Managing Soil and Canopy Temperatures for Healthy Turf

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

Heat stress comes into varieties, direct and indirect. Direct heat stress injury can occur when the canopy temperature is so extreme that it kills the leaf or plant immediately. Direct heat stress injury often goes hand in hand with drought stress. Plants use evaporative cooling to dissipate heat. During drought stress, the plants close their pores (stomata) and evaporative cooling shuts down resulting in a rapid increase in canopy temperature. Except for plants that aren't water stressed, direct heat stress is a rare condition.

Indirect heat stress is more common and harder to quantify. With direct heat stress, the plant either survived or did not. However, indirect heat stress occurs over a longer time period and the symptoms can be difficult to pinpoint, plants don't die but simply weaken. Indirect heat stress is a result of an imbalance between photosynthesis (making sugar) and respiration (burning sugar). Generally, respiration increases as temperatures increase, while photosynthesis peaks at about room temperature and declines as temperatures warm. When temperatures get into the upper 80s, cool-season turf hits a break-even point where the plant is using sugar as fast as it can make it. In the 90s, the plant is using more sugar than it makes. At this point, it starts using its reserves and roots depth declines. This can only go on for so long until the turf begins to thin. The moral of the story appears to be that heat kills, and you should do everything you can to keep your turf cool.

But Dr. Bingru Huang and co-workers (2004) taught us that it is more complicated than that. Her research showed that bentgrass grown in a growth chamber kept at 68 °F during the day and 95 °F at night died quickly, while the same grass grown at 95 °F during the day and 68 °F at night thrived. From this we can conclude that nighttime lows are more important to managing heat stress symptoms than daytime highs. Here's the bad news, according to CALS Scientist Chris Kucharik (Department of Agronomy), Wisconsin has become warmer by about 1.1 °F since 1950. However, during that period the number of days over 90 °F hasn't changed, but our nighttime lows have been consistently higher (see Wisconsin's Changing Climate: Impacts and Adaptation, 2011). Going forward, we can expect this trend to continue and indirect heat stress will probably become more prevalent in Wisconsin.

There are some strategies you can employ to help keep your turf as cool as possible. Dr. Beth Guertal has been conducting soil cooling studies involving fans and irrigation in the Alabama heat for well over a decade. Her results have shown that fans are far more effective than syringing for cooling turf. Syringing (a very light application of water) can create a short-lived decrease in canopy temperature as the water evaporates. It is most effective when done about two hours prior to the daytime high temperature. However, it does not reduce the nighttime lows. For that we need to look to fans and irrigation timing.

A substance with a high heat capacity resists changes in temperature. Another way to look at it is a substance with a high heat capacity will take a lot of heat to increase the temperature, and a long time to cool down relative to materials with lower heat capacities. The heat capacity of air is essentially zero, which is why air is a great insulator. Water has a high heat capacity relative to other substances. This means that soils with more air will cool down much quicker. The wetter the soil, the slower it will cool down. But irrigation water temperature matters too. Groundwater is quite cold, so when you add cold water to a cool dry soil, the soil will remain cooler for a large portion of the day. But if you irrigate a dry soil in the afternoon or evening, the soil is warm and transfers that heat to the water, which will retain it into the night. Therefore, the best time to irrigate soil for managing heat stress is in the morning, when the dry soil has had time to cool to the minimum and the cold groundwater will resist heating up until later in the day. This is essentially what Dr. Guertal and Dr. Han found in their latest study (2009). However, they reported that irrigation timing didn't matter if you are running a fan 24 hours. I highly recommend reading the 2009 report for more details.

While we don't have the challenges of Alabama, I think fans are an underutilized tool in tough growing environments. But they are out there, I still remember seeing my first fan in the early 1990s near the 14th green at the Janesville Country Club, and University Ridge has recently employed a number of fans to protect their new bentgrass greens. While, the cost-benefit of having fans probably doesn't make sense for the majority of Wisconsin courses, I would encourage you to keep them in mind for those problem greens. Finally, remember that keeping soils dry, but safely above the wilt point at night and watering in the morning will be your best bet to combat indirect heat stress.

References:

Wisconsin's Changing Climate: Impacts and Adaptation. 2011. Wisconsin Initiative on Climate Change Impacts. Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, Madison, WI. (available at www.wicci.wisc.edu)

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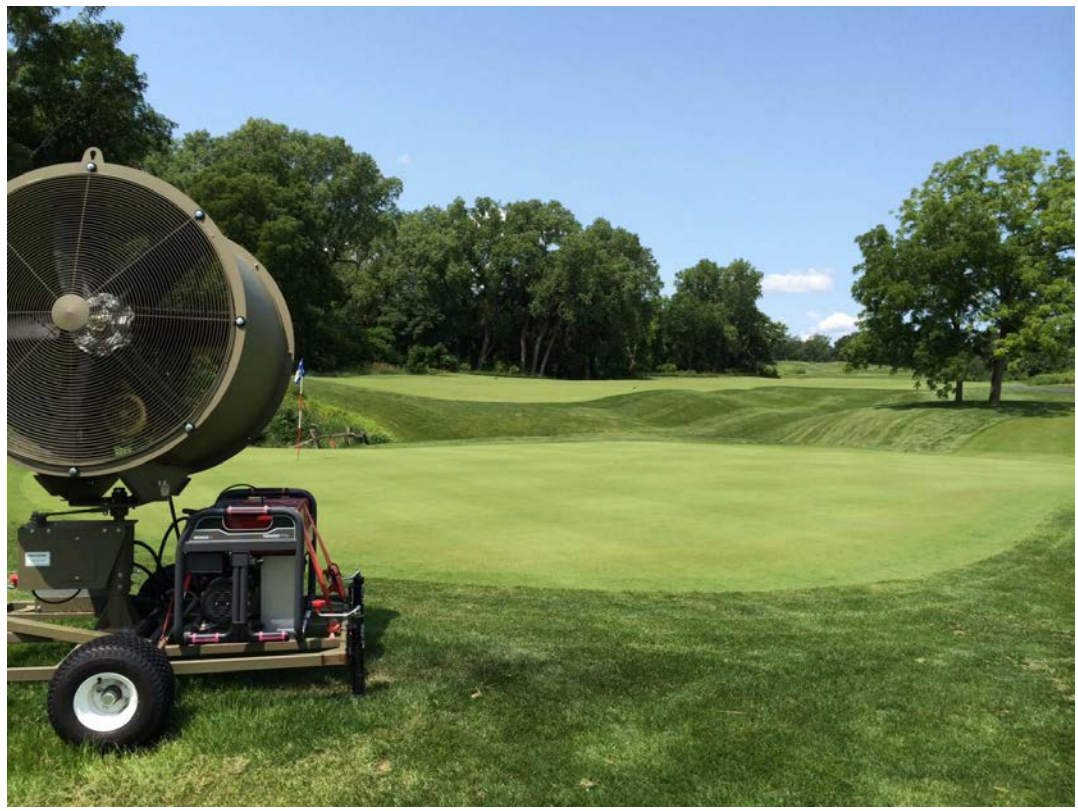

A fan on the 2nd green at University Ridge (photo: Adam Wepfer)