Dealing with heat stress on golf course turf

Summer brings trouble to cool-season grasses.

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Unfortunately, too many turf managers have attempted to solve summer turf problems by simply pulling pest-protection chemicals off the shelf and applying them as often as every other day. Apparently, some have become skeptical of the idea that heat is the main antagonist in summer stress.

Even so, every turfgrass has an optimal temperature for growth, and supra-optimal temperatures diminish a turfgrass' performance. To keep grass growing and healthy through the summer, golf course superintendents should understand how heat afflicts grass. Cultural practices can relieve some of the effects of summer heat, especially when the cultural practices augment a turfgrass' innate heat-resistance characteristics.

Understanding heat stress

Heat stress is most common in cool-season turfgrasses — especially when they are grown in the transitional and warm climatic regions. For example, creeping bentgrass (*Agrostis stolonifera*) is now commonly grown on putting greens in the southern United States where temperatures exceed the species' needs for optimal performance.

Photos courtesy of Dave Green

Shade trees can actually cause greens to heat up if they block natural breezes.

Heat resistance of species

Excellent: Tropical carpetgrass, sarangoongrass, bermudagrass, seashore paspalum, buffalograss, zoysiagrass.
Good: St. Augustine grass, centipedegrass.
Medium: Tall fescue, hard fescue, Kentucky bluegrass.
Fair: Chewings fescue, sheep fescue, red fescue, perennial ryegrass.
Poor: Creeping bentgrass, colonial bentgrass, meadow fescue, redtop, Canada bluegrass.
Very poor: Annual ryegrass, annual bluegrass, rough bluegrass, *Poa supina.*

Predictably, heat stress worsens as cool-season grasses are subjected to longer periods of extraordinarily hot temperatures and high humidity. Absence of wind can add to the problems of heat stress.

Soil temperature is the most critical heat factor affecting a turfgrass plant. In early summer, high air temperatures may not cause significant stress injury because the soil retains coolness from winter. Later in the summer, after the soil has warmed, heat stress becomes a serious threat.

Lethal heat stress destroys the critical protoplasmic proteins in cells. Heat stress injury may be direct and acute or indirect and chronic. Injury first becomes visually evident in cross sections of shoots at the junction of leaf blade and leaf sheath of the second- and third-youngest leaves. Plant death occurs at 106 degrees F and higher, depending on species and cultivar.

Types of heat resistance

Heat resistance is the ability to survive an externally imposed high-temperature stress. There are two types of heat resistance: avoidance and tolerance.

Heat avoidance is the ability to maintain internal temperatures below lethal stress levels by transpirational cooling. Cultivars with higher transpiration rates are better at heat avoidance, assuming they sustain adequate roots for water uptake.

Heat tolerance occurs in plants with an internal physiological ability to survive high internal tissue temperatures, which is attributed to membrane

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"Summerkill" explains turf death

Wintertime turfgrass deaths from cold injury, drought or disease are typically lumped together into the term "winterkill." Yet we have no general word – "summerkill," for example – to describe turfgrass death caused by the summer stresses of heat, drought or opportunistic pathogens. Why not?

The term "summerkill" might be quite useful in the case of death from heat and drought stresses, which are very difficult to tell apart.

Consider annual bluegrass (*Poa annua*). Under heat stress, the grass' roots promptly begin dieback, with no new root initiation or replacement. During periods of high evapotranspiration, an internal plant water stress develops when water loss exceeds the rate of water uptake through the root system. Stomata, openings in leaf tissue that help cool leaves by allowing release of water in evapotranspiration, close when the plant is under excessive internal plant water stress. On hot days, internal leaf temperature can rise to lethal levels above 104 degrees within an hour after stomatal closure. So what kills the grass: heat or water stress? The final cause of death here is heat stress, but an internal plant water deficit played a key role.

This close relationship between heat and water stress occurs frequently during the summer months. The demise of turf under these conditions could easily be described as "summerkill."

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integrity and superior thermal stability of heat-sensitive enzymes.

Heat-avoiding turfgrass cultivars that thrive in the low humidity of Arizona, California or the Great Plains may lack heat resistance in humid areas such as Mississippi, Georgia and New Jersey, because humidity reduces the internal cooling effects of transpiration. On the other hand, heat-tolerant cultivars will be resistant in both humid and arid conditions. This distinction is important to the interpretation of heat-resistance data of cultivars.

Turfgrass heat resistance is reduced by shade, excessive nitrogen and potassium deficiencies. Older plant tissues generally have reduced heat resistance.

Fans can replace natural breezes blocked by trees.

Moderating heat problems

The first principle in any stress environment is to use cultural practices that produce the healthiest plant shoot and root systems possible.

Root zone modification

Water has the highest heat-accumulation ability of any natural material. Wet or saturated soils require more energy to warm up and more time to cool down. By allowing maximum drainage of excess water, high-sand USGA-style root zones accumulate less heat compared with poorly drained clay root zones. Moreover, such a root zone encourages deeper, more extensive root growth, allowing greater water uptake to support high rates of evapotranspiration, the key factor in turfgrass heat avoidance.

Heat-resistant cultivars

Warm-season turfgrasses using the C_4 pathway of photosynthesis — such as bermudagrass (*Cynodon* spp.) and tropical carpetgrass (*Axonopus compressus*) — are physiologically adapted in terms of optimum growth at temperatures of 80 to 90 degrees F. In contrast, C_3 cool-season grasses — such as bentgrasses (*Agrostis* spp.) and annual bluegrass (*Poa annua*) — are physiologically adapted to optimum growth at temperatures of 60 to 75 degrees F. Even so, cool-season grass species demonstrate various capacities for heat resistance, ranging from medium for grasses such as Kentucky bluegrass to very poor for annual bluegrass and rough bluegrass, among others.

Unfortunately, many turfgrass cultivars are marketed as heat-tolerant, when in fact their heat-resistance mechanism is avoidance. For hot, humid areas, it's important to select heat-tolerant turfgrass cultivars that have been proven in independent, comparative, replicated research over a 3- or 4-year period under similar humid conditions.

Cultural practices

A number of turfgrass cultural practices enhance heat-stress resistance. Individually, each may not have a major impact, but collectively they can be significant.

- High potassium fertility — This nutrient enhances rooting, which improves a plant's heat-avoidance capability and improves the physiological heat tolerance of grass tissues. Chemical tests should reveal the appropriate potassium levels needed in leaf tissue and soil.
- Modest nitrogen fertility — We need to maintain sufficient nitrogen to ensure healthy turfgrass, but it's advisable to avoid nitrogen levels that force leaf growth and cause physiological reductions in heat tolerance.
- Minimal thatch or mat — Thatch control encourages deeper rooting,

facilitating water uptake from a greater portion of the root-zone profile. Thatch control may include verticutting, core cultivation and topdressing.

- Cutting height elevation — Slightly higher mowing during hot periods may help grass endure the heat, particularly on putting greens. Because grass growth is slowed by high heat anyway, putting distances aren't likely to decline dramatically if the cutting height rises from 5/32 inch to 3/16 inch, for example. After the heat wave ends, resume mowing at the original level.
- Mower selection — Park the triplex greensmower during severe heat waves and switch to a walk-behind. Solid rollers on either type of mower also will reduce mowing stresses in hot weather.

Syringing

Syringing is the application of a very light amount of water onto the leaves of turf. In hot, low-humidity conditions, evaporation of the water can reduce turfgrass temperatures as much as 10 degrees F if applied 1.5 to 2 hours before maximum midday temperatures, which typically occur around 2 p.m. It works well in Arizona, for example, but at times can be less effective in humid regions of the country. Syringing can also help turf avoid heat stress by correcting an internal plant water deficit.

Air movement

Stagnant air on greens, common where trees and shrubs block the prevailing wind, often intensifies temperature and humidity in and immediately above the turf canopy. This heat can boost root-zone temperatures as well and produce an environment favoring certain pathogens.

If the prevailing wind can flow through an opening cut in the tree and shrub barrier, the extra air movement may be sufficient to cool the green and enhance turfgrass health.

Stagnant air also can be remedied with mechanical fans, especially in hotter climates. I first demonstrated this procedure in the late 1950s, reducing heat by 14 degrees F on bentgrass putting green turf in Indiana using a 4-mph breeze from a fan. Many golf courses now employ fans on selected greens where trees, shrubs or hills restrict air movement. Although the ideal fan may not have been designed yet for greens cooling, some criteria are important to consider in selecting fans:

- Noise — Because of slower blade velocity, a 54-inch diameter fan is 50 percent quieter than a 48-inch fan.
- Effective distance — Fans with greater effective distances can be placed

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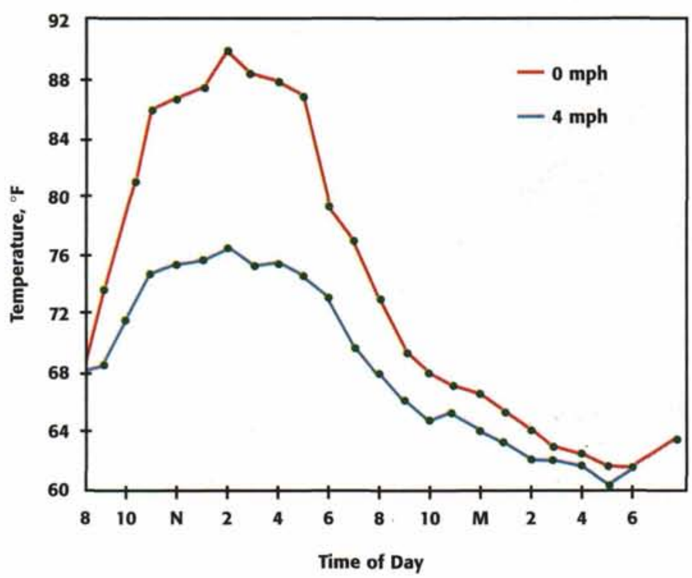
Cooling with fans



Fans can keep greens substantially cooler than unmoving air, as shown in this graph of temperatures from bentgrass turf receiving a 4-mph breeze from a fan compared with turf receiving no fan treatment.

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farther from the perimeter of the green, reducing the aesthetic interference.

• Effective pattern — The wider and longer, the better, up to an air velocity of 4.5 mph.

• Appearance — Color, distance from green, height above turf and size all influence how harmoniously fans blend with the surrounding environment.

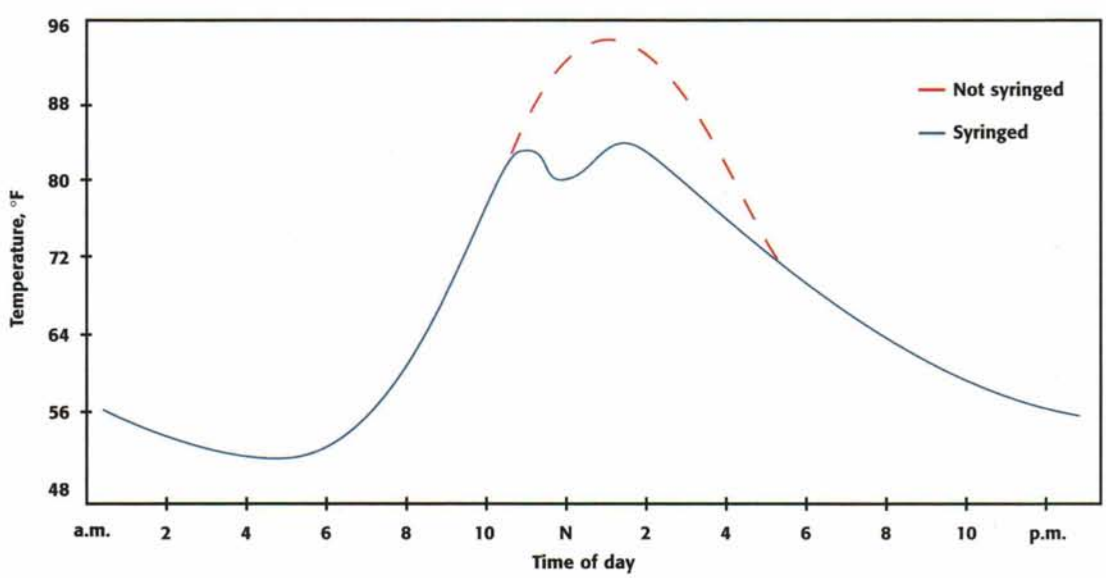
Monitoring temperatures

During the summer, my telephone rings frequently with calls from turfgrass managers facing heat-related turf problems. My first question is always, "What is the soil temperature on the problem site?" Usually the caller doesn't know, and the turfgrass problem can't be properly diagnosed.

Before buying fans or hiring syringing crews, it may be prudent to take temperature readings to determine that the turf truly is suffering from heat stress.

Monitoring devices can reveal soil temperatures, air temperatures and turfgrass canopy temperatures. Air temperature preferably should be measured at ½ inch above the turfgrass canopy, or at 5 feet as the U.S. Weather Service does. Soil temperatures are monitored at 1 and 4 inches below the soil surface. A sensor placed in the canopy must be fully shaded by turfgrass shoots to produce an accurate canopy temperature.

Cooling with water



Under low-humidity conditions, creeping bentgrass is cooler for several critical hours after syringing than untreated turf.

RESEARCH

Thermocouples are the simplest, most reliable sensors for continuous monitoring. Made of heat-sensitive wire, they can be adapted to measure soil or air temperatures (if shielded from sunlight and ventilated by an aspirated device providing minimum air movement of 1.6 feet per second).

Infrared thermometers can offer an instantaneous measurement of leaf canopy temperatures on a digital readout. They can indicate unhealthy canopy temperatures and turfgrass stress problems before the turf shows visible symptoms such as purpling. Infrared thermometers monitor heat by reading invisible light reflected by the turfgrass — a more effective method than attempting to place a contact sensor among turf leaves without exposing it to direct solar radiation.

Both types of sensors are attached to monitoring systems that report temperatures to the turfgrass manager. Calibrate your monitoring system at least annually and perhaps more frequently depending on the intensity of use.

Informed decisions

Summer can put severe stresses on turfgrass. Heat stress is significant, and turfgrass managers require knowledge of its symptoms and its remedies. Monitoring may reveal that turf temperatures are too high, and remedies such as syringing or fanning have proven effective in certain areas. They're part of a strategy to deal with summer turfgrass problems. ■

References

1. Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Englewood Cliffs, N.J.
2. Beard, J.B., and W.H. Daniel. 1965. Effect of temperature and cutting on the growth of creeping bentgrass (*Agrostis palustris* Huds.) roots. *Agron. J.* 57:249-250.
3. Beard, J.B., and W.H. Daniel. 1966. Relationship of creeping bentgrass (*Agrostis palustris* Huds.) root growth to environmental factors in the field. *Agron. J.* 58:337-339.
4. DiPaola, J.M., and J.B. Beard. 1992. Turfgrass — physiological effects of temperature stress. p. 231-267 *In:* Agron. Series No. 32. ASA, Madison, Wis.
5. Duff, D.T., and J.B. Beard. 1966. Effects of air movement and syringing on the microclimate of bentgrass turf. *Agron. J.* 58:495-497.
6. Duff, D.T., and J.B. Beard. 1974. Supraoptimal temperature effects upon *Agrostis palustris*. I. Influence of shoot growth and density, leaf blade width and length, succulence and chlorophyll content. *Physiol. Plant.* 32:14-17.
7. Duff, D.T., and J.B. Beard. 1974. Supraoptimal temperature effects upon *Agrostis palustris*. II. Influence on carbohydrate levels, photosynthetic rate and respiration rate. *Physiol. Plant.* 32:18-22.
8. Minner, D.D., P.H. Dernoeden, D.J. Wehner and M.S. McIntosh. 1983. Heat tolerance screening of field-grown cultivars of Kentucky bluegrass and perennial ryegrass. *Agron J.* 75:772-775.
9. Sifers, S.I., and J.B. Beard. 1993. Comparative inter- and intra-specific leaf firing resistance to supraoptimal air and soil temperatures in cool-season turfgrass genotypes. *Int. Turfgrass Soc. J.* 7:621-628.
10. Watschke, T.L., R.E. Schmidt and R.E. Blaser. 1970. Responses of some Kentucky bluegrasses to high temperature and nitrogen fertility. *Crop Sci.* 10:372-376.
11. Watschke, T.L., R.E. Schmidt, E.W. Carson and R.E. Blaser. 1972. Some metabolic phenomena of Kentucky bluegrass under high temperature. *Crop Sci.* 12:87-90.
12. Wehner, D.J., D.D. Minner, P.H. Dernoeden and M.S. McIntosh. 1985. Heat tolerance of Kentucky bluegrass as influenced by pre- and post-stress environment. *Agron. J.* 75:772-775.
13. Wehner, D.J., D.D. Minner, P.H. Dernoeden, and M.S. McIntosh. 1985. Heat tolerance of Kentucky bluegrass, perennial ryegrasses, and annual bluegrass. *Agron. J.* 73:79-84.
14. Wehner, D.J., and T.L. Watschke. 1984. Heat stress effects on protein synthesis and exosmosis of cell solutes in three turfgrass species. *Agron. J.* 76:16-19.

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