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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

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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			20 cm		
		% O2	% CO2	Moisture MPa	% O2	% CO2	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).

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

> *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.*

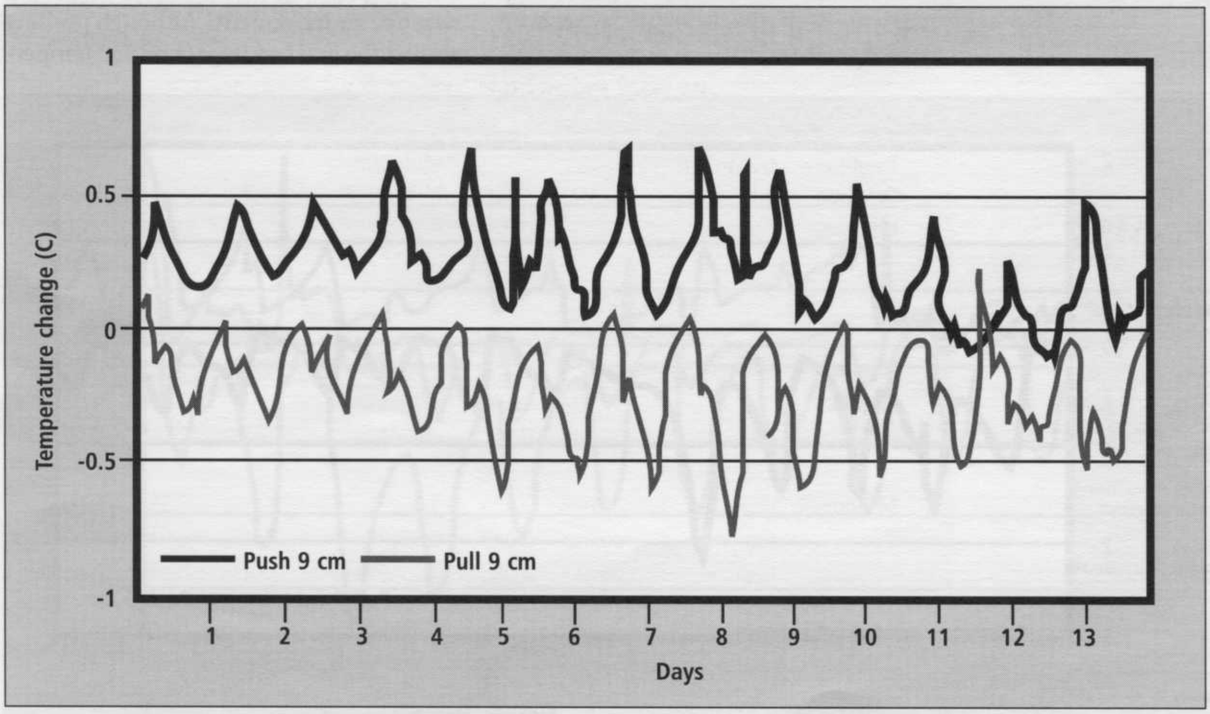

Figure 1. Soil temperature change from untreated at 9 cm following early morning use (4 to 6 a.m.) of subsurface air movement.

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-

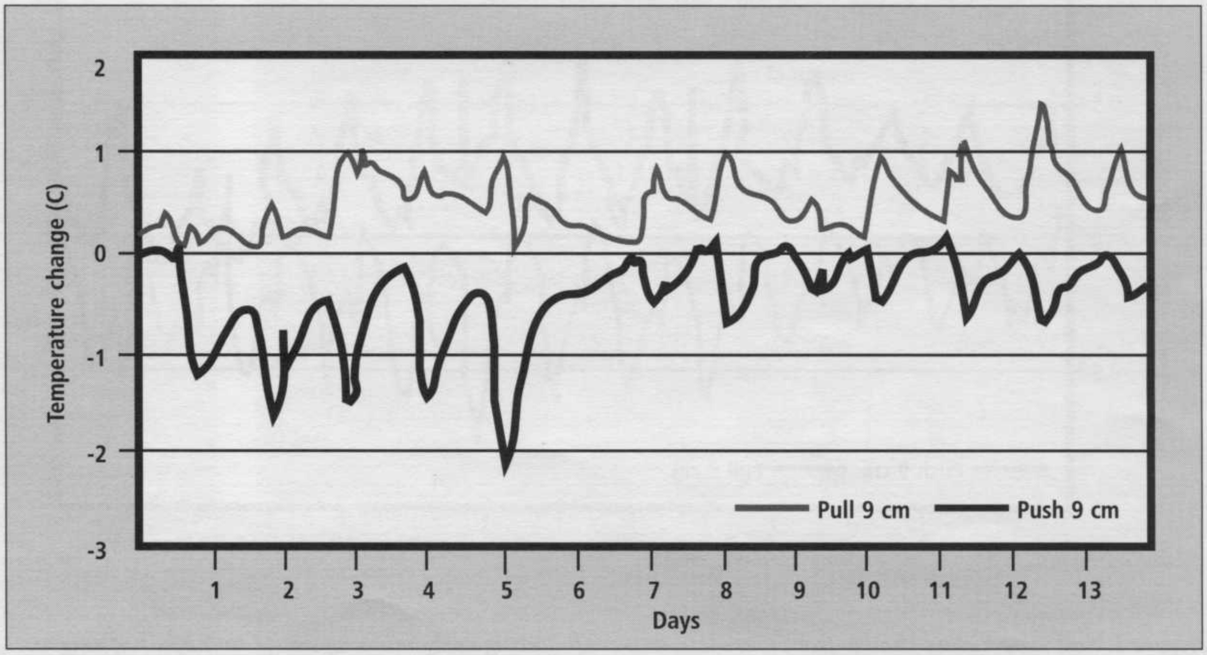

Figure 2. Soil temperature change from untreated at 9 cm depth following daytime use (10 a.m. to 6 p.m.) of subsurface air movement.

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.

— B. Todd Bunnell is a graduate assistant and Bert McCarty is Turfgrass Professor, Dept. of Horticulture, Clemson University, Clemson, SC.

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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.

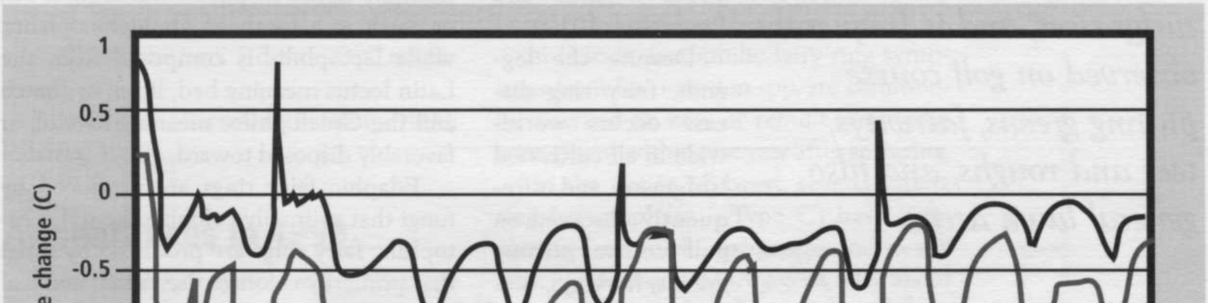

Figure 3. Soil temperature change from untreated at 9 cm following day-long use of subsurface air movement.

Fairy Ring Biology and Management in Turfgrass

By Michael Fidanza, Phillip Colbaugh and Steve Davis

Fairy ring is the name commonly given to circles of mushrooms or rapidly growing, lush green circular bands observed in established turfgrass areas (Couch, 1995).

The term "fairy ring" originated out of myth and superstition from the Middle Ages. For example, magical fairies were thought to dance within the circles of mushrooms at night. A popular myth in Holland stated that the dead grass in the ring center marked the place where the devil churned butter.

In Scotland, it was bad luck for a farmer to till the land where fairy rings were observed. In England, however, it was considered good fortune to build a house on land with fairy rings (Couch, 1995; Shantz and Pie-meisel, 1917).

Despite the legends, fairy ring disease occurs worldwide in all cultivated turfgrasses, and is frequently observed on golf course putting greens, fairways, tees and roughs, and also general lawn areas.

Despite the legends, fairy ring disease occurs worldwide in all cultivated turfgrasses, and is frequently observed on golf course putting greens, fairways, tees and roughs, and also general lawn areas. Fairy ring is attributed to more than 50 species of soil inhabiting, basidiomycete-type fungi (Couch, 1995; Smiley et al., 1992; Smith et al., 1989, Watschke et al., 1995; Vargas, 1994). In turfgrass ecoysystems, these basidiomycete or "mushroom" fungi primarily colonize the thatch and organic matter component in soil. In turfgrass areas, fairy ring symptoms can be expressed in many different ways.

Fairy ring biology in turfgrass

On the surface, fairy ring symptoms can include rings or arcs of dead or unhealthy turf, rings of dark green stimulated and actively growing turf or circular patterns of mushrooms. Below the surface, the fungal mycelium often grows in a roughly circular or ring pattern through the soil, breaking down organic matter and releasing nitrogen in the form of ammonia.

As a result, soil microorganisms process the ammonia into nitrates, which is then readily available to turfgrass roots (Couch, 1995; Vargas, 1994). The conspicuous, actively growing rings of green turf are the result of this nitrogen release in the soil.

According to Couch (1995), fairy ring disease can be classified into two groups: edaphic and lectophilic. Edaphic originates from the Greek edaphos — referring to soil or earth as a foothold for higher plants, while lectophilic is composed from the Latin lectus meaning bed, litter, or thatch and the Greek philos meaning love of, or favorably disposed toward.

Edaphic fairy rings are produced by fungi that primarily colonize the soil. Lectophilic fairy rings are produced by fungi that primarily colonize the thatch and leaf litter.

Fungi that cause edaphic fairy rings can extend mycelium growth to a depth of 2 to 3 feet in the soil profile (Couch, 1995; Shantz and Piemeisel, 1917). Lectophilic fairy rings are more likely to develop on putting greens and other closely mowed, high maintenance turf (Couch, 1995; Fidanza et al., 1998; Fidanza, 1999).

Fairy rings, whether edaphic or lectophilic, can range in size from a few inches to several feet in diameter (Smiley et al., 1992). Also, edaphic and lectophilic fairy rings are classified into three categories based on symptom expression (Couch, 1995; Fermanian et al., 1997; Shantz and Piemeisel, 1917; and Watschke et al., 1995).

Although many basidiomycete-type fungi can cause fairy ring, turfgrass researchers have identified the most common types (Couch, 1995; Fidanza, 1999; Smiley et al., 1992). In many cases, edaphic fairy rings are attributed to:

* Marasmius,
* Chlorophyllum,
* Lepiota (this fungus produces the "really big" mushrooms), and
* Agaricus spp. (referred to as the "meadow mushroom").

Recently, many cases of lectophilic fairy ring have been attributed to Lycoperdon spp. (referred to as the "puff-ball" mushroom) (Couch, 2000; Fidanza et al., 1998; Fidanza, 1999).

Fairy ring, either edaphic or lectophilic, has also been caused by the following:

* Scleroderma,
* Tricholoma,
* Clitocybe,
* Agrocybe,
* Bovista (similar to Lycoperdon),
* Coprinus ("mica cap" mushroom),
* Panaeolina ("haymaker's" mushroom — common on home lawns),
* Coprinus ("shaggy mane" or "inky cap" mushroom), and
* Conocybe spp. ("dunce cap" mushroom),
* and more (Barron and Hsiang, 1999; Fidanza, 1999).

Appearances in 1999

Turfgrass injury symptoms and damage due to fairy ring typically occur during periods of hot, dry and drought-like environmental conditions.

For example, in Florida it is common to observe fairy ring symptoms during the prolonged dry, low rainfall period of late winter through early spring. In many other parts of the United States, fairy ring symptoms are observed during the hot, dry summer months and sometimes into the fall.

During dry periods, mushrooms will often appear within a day after a heavy rain (Watschke et al., 1995). Recently, fairy ring has become an increasing problem on golf courses throughout the country.

Increased fairy ring symptoms have been observed in New England this past fall following the hot, dry summer. Fairy rings in this region are caused primarily by Marasmius, but Agaricus and Lycoperdon spp. are also prevalent.

The Northeast and mid-Atlantic regions experienced one of the worst years for fairy ring problems on greens and fairways. Fairy ring is more noticeable and therefore more serious on greens due to surface quality expectations. In these regions, fairy rings are attributed to Marasmius, Chlorophyllum and Lycoperdon spp.

In the South and Southeast, Lycoperdon spp. has become increasingly problematic on greens, while Marasmius, Chlorophyllum and Agaricus spp. are also observed on golf course turf.

In recent years, fairy ring has become an increasing problem on golf courses throughout the country.

Due to an increase in the construction and use of sand-based greens coupled with the trend toward low fertility, low cutting height, demand for increased green speed and intense maintenance to those greens, an increase in lectophilic fairy ring caused by Lycoperdon spp. has been observed.

In Florida, lectophilic fairy ring symptoms from Lyco-perdon spp. are commonly observed on new or rebuilt ber-mudagrass greens within one year after sprigging.

In the upper Midwest, severe "killing rings" (lectophilic —Type C) have been observed on "push-up" greens and newly built, sand-based USGA greens after about one year. Throughout the Midwest, fairy rings are attributed to Marasmius, Chlorophyllum and Agaricus spp.

Edaphic fairy rings in the Northwest caused by Marasmius spp. are commonly observed on greens, fairways, parks and lawns from spring to early fall. In the Southwest, fairy ring is frequently attributed to Agrocybe and Bovista spp. (similar to Lycoperdon spp.).

How do fairy rings kill turf?

Turf pathologists currently agree that the fungal mycelium in the soil can accumulate in large amounts and also will coat sand and soil particles, which results in a soil profile that is hydrophobic or "water-repelling." The result is a soil profile that is hydrophobic or water repellent.

Therefore, the turfgrass plants are injured or killed due to competition for water and nutrients. Once the soil profile or thatch (which is colonized by the fungal mycelium) becomes dry or hydrophobic, it is difficult to re-wet.

In summary, previous research reveals that fairy ring fungi can injure or kill turfgrass from a complex combination of the development of hydrophobic soil conditions, release of compounds toxic to turfgrass roots and the depletion of available nitrogen for plant growth (Couch, 1995; Watschke et al., 1995).

Management options in turfgrass

Recent ad-vances in turfgrass research have made it possible for golf course superintendents and other turf managers to manage fairy ring with preventive as well as curative approaches.

Recent advances in turfgrass research have made it possible for golf course superintendents and other turf managers to manage fairy ring with preventive as well as curative approaches.

The decision regarding a management strategy depends on whether the actual fungus is edaphic (soil inhabiting) or lectophilic (thatch inhabiting), the level of turf maintenance (i.e., putting green, fairway or home lawn) and the degree to which the symptoms are expressed.

Also, by knowing the environmental conditions or time of year most favorable for the appearance of fairy ring symptoms, turf managers can plan ahead to manage the symptoms, control the fairy ring fungus and maintain healthy turf.

Preventive option. Here is an example of a preventive approach. This example of a preventive strategy began at Sun 'N Lake Golf Club in Sebring, FL (Fidanza et al., 1998). The golf course had rebuilt nine putting greens during the spring of 1995, however, severe turf injury symptoms due to lectophilic fairy ring were observed during the following spring.

Prior to reconstructing the nine remaining greens, the club wanted to prevent fairy ring from again becoming a serious problem. Club officials consulted with Dr. Monica Elliott of the University of Florida to develop a preventive solution.

The nine additional greens were rebuilt during the spring of 1996 in the same manner as before, namely by using a sand-based, modified USGA specification plan. The nine, newly rebuilt greens were sprigged in May 1996 with "Tifdwarf" bermudagrass. In November 1996, the greens were overseeded with "Gator" perennial ryegrass.

For this field study, the nine reconstructed greens were split, with one-half receiving a treatment program of ProStar (50WP fungicide plus Primer soil wetting agent — 3 oz. + 6 fl. oz. per 1000 sq. ft.), and the second half was left as an untreated check for comparison.

At the time of this study, ProStar 50WP was the only fungicide labeled for fairy ring control. Also, a soil wetting agent was included to help alleviate the hydrophobic soil conditions.

The fungicide/soil wetting agent tankmix was first applied in September 1996 and continued at six-week intervals through January 1997 for a total of four preventive applications.

By March 1997, necrotic injury symptoms attributed to lectophilic fairy ring (identified as Lycoperdon spp.) began to appear on the untreated half of each green. The appearance of fairy ring corresponded to the typical dry, drought-like environmental conditions common in Florida at that time of the year.

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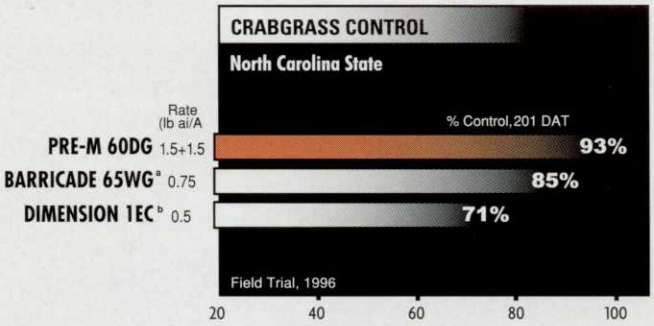

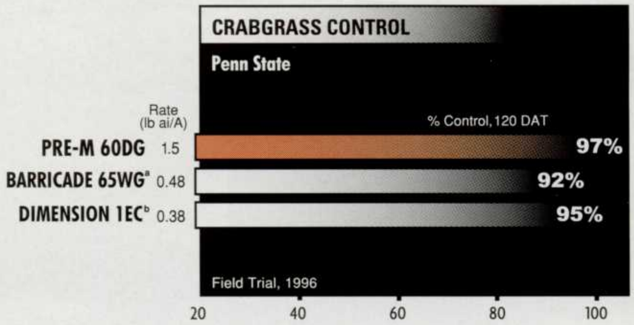

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DIMENSION[b]	*H*	*M*	*H*	*M*	*H*	*M*	*M*	*M*
TEAM[c]	*H*	*M*	*M*	*M*	*M*	*M*	*NR*	*NR*
RONSTAR[d]	*M*	*H*	*NR*	*M*	*M*	*NR*	*NR*	*NR*
SURFLAN[c]	*H*	*H*	*H*	*M*	*MH*	*M*	*H*	*H*

Level of control ***M**edium* ***M**edium–**H**igh* ***H**igh* ***N**ot **R**egistered*

[a] ™ Novartis [b] ™ Rohm and Haas Co. [c] ™ Dow AgroSciences [d] ™ Rhône-Poulenc

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*Source: Kline & Company Report, US Acre Treatments by Turf Management.

An average of 23 rings were observed on the untreated half of each green. The majority of the rings ranged from <1 to 2 feet in diameter.

The overall quality in the untreated half of each green was considered unacceptable by the superintendent. No necrotic rings or fairy ring symptoms, however, were observed on the treated half of each green.

Due to the severe turf injury on the untreated half of each green, a curative application of ProStar 50WP plus Primer (6 oz. + 6 fl. oz. per 1000 sq. ft.) was delivered to the untreated half of each green in March 1997.

By May 1997, no necrotic rings or turf injury was visible in those previously untreated halves, and the bermudagrass had recovered and filled into the previously damaged areas.

Curative option. Here are alternative strategies to consider. For lectophilic fairy rings on greens, success has been observed with the use of a combination approach of a fungicide plus soil wetting agent. Couch (1999, 2000) has outlined an integrated approach of fungicide, soil wetting agent, irrigation and cultural practices to manage fairy ring in turf.

The wetting agent helps to alleviate the hydrophobic soil condition, thereby allowing water to move more easily through the thatch and soil profile, and the irrigation helps the fungicide penetrate and reach the fungus.

In some Southern California cases, heavy irrigation following a fungicide application seemed to "push" the material through the sand profile away from the lectophilic fungal mycelium in the thatch (Fidanza, 1999).

Research at Texas A & M has shown the positive benefits of subsurface injection equipment to control fairy ring (Colbaugh, 1999). This provides better placement of a control agent into the thatch and soil profile, thus reaching the fairy ring fungus with no adverse effects to the desired turf.

Although not always practical on golf course turf, fairy ring can also be managed through suppression and by destructive methods. Symptoms can be suppressed through the use of cultural practices such as aerification, core cultivation, deep watering and the use of surfactants to thoroughly wet the soil profile plus fertilization to promote healthy turf and therefore mask the symptoms (Couch, 2000; Watschke et al., 1995). Fairy ring symptoms may be temporarily alleviated but the fairy ring-causing fungus is still viable in the thatch or soil.

Destructive methods are another way to control fairy ring (Watschke et al., 1995). These methods may be costly, labor intensive, unsuccessful and not always practical for most golf courses. One example is to remove the turf in the area affected by fairy ring, till and mix the underlying soil in several directions, then reseed or sod the area. By mixing the soil, this will promote the natural antagonism that occurs among fairy ring mycelium in the soil. Fairy rings have been known to dissipate when they contact each other due to their antagonistic nature.

Although not always practical on golf course turf, fairy ring can also be managed through suppression and by destructive methods.

Curative research efforts are underway. Research on fairy ring management includes the evaluation of fungicides, various soil wetting products and types and cultural practices (Colbaugh, 1999; Couch, 1999; Fidanza, 1999). The goal is to develop strategies aimed at maintaining healthy turf, reducing hydrophobic soil conditions attributed to the fairy ring fungi and controlling the fungus.

At Texas A& M University, research is also focused on understanding the biology and pathogenic nature of these fungi that cause fairy ring in turf. Preliminary results show that some types of fairy ring fungi can inhibit creeping bentgrass growth and development, while other types have no influence.

You can help with this research! Please forward samples of actual mushrooms, or photos of fairy ring mushrooms and turf symptoms, to the following:

Fairy Ring Characterization Project
Attention: Dr. Phillip Colbaugh
Texas A & M University
17360 Coit Road
Dallas, TX 75252

If you are sending a mushroom, wrap the sample in a dry paper towel and ship overnight. Along with the actual mushroom sample or photo, be sure to include relevant information such as state, location on golf course, turfgrass variety and environmental conditions.

— Michael Fidanza is in Research and Development at Aventis Environmental Science; Phillip Colbaugh is associate professor of Urban Plant Pathology at Texas A & M University; and Steve Davis is technical representative for Aventis Environmental Science.

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Nature 'Antes Up' For Insect Pest Control

Thieving, marauding ants on a golf course demonstrate one natural way to control Japanese beetles. It appears that healthy ant colonies may help limit those beetle populations

By Timothy J. Gibb

To most everyone who walks on a golf course, the large expanses of turfgrass appear to be a fairly sterile environment, largely devoid of much species diversity. However, upon closer inspection, quite the opposite is true.

Turfgrass provides a complex and diverse habitat for many different forms of plant and animal life. When observed closely, the species richness of a stand of healthy turfgrass is almost overwhelming. Within a shovel full of turfgrass, thatch and accompanying soil, one can find hundreds of different living organisms.

Each has its own set of growth and survival requirements. Each must also compete and interact with all of its surrounding organisms: microbes, bacteria, fungi, micro invertebrates, insects and plants, and even the occasional macro-vertebrate organism.

Ants on a hand, depicting their relatively small size.

Complex chain of behaviors

The African savannas are known for their complex food chain of producers, decomposers, herbivores and predators, but turfgrass ecosystems have an equivalent food chain. . . albeit on a much smaller scale.

The reason that every disease, weed and insect pest does not become damaging every year should be credited to the natural controls that Mother Nature provides.

Just like in Africa, turfgrass has its own versions of producers, herbivores and predators, and each must compete with each other for existence.

In so doing, each impacts the survival of the next and eventually a balance — the balance of nature — occurs, wherein no single population will be allowed to grow unchecked.

Man has taken advantage of the fact that some species outcompete or destroy other species in certain situations. He has extracted and artificially manipulated one population to the detriment of another. This is called "biological control."

Using one biological agent to control another is not a new concept or practice. Cats that keep a mouse population under control are a good example of a biological control that has been used for thousands of years. Because of their value as biological control agents, cats have been adored, bred and propagated throughout the world.

What golf course superintendents often do not appreciate is the fact that nature provides her own biological controls for most every established pest on the course. A significant amount of biological control, though unrecognized by even the most observant golf course manager, occurs beneath his very feet. The reason that every disease, weed and insect pest does not become damaging every year should be credited to the natural controls that Mother Nature provides. We simply take many of these for granted.

Eggs of other arthropods, even though laid with great care, are quickly found and taken away or consumed on the spot by thief ants.

Ants and natural control

Take ants for example. Until recently, the value and the role of ants in pest elimination has gone unnoticed by most scientists, as well as golf course superintendents. Ants have only recently been credited as significant control agents of potentially destructive pests which live or lay eggs in turfgrass.

For example, recent studies have shown that up to 75% of webworm eggs can be expected to be consumed by ants. Though their effects have not been quantified, ants also have been cited as primary insect predators on many additional turfgrass pests including chinch bugs, billbugs, army and cutworms.

Most recently, Purdue University research scientists have quantified ants' beneficial effects on white grubs. Studies have found that the majority of natural biological control of white grubs can be attributed to a tiny species of ant that lives below the surface of the soil. Most people do not even know that it exists, although it appears to be common throughout the United States wherever golf courses, lawns, parks or other areas of turfgrass exist.

Due to its color, size and the fact that it lives below ground, never making the visible mounds characteristic of other ant species, this ant is difficult to see.

Its scientific name is Solonopis but it is commonly called a "thief" ant. It derives its common name from its habit of stealing and consuming eggs and larvae from other insects. Thief ant workers are tiny, approximately 1.5 mm to 1.8 mm in length and are light yellow in color. They always nest underground or under objects such as rocks and wood that are totally or partially buried in the soil.

Thief ants are masters at being able to locate any potential food material in the soil. Eggs of other arthropods, even though laid with great care, are quickly found and taken away or consumed on the spot by thief ants. These ants build very narrow tunnels that are presumably too narrow for the defenders or other predators to follow.

One of the most exciting things about recent surveys is that this thievery appears to be very extensive in turfgrass soil systems. Home lawns, parks, golf courses and turfgrass industrial sites were surveyed. These represented different combinations

Ants' random underground foraging pays off when they find a Japanese beetle egg.

Even the Japanese beetle egg is much too large for a single thief ant.

of turfgrass size, management inputs, soil types and moisture levels.

Results indicated that the ants were common in all sites with one exception. Sites that had a history of regular applications of organophosphate or carbamate insecticide use were found to be nearly void of ants.

Given how extensively this ant is distributed, its potential impact on the overall terrestrial turfgrass ecology, as well as its potential as a natural control agent of turfgrass pests, has long been underappreciated.

How thief ants impact pest species

As generalists, thief ants are able to impact pest species that are present, or susceptible, for even a short period time, since other food sources can be used when the pest is not present. This allows the thief ant populations to remain relatively high and negates the usual lag time needed for predator populations to increase before pest control is achieved.

The thievery and marauding activities of the tiny thief ants may be more widespread than even first estimated. In recent studies, thief ants have been shown to be extremely important predators of chinch bug eggs, sod webworms. White grub eggs also are known to be reduced in turfgrass because of this ant.

In Purdue studies, where eggs were placed in subsurface holding containers in the soil, up to 65% of eggs were taken by thief ants within 4 days. Only a few additional eggs were taken by other ants or other insect predators. Reducing the number of viable white grub eggs by 65% is highly significant and in some cases would negate any need for additional pesticides applied to prevent grub damage.

Unfortunately due to applications of some commonly used insecticides, thief ant populations are reduced and Japanese beetle eggs consequently have a much better chance of survival. This finding poses serious questions regarding the routine use of pesticides in lawn care.

The Purdue study then looked at the effect of commonly used insecticides on thief ant populations. Two relatively new insecticides — Merit and Mach 2 — boast long residuals in soils. They were compared with two of the more commonly used insecticides: Diazinon (an organophosphate) and Oftanol (a carbamate).

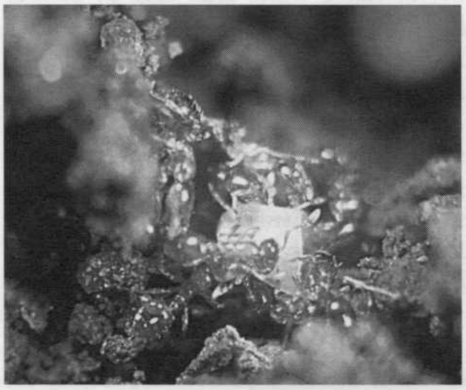
In Purdue studies, where eggs were placed in subsurface holding containers in the soil, up to 65% of the eggs were taken by thief ants within 4 days.

Applications were made at different times throughout the growing season and ant survivorship, as well as grub mortality, were measured. Somewhat surprisingly, the study revealed that both Merit and Mach 2 had almost no effect on the ant populations compared to both the organophosphate and the carbamate, which had an immediate and significantly negative effect on the ants.

Furthermore, the grub populations were reduced to much lower levels in the Merit and the Mach 2 trials than either of the OP or carbamate treatments. This may, in part, be due to a combination of natural ant control with the effects of the chemical treatment.

'Ecosystem' strategy

The concept of an ecosystem where any factor affecting one species must have an influence on all the species present must be the paradigm by which golf course superintendents begin to view turfgrass. To successfully understand any part, we must appreciate the system as a whole.



Many ants work cooperatively to help take this egg back to the nest.

The many factors, both living and nonliving, which make up the golf course environment are all affected by any turf management practice (mowing, fertilization, soil amendments, irrigation or application of herbicide, fungicide or insecticide).

> *Thief ants have been shown to be important predators of chinch bug eggs, sod webworms and, now, white grub eggs.*

Integrated Pest Management, the keystone of sustainable agricultural production systems, is a relatively new concept to many golf course superintendents. Capitalizing on the natural controls of any given pest is at the heart of IPM implementation.

A poor understanding of the identification and ecology of naturally occurring turfgrass predators hampers the ability of researchers to develop biologically intensive management tactics. This has left the natural enemies of turfgrass pests — including arthropods, nematodes and entomophagous pathogens — virtually unused by the turf industry.

Recognizing the overall effects of ant predation in turfgrass and understanding what factors may influence them will allow for improved turfgrass management. Basic understanding and appreciation of the benefits of ants and other naturally occurring controls will allow superintendents to understand how to conserve these important natural enemies.

In so doing, superintendents have the potential to decrease total pesticide used on golf courses while maintaining adequate pest management and reap the benefits of increase public and environmental safety. This is a sure bet, so ante up for ants.

— Timothy Gibb is in the Department of Entomology at Purdue University.

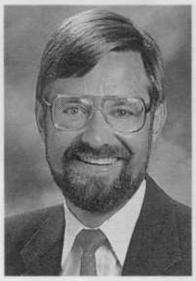
PURDUE UNIVERSITY'S THIEF ANT SURVEY OF TURFGRASS SOIL SYSTEMS CHECKED:

- home lawns
- golf courses
- turfgrass industrial sites
- different combinations of turfgrass size, management, soil types and moisture levels

These underground ants were common except where a site had a history of regular application of organophosphates or carbamate insecticides.

FROM THE EDITOR

FORECAST:
DRY AND INTRUSIVE



It's green-up time. You've done your preparatory work. Your irrigation systems are inspected, overhauled and in place, but the prospects of pulling down a water table already under pressure is not a pleasant one. This spring is forecast to be a dry one.

Be prepared to defend what many people see as the nonessential use of water on turfgrass to the local press and even country club members. The public has a pesky way of poking its nose into what many people see as their private affair but which, in the larger scope of things, may be a legitimate concern.

Which brings us to the topic of insecticides. Most turfgrass operations now follow policies of spraying when the public is not around. All of you should be posting the appropriate warnings when using restricted materials. Again, with an early season, there will be heightened attacks by insects on grasses and ornamentals. Be prepared to deal with the public on this issue. A proactive approach with your internal public (i.e., members of the club or owners of buildings) is probably best.

Whichever way the weather goes — wet or dry, hotter or cooler — the odds are good you'll be bugged at some point this season by outsiders questioning your management plans. Be prepared to give reasoned, nonemotional, practical answers to their questions.

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- Back to Basics series:

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- Why it Takes 10 Years to Bring Products to Market
- EPA's Vermiculite Scare
- Weeds as Indicators of Environmental Conditions

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