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This publication includes lecture notes of papers presented at the 2001 New Jersey Turfgrass Expo. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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MANAGEMENT PRACTICES ASSOCIATED WITH ANTHRACNOSE AND ABIOTIC STRESS ON GOLF COURSE TURF

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Anthracnose is a destructive disease of weakened or senescent turf. The disease occurs throughout the world on almost all turfgrass species but is particularly severe on annual bluegrass (*Poa annua* L.) and creeping Bentgrass (*Agrostis stolonifera* L.). The causal agent, *Colletotrichum graminicola* (Ces.) G.W. Wils., spends most of its time as a saprophyte in the thatch or in infested plant material. However, when environmental conditions are conducive to infection (i.e., high humidity or extended periods of leaf wetness) and the plants are under stress, the fungus may become pathogenic and infect leaf, stem, or root tissue. The disease can occur almost any time of year but is most common between April and September in the Northeast and Mid-Atlantic States. Although close-cut greens are most frequently affected, anthracnose can occur on turf maintained at any mowing height.

SYMPTOMS AND SIGNS

Anthracnose first appears as small patches of yellow to reddish-brown turf, 1 to 2 inches in diameter (Figure 1). As the disease progresses, large, irregularly shaped areas may develop on infected greens, tees, or fairways. On individual plants, the pathogen may first infect older or senescing leaves causing yellow leaf lesions (Figure 2). When plants are weakened by mechanical or environmental stress, the pathogen may also attack stems and leaf sheaths resulting in a basal stem rot. Lesions on the stems and leaf sheaths are at first water-soaked, but quickly turn black as the tissue is destroyed. At this point, the main shoot may be easily pulled from the infected crown and the entire plant may die. Upon close examination with a magnifying glass or 10X hand lens, affected foliage and stems are often covered with small, black reproductive structures called acervuli (Figure 3).

Acervuli first appear as small black protrusions just underneath the epidermis. Once mature, however, these structures produce long black spines (setae) that are frequently used as a diagnostic feature for anthracnose. Each acervulus contains dozens of one-celled, crescent-shaped, asexual spores called conidia. It is the conidia that are moved by wind, water, or other mechanical means to uninfected turf and cause infection.

Figure 1. Yellowing and general thinning associated with early symptoms of anthracnose on *Poa annua*.

RECENT EPIDEMICS

During the past few years, we have seen an increase in the incidence and severity of anthracnose on golf courses throughout the east coast and midwestern states. In many cases, epidemics were so severe that fungicides were unable to effectively control the disease when used at labeled rates or at recommended intervals of application. This often has

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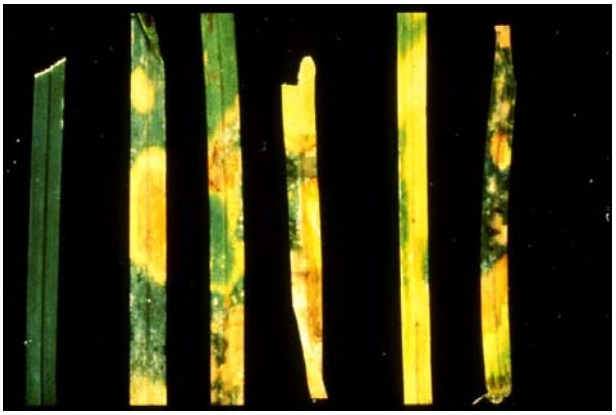

Figure 2. Leaf spots caused by *Colletotrichum graminicola* on *Poa annua*.

resulted in extensive damage and major disruptions in play, particularly on greens. As a result, many superintendents have begun to question why anthracnose has become so difficult to control. To answer this question, we consulted with other agronomists and pathologists from the affected regions. From these discussions, it became apparent that certain management practices commonly employed on golf courses may be enhancing abiotic stress and thus predisposing turf to anthracnose. Although it is doubtful that any particular factor is responsible for the recent increase in anthracnose observed in the United States, it is likely that various combinations of these factors may be enhancing the severity of this disease and making it more difficult to control.

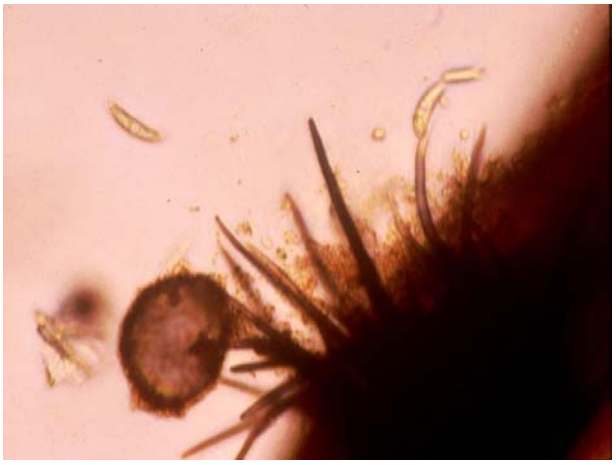

Figure 3. An acervulus with one-celled conidia produced by the anthracnose pathogen *Colletotrichum graminicola*.

FACTORS CONTRIBUTING TO ABIOTIC STRESS AND/OR ANTHRACNOSE

Plant Stress

Even though *C. graminicola* can attack both annual bluegrass and bentgrass turf, anthracnose is more often a serious problem on the former species. Annual bluegrass is at best a weak perennial that is known for its prolific production of seed heads, particularly between late-April and early June. While seed heads are unsightly and may adversely affect the playability of a green, they are also a sink for carbohydrates (sugars), and thus often significantly deplete the carbohydrate reserves of the plant by early summer. If environmental conditions are also stressful at this time (e.g., hot, humid weather), then annual bluegrass may be particularly susceptible to anthracnose.

Fertility

Of the 17 essential nutrients required for plant growth, nitrogen is often the element that has the greatest impact on plant vigor. Over the past 20 years there has been a strong trend towards reducing the amount of nitrogen applied to golf course greens, tees, and fairways. In some cases, this has resulted in turf that is deficient in nitrogen at certain times during the growing season.

The practice of “spoon feeding” turf with a 0.1 to 0.125 lb nitrogen (N)/1000 ft^2 when plants are of low vigor may not be sufficient to maintain a healthy, disease-free playing surface. Moreover, deficiencies in phosphorous or potassium may also predispose turf to anthracnose. Some superintendents have also abandoned the practice of applying moderate rates of a slow release nitrogen source (0.75 to 1.5 lb N/1000 ft^2) on greens in the fall or spring, thus further reducing the supply of this important nutrient. On fairways, removal of clippings has become a common practice. However, if fertility levels are not adjusted to compensate for the nutrients removed, then nutrient deficiencies may develop. Clipping removal can remove 25 to 60% of applied nitrogen per season.

Irrigation

Drought stress appears to predispose turf to anthracnose. Not only can low soil water availability reduce plant vigor, thus weakening the plant’s natural defenses against disease, but *C. graminicola* can readily colonize weakened turf. The tendency to maintain dry turf and soil to improve playability and to

enhance the competitiveness of bentgrass may actually stimulate disease development on annual bluegrass. Wilt stress, particularly from mid-day to late afternoon, is something that should be avoided. Wilt at this time will exacerbate the turf's exposure to high temperature stress. Tree root competition is also a factor that has been associated with decreasing turf vigor and potentially enhancing anthracnose.

Mowing

Low mowing height has been reported to increase many turfgrass diseases (e.g., summer patch, leaf spot, bentgrass dead spot, etc.). Many of the superintendents that had severe outbreaks of anthracnose over the past few years were maintaining greens at or below 1/8 inch. Where annual bluegrass is a major component of the putting surface, low mowing can deplete the carbohydrate reserves of this species, often already weakened by environmental stress.

Mowing frequency may also affect anthracnose. The increased wear caused by double and triple cutting, particularly at a very low cutting height, can result in greater wounding and may potentially enhance the incidence of stress related diseases. Note that double cutting at a higher cutting height is preferable to mowing at a lower height to achieve greater putting speed. Several of the agronomists questioned also felt that the use of grooved front rollers increases wounding, compared to smooth rollers. The impact of grooved rollers on anthracnose, however, is currently unknown.

Pesticides

After reviewing the scientific literature, it is apparent that few good fungicide studies have been conducted for the control of anthracnose. This is partially due to the inability of research (until recently) to consistently reproduce the disease artificially in field trials where uniformity of infection is required to accurately assess fungicide efficacy. Similarly, studies conducted on golf courses naturally infested with *C. graminicola* have also yielded limited information, often because of the simultaneous occurrence of other turfgrass diseases. As a result, only six or seven reliable studies have been reported over the past 15 years. From this information, it would appear that only five chemical classes or groups can effectively suppress anthracnose, and only four of these groups are currently labeled for the control of this disease (Table 1).

Table 1. Fungicide groups reported to control anthracnose on turf.

I.	Demethylation Inhibitors (Sterol Inhibitors):
	• Banner
	• Bayleton
	• Eagle
	• Rubigan
	• Sentinel
II.	Strobilurins
	• Heritage
	• Compass
	• BAS 500/505
III.	Benzimidazoles
	• Fungo
	• Cleary 3336
IV.	Nitriles
	• Daconil
	• ChloroStar
	• Manicure
V.	Combinations (III + IV)
	• ConSyst
	• Spectro

Information pertaining to the influence of plant growth regulators and herbicides on anthracnose is also very limited. However, it would appear from a study conducted in Kentucky that products such as Primo or Dimension might slightly increase this disease. Clearly, more research is required before more definitive conclusions can be drawn.

ADDRESSING THE PROBLEM

Improve Cultural Practices

Since it is apparent that nitrogen deficient turf is more susceptible to anthracnose than well-fertilized plants, turf managers should be sure to maintain adequate nitrogen levels. Annual bluegrass typically requires 1.5 to 4 lb N/1000 ft^2 per year depending on the age of the green and the intensity of traffic. Spoonfeeding turf with 0.1 to 0.125 lb N/1000 ft^2 may not be enough to ensure proper plant growth when turf vigor is low. Moreover, it should be remembered that some nitrogen from foliar applications of urea can be lost through volatilization. To improve plant vigor, superintendents should consider periodically increasing the

frequency of nitrogen applications from every 2 weeks to once a week. In addition, consideration should be given to applying moderate rates of a slow release nitrogen source (0.75 to 1.5 N/1000 ft^2) to greens in the fall or spring to prevent the "nitrogen bank" in the green from becoming depleted. It is also important to avoid severe water stress at all times.

Avoiding drought stress can help to improve turf vigor and may reduce the development of anthracnose. Care should be taken when training crew members about hand watering. Syringing stressed turf during the day is as much an art as a science. Too much or too little syringing can damage turf. In particular, avoiding wilt stress after 3 PM, when the crew goes home, is an important consideration. Also, remember that straight sand topdressing does not retain as much moisture as do mixes with higher organic matter content. If you have changed to straight sand topdressing, make sure you have altered irrigation practices accordingly.

Where possible, raise the mowing height when turf is under environmental stress. Simply raising the cutting height 1/32 of an inch will increase the photosynthetic capability of the turf, thus increasing the carbohydrate level in the plant. This should also aid in recovery once the disease is suppressed with fungicides. One approach that can be used to compensate for a slight increase in cutting height is the use of lightweight rolling. Research has shown that lightweight rolling can simulate the effect of a double cut or a 1/32-inch reduction in the mowing height. Moreover, no detrimental effect of rolling greens has been observed with as many as three rollings per week.

Although some agronomists have suggested that grooved rollers may increase wounding compared to smooth rollers, the impact of roller type on anthracnose is currently unknown. However, any attempt to reduce wounding (e.g., avoid aerifying, verticutting, or sand topdressing when the disease is active) would presumably reduce the incidence of new infections. Other factors that may suppress anthracnose in the long run include: reducing excessive thatch and compaction when the disease is not active, removing dew and guttation water in the early morning hours, and improving air circulation.

Implement an Effective Fungicide Program

Although additional research is needed to improve current fungicide recommendations, turf managers can effectively control anthracnose by following a few important points. First, on sites that have had a previous history of this disease, it is best to apply fungicides on a preventive basis two to three weeks before symptoms typically develop. For many locations in the tri-state area this may mean starting applications in early- to mid-May. On other sites, fungicide treatments may have to commence in April. In either case, the key to good disease control is to prevent severe epidemics from getting established. Once severe outbreaks occur, adequate disease control with fungicides is more difficult to attain.

To date, only fungicides within the benzimidazole, strobilurin, nitrile, and demethylation inhibitor (DMI) classes have been reported to consistently control anthracnose (Table 1). Fosetyl-Al (i.e., Aliette Signature) has also provided good disease suppression in some tests when used in combination with chlorothalonil (e.g., Daconil Ultrex). However, fosetyl-Al is not currently labeled for the control of anthracnose. Even though fungicides within the dicarboximide class are registered for the suppression of this disease, iprodione (i.e., Chipco 26GT) and vinclozolin (e.g., Curalan) have not provided effective control in most studies. Moreover, flutolanil (e.g., ProStar) has been shown to intensify anthracnose on bentgrass studies at Rutgers and, therefore, should not be applied to turf infested with *C. graminicola*.

Recently, laboratory studies have identified isolates of *C. graminicola* with reduced sensitivity to fungicides within the benzimidazole and strobilurin classes. Although this has yet to be confirmed in the field, every effort should be made to delay or prevent the development of fungicide resistant isolates of this pathogen. For best results, do not apply more than two or three consecutive applications of any fungicide used to control anthracnose. Alternating or tank mixing products with different modes of action (i.e., different fungicide classes) is still considered by most turfgrass pathologists to be the most effective strategy for preventing this problem.

When developing a fungicide program for your golf course, try to schedule the application of products when more than one target disease can be controlled. For example, applying a DMI or a nitrile fungicide in late May may help control both anthracnose and dollar spot, whereas rotating a strobilurin into an anthracnose program in late June or early July will also help prevent summer patch and brown patch. Moreover, be sure to follow label directions carefully regarding appropriate fungicide rates and intervals of application to optimize disease control.

Finally, the amount of water applied with a fungicide can affect efficacy. Products applied in less than 1 gallon of water/1000 ft^2 will almost certainly result in reduced levels of control. This is particularly true for the nitrile fungicides, since they are contact fungicides that must thoroughly cover leaf and stem tissues to be effective. In no instance should contact fungicides be watered into the thatch layer. Although much still needs to be learned about the etiology and control of this disease, superintendents can effectively manage anthracnose by improving cultural practices and employing sound chemical application strategies.