MODERATING HEAT STRESS ON TURFGRASSES

by

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Introduction

Unfortunately, too many turfgrass managers attempted to solve summer turf problems by just removing pest protection chemicals from the shelf and applying them at intervals as close as two days. This is done without having properly diagnosed that a disease problem exists.

Apparently some turfgrass manager have difficulty accepting the possibility that the loss of turf is occurring as a result of an environmental stress such as heat. Perhaps this is due to a lack of understanding of plant stress resulting from super-optimal temperatures. Thus, the thrust of this article will be to provide an understanding of the heat stress kill mechanism and heat stress resistance, plus the cultural approaches for minimizing heat stress.

UNDERSTANDING HEAT STRESS

Heat stress is most commonly a problem with C_3, cool-season turfgrasses, especially when attempts are made to extend them into the transitional and warm climatic regions. For example, creeping bentgrass (*Agrostis stolonifera*) for putting greens is being extended well beyond its normal adaptation limits in terms of heat stress. Heat stress typically is most severe on turfgrasses under conditions characterized by extraordinarily high temperatures and high humidities, that are sustained for several months. Also, periods with an absence of wind movement further accentuate the high heat and humidity levels near the surface of the turfgrass. Early summer high air temperatures with cool soil temperatures are not nearly as stressful as late summer periods when both the air and soil temperatures are at heat stress levels. This is because a high soil temperature is the most critical heat pool affecting the turfgrass plant.

Lethal heat stress results from the destruction of the critical protoplasm proteins in living cells. The heat stress injury may be direct and acute, or indirect and more chronic in nature. Visual injury is first observed via cross sections of grass shoots at the junction of the leaf blade and leaf sheath of the second and third youngest leaves. Plant death occurs at temperatures of 106°F (41°C) and higher, depending on the particular turfgrass species and cultivar.

Heat resistance is the ability to survive an externally imposed high temperature stress. When you assess research reports of heat stress resistance of turfgrass cultivars, it is important to understand there are two types of heat resistance: (a) heat avoidance and (b) heat tolerance. **Heat avoidance** is the ability to sustain internal temperatures below lethal heat stress levels via transpirational cooling. The higher the evapotranspiration rate of a cultivar, the greater the heat avoidance, assuming adequate rooting can be sustained for water uptake. In contrast, **heat tolerance** is the internal physiological ability of the plant to survive high internal tissue temperatures, which is attributed to better thermal stability of heat sensitive enzymes and membrane integrity. The heat resistance of turfgrasses is reduced (a) when grown under shaded environments, (b) by excessive nitrogen (N) levels, (c) by deficiencies of potassium (K), and (d) in older plant tissues.

Turfgrass cultivars that exhibit improved heat resistance in low humidity environments, such as Arizona, California, or Kansas, may fail to exhibit comparable heat resistance in humid areas such as Mississippi, Georgia and New Jersey, if the resistance is of a heat avoidance type. In contrast, turfgrass cultivars with good internal heat tolerance will exhibit this trait in both humid and arid climatic regions. This is an important distinction to understand in interpreting heat resistance data among cultivars.

MODERATING POTENTIAL HEAT STRESS PROBLEMS

The approaches to minimizing the adverse effects of heat stress on turfgrasses are multi-dimensional. The first principle in any stress environment is to select those cultural practices that produce the most healthy plant shoot and root systems possible. Some key cultural approaches to heat stress moderation include the following:

I. Proper Root Zone Modification. Water has the highest heat accumulation ability of any material. Wet or water-saturated soils require more energy to warm up and a longer time to cool down. Thus, the construction of high-sand root zones with USGA Method specifications to ensure maximum drainage of excess water also reduces the level of soil heat accumulation, when compared to poorly drained, clayey root zones. Also, a high-sand root zone of the proper particle size distribution is sufficiently aerated to allow deeper, more extensive root growth, thus allowing greater water uptake to support the high rates of evapotranspiration needed for heat avoidance.

II. Use of Heat Resistant Cultivars. The C_4, warm-season turfgrasses, such as bermudagrasses (*Cynodon* spp.) and tropical carpetgrass (*Axonopus compressus*), are physiologically adapted in terms of optimum growth at temperatures of 80 to 95°F (27-35°C). In contrast, the C_3, cool-season turfgrasses, such as bentgrasses (*Agrostis* spp.) and annual bluegrass (*Poa annua),* are physiologically adapted to optimum growth at temperatures of 60 to 75°F (16-24°C). The use of cool-season grasses beyond their adaptation zone may exceed their limit for survival. Please note that for most species the intraspecies heat resistance among cultivars is quite variable, such that a few cultivars would rank well above the mean ranking shown, while a few would rank well below.

Unfortunately, a number of turfgrass cultivars are being promoted as heat tolerant when in fact they are only heat avoiding in terms of their heat resistance mechanism. Thus, it is important when selecting heat tolerant turfgrass cultivars for humid climatic regions to obtain the supportive replicated research data that the cultivar has demonstrated true heat tolerance rather than only heat avoidance. It is best to obtain independent, comparative, replicated assessment data that have been conducted for a minimum of 3 to 4-years duration under similar humid conditions that demonstrate significant improvements in inherent heat tolerance when exposed to high internal tissue temperatures.

III. Cultural Practices To Maximize Heat Stress Resistance. There are a number of turfgrass cultural practices that enhance heat stress resistance. Individually each may not have a major impact, but collectively they can have a significant effect. Cultural factors of benefit in maximizing heat stress resistance include:

- **High potassium level.** Potassium (K) enhances rooting, which contributes to improved heat avoidance and also improves physiological heat tolerance of grass tissues. Chemical tests will provide the basis for selecting the appropriate potassium levels needed in the leaf tissue and the soil.
- **Modest to minimal nitrogen level.** Sufficient tissue nitrogen (N) levels should be maintained to ensure a healthy turfgrass plant, but it is advisable to avoid excessive nitrogen levels that force leaf growth and cause internal physiological reductions in heat tolerance.
- **Minimal thatch or mat.** Preventive thatch and mat depth control encourages deeper rooting, thereby facilitating water uptake from a greater portion of the root-zone profile. The thatch control aspects may include vertical cutting, core cultivation, and/or topdressing.

- **Cutting height elevation.** A slight cutting height elevation, especially on putting greens, during severe heat stress periods may prove beneficial and has minimal effect on putting speed as the grass growth has been slowed. For example, raise the height from 5/32 to 3/16 inch (4.0-4.8 mm), being sure to lower the cutting height to the original level once the heat stress has subsided.
- **Mower selection.** On putting greens, switch to a walking greensmower from a triplex unit during the severe heat stress period and/or change to a solid roller to lesser wear stress when shoot growth recovery is impaired by heat stress.

IV. Syringing For Heat Stress Avoidance. Syringing is the application of a very light amount of water in which only the leaves are wetted. It can be used for the purpose of cooling the turf canopy. It has the potential of reducing temperatures in the order of 10°F (5.5°C), if applied 1.5 to 2 hours before maximum mid-day temperatures that typically occur around 2:00 p.m. A low atmospheric humidity adjacent to the turf canopy maximizes evapotranspirational cooling. In hot, arid portions of the country, such as Arizona, syringing during mid-day heat stress has been used to maximize heat avoidance through high evapotranspiration rates. Unfortunately, this method of heat avoidance is of limited benefit in humid climatic regions during periods of high humidity.

V. Air Movement Enhancement. Air stagnation on putting green sites, especially when surrounded by trees in the direction of the prevailing wind, accentuates the stratification of higher temperatures and higher humidities near the turf canopy. This in turn accentuates heat build-up in both the turfgrass canopy and root zone, plus the environment for disease pathogens is more favorable.

If a tree-shrub barrier is the primary problem, then cutting an opening in the direction of the prevailing wind usually proves beneficial. Air stagnation also can be significantly reduced through the mixing action achieved by mechanical fans, especially in hotter climates. This author conducted the first research in the late 1950's that demonstrating the value of fans in reducing heat levels on bentgrass putting green turfs. A 14°F (7.8°C) cooler turf temperature was achieved by the use of a fan that produced a 4 mph (6.4 km hr^{-1}) air movement, under the conditions in West Lafayette, Indiana.

Fans are now becoming more commonly used around selected putting greens, where the surrounding trees and shrubs and/or low site placement with higher surrounding hills causes a serious restriction in air movement. The development of the best possible mechanical fan design is still evolving. Some criteria to consider in selecting fans include:

- noise level generated - a 54-inch (137 cm) diameter fan is 50% more quiet than a 48-inch (122 cm) unit, due to a lower blade velocity.
- effective distance - a longer effective distance allows placement of the fans from 40 to 50 feet (12-15 m) away from the perimeter of the putting green.
- effective pattern - the wider and longer the better, up to an associated air velocity of 4.5 mph (7.2 km hr^{-1}).
- relative obtrusiveness - color, distance from green, height above turf, and bulk size all influence just how harmoniously the fans blend with the surrounding environment.

Fans also will become more frequently used in sport stadia constructed with an erect, tall, fully-surrounded, seating design.