

Subsurface cooling and aeration

Bentgrass greens have greater turf density after displacement of subsurface air.

Roy Dodd, Ph.D.; Bruce Martin, Ph.D.; and James Camberato, Ph.D.

The hot, humid climate of coastal South Carolina and players' heavy use of Wild Wing Plantation golf complex in Conway, S.C., make growing bentgrass extremely difficult. Such an environment should provide a vigorous test for the process of subsurface cooling, which is believed to aid the survival and growth of creeping bentgrass (*Agrostis*

palustris) in hot regions.

During grow-in, however, few benefits to turf growth were evident from subsurface cooling at Wild Wing, aside from increased shoot density at the end of the growing season. The root zone cooled, and oxygen levels increased, but

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Photo courtesy of Bruce Martin

A specially constructed 12,000-square-foot chipping green at Wild Wing Plantation in Conway, S.C., allows researchers to isolate four separate subsurface areas for various air-displacement treatments.

KEY POINTS

- Subsurface air movement in a green's drainage system can cool or heat a green, depending on the air temperature and whether the air is vacuumed or pressurized into the green.
- Carbon dioxide levels in the root zone decrease with subsurface air displacement.
- Cooling and carbon dioxide reduction in the root zone may not have much effect on turfgrass quality, ball roll or rooting depth, although density improves in the autumn following summertime subsurface air treatments.

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turf quality, rooting depth and green speed were not affected by subsurface air displacement under the new, experimental green. Perhaps future results will reveal a benefit as the root zone ages.

This research occurred on a specially constructed 12,000-square-foot chipping green. The four courses at Wild Wing have a combined annual play of at least 160,000 rounds. The green is beside the driving range and gets plenty of putting traffic, as well as chipping.

The green was constructed in the spring of 1997 and grown in during that summer. Vertical sheets of plastic, reaching upward from the subgrade to within two inches of the putting surface, separate the green into quadrants and prevent subsurface air flow between sections. Drainage pipes and valves allow subsurface cooling and aeration treatments to be applied independently to each quadrant. Within each quadrant are four 25-by-60-foot plots of bentgrass: A-

1, Crenshaw, Pennlinks and Penncross. Temperature-measuring thermocouples are buried at various locations at depths of 2, 4, 6 and 14 inches.

Subsurface cooling and aeration treatments were applied with an in-ground 7.5-horsepower SubAir blower. Air was injected into the drainage system and up through the greens mix from March through September 1998. The green was mowed at $\frac{5}{32}$ to $\frac{3}{64}$ inch and topdressed every two weeks. Nitrogen fertilization was minimal in order to maintain thin leaves and turf quality from a putting standpoint.

The following measurements were taken periodically:

- Soil temperature, at 2, 4, 6 and 14 inches deep
- Soil carbon dioxide level, at 8 inches deep
- Turf quality, on a scale of 1 to 9 with 9 being best
- Rooting depth, five soil cores per plot
- Green speed with a Stimpmeter, four ball rolls per plot
- Shoot density, number of shoots in two 0.69-square-inch areas of turf per plot

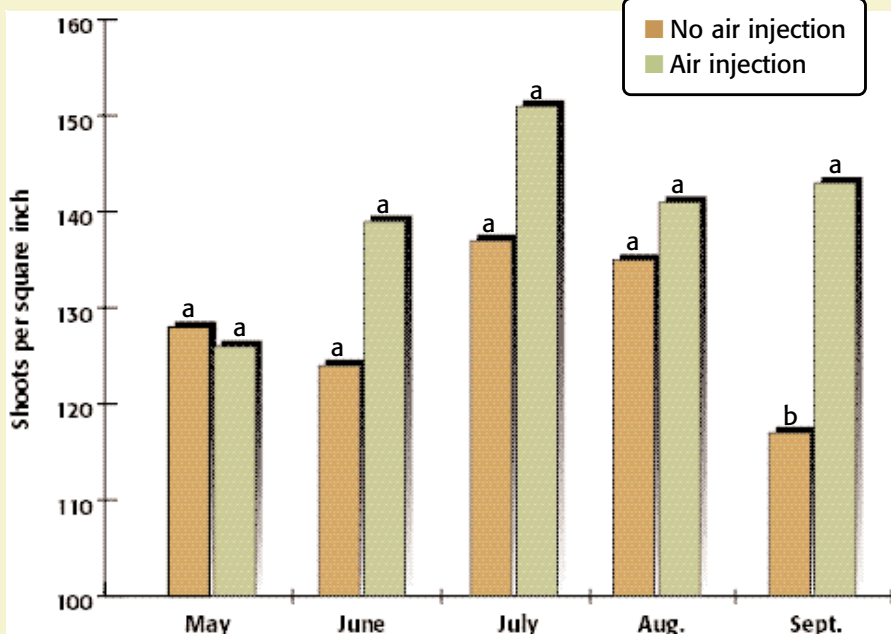
Cooling and aeration

The SubAir unit can either pull air into the green in a vacuum mode, or push air through the green in an injection or pressure mode. Temperature in the greens mix can be increased or decreased by as much as 4 F, depending on the direction of air movement and the time of day.

For example, the temperature at the 2-inch depth increased 4 F when air was pulled into the green during a sunny day because the air at the green surface had been heated intensely by the sun. During the night, however, pulling air into the green actually cooled the greens mix by 2 F.

Air injection — pushing air through the green — decreased afternoon temperatures 3 F at the 2-inch soil depth. No temperature differences were seen between air injection and the no-air treatment during the early morning hours.

Shoot density



Subsurface air injection increased shoot density of four bentgrass cultivars to a statistically significant extent in September. Columns topped by the same letter within a month are not statistically different.

Another possible benefit of air injection is the replacement of soil carbon dioxide with oxygen. Turfgrass roots and soil microorganisms produce carbon dioxide. Purging of carbon dioxide using subsurface air injection is rapid.

The ambient level of carbon dioxide in the greens mix at 8 inches deep without air injection was 0.30 percent. After 20 seconds of air injection, soil carbon dioxide levels were reduced to 0.21 percent, and after 140 seconds, carbon dioxide levels were down to 0.14 percent. After air injection stopped, soil carbon dioxide gradually increased. Soil carbon dioxide increased to 0.21 percent only after 150 minutes. Changes in soil oxygen levels mirror changes in carbon dioxide: when carbon dioxide decreases, oxygen increases and vice versa.

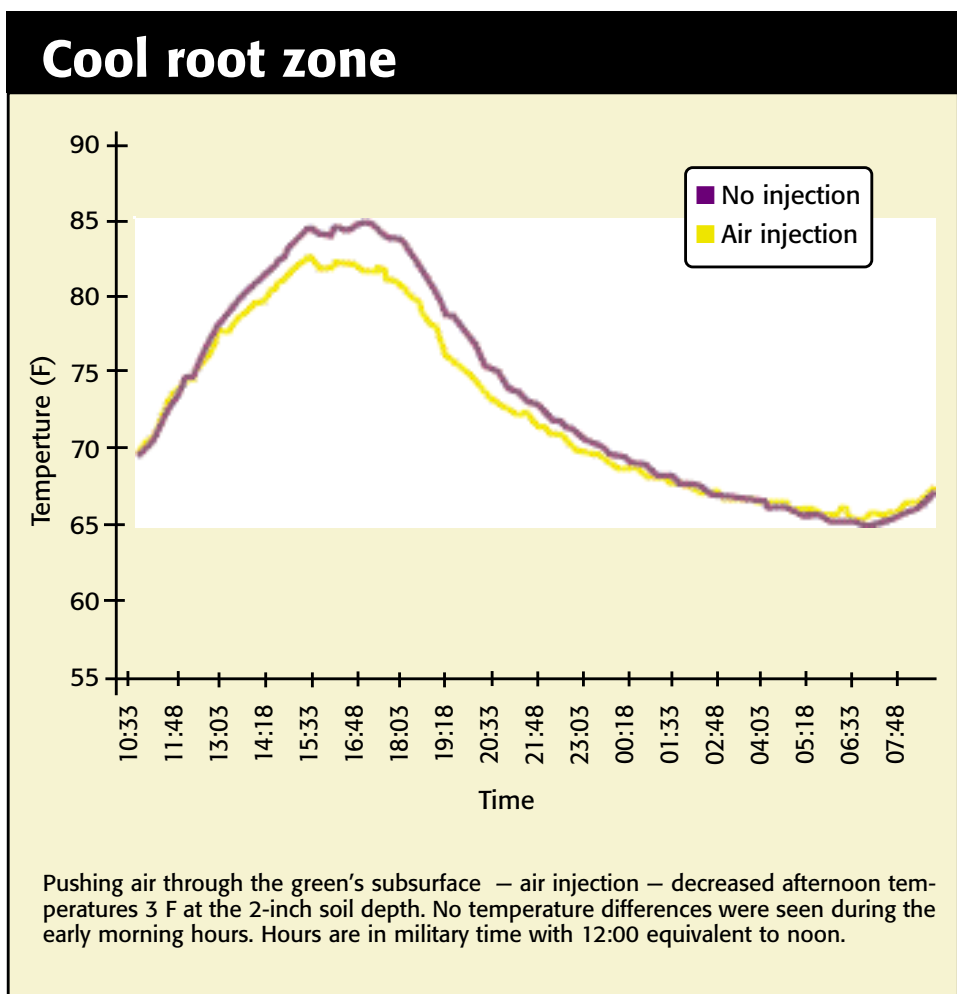
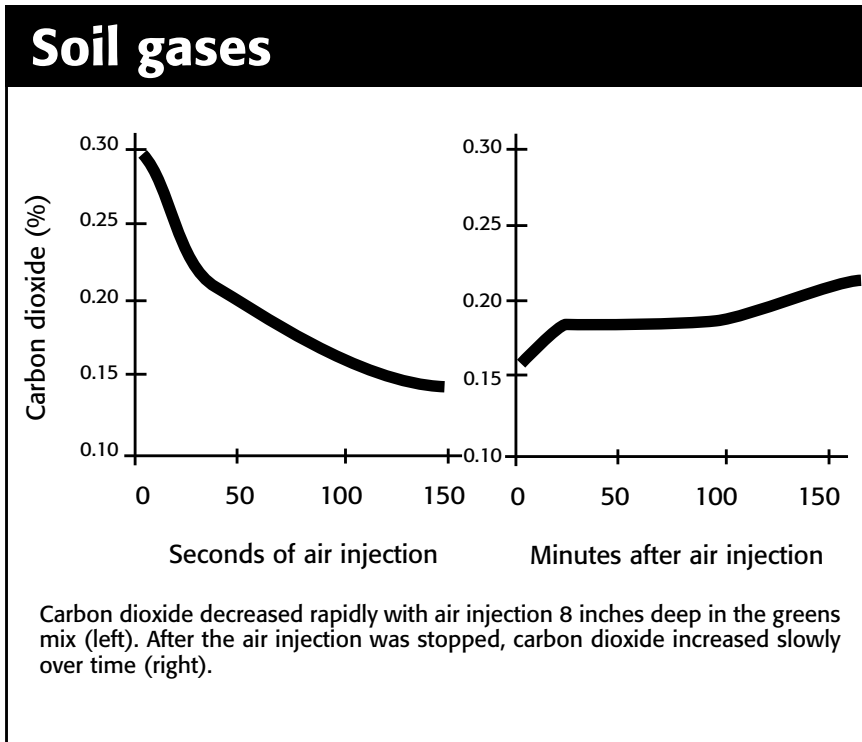
Turf properties

These results were collected over a 20-month period. Air was injected into half the plot area for seven months beginning three months after measurements were initiated and one year after seeding the green. Turf quality was superb throughout this period, in part because the green was newly constructed. Even though air injection cooled and aerated the root zone, the effects of air injection on turf properties were minimal.

Turf quality was evaluated on 23 occasions after September 1997. Air injection did not affect turf quality, but cultivar differences in turf properties were pronounced. The new heat-tolerant bentgrasses, A-1 and Crenshaw, were far superior in the summer to the older cultivars, Pennlinks and Penncross.

Rooting depth was measured seven times between September 1997 and March 1999. There was no effect of subsurface air injection on rooting depth. Surprisingly, Pennlinks and Penncross rooted about 1/2 inch deeper than A-1 and Crenshaw. This occurred even though A-1 and Crenshaw had superior

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turf quality during summer months. There was no effect of subsurface air injection on rooting depth.

Green speed was determined nine times after establishing the green, but it was not affected by air-injection treatments.

Shoot density was evaluated from May through September 1998. Cultivar differences in shoot density were fairly consistent throughout this period. A-1 had the highest shoot density of the four cultivars (178 shoots per square inch), followed by Crenshaw (147 shoots per square inch) and then Pennlinks and Penncross (each had 107 shoots per square inch). Crenshaw was 36 percent denser, and A-1 was 66 percent denser than the older Penn varieties. In June, July and August there was a trend toward higher shoot density with air injection. Subsurface cooling

and aeration increased shoot density 23 percent at the September measurement.

Summary

Injecting air through the greens mix cooled and aerated the turfgrass root zone. Pulling air through the greens mix during the evening hours also provided cooling, but pulling air during the day heated the root zone. Aeration and cooling did not result in increased turf quality, rooting depth or green speed, but did result in increased shoot density at the end of a hot summer.

The high shoot density of A-1 and Crenshaw contributed to high turf-quality ratings.

Research on this green will continue for several years. The benefits of assisted subsurface air displacement may increase as the green matures and natural air exchange in the root zone declines. In addition, cultivar differences may widen as heat stress continues to decimate Pennlinks and Penncross in the summer. Perhaps these cultivars, but not A-1 and Crenshaw, will benefit from decreased root-zone temperatures.

Many other important questions exist. If pulling and pushing air into greens proves to be beneficial, when do you pull and when do you push? And, for how long and at what time of the day? Can this technology heat a green to reduce frost or to speed up bermudagrass transition?

These and other questions should be answered in time.

Acknowledgments

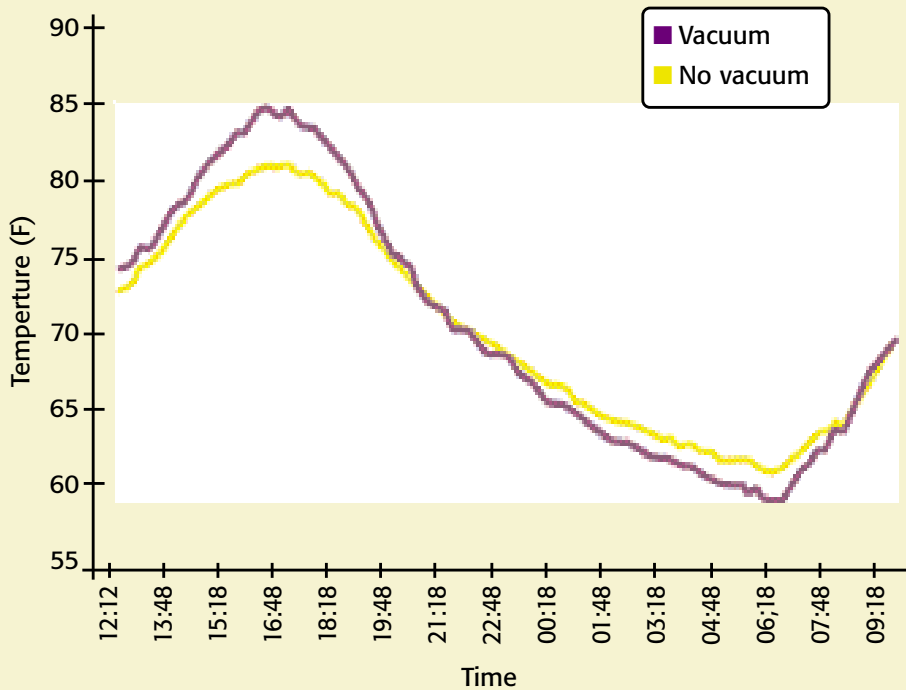
We thank all the turf industry partners who assisted us in constructing the research green at Wild Wing Plantation and the golf course staff who did a superb job maintaining the green.

Reference

1. Trusty, Steve, and Suz Trusty. 1998. Hot town, cool bentgrass. *Golf Course Management* 66(4):186-191.

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Daytime heating



The temperature at the 2-inch depth in an experimental green increased 4 F when air was pulled into the green during a sunny day. During the night, pulling air into the green actually cooled the greens mix 2 F. Hours are in military time with 12:00 equivalent to noon.