). One caveat is that Oklahoma researchers have found airflow restriction is even more important than shade when it comes to creeping bentgrass canopy density (Koh et al., 2003).

What to do.

In his book, *Creeping Management: Summer Stresses, Weeds and Selected Maladies*, Dr. Peter Dernoeden suggests several shade management strategies for greens. All six recommendations are science-based and follow. Promote full sun by removing trees and brush. Syringe or hand water as needed to promote soil drying and transpiration. Use fans to improve air circulation. Improve drainage and air exchange between the soil and atmosphere. Control algae and thatch. Apply less nitrogen to shaded versus full-sun greens.

Add one more – height of cut.

So, besides physiological bad news for turfgrass (everybody knows light is necessary for plant photosynthesis), a shaded green has other ingredients in a recipe that might lead to a failing green: *Poa annua* + restricted airflow + fast green speeds. Fast green speeds are doable. We just teach golfers there is a little thing called turfgrass science that comes to bear quickest in summer. Midsummer physiological decline of greens is a reality, is independent of disease, and has been detailed scientifically (i.e., this article and many others). The take home message might just as well be… Shaded greens are physiologically different, and height of cut adjustment (up) around midsummer is probably necessary to preserve their health. **-OC**

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North
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Bryn Mawr Country Club, Brian Bossert
Knollwood Club, Randy Wahler
North Shore Country Club, Dan Dinelli
Skokie Country Club, Don Cross

West
Aurora Country Club, John Gurke
Cantigny Golf, Scott Witte
Chicago Golf Club, Jon Jennings
Medinah Country Club, Tom Lively
Ruth Lake Country Club, Dan Marco

South
Beverly Country Club, Keith Peterson
Coyote Run Golf Club, Dave Ward
Crystal Tree Golf & Country Club, Les Rutan
Joliet Country Club, Mark Kowaliczko
Prairie Bluff Public Golf Club, Ken Shepherd

Literature cited

Bell, G., T. Danneberger, and M. McMahon. 2000. Spectral irradiance available for turfgrass growth in sun and shade. Crop Sci. 40:189-195.

Dernoeden, P. 2000. Creeping Bentgrass Management: Summer Stresses, Weeds and Selected Maladies. Chelsea, Michigan: Ann Arbor Press. Pp. 21-25.

Fry, J., and B. Huang. 2005. Applied Turfgrass Science and Physiology. New Jersey: John Wiley & Sons. Pp. 111-123.

Huang, B. and X. Liu. 2003. Summer root decline: Production and mortality for four cultivars of creeping bentgrass. Crop Sci. 43:258-265.

Koh, K., G. Bell, D. Martin, and N. Walker. 2003. Shade and airflow restriction on creeping bentgrass golf greens. Crop Sci. 43:2182-2188.

Xu, Q., B. Huang, and Z. Wang. 2002. Photosynthetic responses of creeping bentgrass to reducing root-zone temperature at supraoptimal air temperature. J. Am. Hort. Sci. 127:754-758.

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