Heat Kills: Managing Turf Heat Stress

by Wendy Gelernter, Ph.D. and Larry J. Stowell, Ph.D.

Bottom line: There is little we can do to prevent high summer temperatures from occurring, or to predict when they will occur. To combat this uncertainty, it is necessary to be prepared for the worst – air temperature maximums of 100°F or higher. These temperatures spell the beginning of the end for cool season greens <u>unless</u> preventive measures are implemented, including temperature monitoring programs, syringing, fans, monthly aerifications and use of nitrate nitrogen, as opposed to ammonium or urea based products.

Figure 1. This bentgrass green completely failed after two days of maximum temperatures above 115°F, and little or no air movement. No fans were present. Although syringing was implemented, the lack of air movement resulted in insufficient cooling for bentgrass to survive.

1999: Another year of weather extremes

The concept of a "normal weather" year has slipped another notch away from reality as we experience the truly strange climate extremes of 1999. Air temperatures in the Western U.S. have been lower than normal, with record-breaking minimum temperatures in the 30's recorded throughout California, Nevada and Oregon during June. Unusually heavy monsoon rains have also been experienced in the West this summer, the most widely reported of which was the three-inch Las Vegas thunderstorm that recently claimed two lives. During this same time period, the eastern two-thirds of the country has sweltered under record high temperatures of 95°F and above. And drought conditions, particularly in the mid-Atlantic region, are causing damage to crops and livestock.

The influence of La Niña (the presence of abnormally cold ocean temperatures in the equatorial Pacific) is being blamed for much of our freaky weather this year, but this may not be completely accurate. In fact, climatologists have yet to determine how and if another phenomenon – the long-term trend towards warmer temperatures (sometimes called "the greenhouse effect") interacts with the climate changes caused by La Niña (and El Niño, for that matter). As a result, long-range forecasting for heat or other climatic anomalies is still beyond our technical know-how. To deal with this gap in our knowledge, the only sane strategy is to plan for the worst – that is, an unusually hot summer. In this issue of *PACE Insights*, we will update you on recent information on turf heat stress, as well as some strategies for alleviating it.

Symptoms of heat stress

The two greens in Figures 1 and 2 should convince any skeptics of the devastating effects of high temperatures on cool season turf. Figure 1 illustrates the importance of air movement for a bentgrass green during extreme high temperatures. In the poa green in Figure 2, the value of shade during hot weather is illustrated.

During hot weather, the first part of the turf plant to suffer is the root system. At first, the roots' rate of growth will slow down, which will result in a parallel decrease in the growth of new turf foliage. As temperatures get higher, the roots will struggle more and more to survive, and will eventually stop functioning. This in turn leads to a complete shut-down of turf growth. At first, the turf will begin to thin, frequently turning a darker color. If temperatures remain too high, large patches of turf will begin to turn brown or white as the entire turf plant – shoots, roots and crowns – gradually dies.

Figure 2. Annual bluegrass green, following several days of maximum air temperatures of 110°F – 120°F. Note that the only undamaged turf was shaded by trees, where temperatures were significantly cooler.

The critical role of turf canopy temperature

The <u>turf canopy</u> refers to the small area defined by the verdure (turf foliage) above the thatch area.

It is the temperature in the turf canopy that makes the difference between life and death for turf.

The canopy temperature at which irreversible turf damage occurs – the **thermal death point** – varies from one turf variety to the next. Based on our field research and observations, we have been able to come up with some rough estimates for these values. For *Poa annua*, canopy temperatures of 115°F for two hours or more will result in death. For bentgrass (which is a bit more heat tolerant), a canopy temperature of 120°F for two hours will result in turf death. It is important to realize that even lower canopy temperatures can cause problems if they persist for longer than two hours. In other words, four hours at a canopy temperature of 110°F might cause the same damage as two hours at 115°F.

Measuring turf canopy temperatures

The most reliable way to measure turf canopy temperatures is with a bead thermocouple that is hooked up to a digital thermometer (see description below). This is a relatively easy procedure, but it is not yet widely used. There are several more popular, but less accurate ways to measure canopy temperatures as well, including the use of air temperatures or soil temperatures. The plusses and minuses of these two indirect approaches are discussed below.

<u>The relationship of air temperature to canopy temperature:</u> We frequently assume that air temperature is a good indicator of turf canopy temperature, but this is not always the case. While turf canopy temperatures generally run 10-15°F higher than the air temperature during the peak heat of summer, this rule of thumb can be very misleading. This is because other factors such as relative humidity, soil moisture, wind speed, and even compaction can affect turf canopy temperature. It is for this reason that on any given golf course, some greens will fail during hot weather, while others will not. For example, turf canopy temperatures may reach the plant's thermal death point on greens that are surrounded by trees, or are situated in a low spot where air movement is low. At the same time, on other greens with better air movement (wind speeds that sometimes go above 4 mph) the turf will look fine, despite high air temperatures.

There are therefore risks to using air temperature as your only indicator of turf canopy temperature. Most importantly, greens with poor air movement, that are stressed due to drought or other factors (high salts, low fertility, etc.) or that are compacted may fail even when air temperatures are only in the low 90s. This is because these other factors have the effect of raising turf canopy temperatures significantly -- more than the 10-15°F rule of thumb guide given above. In these situations, using air temperature as the only indicator of turf canopy temperature would convince us that turf canopy temperatures were low enough, and that everything was fine -- even when it wasn't. The result? Dead greens.

<u>The relationship of soil temperature to canopy temperature:</u> Measuring soil temperatures as an indicator of turf canopy temperature can likewise be misleading. This is because soil temperatures tend to increase very slowly, while turf canopy temperatures can change quite rapidly. Therefore, relying on soil temperatures would likely give you a rosier picture (more stable, lower temperatures) than actually exists within the turf canopy.

Equipment for monitoring canopy temperatures

If you have suffered from heat related stress problems in the past, we strongly suggest that you enhance your management program by including a monitoring program for turf canopy temperatures and wind speeds during the summer months. These are relatively easy procedures that require a small financial investment ($200-$300), but can provide gratifying returns. The equipment that you'll need is described below.

<u>Bead thermocouple:</u> The small size of this thermocouple allows more accurate readings of actual turf canopy temperatures. Larger probes that are good for measuring soil or air temperatures may change the temperature in the small area you want to measure and/or measure temperature in the wrong spot. Two pieces of equipment are required: a digital thermometer (Thermometer mini-K, Grainger part # 1M934: $79) and a bead thermocouple (Grainger part # 1T322: $13.20). Grainger's can be reached via their web page (www.grainger.com) or by obtaining their local warehouse number from your phone company information service.

<u>Turbometer:</u> This piece of equipment (available from Ben Meadows [800-241-6401] part 110958, $123.95) is used to measure wind speed. Use it to identify or confirm those greens with the poorest air movement by measuring wind speeds at one or more specified times of day during the course of the summer.

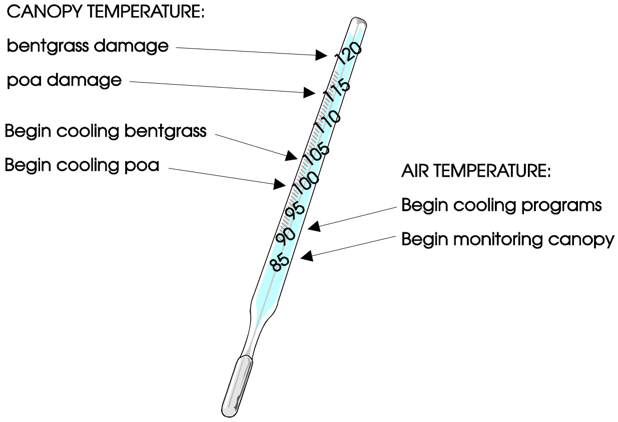
A temperature monitoring program

1. Select a minimum of three greens where you will do the bulk of your turf canopy monitoring. Your best bet is usually to choose those greens that have failed in the past during hot weather.
2. Begin turf canopy temperature monitoring when maximum air temperatures for the day reach 85°F. Monitor and record turf canopy temperatures every day that the maximum air temperatures reaches 85°F or higher.
3. To measure turf canopy temperatures, make measurements during the hottest part of the day (usually around 2:00 pm in most areas). Place the bead in the area between the base of the foliage and the top of the thatch layer. Allow a few moments for the thermometer to equilibrate, and for the reading

to remain stable. Record the readings in a hardbound notebook, with a ballpoint pen, so that your records remain legible for years to come.

4. Begin preventive cooling programs (see below) when turf canopy temperatures reach 100°F for poa, or 105°F for bentgrass (Figure 3).
5. If you are unable to regularly monitor turf canopy temperatures, monitoring air temperatures is a distant second choice, but still much better than not monitoring at all. Preventive cooling programs should be initiated when air temperatures reach 90°F in most cases, but you need to remain aware of the weaknesses of relying completely on air temperature, as described above.
6. A quick test for turf canopy temperatures, in the event a bead thermocouple isn't available, is to place the flat of the palm of your hand on the turf surface. If the surface feels warm, the canopy temperature is probably above 98°F (your body temperature) and therefore close to, or within the danger zone of 100°F - 105°F.

Figure 3. Critical air and turf canopy temperatures (°F) for managing heat stress on cool season turf.



PREVENTION: Cooling programs

Preventive cooling strategies that lower the temperatures in the turf canopy must be taken **before** the critical canopy temperatures of 115 – 120°F are reached. Based on our observations, preventive actions should be taken when air temperatures reach about 90°F, or when turf canopy temperatures reach 100°F (for poa) or 105°F (for bentgrass), as illustrated in Figure 3. These are rough numbers, empirically developed, and need much refinement, but should help provide some guidelines until more data is available. Your preventive cooling program should include one or more of the following components:

Fans and blowers (Figures 4 and 5): In hot weather areas of the country such as Palm Springs, fans are relatively common and reliable tools for reducing turf canopy temperatures, but they are relatively unknown elsewhere. They are particularly useful on greens with low air movement and/or greens that don't drain well. In these situations, fans have been observed to decrease turf canopy temperatures by 10°F or more when they are situated correctly (two to four fans are usually required per green, depending on the size, conformation and surrounding areas of the green). Although fans are a large investment, they should be considered for golf courses where heat stress has resulted in greens failures on a regular basis. A variety of commonly used fans are available from Patterson Fan (Blythewood, SC 800-768-3985) and other suppliers. If you are located in an area where temperatures get into the dangerous zone only occasionally, or if your greens are not wired for electricity, or if you budget simply won't withstand the purchase of fans, you may want to consider the use of leaf blowers, or tractor mounted blowers as a stopgap measure. While these measures are not practical (from a time and labor efficiency standpoint) when used on a regular basis, they can simulate the effects of fans in hot spots on the golf course during the occasional hot spell.

Figure 4. August 5, 1998. Death of the turf in this bentgrass nursery followed several days where maximum temperatures were 115°F or more. There were no fans at this location on the golf course.

Figure 5. August 5, 1998. The use of fans on the same golf course, with the same bentgrass variety, on the same date as pictured in Figure 4, resulted in good turf survival, despite the high air temperatures.

Syringing: There is a variety of syringing techniques that superintendents have developed over the years that fit the profile of their course. Variation exists in the duration and frequency of syringing, and the use of hand watering vs. irrigation heads, for example. Whatever the method, it is clear that that frequent irrigation of greens for short periods of time can produce significant (a decrease of 10°F or more) cooling of the canopy, especially when there is sufficient (4 mph) air movement, either from wind or fans. The amount and frequency of syringing will vary from course to course depending on your irrigation system, weather patterns and drainage. To determine how frequently syringing is needed at your location, select a green with high canopy temperatures, and use the bead thermocouple to determine canopy temperatures before and after a single syringe cycle. Check the canopy temperature every 10 or 15 minutes after this initial syringe to determine how long it takes for the canopy temperature to climb back to the 100-105°F danger level. This period of time then becomes your syringing frequency. For example, if it takes 1 hour for turf canopy temperatures to rise again to 100-105°F, then your syringe cycles should be 1 hour apart until canopy temperatures begin to decline.

MORE PREVENTION: Maintain turf health

Manage diseases: While the benefits of syringing as a preventive action are clear, there is also a risk -- of enhanced plant disease due to increased moisture on the surface of the green. For this reason, a strict preventive fungicide program needs to be in place before any syringing program begins, with a particular emphasis on pythium, anthracnose and algae control.

Aerify: Increase soil aeration on greens during the summer months. Hollow or solid core aerification using 1/4 inch tines, on a monthly basis (June - November) will increase oxygen levels in the soil, thus contributing to root health, salinity management and disease management, as well as to decreasing the accumulation of ammonium. Aerification will also promote gas exchange, thereby helping to prevent the anaerobic conditions that occur during the summer.

Switch to nitrate-based fertilizers (ammonium nitrate, calcium nitrate, potassium nitrate, etc.). For optimum turf health, maintain total soil nitrogen levels at less than 20 parts per million (ppm). Nitrate levels should range between 3 - 20 ppm, and ammonium levels should be less than 7 ppm. There should be at least three times as much nitrate as ammonium in the soil.

To achieve this goal, spray applications of low rates of nitrogen is the safest bet (not more than 1/4 lb N/1000 sq ft per week). By avoiding ammonia based fertilizers (such as proteinaceous organic fertilizers, urea products and ammonia products) during the peak heat of the summer, you will lessen the possibility of ammonia damage.

For a more detailed explanation of the biological processes involved in ammonia toxicity during the summer, see the October, 1997 issue of *PACE Insights.*

From bad to worse: the role of damaged turf in escalating heat stress

Beware the presence of small, damaged patches of turf on greens during hot weather – they are difficult, if not impossible to repair. The reason? Stressed or dead turf has lost the ability to operate its stomates correctly and therefore cannot cool itself down via evaporative cooling. As a result, canopy temperatures in and around damaged turf may be significantly higher (15°F or more) than around healthy turf at the same location (Figures 6 and 7). During hot weather, attempts to re-seed into the dead turf may therefore be futile, because the extremely high temperatures there will kill tender germinating seedlings. In contrast, healthy plants stay cooler because they have a complex internal system of evaporative cooling that is regulated by the opening and closing of their stomates.

Figure 6. In the photo on the left, turf canopy temperatures on healthy areas of this poa green registered 94.7°F, using a bead thermocouple. A close-up of the bead thermocouple inserted into the canopy for temperature measurement is shown on the right.

Figure 7. Canopy temperatures of 110.28°F were observed on a nearby area on the same poa green where the turf was damaged by anthracnose. The damaged turf was 15°F hotter than the healthy turf.