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IN THIS ISSUE

The Nature of Gray Leaf Spot and Its Management

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Gray leaf spot is caused by the fungus *Pyricularia grisea* and is a common disease of St. Augustinegrass (*Stenotaphrum secundatum*) lawns in the southeastern United States. It can be particularly damaging to newly sprigged lawns, but may be a chronic problem in mature stands of St. Augustinegrass grown in subtropical climates. Bermudagrasses (*Cynodon* spp.), centipedegrass (*Eremochloa ophiuroides*), fescues (*Festuca* spp.), bentgrasses (*Agrostis* spp.), Kentucky bluegrass (*Poa pratensis*), and ryegrasses (*Lolium* spp.) are listed as species susceptible to gray leaf spot. Some of the aforementioned turfgrass species only were shown to be blighted by *P. grisea* in growth chamber studies. **In the field, however, there is only good documentation that the pathogen inflicts significant damage to St. Augustinegrass, annual (*L. multiflorium*) and perennial ryegrasses (*L. perenne*), and tall fescue (*F. arundinacea*).** The pathogen also causes blast, the most important disease of rice (*Oryza sativa*) worldwide.

History of gray leaf spot on turfgrasses

Gray leaf spot was formally reported causing serious blighting of perennial ryegrass fairways on two golf courses in southeastern Pennsylvania in 1991 (Landschoot and Hoyland, 1992). It appeared in late August/early September, coinciding with unseasonably warm temperatures and high relative humidity. **In 1995, gray leaf spot reached epidemic proportions in perennial ryegrass grown on golf courses in the Mid-Atlantic regions.** The disease was most severe in southeastern Pennsylvania, Delaware, and non-mountainous areas of Maryland, Virginia, and Kentucky. In Maryland, the disease was first observed in 1986 on a golf course near Annapolis. Between 1986 and 1994, the Maryland disease diagnostic lab received only a few samples of perennial ryegrass affected with the disease. The disease, however, was probably causing low levels of injury in roughs on numerous golf courses for years, resulting in a gradual buildup of inoculum. Evidently, environmental conditions in 1995 were ideal for disease development and the inoculum had by this time reached sufficient levels on many golf courses to initiate the epidemic. The 1995 summer was among the warmest and driest of the century in the Mid-Atlantic region, suggesting that heat and low soil moisture levels were important predisposing conditions. In 1996, the disease recurred, but was not as widespread as in 1995, and most injury occurred in roughs and green surrounds. The 1996 summer, however, was among the coolest and wettest in the prior 50 years. The ability of the pathogen to cause significant levels of injury in two very different summer environments suggested that inoculum levels were sufficient to ensure that the disease would be a recurring problem in the region. **By 1998,**

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however, the disease had moved out of the Mid-Atlantic region and was observed as far north as Rhode Island and Iowa, and as far west as Nebraska, Kansas, and Oklahoma. The summer of 1998 was warm, not hot, but it was very dry. The summer of 1999 was among the driest ever recorded in many regions of the USA, and gray leaf spot pressure was low. According to Dr. Waker Uddin (personal communication) of Penn State University, the night-time relative humidity levels critical for gray leaf spot development were too low and conditions were too dry in the summer of 1999 for an epidemic to occur.

The cause of the rapid spread of the disease is unknown. There are no reports of the disease in the Pacific Northwest, where most perennial ryegrass seed is grown. Therefore, there is no evidence that the pathogen is being spread by seed. Dr. Mark Farman (Personal communication) of the University of Kentucky has found that the biotype of *P. grisea* that attacks perennial ryegrass is different from that which attacks rice. Hence, the origin of the pathogen may not have come from rice-producing areas in the USA, and the primary source of the inoculum is unknown. **The most likely means of spread is by wind dispersal of spores and by mowers.** Indeed, early outbreaks of the disease in Louisiana and Mississippi were believed to be due to spores being carried on wind currents by hurricanes. **Once the pathogen is established at a site, the spores are rapidly dispersed by mowing.** Dissemination of the fungus by golfers dispersing the pathogen in their travels with contaminated golf shoes or clubs also is possible. The mechanism by which the pathogen overwinters is unknown. It is likely, however, that it survives as dormant mycelium in dead tissues.

Predisposing environmental factors

Most of what is known about the environmental conditions that trigger the disease comes from researchers who studied the disease on St. Augustinegrass, rice, and tall fescue. To reach epidemic levels, rainy weather or prolonged periods of high humidity and temperatures above 70°F are required. Uddin et al. (1998) reported that gray leaf spot in tall fescue was favored most by leaf wetness durations of 36 to 40 hours at 80°F (27°C) or 16 to 40 hours of leaf wetness at 83°F (28°C). The disease, however, could develop in tall fescue after only 8 hours of leaf wetness at temperatures above 76°F (24°C). Dr. Uddin (personal communication) recently has learned that **the fungus requires frequent cycles of leaf wetting and drying in order for spore production to become prolific. Disease severity intensifies with increasing temperature, but high humidity at night or long leaf-wetness durations are essential for disease development.**

Symptoms and signs of gray leaf spot in perennial ryegrass golf turf

Working with both perennial and annual ryegrasses, Trevathan et al. (1994) found that seedlings were killed by *P. grisea,* but mature plants only developed leaf spot lesions, and sometimes leaves were blighted. Landschoot and Hoyland (1992) also observed seedling death, but on mature plants *P. grisea* primarily caused leaf spotting and perennial ryegrass crowns generally were unaffected. As noted in several texts, gray leaf spot in perennial ryegrass historically was regarded as a seedling, damping-off disease. It was widely believed that mature plants generally survived infection by *P. grisea.* The epidemic of 1995, however, revealed that **the pathogen was extremely virulent and could kill large areas of turf in a few days.** The increased virulence of *P. grisea* may have been the result of a genetic change in the fungus, resulting in a new biotype or race of the pathogen.

The first infected perennial ryegrass plants on golf courses normally appear in Maryland by the third week of July, but often develop later in other states. Most samples typically arrive in our diagnostic lab in August and September. **Once blighting develops, the disease can remain active until the first severe frosts in early November.** In general, however, the disease subsides in October. The fungus produces enormous numbers of spores overnight. It initially attacks leaves, and within hours leaf tips may appear water-soaked and chlorotic. Thereafter, leaf spot lesions and leaf twisting occur. Below the twisted areas, a small number of leaf lesions are sometimes evident. Frequently, the youngest emerging leaf is twisted in the shape of a "fish hook." Plants with the fish hook symptom may not have any lesions. This suggests that germinating spores can penetrate basal leaf sheaths at or below the soil surface. It also is possible that spores are splashed by rain or irrigation, and are carried by water into the leaf sheaths. Spores can be disseminated rapidly by mowing, resulting in a streaking pattern similar to that associated with *Pythium* blight. Evidently, within a very few hours the spores germinate, penetrate cut leaf wounds, and begin to cause blight before the leaves dry in the morning.

The leaf lesions are generally circular to oblong, about 1/8 to 1/4 in. (2–6 mm) long and grayish-brown

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...Annual Bluegrass...

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seed germination occurred. We also can interpret these data to say that only about 20–25% of the annual bluegrass seed germinated after mid-October while the remainder germinated prior to mid-October.

Of course, we have to keep in mind that these dates apply for this particular site and other areas with a similar climate. In addition, yearly variations in weather conditions at this site may produce different results in other years. But the point is that annual types of *Poa annua* germinate early in the autumn and a majority of germination occurs in the autumn for many climates.

Comparative Timings of Herbicide Application for Annual Bluegrass Control. North Carolina State University, Raleigh, NC. 1996–97.

Application Date	Percent Control *
August 13	91
September 12	99
October 11	21
November 13	24

* Percent control ratings were recorded April 25 of the following spring.

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with a dark brown border. Gray or brown lesions with or without a dark brown border frequently develop along the edges or margins of leaf blades. A yellow halo occasionally can be observed bordering lesions. Lesions, however, may be the size of a pinhead and very dark brown. These lesions are similar to those caused by the net blotch pathogen, *Drechslera dictyoides.* Net blotch, however, generally is associated with extended periods of overcast and rainy weather of spring. Because leaf spotting pathogens such as *D. dictyoides, Bipolaris sorokinana,* and *Curvularia* spp. can cause leaf lesions and leaf twisting that mimic *P. grisea,* **disease diagnoses based on leaf lesions in the field are difficult.**

In the early morning hours the twisted leaf tips of lesions on the margins of leaves may appear felted, and infected tissues may be gray, dark brown, purple, or yellow. The felted appearance is the result of the production of huge numbers of spores and their spot-bearing stalks known as conidiophores. **The most effective means of positively diagnosing gray leaf spot is to microscopically confirm the presence of the spores.**

From a standing position, the first observable symptom is the appearance of reddish brown or gray colored spots 1 to 2 in. (2–5 cm) in diameter, which could easily be confused with *Pythium* blight or dollar spot, respectively. **There is, however, no foliar mycelium associated with gray leaf spot.** During prolonged hot, humid, and dry weather the dead spots of turf enlarge to 3 to 18 in. (8–46 cm) in diameter. At this point disease symptoms mimic brown patch (*Rhizoctonia solani*). Large areas of turf may collapse in 3 to 5 days. Under less favorable environmental conditions, large pockets of dead turf may require a 3- to 4-week period to develop. Infected stands often develop a bluish-gray hue, which is typical of drought stress symptoms. Hence, perennial ryegrass in roughs or fairways that appear wilted in the presence of good soil moisture is a good indicator of gray leaf spot. The disease is most severe in heat-sink areas, such as south-facing hillsides and knolls. To date, the disease has been restricted to perennial ryegrass, while creeping bentgrass (*A. stolonifera*), annual (*P. annua*), rough (*P. trivialis*) and Kentucky bluegrass, fescues, and bermudagrasses growing in severely damaged perennial ryegrass fairways and roughs have been unaffected.

Another feature of the disease was that **it generally begins and is more destructive in golf course roughs, particularly the intermediate rough where the soil was compacted by cart traffic.** Evidently, the higher canopy in the rough provides a more favorable microenvironment for the pathogen. This is supported by the observation that the disease is generally less severe in low-cut perennial ryegrass approaches and collars.

Cultural management

Research conducted by Vaiciunas and Clarke (1998) showed that **gray leaf spot was less severe as mowing height was reduced from 3.5 to 0.5 in. (7.6–1.5 cm) during low disease pressure periods.** Under high disease pressure, however, mowing height did not impact disease severity. They also found that **nitrogen**

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(N) fertilization reduced disease severity when epidemics developed in the autumn. However, when the epidemic began earlier in the summer, applications of nitrogen at rates exceeding 1.5 lb N/1,000 ft^2 (75 kg N/ha), applied in 0.5 lb N/1,000 ft^2 (25 kg N/ha) increments on a 28-day interval, intensified the disease. They reported **a benefit from removal of clippings, but only when disease pressure was low.** Earlier research conducted in St. Augustinegrass also showed that clippings removal reduced disease severity (Parris, 1971). The effect of herbicides and plant growth regulators on the incidence and severity of gray leaf spot is unknown. Some management practices that may help to reduce gray leaf spot severity would include: reduce mowing height; avoid mowing when leaves are wet; collect clippings; apply small amounts of nitrogen fertilizer at 0.1 to 0.125 lb N/1,000 ft^2 (5–6 kg N/ha) in spoon-feeding programs during the summer; and maintain adequate soil moisture levels by irrigating during daytime hours.

Observations by Turner in 1997 indicated that some perennial ryegrass cultivars showed good gray leaf spot resistance during a moderate disease pressure summer in Maryland (1998 NTEP Prograss Report). However, during a high disease pressure period in 1998, all cultivars in the Maryland study were damaged severely by the disease. **Germplasm screening programs conducted at Rutgers University and elsewhere have shown that there is no genetic resistance to *P. grisea* among all commercially available perennial ryegrass cultivars.**

Severely damaged fairways overseeded in late July or August often do not tiller or establish good density or quality playability because of high temperature stress. During renovation, seed must make contact with soil. This is best achieved using a slicer seeder. Broadcasted seed does not establish well because the seed is either directly attacked or very young seedlings are killed as they emerge. Seedlings will be attacked by *P. grisea,* and possibly *R. solani* and *Pythium* spp. Hence, tank-mixes of a broad spectrum fungicide with a *Pythium*-targeted material need to be applied to seedlings. Low rate, weekly sprays of a water-soluble nitrogen source, like urea at 0.1 to 0.125 lb N/1,000 ft^2 (5–6 kg N/ha), and syringing 2 to 3 times daily also help to improve seedling vigor.

In extreme cases, renovation to a resistant species may become necessary. While creeping bentgrass, bermudagrass, and Kentucky bluegrass are reported hosts, all of these grasses have thus far shown outstanding resistance to gray leaf spot on golf courses. Creeping bentgrass, bermudagrass and Japanese zoysiagrass (*Zoysia japonica*) are all good fairway species. Choice of species is dependent on the climatic region.

Chemical control

Where the disease is chronic, preventive applications of fungicide appear to be the best approach to controlling gray leaf spot. Once the disease develops, higher rates and more frequent fungicide applications are required. Daconil® (chlorothalonil) is effective. However, even high rates are not likely to provide more than 5 to 10 days of control. Daconil® is a contact fungicide and as such the effectiveness of the material is diminished by removing the fungicide during routine mowing and probably by the effects of UV light and other factors. Fungicides that penetrate tissues provide a longer residual, but commercially acceptable levels of control may be provided for only 10 to 21 days, depending on the product and rate applied. Compass® (trifloxystrobin) and Heritage® (azoxystrobin) are very effective, particularly at the high label use rate. Spectro® (a pre-packaged mixture of chlorothalonil + thiophanate), CL 3336® and Fungo 50® (thiophanate), and Lynx® (terbuconazole, not yet registered) also have very good activity. CL 3336® and Spectro® provide 10 to 14 days control at higher label rates. Banner® (propiconazol) and Bayleton® (triadimefon) alone are not very effective, but when tank-mixed with Daconil® they also provide 10 to 14 days of control during high pressure epidemics. In curative programs, however, all of the aforementioned fungicides should be tank-mixed with Daconil®. Fungicides like Chipco 26GT® (iprodione) and ProStar® (flutalonil) have no activity against gray leaf spot.

There is no doubt that the pathogen has become well established, and **gray leaf spot will be a potential problem in perennial ryegrass grown on golf courses from the Great Plains states to the Atlantic seaboard.** Along with golf courses, perennial ryegrass grown on athletic fields and lawns also is vulnerable to the disease. Where gray leaf spot is known to be chronic, fungicide applications should begin in early to mid-July. As previously noted, however, the disease often begins in August or September in many regions. Hence, **you need to know when the disease develops in your region to properly time the first spray. Field observations indicate that the disease is best managed before any blighting becomes evident.** Once

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JB COMMENTS

The Diversity in Evapotranspiration Rates of Turfgrasses

There are major differences in the evapotranspiration rates among many turfgrass species, especially under peak environmental conditions, which maximize the evapotranspiration rate. Unfortunately, this water conserving characteristic is not being utilized sufficiently. **Evapotranspiration rate (ET)** is the amount of water evaporated from a turf area per unit of time. It may be expressed as inches per week (in./wk) or mm/day (mm/d). The relative maximum evapotranspiration rates of 21 turfgrasses when grown in their respective climatic regions of adaptation and preferred cultural regime are shown in the accompanying table.

Any cultural and/or environmental factors that alter the leaf area or shoot density of a given turfgrass species may result in a significant shift in its relative ranking compared to the other species. Cultural factors that contribute to an increased evapotranspiration rate include (a) higher cutting height, (b) higher nitrogen nutritional level, which stimulates the leaf extension rate and resultant leaf area, and (c) high to excessive irrigation rate and/or frequency, which increases the stomatal density on leaves. Typically, turfgrass species that have a higher shoot density, narrower leaf width, and more horizontal leaf orientation tend to have a lower evapotranspiration rate than the more erect, low-density, wide-leafed species. The peak ET rates can range from 3 to 12 mm per day among turfgrass species. It should be noted that certain cultivars ranking lower in ET rate can exhibit ET rates in the 1.5 to 2.0 mm per day range under conditions of minimal to low evaporative demand.

Relative Ranking*	ET Rate ($mm\ d^{-1}$)	Turfgrass
very-low	< 6	American buffalograss
low	6–7	**hybrid bermudagrass centipedegrass **dactylon bermudagrass **zoysiagrasses
moderate	7–8.5	hard fescue Chewings fescue red fescues bahiagrass seashore paspalum St. Augustinegrass
high	8.5–10	perennial ryegrass common carpetgrass kikuyugrass tropical carpetgrass
very high	>10	tall fescue creeping bentgrass annual bluegrass *Kentucky bluegrass rough bluegrass annual ryegrass

*Based on the most widely used cultivars of each species.

**Significant variability occurs among cultivars within the species.

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blighting appears, a high rate of Daconil® should be tank-mixed with one of the aforementioned penetrants. Affected areas should then be re-treated in 5 to 7 days with another application of Daconil®. Thereafter, tank-mix combinations will likely be required on 10- to 21-day intervals, depending on the fungicide, rate applied, and environmental conditions. It is important to use high water volumes of greater than 50 gallons per acre (470 L/ha), and to delay mowing for 24 hours following the application. **Vigilant scouting for gray leaf spot requires almost daily attention from July through October.** The disease can be very active in September and October, and is especially destructive to new seedlings in overseeded areas previously damaged by gray leaf spot.

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