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TURFGRASS TRENDS

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RESEARCH UPDATE

Subsurface Air Movement: Timing, Intervals and Direction

By B. Todd Bunnell and Bert McCarty

Pushing or pulling ambient air through the soil column of golf greens via subsurface drain lines is an innovative method of potentially reducing heat and water stresses, and toxic gas buildup. Commercial air exchange units currently utilize a blower/vacuum attached to the drain line outlet of a golf green. The proposed advantages are improved soil aeration, purging of unwanted gases, root zone cooling, improved soil water status, and overall root and shoot performance (Dodd et al., 1999).

Limited research exists in this area. Preliminary results show temperatures can be increased or decreased as much as 2 C during the summer months depending upon direction of air movement (Dodd at al. 1999). Pulling air heightens soil temperatures 2 C at the 10-cm depth while injecting air reduces temperatures 2 to 3 C at the same depth during the afternoon. Differences in rooting and shoot densities have not been found with either air direction (Dodd et al., 1999).

IN THIS ISSUE

- **Subsurface Air Movement: Timing, Intervals, Direction . 1**

  Bentgrass growth response

  Soil gases

  Soil moisture

  Soil temperature

  Rooting
- **Fairy Ring Biology and Management in Turf 6**
- **Nature 'Antes Up' for Insect Pest Control . 11**
- **Forecast: Dry and Intrusive. 15**

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Bentgrass growth response to subsurface air movement

At Clemson, we did a study to further investigate the effects of subsurface air movement on plant and soil factors of creeping bentgrass golf greens. The study was performed during the summer of 1999 on Clemson University's 85:15 sand: peat specified creeping bentgrass research green. Within the green are 75 m2 cells individually separated by PVC sheeting, thus allowing drainage and irrigation individuality for differing subsurface air movement regimes.

Subsurface air movement was induced with two 7.5-hp specially designed air pumps (SubAir1, model#ES1867), each equipped with a butterfly valve for air direction control — either pressure or pushing (positive) or vacuum or pulling (negative). Pumps were connected to 19-cm drain lines leading into an air-water separator vault. The vault connected to 14-cm drain running the perimeter of the research plot. Individual cells were fitted with a gate valve to allow 4 cm of water pressure within plots. Drain size was reduced to the standard 9-cm perforated pipe beneath the green surface and positioned 2.25-m from the center.

Treatments included different intervals of pushing or pulling air and an untreated control. Air was pushed or pulled from 4 to 6 a.m. (early morning), 10 a.m. to 6 p.m. (daytime), and 24 hours (daylong). Control plots were used for each treatment group.

Measurements were collected to determine treatment effects on soil moisture, temperature and gas levels at two depths of 9 and 20 cm. Root samples were collected at the end of each study for root growth response.

Soil gases

Oxygen is essential for healthy turf growth. Root cells are nonphotosynthetic, thus absorb O_2 and release CO_2. Oxygen is required by roots for growth, water and nutrient uptake (Williamson, 1964). Plants grown under soil O_2 concentrations lose turgor pressure and increase wilting (Letey et. Al.,

TABLE 1

Soil gases and moisture levels at 9 and 20-cm depth.

Treatment duration	Air treatment movement	9 cm % O2	9 cm % CO2	9 cm Moisture MPa	20 cm % O2	20 cm % CO2	20 cm Moisture MPa
4-6 a.m.	Untreated	20.43a	0.67a	0.00482c	20.47a	0.45a	0.00298c
	Pull	20.50a	0.33b	0.00602a	20.51a	0.27a	0.00407a
	Push	20.50a	0.33b	0.00535b	20.56a	0.18a	0.00375b
10 a.m. - 6 p.m.	Untreated	20.46a	0.29a	0.00384c	20.37a	0.68a	0.00257c
	Pull	20.55a	0.12b	0.00544a	20.44a	0.20b	0.00392a
	Push	20.56a	0.11b	0.00440b	20.48a	0.16b	0.00332b
24 hours	Untreated	20.66a	0.25a	0.00291c	20.51a	0.38a	0.00200c
	Pull	20.86a	0.04b	0.00485a	20.83a	0.04a	0.00393a
	Push	20.85a	0.05b	0.00361b	20.83a	0.04a	0.00280b

* Within duration and variables, means followed by the same letter are not significantly different according to Fisher's LSD (0.05) test.

* Means separation of soil moisture performed significant P=0.10.

1961). In contrast, soil CO_2 may become toxic to root growth at high levels. As CO_2 enters plant cells, the low pH can injure root systems and stunt growth (Williamson, 1964). Additionally, Chang and Loomis (1945) noted increased CO_2 levels reduce water and nutrient uptake by roots.

Early morning subsurface air movement from 4 a.m. to 6 a.m. did not significantly increase O_2 gas at both depths of 9 and 20 cm (Table 1). Carbon dioxide levels, however, were decreased by 51 and 45% when pulling and pushing air at the 9-cm depth, respectively, compared to the untreated.

Daytime usage from 10 a.m. to 6 p.m. also did not increase soil O_2 (Table 1). However, CO_2 reductions were seen at 9- and 20-cm. At 9-cm, a CO_2 reduction of 59% and 62% followed pulling and pushing air compared to the untreated, respectively. Pushing and pulling air-reduced soil CO_2 by 71% and 76% respectively compared to the untreated at the 20-cm depth.

Daylong subsurface air movement had the greatest impact on soil gas levels (Table 1). Soil carbon dioxide reductions of about 82% followed pulling and pushing air. Soil O_2, however, was not altered with 24-hour subsurface air movement.

Soil moisture

Soil moisture levels were measured with tensiometers installed at 9- and 20-cm. Measurements were recorded in centibars and converted to Mpa. With tensiometers, higher Mpa values represent less soil water content.

Pushing and pulling subsurface air movement from 4 a.m. to 6 p.m. reduced soil moisture from the untreated by 25% and 11% respectively, at 9-cm (Table 1).

Soil CO_2 may become toxic to root growth at high levels. As CO_2 enters plant cells, the low pH can injure roots and stunt growth.

Additionally, pulling air reduced soil moisture compared to pushing air by 13%. Pulling and pushing air reduced soil water content at 20-cm compared to the untreated by 37% and 26% respectively. Pulling air had 9% drier soil compared to pushing air at 20-cm.

Pulling air during the daytime from 10 a.m. to 6 p.m. again reduced soil moisture compared to pushing air and the untreated 27% and 42% respectively, at the 9-cm (table 1). Additionally, at 20-cm, pulling and pushing air reduced moisture from the untreated by 53% and 29% respectively.

Pulling air for 24 hr at 9-cm reduced soil moisture the most compared to the

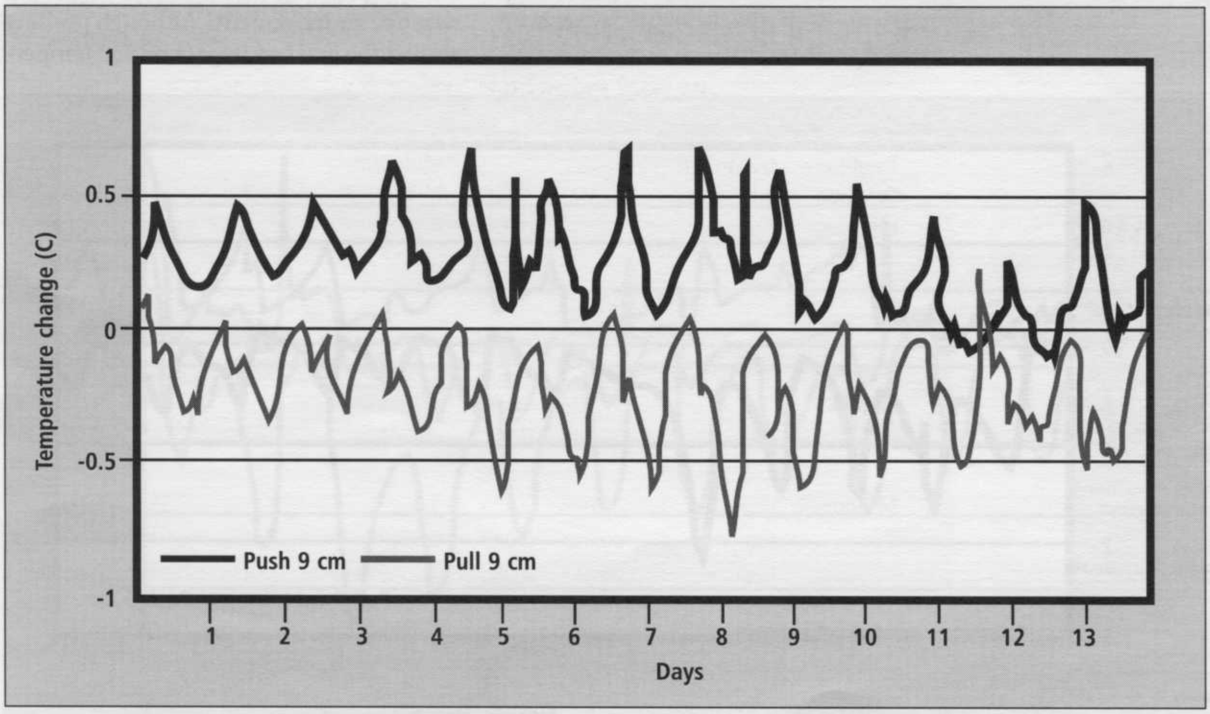

Figure 1. Soil temperature change from untreated at 9 cm following early morning use (4 to 6 a.m.) of subsurface air movement.

untreated by 67% (Table 1), while pushing air reduced soil moisture by 24%. Similar trends followed at 20-cm with pulling air reducing soil moisture by 96% compared to the untreated and 40% compared to pushing air. Pushing air reduced soil moisture by 40% compared to the untreated.

Soil temperature

Soil temperature was measured by thermocouple wire at a 9- and 20-cm depth. Temperature was automatically logged every 15 minutes.

Soil temperature was not greatly influenced by early morning usage of subsurface air movement.

Temperature differences between treatments were averaged over the 13 days to represent an overall cooling or heating of the soil following differing directions and duration of subsurface air movement. A negative temperature change signifies a temperature reduction.

Soil temperature was not greatly influenced by early morning (4 to 6 a.m.) usage of subsurface air movement (Figure 1). Pulling air during morning hours reduced soil temperature by an average of 0.21C, with a maximum decrease of 0.75C. A slight increase of 0.26 to 0.65C in soil temperature followed pushing air.

Pushing air during the day (10 a.m. to 6 p.m.) decreased soil temperature by an average of 0.43C, with a maximum decrease of 2.2C (Figure 2). In contrast, pulling air from 10 a.m. to 6 p.m. heightened soil temperature from 0.5 to 1.5C compared to untreated and pushing plots.

Air pushed into the subsurface air unit follows a path underground and through the gravel year of the USGA golf green where temperatures are usually cooler then ambient summertime temperatures causing a potential decrease in root zone, which often increases soil temperature.

Both directions of subsurface air movement exhibited an overall reduction of soil temperature during daylong (24-hrs) subsurface air movement (Figure 3). Pulling air reduced soil temperature by 0.18C, to a maximum of 0.8C where pushing air reduced soil temperatures by 0.37C, with maximum reductions of 2.2C at both depths.

This decrease appeared to result from advantages to nighttime and early morning negative air movement. Although pushing air had the greatest impact on soil temper-

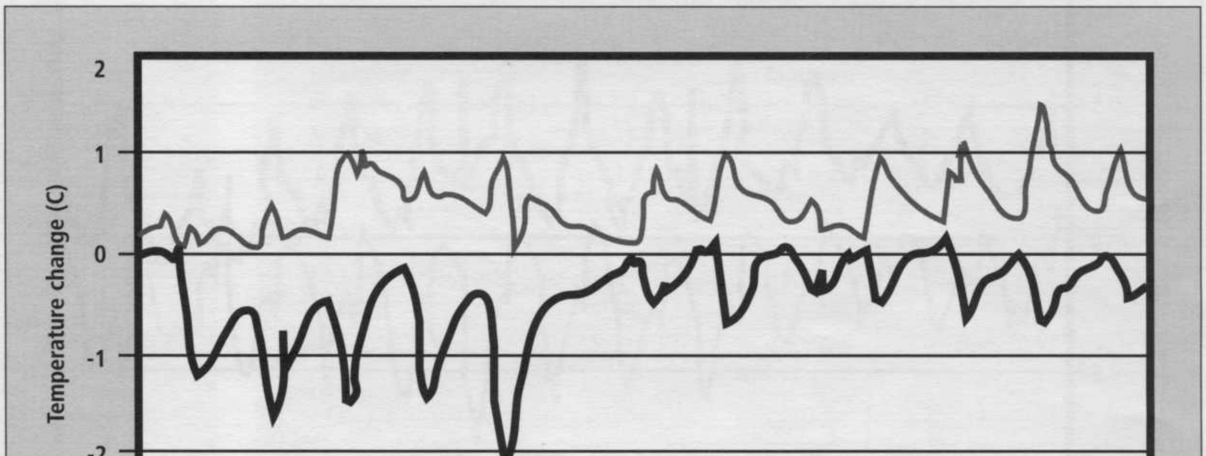

Figure 2. Soil temperature change from untreated at 9 cm depth following daytime use (10 a.m. to 6 p.m.) of subsurface air movement.

ature reduction, the ability to pull air during night and morning also proved beneficial in reducing soil temperatures.

Rooting

Although not statistically different, utilization of subsurface air movement demonstrated a positive trend on rooting weight and length. Pulling from 4 to 6 a.m. or from 10 a.m. to 6 p.m. or continuously (24 hr) increased root length about 25%. Pushing air from 4 to 6 a.m. had little effect, but 27% increases in root length followed pushing air from 10 a.m. to 6 p.m. or running continuously.

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NOTES

1. SubAir, Inc., 430 Industrial Park Rd. Deep River, CN 06417

SUBSURFACE AIR MOVEMENT

- Current research indicates its use in cooling root zone temperatures, decreasing soil moisture levels, improving the soil atmosphere and possibly increasing root growth.
- Options are numerous for duration and flow direction.
- Pulling and pushing air gave positive results in soil moisture reduction, root growth, increased soil O2 and decreased CO2.
- Greatest reductions in soil temperature followed day-long use of pushing air.
- Pulling air reduced soil temperatures when implemented during night or morning hours.
- Subsurface air movement has the potential to be a useful tool to golf course superintendents. Continued research, however, is necessary to understand its full potential.

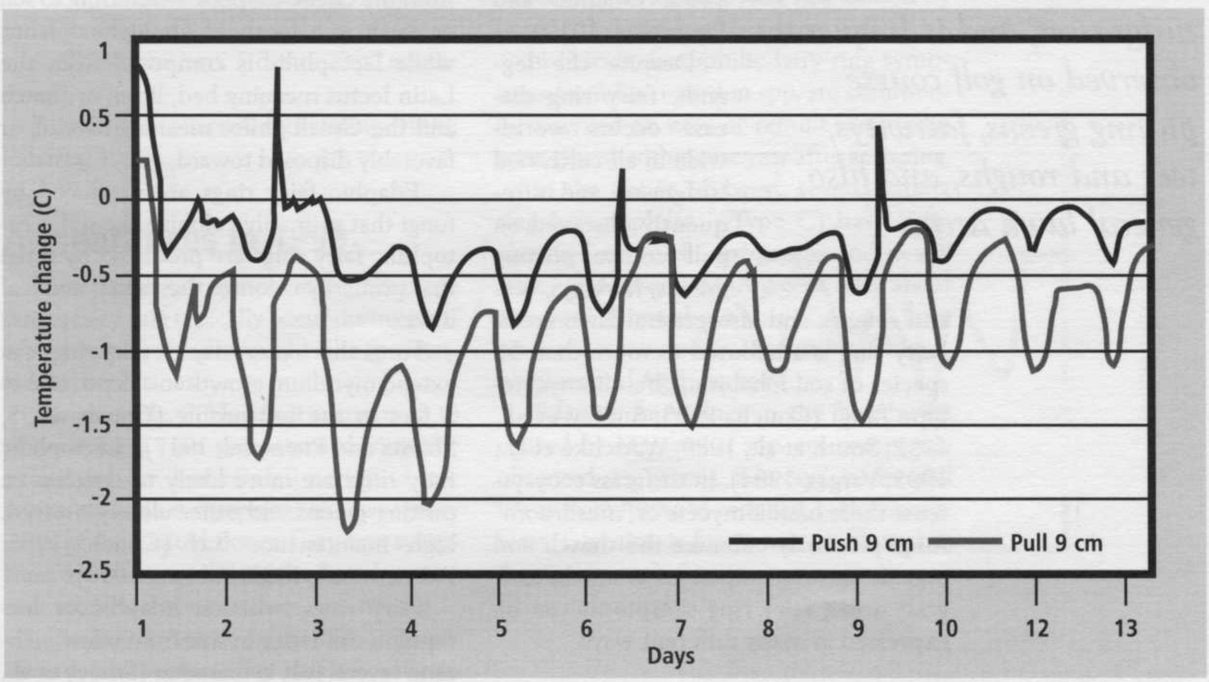

Figure 3. Soil temperature change from untreated at 9 cm following day-long use of subsurface air movement.