New insight on fairy ring

Determining potential problems associated with fairy ring on golf course turf will lead to new ways to control this long-standing problem.

In recent years, fairy ring, with an unpredictable and destructive nature that can frustrate even the most skilled superintendents, has become a persistent problem and an unsightly nuisance on golf course turf. Various cultural practices, applications of fungicides and soil surfactants, and other measures are commonly used to treat and control fairy ring (2,3,4,5). Sometimes these treatment programs work, and sometimes they do not. What works on one golf course may not work on another, or even at a different location on the same course.

What's going on above the soil?

Mushrooms growing in a circle, lush green circular bands of grass or distinct rings of wilted and dead grass are all symptoms of fairy ring in turf (1). Although these symptoms and subsequent turf damage can occur at any time during the year, the most severe turf injury from fairy ring is often observed during hot, dry weather. Symptoms are more pronounced in turf that is "lean" or underfertilized and in turf subjected to intense maintenance practices. Fairy ring symptoms are categorized by types based on the appearance of the affected turf and the surrounding area.

Type I

Type I symptoms are the most severe, with wilted, necrotic or dead turf appearing in rings or arcs. These sites are often associated with water-repellent or hydrophobic soil conditions and are difficult to keep wet or to re-wet. These "killer rings" can appear on creeping bentgrass greens in the middle of summer, posing a challenge for superintendents who must battle the cause of fairy ring while they also help the turf recover.

Type II

Type II symptoms are circles or arcs of dark green, actively growing turf. Essentially, the grass plants respond as if they have received a dose of nitrate nitrogen, provided by the breakdown of organic matter by the fairy ring fungi. Type II symptoms can appear literally overnight on greens during hot and dry summer stress conditions. The dark green bands quickly turn gray and then brown, and the turf begins to wilt and die. (It is possible, however, for turf to exhibit type II symptoms for several years and never wilt and die.) Therefore, daily hand-syringing with a wetting agent is needed to keep enough moisture in areas with type II symptoms that have turned quickly into areas with type I symptoms (1,2,9).

Type III

The appearance of mushrooms is classified as a type III symptom. The mushrooms are in rings, semicircles or random clusters and often appear within a day after rain. Mushrooms also may be observed growing along the edges of type I or type II rings.

What's going on below the turf?

The fungi that cause fairy ring symptoms in turf belong to the basidiomycete or mushroom

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Lepiota species mushroom emerging from the turf.
Photos by M. Fidanza

family (1). In turf, these fungi colonize thatch and mat (they are *lectophilic*) or grow in the soil and root zone (they are *edaphic*). As the fungi decompose organic matter, their mycelia, other hydrophobic substances (for example, proteins, carbohydrates or other organic compounds secreted by the fungal organisms) and, possibly, hydrophobins (small, secreted proteins from fungi that coat the aerial structures of these microorganisms with a hydrophobic water-repellent layer) coat the surfaces of sand and soil particles, contributing to the development of soil water repellency in the root zone (7,8). The loss of turf or thinning stand density is due to the depletion of plant-available water in the soil. Severe lack of soil moisture also causes turf loss by preventing soil microorganisms from converting ammonium to nitrate so that nitrate is unavailable for turf growth and ammonium accumulates to levels that are toxic to plant roots.

A recent study

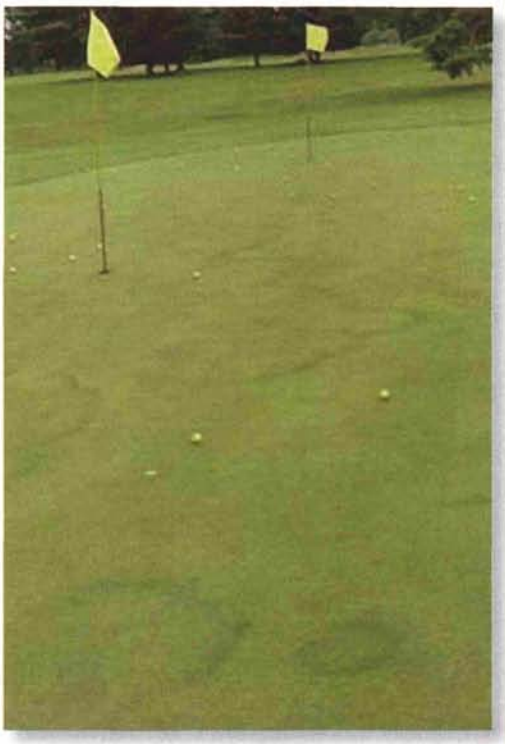
In a recent investigation, I attempted to characterize soil chemical and physical properties associated with turf suffering from type I fairy ring. Soil cores 0.75 inch (1.9 centimeters) in diameter and 3-4 four inches (7.6-10.2 centimeters) deep were extracted from type I fairy ring sites on three different golf courses in eastern, central and western Pennsylvania.

From each golf course, I collected soil cores from three turf sites affected by type I fairy ring on a single fairway. For each fairy ring site, I collected 12 soil cores from healthy turf inside the ring, 12 soil cores from healthy turf outside the ring and 12 soil cores from within the "dead zone." Results from laboratory and field tests were compared from necrotic zones (soil within the rings of dead turf) and healthy zones (soil below healthy turf inside and outside the ring areas). Results were basically the same (not significantly different) for all three golf courses. For simplicity, the information presented here will focus on only one location, a single perennial ryegrass fairway in southeastern Pennsylvania with severe type I fairy ring symptoms. At this particular site, mushrooms growing in the affected turf area were identified as *Agaricus campestris*, the common meadow mushroom.

Conditions in the necrotic zones

Soil pH was slightly higher in the necrotic zones (6.3 pH vs. 5.9 pH for soil underlying healthy turf), although fairy ring is presumed to occur in a wide range of soil pH (10). Concentrations of ammonium, potassium, sulfur and soluble salts (as determined from electrical conductivity) were statistically higher in necrotic zones compared to adjacent healthy turf areas. Volumetric water content was significantly lower in soil within the necrotic zones, and an average

Type I fairy rings are rings or arcs of wilted necrotic turf.



Type II fairy rings are circular bands, rings or arcs of dark green, lush, actively growing turf.

of 301 seconds was required for a drop of water to penetrate into the top 1 inch (2.5 centimeters) of soil affected by fairy ring, whereas only 8 seconds was required, on the average, for a drop of water to penetrate soil from healthy turf areas.

Excessive ammonium concentrations

Hydrophobic soil conditions and the depletion of plant-available water can impair soil microbial activity needed for nitrification or the conversion of ammonium to nitrate in the soil (6,10). Excessive ammonium is toxic to roots and can lead to a general decline in overall turf quality and function. Poorly performing golf course turf has been reported with ammonium levels consistently greater than 7 ppm (6). At this study site, the ammonium concentration in the soil below the necrotic zone was 441 ppm, or 63 times greater than the ammonium concentration of 7 ppm in the soil below the healthy turf. The accumulation of ammonium in soil is more common in the summer when soils typically have less oxygen than usual (6). In this situation, aerification is needed to allow oxygen into the soil root zone, to promote nitrification, and to "vent" excess ammonium out of the soil (1,2,9). Care should be taken when aerifying annual bluegrass/creeping bentgrass greens during sensitive summer stress periods, when mechanical injury from aerifying can occur and drastically reduce the opportunity for turf recovery.

Sulfur and potassium

The accumulation of sulfur in soil underlying those necrotic zones is also related to low soil microbial activity. High concentrations of sulfur can lead to the production of hydrogen sulfide (H_2S), which is toxic to plant roots and can combine with iron and magnesium sulfides to create a "black layer" soil with low levels of oxygen (1). The accumulation of potassium in necrotic zones is a reflection of higher soluble-salt measurements as well as lower soil moisture.

Soil cation exchange capacity, magnesium and calcium

Soil cation exchange capacity and concentrations of magnesium and calcium were similar throughout sites that were affected with type I fairy ring and those that were not. When soil cation exchange capacity, concentration of magnesium and concentration of calcium in soil under healthy turf were compared to those in soil in the "dead zones" of type I fairy ring sites in the same fairway, there were no significant differences at any of the three golf courses. Although no statistical differences were detected in percent soil organic matter, the high levels of organic matter measured at these sites could offer a great opportunity for growth and development of fairy ring fungi.

Conclusions

Results from this study support previous findings from anecdotal observations of 100 to 200

With type III fairy rings, actual mushrooms appear, sometimes growing in circles or arcs, with typically no turf stimulation or damage.

Soil chemical and physical properties were compared from the necrotic zone and the healthy turf areas inside and outside of the necrotic zone.

The research says

→ Fairy ring is characterized by three types of symptoms: type I, the most severe, is characterized by wilted, necrotic or dead turf appearing in rings or arcs and is often associated with water-repellent or hydrophobic soil conditions.

→ The fairy ring fungi break down organic matter to produce type II symptoms, circles or arcs of dark green, actively growing turf.

→ Type III symptoms are the appearance of mushrooms in rings, semicircles or random clusters, often within a day after rain.

→ Where fairy ring occurred, soil pH was slightly higher; concentrations of ammonium, potassium, sulfur and soluble salts were statistically higher; volumetric water content was significantly lower in soil; and water-droplet-penetration test times were significantly longer.

→ The fungi that cause fairy ring directly or indirectly contribute to the development of water-repellent soil and the depletion of soil moisture, resulting ultimately in turf death.

years ago (10), showing that fairy ring has been a problem for many years. More research on fairy ring ecology and the development of successful and consistent management practices to control fairy ring in turf are still needed today.

In this investigation, necrotic zones were associated with the fungi that cause fairy ring, which, either directly or indirectly, contributed to the development of soil-water repellency and the depletion of soil moisture. The effect of soil water repellency or soil hydrophobicity may have contributed to a decrease in soil microbial (bacterial) activity and an increase in the saprophytic activity of the basidiomycete fungi, and thereby an accumulation of ammonium and other harmful chemical and physical soil attributes that resulted in dead turfgrass.

For more information on fairy ring, visit the International Centre for Fairy Ring Research at www.berks.psu.edu/faculty/mFidanza/mFidanza.html.

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