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Getting to the Root of Summer Bentgrass Decline

How summer heat affects creeping bentgrass roots.

BY BINGRU HUANG

Thinning of turf canopy, yellowing of leaves, and death of roots are often observed on creeping bentgrass greens during midsummer in many areas of the country. Dieback of creeping bentgrass on putting greens has been referred to as summer bentgrass decline (SBD). The cause of summer bentgrass decline has been attributed to numerous factors, including high temperature, excessive or deficit soil moisture, poor soil aeration, and high relative humidity.

HIGH SOIL TEMPERATURES

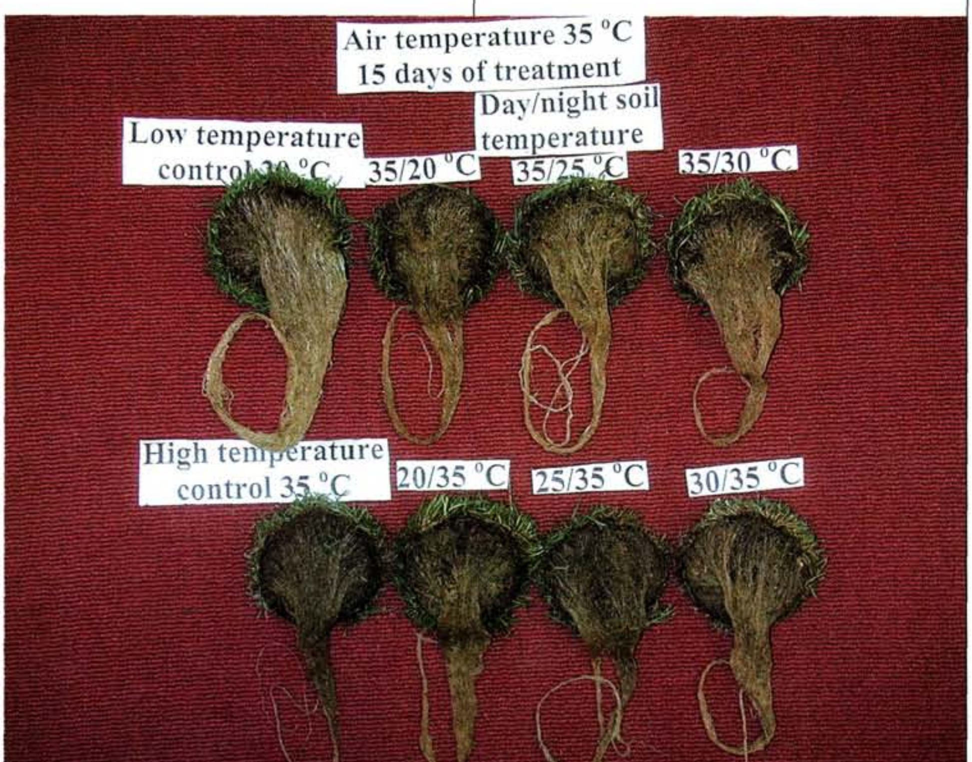
High temperature is found to be the primary factor leading to SBD. Specifically, high soil temperature is more detrimental than high air temperature in causing SBD. This decline is particularly a problem on greens with poorly aerated soils due to poor drainage and/or compaction. It also is a problem on sites with reduced evapotranspirational cooling due to poor air circulation and high humidity. These factors all contribute to soil heat retention, and thus higher soil temperatures at night.

Although little can be done to modify the air temperature, one approach to prevent summer heat injury in creeping bentgrass when air temperature is high is to reduce soil temperature using proper cultural practices. Our studies have shown that lowering soil temperature can prevent or alleviate heat stress injury in creeping bentgrass when air temperature is high.

In previous experiments, reducing soil temperature by only 5°F (from 95°F to 90°F) constantly for 24 hours a day improved creeping bentgrass turf quality, and shoot and root growth when air temperature was maintained at 95°F. Root and shoot growth improvements were greater as soil temperatures were further reduced toward optimum soil temperature. However, continuous soil temperature reduction for 24 hours a day can be costly, and reducing soil temperature during the day when play takes place may not be practical.

Soil temperature is controlled by radiation, convection, or conduction. Radiation is the major contributor to increasing soil temperatures. Reducing soil temperature during the night may be easier and more economically feasible than during the day, because nighttime soil temperature is no longer affected by radiation.

Furthermore, lowering nighttime temperature may reduce carbohydrate consumption and increase carbohydrate



Research investigates the impact of different soil temperatures on the growth of creeping bentgrass roots. Results indicate that lowering soil temperature can alleviate heat stress injury in creeping bentgrass when air temperature is high.

availability by suppressing dark respiration. Respiration uses stored carbohydrates to supply metabolic energy. Dark respiration is sensitive to temperature changes and decreases with lowering temperatures. Carbohydrate availability decreases during the night because all plant parts go through dark respiration, and there is no photosynthesis and carbohydrate production. During the daytime, photosynthesis prevails and results in carbohydrate accumulation.

To capture, record, and analyze root images, a video camera is mounted in a tube and inserted into plexiglass tubes buried in field research plots.

GROWTH CHAMBER STUDIES

Experiments were conducted to examine whether bentgrass growth could be improved by lowering soil temperature for 12 hours a day and whether nighttime temperature reduction is more effective in improving bentgrass growth and quality than reducing daytime temperature. Creeping bentgrass (Penncross) was grown in growth chambers under three different day/nighttime soil temperature regimes.

The bentgrass was exposed to three treatments:

- Air temperature maintained at 95°F for 24 hours per day (heat stress).
- Soil temperature maintained at 70°F and 77°F for 12 hours during the dark period (nighttime) and at 95°F for 12 hours during the daytime.
- Soil temperatures maintained at 70°F and 77°F for 12 hours during daytime and at 95°F for 12 hours at nighttime.

Reducing soil temperature to 70°F or 77°F for 12 hours during either daytime or nighttime for two weeks following heat stress was sufficient to maintain turf quality above the acceptable level and to increase shoot vertical extension rate and leaf chlorophyll content. Plants exposed to reduced nighttime temperatures had a higher turf quality, shoot growth rate, leaf chlorophyll content, and a more extensive root system than those with reduced daytime temperatures at 70°F and 77°F.

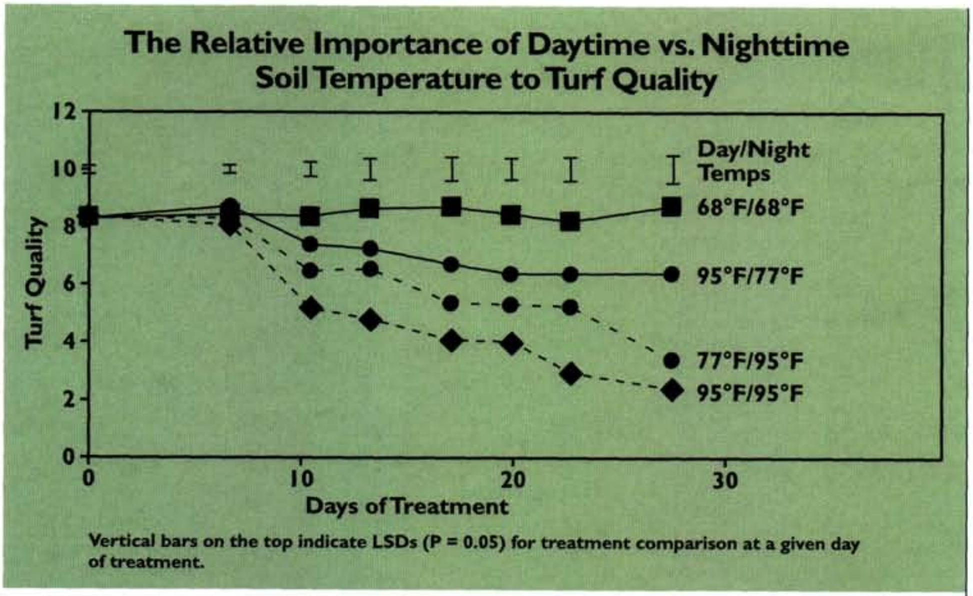
Plants exposed to reduced nighttime temperatures had approximately 45% greater root weight than those exposed to reduced daytime temperatures at 70°F and 77°F. Root growth may be affected by the alteration of carbohydrate distribution patterns in roots and shoots due to changes in daytime or nighttime soil temperatures. Lowering soil temperature during the night increased root carbohydrate content in proportion to that in shoots.

REDUCING SOIL TEMPERATURES IN THE FIELD

Generally, lowering soil temperature on shoot and root growth was more effective at the lower temperature (70°F) than higher temperature (77°F) and during nighttime than during daytime. Therefore, soil temperature should be reduced to as low a level as possible and should be practiced at night, if possible, to achieve better plant growth and turf quality in the summer.

Various methods, including fans, syringing, and subsurface cooling systems, have been recommended to reduce soil and canopy temperature (1, 4, 7). Some superintendents use fans from early morning to the evening. Others run fans only during the early morning to mid-morning when dew and surface moisture are greatest. A decrease in canopy temperatures (4° to 10°F) during peak periods of sunshine and air temperature (11 a.m. to 2 p.m.) and a decrease in soil temperature at the 4" depth of 2° to 6°F has been reported due to the use of fans (6).

A subsurface cooling system is a unit that either blows air into a green through existing drain lines or pulls out excess water from the green. Soil temperature can be increased or decreased using this system, depending on the direction of air movement and the time of the system in operation. Dodd et al. (4) reported that pulling air through the green for several hours during the evening decreased the temperature by 3° to 4°F at a 2" soil depth; air injection through the green during a sunny day actually increased soil temperature by 3°F because of the high air temperature on a hot day. Bigelow et al. (3), however, found that air injection or water



In growth chamber experiments at Rutgers University, researchers established that elevated nighttime temperatures are more deleterious to Penncross creeping bentgrass turf quality than elevated daytime temperatures.

pulling through the greens for a short time period (5 minutes) using the subsurface system had no effect on soil temperature. Therefore, when soil cooling practices are implemented, the duration should be considered.

Achieving a large magnitude of soil temperature reduction through routine management practices generally can be difficult. Injecting cool air through the green or pulling excessive warm water out followed by irrigation with underground, cool water, or syringing with cool water in combination with fans may be better in lowering soil and turf canopy temperatures. Other techniques that can reduce soil temperature under golf greens need to be explored.

In summary, our research results suggest 12-hour soil cooling was adequate to improve turf quality and root growth. However, the effectiveness increases with the duration of soil cooling. If there is a choice of nighttime vs. daytime cooling, nighttime cooling was more effective than daytime cooling in alleviating heat injury. A greater level of soil temperature reduction may be needed to achieve effective enhancement in turf and root growth in cases where soil cooling can only be practiced during the day.

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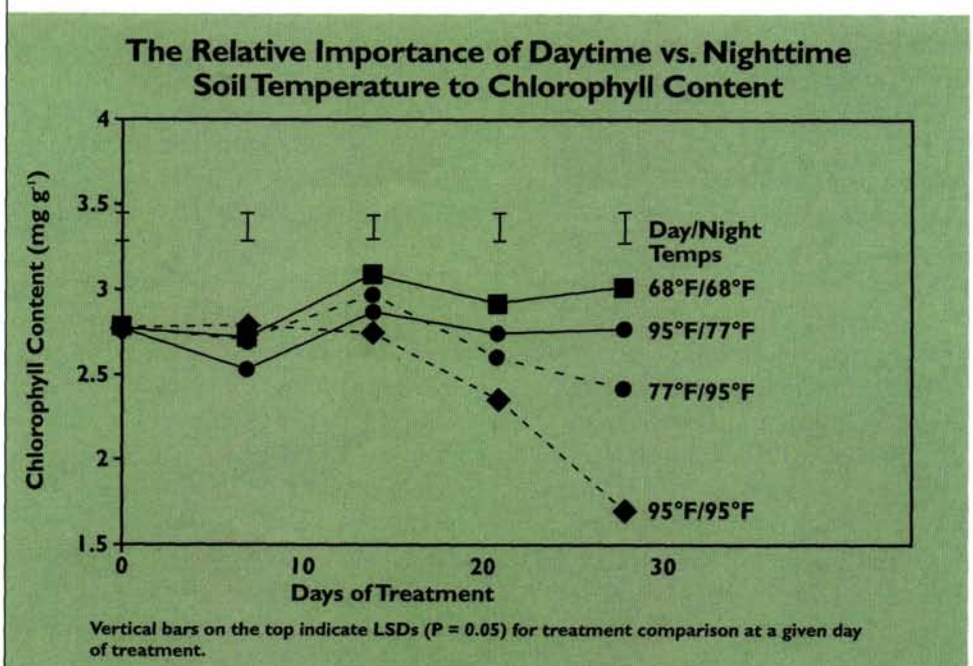
BINGRU HUANG *is associate professor in the Rutgers University Plant Science Department.*



Elevated nighttime temperatures resulted in much more rapid loss of chlorophyll in Penncross creeping bentgrass compared to elevated daytime temperatures.