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Managing Anthracnose on Golf Course Putting Greens

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Introduction

Anthracnose is a destructive disease of cool-season putting green turf caused by the fungal organism *Colletotrichum cereale* (formerly *C. graminicola*). *Colletotrichum cereale* infects turf when plants are weakened by physiological or mechanical stresses. Anthracnose incidence and severity have increased throughout the southern United States over the past 15 years. The proliferation of this disease may be due to the intense management practices performed on putting greens such as decreased mowing heights, reduced irrigation and minimal nitrogen fertilization to increase green speeds. Diagnosticians have improved their ability to recognize *C. cereale* structures, resulting in the trend of increased disease identification frequency.

Colletotrichum cereale infects leaf, crown, stolon or root tissues of creeping bentgrass (*Agrostis stolonifera*) or annual bluegrass (*Poa annua*), but it is normally more severe on annual bluegrass. Anthracnose is characterized by the portion of the plant the fungus infects resulting in foliar blight or basal (stem) rot. Host specificity has been identified in *C. cereale* isolates, meaning that infection of creeping bentgrass or annual bluegrass will be more severe in mixed turfgrass stands depending on host preference.

Symptoms

Foliar Blight. These symptoms are predominantly observed on creeping bentgrass putting greens during the summer with the onset of heat stress but may occur on annual bluegrass putting greens. Foliar blight symptoms in the turf include large, irregularly shaped patches lacking turf density and appearing yellow to bronze (Figure 1). Initially, leaf symptoms occur on older leaves near the base of the plant but progress to younger leaves (Figure 2). Leaves

Figure 1. Irregularly shaped, chlorotic areas of anthracnose foliar blight.

Figure 2. Progression of anthracnose with youngest leaves healthy and green, but deeper in canopy, there is chlorosis and necrosis along with heavy thinning. *(Courtesy M. Tomaso-Peterson)*

infected by *C. cereale* exhibit chlorosis (yellowing) at the tip of the leaf that moves downward, eventually becoming necrotic (Young et al., 2008).

Basal Rot. These symptoms are generally observed on annual bluegrass putting greens but may also be observed on creeping bentgrass greens as well. This disease differs from foliar blight in that basal rot may occur throughout the year. Turf symptoms are initially 0.25- to 0.5-inch diameter spots appearing orange to bronze. As the fungus begins infecting crown and stem material, the patches will enlarge and coalesce but remain sporadic throughout the symptomatic area. As stems and crowns are infected by the pathogen, the symptoms of these tissues progress from a water-soaked appearance to black, rotted tissue (Figure 3). Leaf symptoms on annual bluegrass and creeping bentgrass are similar to foliar blight symptoms, with the older leaves initially becoming chlorotic and progressing to younger leaves (Smiley et al., 2005).

Figure 3. Basal rot symptoms on creeping bentgrass. *(Courtesy A. Windham)*

Disease Cycle

Colletotrichum cereale overwinters in the thatch of putting greens and lives on organic matter. As environmental conditions become favorable for its growth with increasing temperatures and high humidity in the plant canopy, fungal mycelium will begin growing in search of susceptible host material. As the mycelium extends to older, senescing leaf material, the terminal end of the mycelium will enlarge and darken to form an appressorium (ia) (Figure 4). The appressoria produce a penetration peg that penetrates the epidermal cells of the leaf, allowing the fungus to consume simple carbohydrates from the plant. As the fungus colonizes the plant, an asexual fruiting body called an acervulus (i) is formed within the epidermal cells of the leaf. The acervulus gives rise to black, sterile hairs called setae that extend out of the leaf and are a key diagnostic characteristic of *C. cereale* infection (Figures 5 and 6). The acervulus also produces copious amounts of asexual spores known as conidia that continue the infection process (Figure 6). Conidia are dispersed by water

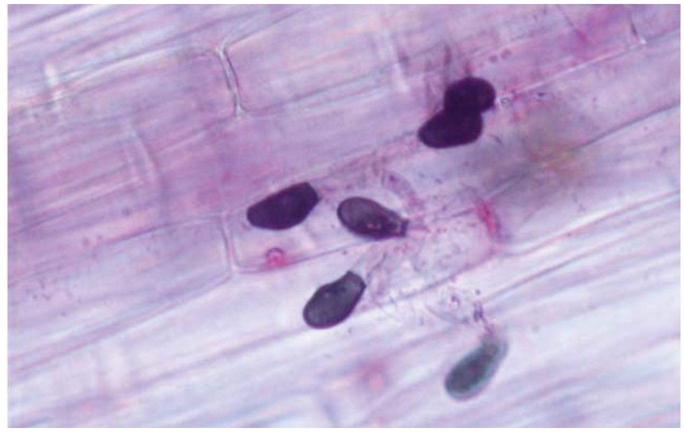

Figure 4. Appressoria formed by *Colletotrichum cereale* to penetrate epidermal cells. *(Courtesy M. Tomaso-Peterson)*

Figure 5. Acervuli and setae protruding through outer leaf cells viewed with dissecting microscope. *(Courtesy M. Tomaso-Peterson)*

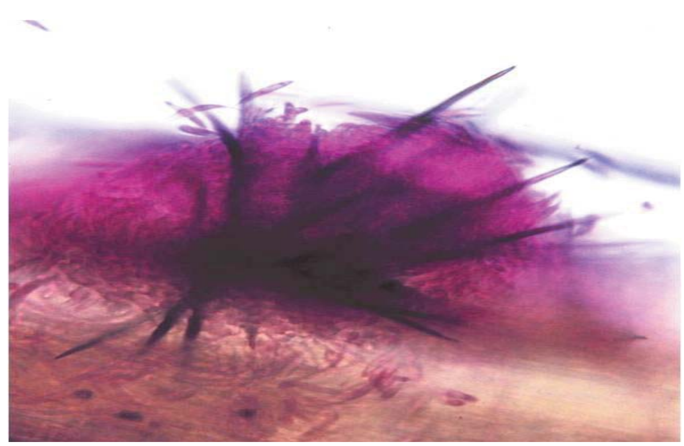

Figure 6. Acervulus with setae producing a mass of conidia. *(Courtesy M. Tomaso-Peterson)*

movement and machinery passing through the infected area. As long as environmental conditions remain favorable for fungal growth, these conidia will germinate and infect susceptible plants as previously described.

Management

There is little research published on the management of anthracnose, mostly due to the difficulty of getting consistent infection over a study area. Researchers at Rutgers University have determined a method of inoculation on annual bluegrass putting greens that has allowed them to conduct many studies to determine management practices that either exacerbate or minimize anthracnose severity. Unfortunately, minimal information is available for management practices on creeping bentgrass; however, these practices should be consistent with managing anthracnose on either annual bluegrass or creeping bentgrass.

Cultural Management Practices. The key goal in any anthracnose management strategy should be to reduce turf stress and have the healthiest, most vigorous stand of turf possible. There are many agronomic practices incorporated into management strategies that actually increase stress on putting green turf such as reduced nitrogen fertility, extremely low mowing heights, decreased irrigation and cultural practices. Even though these practices increase turf stress, they are continually performed to increase ball roll and surface playability. The following paragraphs will briefly discuss alterations to the extreme management practices that have decreased anthracnose severity in studies conducted on annual bluegrass putting greens.

Nitrogen fertility. Adequate nitrogen fertility appears to minimize anthracnose severity better than other management practices. Applying 0.1 lb N/1,000 ft^2 every seven days throughout the summer months significantly reduced anthracnose severity compared to applying this rate every 28 days (Inguagiato et al., 2008). Spoon-feeding on a biweekly to monthly basis may reduce the vigor of plants based on a lack of nutrition, which would stress the plant, leaving it prone to *C. cereale* infection. Golf course managers may also be able to increase the amount of nitrogen in the soil by applying larger quantities of slow-release nitrogen (0.75 to 1.5 lb N/1,000 ft^2) in the fall or spring. No studies have correlated anthracnose severity with phosphorus or potassium deficiencies, but it would be important to fertilize with these nutrients based on soil test recommendations.

Mowing height. The second management practice that had a significant effect on anthracnose severity was mowing height. Many creeping bentgrass and annual bluegrass putting greens are maintained at or below 0.125 inch even under stressful environmental conditions, which greatly increases the host's susceptibility to fungal infection. Research has shown significant decreases in anthracnose severity when mowing heights are raised by as little as 0.015 inch (0.110 to 0.125 inch or 0.125 or 0.140 inch). Golf course managers may be hesitant to increase mowing height due to potentially reducing ball speed on putting greens. However, double-cutting at the higher cutting height each day and rolling plots every other day to improve speeds will not increase disease severity at higher mowing heights (Inguagiato et al., 2009). Although no research was performed to determine the specific reason for the decrease in severity at higher mowing heights, it was hypothesized that increased leaf area would allow more photosynthesis to occur and more carbohydrates could be distributed throughout the plant to minimize stress.

Water management. Soil moisture management plays a key role in stress management and, therefore, in susceptibility of the host to infection. To alleviate plant stress by reducing temperatures within the canopy, syringe putting greens on warm (≥ 85º F), dry and sunny afternoons. If grasses were to become heat stressed late in the afternoon, *C. cereale* would have ample time to infect those plants prior to the turf recuperating in the evening. Areas on putting greens that are prone to drying (such as slopes) may need additional irrigation early in the morning to reduce afternoon moisture stress. Soil moisture deficits affect turf and anthracnose severity as previously discussed, but excessive water may also have a negative effect. So overwatering should be avoided. Saturated soils lead to anaerobic situations, reducing the availability of oxygen to roots and increasing plant stress.

Root cultivation. As mentioned in the introduction to this section, cultural practices that increase stress on turf will increase anthracnose severity. Therefore, aerification, deep vertical mowing (> 0.2 inch, ≥ 5 mm), topdressing and use of groomers on mowers should be avoided when the summer heat stress period has begun. Aerification should be performed in the spring and fall when the grasses are vigorously growing. Interestingly, research has shown that light vertical mowing (0.12 inch, 3 mm depth), which does not cut stolons but removes organic matter, had no effect on anthracnose severity. Even during the stressful times of year, it is still important to maintain aerobic conditions in the root zone for respiration. Spiking and hydrojecting putting greens are two possible solutions that result in minimal stress while facilitating the movement of oxygen into the root zone.

Air circulation. The final management practice that will reduce anthracnose severity is maintaining adequate air movement throughout the putting green. Many golf courses throughout the Southeast with creeping bentgrass putting greens have installed fans at each green that run throughout the peak environmental stress periods. Continual air movement over the surface of the turf will maintain transpiration rates and reduce leaf wetness periods that lead to fungal infection. If fans are cost prohibitive, selective pruning of trees or shrubs adjacent to green surrounds will increase natural air movement. The mentioned management practices may reduce anthracnose severity, but fungicide applications must be incorporated with these practices to obtain the best control of anthracnose.

Fungicide applications. There are eight chemical classes of fungicides labeled for anthracnose control – benzimidazoles, dicarboximides, demethylation inhibitors (DMIs), nitriles, phenylpyrroles, phosphonates, polyoxins and QoIs (Murphy et al., 2008). Only three of these classes have been effective when applied alone at curative rates (benzimidazoles, DMIs and QoIs); therefore, it is imperative to initiate a preventive fungicide program for anthracnose control in April or May, depending on environmental conditions. On putting greens that exhibit annual anthracnose symptoms, these preventive fungicide applications are imperative.

As mentioned, the arsenal of fungicides capable of managing anthracnose is limited. Additionally, research over the past six years has illustrated reduced sensitivity of *C. cereale* to some of these fungicides, indicating that some *C. cereale* isolates are resistant to fungicides. Fungicide resistance to the benzimidazole, DMI and QoI class of fungicides has been identified in *C. cereale* populations of annual bluegrass putting greens from around the United States. A recent study completed at Mississippi State University evaluated *C. cereale* isolates collected from creeping bentgrass putting greens throughout Mississippi and Alabama. Approximately 90 *C. cereale* isolates were collected over a two-year period, and 100 percent of these isolates exhibited fungicide resistance to both azoxystrobin (QoI) and thiophanate-methyl (benzimidazole). These two fungicides have different modes of action, but small adjustments in *C. cereale's* genetic makeup confirmed that these isolates were resistant to the fungicides. The results from this study were similar to other studies that identified fungicide resistance in *C. cereale* and other fungal pathogens studied in various parts of the United States. Anecdotal evidence of azoxystrobin resistance was obtained in a fungicide trial performed on a creeping bentgrass putting green in Arkansas (Milus et al., 2002). Fortunately, all is not lost, but this information illustrates the importance of implementing a preventive fungicide program since the chemistries identified as resistant are the three listed as curative fungicides for anthracnose.

The eight fungicide classes listed contain fungicides consisting of various topical modes of action (i.e., contacts and penetrants) that may be applied to prevent *C. cereale* infection. The contacts (7 to 10 days) give a shorter span of protection compared to penetrant (14 to 28 days) fungicides because they do not enter the plant. This preventive program should include a rotation of various topical and biochemical modes of action, taking care not to use fungicides within the same class in consecutive applications. In the case that environmental conditions favor fungal infection, tank-mixing may increase the efficacy of the fungicide application. Tank-mixes of fosetyl-Al + chlorothalonil, fosetyl-Al + mancozeb and propiconazole + chlorothalonil applied on 14-day intervals have resulted in good control in fungicide trials (Vincelli and Powell, 2009). Fosetyl-Al applied alone or tank-mixed has exhibited good to excellent control in many studies. It has been hypothesized that the fungicide may actually increase the health of the plant rather than affecting the fungus in a negative way, which would be a positive attribute in managing *C. cereale* since it infects stressed tissue. Benzimidazole, DMI and QoI fungicides should be included in the rotation, but areas concerned about potential fungicide resistance issues should tank-mix these fungicides with contact fungicides. This application would control sensitive isolates and manage resistant isolates with the contact fungicide until the subsequent application.

Table 1. Efficacy of fungicides for the control of Anthracnose diseases of turf. Adapted from Tredway et al. (2009) and Vincelli and Powell (2009).

Fungicide	Efficacy†	Resistance Risk‡	FRAC§	Fungicide Trade Name	Interval (days)
chlorothalonil + propiconazole + fludioxonil	++++	3	M5 + DMI + phenylpyrolle	Instrata	14-28
Azoxystrobin	++++	9	QoI	Heritage	14-28
Fluoxastrobin	++++	9	QoI	Disarm	14-28
azoxystrobin + propiconazole	++++	9	QoI + DMI	Headway	14-28
thiophanate-methyl	+++	9	dicarboximide	3336, Fungo, Systec, T-Storm	10-14
flutolanil + thiophanate-methyl	+++	9	carboximide + benzimidazole	SysStar	14-30
iprodione + thiophanate-methyl	+++	9	dicarboximide + benzimidazole	26/36, Fluid Fungicide	14-21
fenarimol	+++	6	DMI	Rubigan	30
metconazole	+++	6	DMI	Tourney	14-21
myclobutanil	+++	6	DMI	Eagle	14-21
propiconazole	+++	6	DMI	Banner MAXX, Propiconazole G-Pro, Propiconazole Pro, Quali-Pro Propiconazole, Savvi, Spectator	14-28
triticonazole	+++	6	DMI	Trinity, Triton	14-28
chlorothalonil	+++	3	M5	Daconil, Chlorostar, Echo, Manicure	7-14
chlorothalonil + thiophanate-methyl	+++	6	M5 + benzimidazole	Spectro, ConSyst	7-14
chlorothalonil + propiconazole	+++	4	M5 + DMI	Concert	7-28
fludioxonil	+++	3	phenylpyrrole	Medallion	14
polyoxin D	+++	6	polyoxin	Endorse	7-14
phosphite	+++	3	phosphonate	Alude	14
pyraclostrobin	+++	9	QoI	Insignia	14-28
fosetyl-Al + chlorothalonil	+++	3	Phosphonate + M5	Signature + Daconil	7-14
fosetyl-Al + mancozeb	+++	3	Phosphonate + M3	Signature + Fore	7-14
triadimefon	++	6	DMI	Bayleton	14-45
triadimefon + trifloxystrobin	++	9	DMI + QoI	Tartan, Armada	14-28
trifloxystrobin	++	9	QoI	Compass	14-21

†++++, excellent control when conditions are highly favorable for disease development; +++, good control when disease pressure is high, or excellent control when disease pressure is moderate; ++, good control when disease pressure is moderate, excellent control when disease pressure is low; +, good control when disease pressure is low; 0, does not provide adequate control under any conditions; and ?, cannot be rated due to insufficient data.

‡1 = Rotating and tank-mixing not necessary, but recommended to avoid potential side effects from continuous use of same chemical class; 2 = Rotate to different chemical class after 3-4 applications, tank-mixing not necessary; 3 = Rotate to different chemical class after 2-3 applications, tank-mixing not necessary; 4 = Rotate to different chemical class after 1-2 applications, tank-mixing not necessary; 6 = Rotate to different chemical class after 1-2 applications, tank-mixing with low or moderate-risk product recommended; and 9 = Rotate to different chemical class after EVERY application, tank-mix with low- or moderate-risk product for EVERY application.

§Biochemical target site of action according to the Fungicide Resistance Action Committee. M3, M4 and M5 indicate multi-site inhibitor with no significant risk of resistance. Multiple repeat application of fungicides with similar sites of action can result in fungi that are resistant to some fungicides. Alternate between different sites of action to avoid resistance and improve disease control.

There are cultivars of creeping bentgrass that exhibit better heat tolerance than others; therefore, they may not be affected by *C. cereale* as much as standard cultivars with less heat tolerance. A five-year, multi-state study is currently being performed to evaluate fungicide applications and management practices to better manage anthracnose. This project also includes work being done by turfgrass breeders and geneticists to try and develop cultivars exhibiting resistance to *C. cereale* infection. Keep an eye out for further research and new cultivars that may reduce anthracnose severity on your golf course.

Summary

- To this point, a combination of management practices and fungicide applications is the only means to manage anthracnose.
- Reduce turf stress by syringing, hydrojecting, promoting air circulation and raising the mowing height during summer months.
- Skip light topdressings, aerification, deep vertical mowing (> 0.2 inch, ≥ 5 mm) and use of groomers on mowers when the summer heat stress period has begun.
- Cultivate and fertilize turf in the spring and the fall to improve putting green health.
- Increase summer putting green fertilization to ≥ 0.1 lb N/1,000 ft^2/week to reduce anthracnose.
- Alternate fungicide chemistries since benzimidazole, DMI and QoI fungicides are prone to resistance development among *C. cereale*.

Additional Information

Additional publications are available at <http://www.uaex.uada.edu/>.

Additional information about managing the turf on golf courses is available at <http://turf.uark.edu/>.

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