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The USGA provided funding for this research.



Cooler soil protects creeping bentgrass

Cooling soil temperatures at night seems to benefit creeping bentgrass more than cooling them during the day.

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Creeping bentgrass (*Agrostis stolonifera*), the most widely used cool-season grass on golf greens across the country, provides a fine-textured turf with superior shoot density, uniformity and color when properly managed in cool climates. However, turf quality often declines during summer months. Maintaining good putting green turf for most of the season is a challenge for superintendents, but understanding the interaction between grass and its environment could help superintendents develop more effective management practices.

Creeping bentgrass and heat

Creeping bentgrass grows most vigorously when the air temperature is between 60 and 75 F and the soil temperature is at 50 to 65 F. In many areas, particularly the southern states and the transition zone, however, temperatures often exceed this range for extended periods during the summer. High temperature has been considered the primary environmental factor in creeping bentgrass death in the summer.

High temperature, combined with other stresses such as lack of moisture, disease, lack of nutrients and low mowing height, can severely weaken turf and result in the loss of greens (1,4,7,8,9). Under high-temperature conditions, bentgrass does not efficiently produce carbohydrates by photosynthesis, reserved carbohydrates are depleted and plants eventually die.

Research has demonstrated that soil temperature has a greater effect on creeping bentgrass growth than does air temperature and that high soil temperature is more deleterious than high air temperature (7,8).

When soil temperature was gradually lowered from 95 F to 68 F over a 24-hour period while air temperature was maintained at 95 F, turf quality was the same as it was under optimal air and soil temperature conditions (7,8). Reducing soil temperature from 95 F to 90 F for 24 hours a day was effective in alleviating quality decline of creeping bentgrass (10).

Cooling with fans

Various methods, including fans (2,5), syringing (2) and subsurface systems (3,6), have been used to reduce soil temperature. Fans have been reported to decrease canopy temperatures 4 to 10 F during peak periods of sunshine and air temperature (11 a.m. and 2 p.m.) and to decrease soil temperatures 2 to 6 F at a depth of 4 inches (5).

Fans usually run 24 hours a day at green sites that hold soil moisture and at pocketed areas. At small problem sites on individual greens, fans should be run from early to mid-

morning to the early evening. Other sites may require fans only from the early morning to midmorning hours when dew and surface moisture are greatest. It has been suggested that fans be used solely to reduce soil and turf temperatures and that they should not be run continuously, but turned on at dawn and off at sunset (5). Regardless of the method used, continuous soil-temperature reduction can be costly and may not be practical.

Nighttime soil temperatures

During the summer, the nighttime soil temperature is often higher than the air temperature, especially when the soil is moist. It may be easier and more economical to reduce soil temperatures at night rather than during the day because nighttime soil temperature is not affected by solar radiation.

Lowering night temperature may reduce plant carbohydrate consumption and increase carbohydrate availability by suppressing dark respiration. Carbohydrate availability decreases at night because all plant parts go through dark respiration, and photosynthesis and carbohydrate production do not take place. In contrast, during the day, photosynthesis prevails and results in carbohydrate accumulation.

Dark respiration decreases with lower temperatures. In general, to produce the maximum potential growth rate, plants require temperatures to be lower at night than during the day. It is not clear whether reducing daytime soil temperature or nighttime soil temperature is more effective in improving creeping bentgrass turf quality when air temperature is supraoptimal. Such information would be helpful for turfgrass

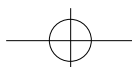
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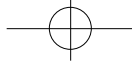
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Creeping bentgrass does best between 60 and 75 F and often declines in the hot summer months.

Research has shown that high soil temperatures are more damaging to creeping bentgrass growth than high air temperatures.

This study showed that reducing nighttime soil temperatures is more effective than reducing daytime soil temperatures in promoting creeping bentgrass growth.





RESEARCH

managers attempting to alleviate summer bentgrass decline.

Research

A study was conducted in growth chambers to investigate whether reducing soil temperature at night is more effective in improving turf quality and plant growth under high air temperature condition and to determine the effectiveness of different levels of soil temperature reduction during the day or night.

The experimental setup was unique in that soil temperature could be maintained at a different level than the air temperature, and the daytime and nighttime soil temperatures were different. Shoots of Penncross creeping bentgrass plants were maintained day and night at 95 F. Roots were exposed to three

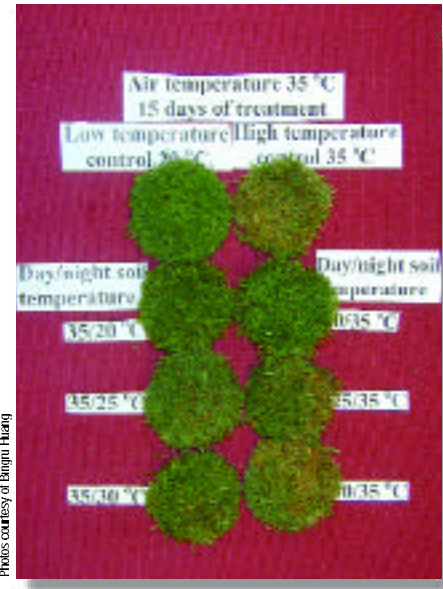
different day/night soil temperature regimes:

- maintaining high soil temperature continuously for 24 hours per day (day and night) (95/95 F)
- lowering soil temperatures for 12 hours during the day to 77 or 86 F
- lowering soil temperature for 12 hours during the night to 77 or 86 F

Turf quality was rated visually based on color, uniformity and density, on a scale of 1 to 9, where 9 is the best quality and 6.0 is the minimum acceptable level. Root growth was evaluated by measuring root fresh weight.

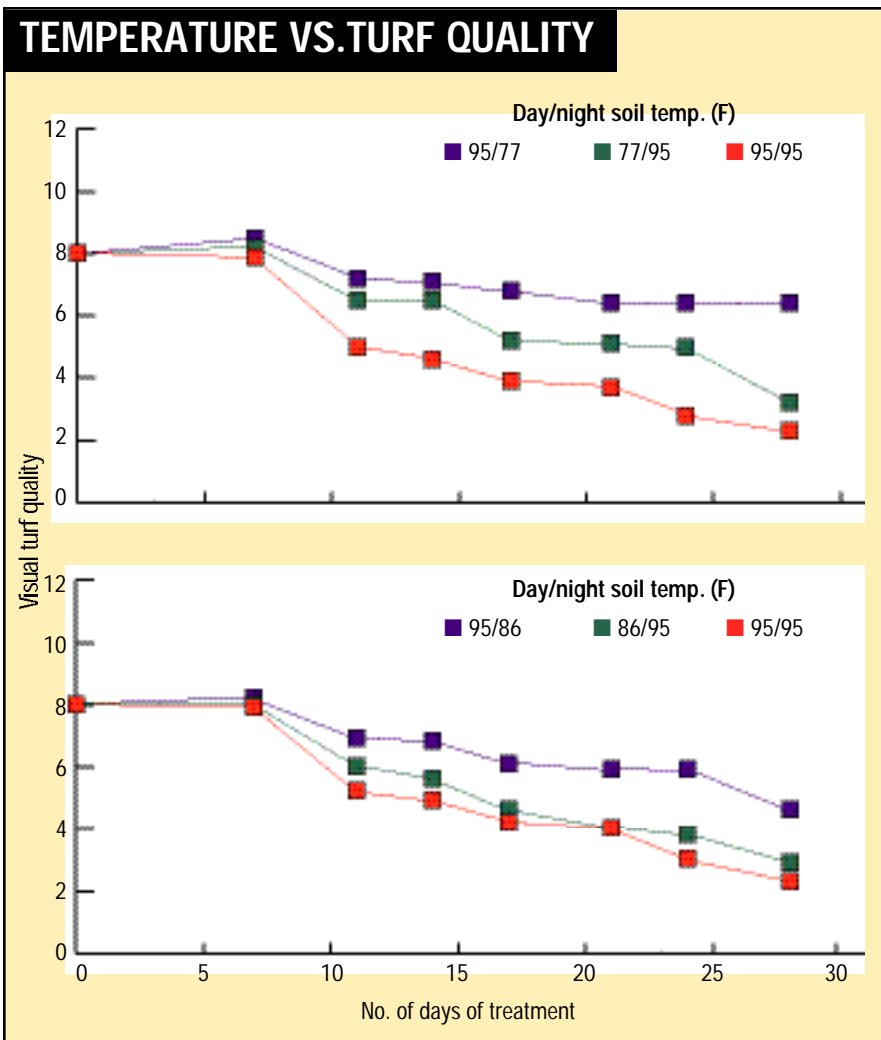
Results and discussion

Previous research has demonstrated that the upper limiting soil temperature range for bentgrass is between 80 and 95 F. In this



Photos courtesy of Binbin Huang

Reduced nighttime soil temperatures improved shoot growth in creeping bentgrass.

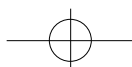


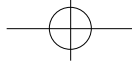
range, bentgrass growth declines, and the ability of the plant to recuperate from traffic or disease, insect or weed pressure, is dramatically reduced.

In this study, visual turf quality declined rapidly when both air and soil temperature was maintained at 95 F for 24 hours a day. Lowering nighttime soil temperature to 77 F at a daytime soil temperature of 95 F helped maintain turf quality above the acceptable level (6.0) for about 30 days and improved root growth. Reducing the nighttime soil temperature to 86 F also slowed the decline in turf quality and root growth, but was not as effective as lowering the temperature to 77 F. Turf quality and root growth improved when the daytime soil temperature was reduced to 77 F, but not when it was reduced to 86 F.

These results suggest that, to achieve the same results, daytime soil temperatures would need to be reduced even more than nighttime soil temperatures. Reducing the soil temperature to 77 or 86 F at night was more effective in improving turf quality and root growth than reducing it to those same levels during the day.

Nighttime soil temperature is more important than the daytime soil temperature in controlling shoot and root growth of creeping bentgrass. The physiological mechanisms of





RESEARCH

the differential effects of lowering day and night soil temperatures on creeping bentgrass are not clear and deserve investigation.

Summary

Our study shows that, when the air temperature is supraoptimal, lowering the soil temperature at night is more effective than lowering it during the day to maintain shoot and root growth of creeping bentgrass. If the soil temperature is reduced during the day rather than at night, the soil temperature reduction must be greater to enhance turf and root growth. Therefore, cultural management practices that may lower nighttime soil temperatures may be paramount.

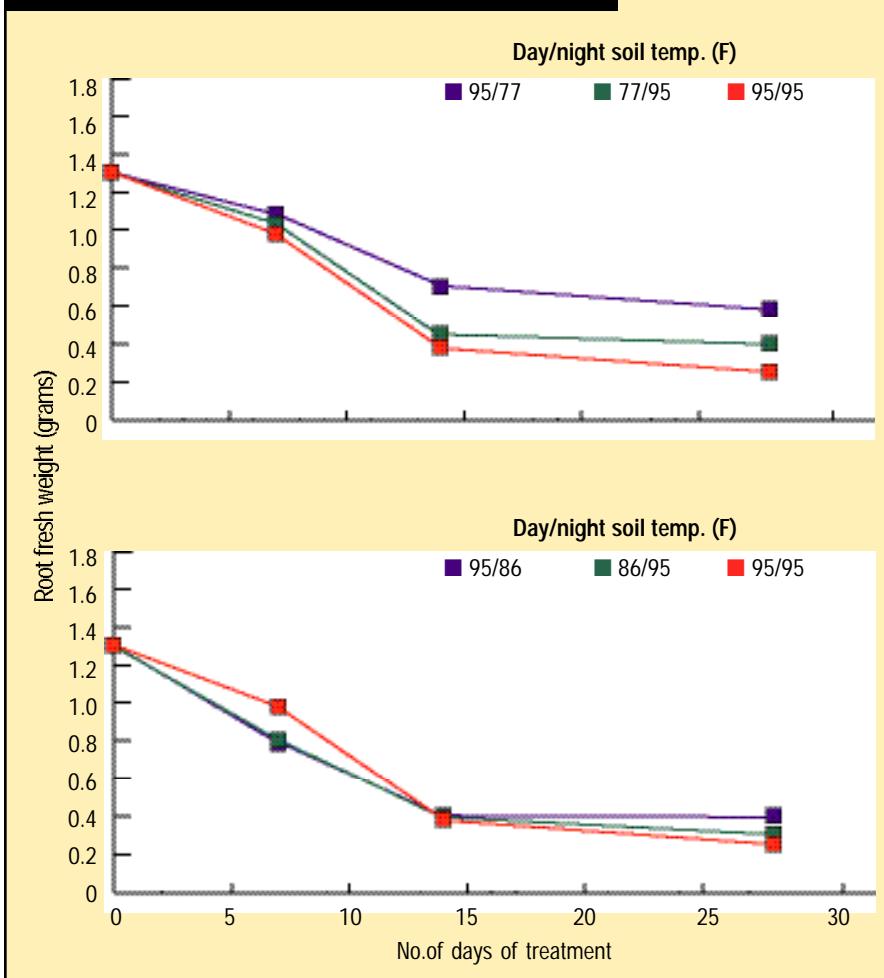
Acknowledgments

Thanks to the USGA for financial support of this research.



Lowering nighttime soil temperatures resulted in increased root growth in creeping bentgrass.

TEMPERATURE VS.ROOT GROWTH



Literature cited

1. Beard, J.B., and W.H. Daniel. 1965. Effect of temperature and cutting on the growth of creeping bentgrass (*Agrostis palustris* Huds.) roots. *Agronomy Journal* 57:249-250.
2. Beard, J.B. 1998. Heat stress causes and prevention. *TurfNews* 6:1-6.
3. Dodd, R., B. Martin and J. Camberato. 1999. Subsurface cooling and aeration. *Golf Course Management* 67(9):71-74.
4. Huang, B., X. Liu and J.D. Fry. 1998. Shoot physiological responses of two bentgrass cultivars to high temperature and poor soil aeration. *Crop Science* 38:1219-1224.
5. Taylor, G.R. II. 1995. The effects of mechanically induced air movement on the temperature, leaf water potential and soil moisture percentage of creeping bentgrass (*Agrostis stolonifera* L.) golf greens. M.S. thesis. North Carolina State University, Raleigh.
6. Trusty, S., and S. Trusty. 1998. Hot town, cool bentgrass. *Golf Course Management* 66(4):186-191.
7. Xu, Q., and B. Huang. 2000a. Growth and physiological responses of creeping bentgrass to changes in air and soil temperatures. *Crop Science* 40:1363-1368.
8. Xu, Q., and B. Huang. 2000b. Effects of differential air and soil temperature on carbohydrate metabolism in creeping bentgrass. *Crop Science* 40:1368-1374.
9. Xu, Q., and B. Huang. 2001a. Morphological and physiological characteristics associated with heat tolerance in creeping bentgrass. *Crop Science* 41:127-133.
10. Xu, Q., and B. Huang. 2001b. Lowering soil temperatures improves creeping bentgrass growth under heat stress. *Crop Science* 41:1878-1883.

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