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Gray Leaf Spot
An Emerging Disease of Perennial Ryegrass

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Perennial ryegrass has increased in popularity for a variety of turfgrass uses. In Kentucky and most of the transition zone, this cool-season grass is widely used for fairways, tees, green surrounds, approaches and roughs. Many golfers find this grass to be their preferred choice for fairways. In locations further north, perennial rye is used alone or in combination with Kentucky bluegrass. In most southern locations, it is used for overseeding bermudagrass fairways and greens.

During the hot, very humid weather of the summer of 1995, perennial ryegrass swards in many areas of the transition zone suffered severe to catastrophic epidemics of wilting, blighting and turf loss. At that time, several plant pathologists suspected that a leaf-infecting fungus called *Pyricularia grisea* was the cause of these epidemics. However, conclusive proof that this fungus was indeed the cause was lacking. It is interesting to note that, as recently as four years ago, we knew so little about this disease of perennial ryegrass that turfgrass scientists were disagreeing as to what actually killed the turf.

Since 1995, epidemics of gray leaf spot on perennial ryegrass have been diagnosed throughout the transition zone from New Jersey to Virginia and as far west as Kansas. Significant outbreaks north of the transition zone have been observed in Connecticut, Rhode Island, southern Pennsylvania, southern Ohio, Iowa, southern Illinois and eastern Nebraska.

Much has been learned about gray leaf spot since the 1995 epidemic, including the fact that the fungus *Pyricularia grisea* is indeed the cause of widespread loss of perennial ryegrass in many regions.

The Pathogen

Pyricularia grisea is known to infect plants in over 20 genera of grasses. The first destructive outbreak of this pathogen on perennial ryegrass was observed as early as 1986 by Dr. Pete Dernoeden in Maryland. However, until the 1995 epidemic, gray leaf spot was not considered a significant disease threat over most of the area of perennial ryegrass adaptation. Among turfgrasses, *P. grisea* is also known to attack St. Augustinegrass and tall fescue. It is also possible to find leaf spots caused by *P. grisea* on certain weed grasses — notably large crabgrass and foxtails — as well as on German foxtail millet.

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This fungus infects the foliage, causing leaf spots and blighting. Under humid conditions, *P. grisea* produces microscopic spores on both upper and lower surfaces of infected leaves. These spores are produced on microscopic stalks so that the spores are held above the leaf surface, ready to be carried by air movement when dislodged.

Leaf wetness, high humidity and suitable temperatures are the three most important environmental factors that govern infection and by sporulation of *P. grisea*. Increasingly longer periods of leaf wetness allow for increasingly greater levels of infection. Studies indicate that temperatures in the high 70s to low 80s EF are ideal for infection of ryegrasses. On annual ryegrass, wetting periods with a temperature of 95EF had greatly reduced infection levels, so apparently high temperatures during wetting periods can inhibit infection activity by the fungus. While temperature can influence activity of *P. grisea*, it also may affect the susceptibility of perennial ryegrass to infection. One of our knowledge gaps is an understanding of how periods of high temperatures may predispose perennial ryegrass to infection — that is, increase its susceptibility.

Although tall fescue is also a host, it is generally regarded as less susceptible than perennial ryegrass. Epidemics of gray leaf spot on tall fescue have been reported in the southeastern-most portion of the range of this cool-season grass, namely in Georgia and in the Carolinas. Encouragingly, some varieties of tall fescue show substantial resistance to gray leaf spot and may even be a source of resistance genes for perennial ryegrass.

Recent studies of the molecular genetics of *P. grisea* by Dr. Mark Farman at the University of Kentucky have given us important insights into this fungus. His DNA fingerprinting studies, using neutral genetic markers, have shown that the strains of *P. grisea* that attack perennial ryegrass and tall fescue (hereafter referred to as prg/tf strains) are very nearly identical to one another and completely different from the strains which infect all other grasses. He also has found that prg/tf strains exhibit extremely little genetic diversity, even when collected from different regions of the U.S. These research findings have several important implications:

(1) Even though *P. grisea* infects many grass species, grasses other than tall fescue are not sources of inoculum for outbreaks of gray leaf spot on perennial rye.

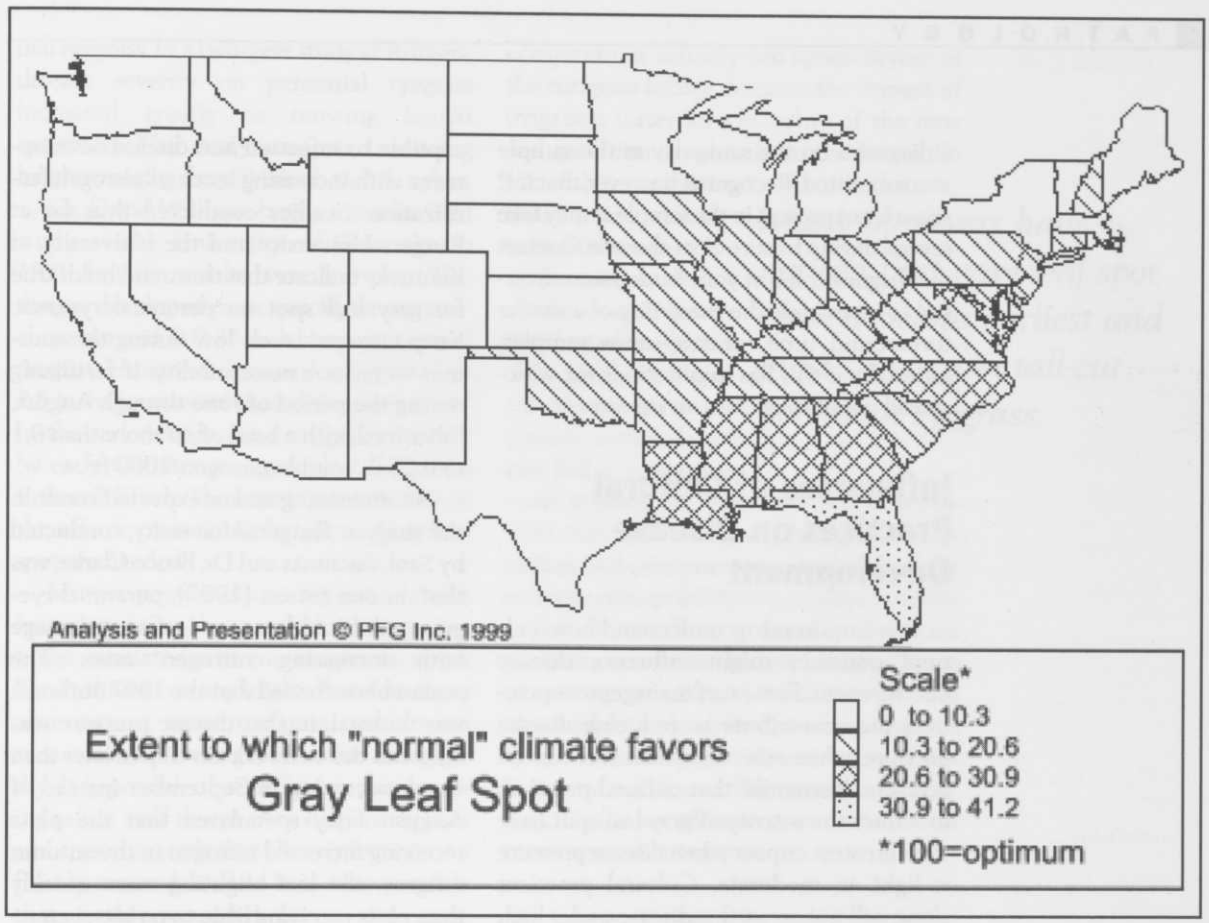
(2) The prg/tf strains of *P. grisea* that are wreaking so much havoc across much of the nation originated from some single, unidentified source.

(3) There appears to be no sexual recombination in prg/tf strains of *P. grisea* thus far. Consistent with this conclusion is the fact that the sexual stage of this fungus — which is known among plant pathologists by the name *Magnaporthe grisea* — has not yet been found in nature on perennial ryegrass. This is reassuring, because sexual reproduction would greatly increase genetic variability in the fungus. This, in turn, would also reduce the chances of long-term success through breeding for resistance and it would also increase the risk of fungicide resistance.

Symptoms

On established perennial ryegrass, the disease first appears as patches an inch or two in size and the leaf blades turn a reddish-brown color. These initial infections can enlarge to patches a foot or two in size within days. As the disease progresses, large, diffuse areas of turf can quickly become blighted. Affected turf often appears wilted despite adequate irrigation. In extremely severe outbreaks, most or all of the turf is killed.

Several types of symptoms can be found when individual leaves are inspected. Sometimes one can find brown, oval lesions which develop tan centers as they expand. These lesions can look very similar to "Helminthosporium" leaf spots. *P. grisea* may also produce leaf spots which are gray in color and which sometimes develop a yellow halo. These are often most common along the margin of leaf blades, a unique



feature of this disease. In yet other instances, infected leaves, especially the youngest leaves, may simply develop an olive-green, watersoaked appearance with no indication of a discrete lesion. When the youngest leaves of perennial ryegrass are infected and killed by *P. grisea*, they sometimes appear twisted and curled, a symptom referred to as a "fishhook" symptom.

Seedlings of perennial ryegrass are very susceptible to gray leaf spot. Plants less than 8 to 12 weeks old may rapidly blight. New seedings often fail when the disease is active during emergence and establishment.

P. grisea produces sporulation on diseased tissues under humid conditions. The fungus has a remarkable ability to produce very dense sporulation overnight on both upper and lower leaf surfaces. Dense sporulation looks like a grayish felt with a hand lense or even with the naked eye. No foliar mycelium is visible on diseased tissues. All of the fungal mycelium is within infected leaf blades and sheaths.

Scouting

Gray leaf spot commonly first appears in tall-cut perennial ryegrass, such as roughs, green surrounds or lawns. For scouting purposes, it is convenient that the disease is commonly first observed in roughs, since golfers are often more tolerant of disease damage in low-maintenance turf. The disease is commonly observed first in "heat-sink" areas: southern slopes and areas where the turf is exposed to long periods of summer sunshine. Some observers also note that it develops early in areas of cart traffic or other sites with compacted soil. Therefore, concentrate on these areas when scouting for early activity of gray leaf spot.

Questionable samples should be examined microscopically for confirmation of the pathogen. In our Plant Diagnostic Laboratory at the University of Kentucky, such samples are treated as high priority. When a sample is infected, positive diagnosis is usually possible within 24 hours and it is not unusual for us to provide the superintendent with

a diagnosis on the same day as the sample was submitted. Recognize, however, that if *P. grisea* is not present in the sample, it may take several days to be sure of its absence. Contact the diagnostic lab at your land-grant university to investigate the possibility of a similar turnaround time for suspicious samples, especially if this has implications for widespread use of fungicides on fairways.

Influences of Cultural Practices on Disease Development

It is important to understand how cultural practices might influence disease development. Some turf management practices may contribute to reducing disease pressure, while others may enhance disease pressure. Recognize that cultural practices to reduce the activity of gray leaf spot have their greatest impact when disease pressure is light to moderate. Cultural practices alone will not arrest this disease under high disease pressure and many superintendents will find it necessary to use fungicides preventively.

Variety Selection

There is rather strong evidence from several sources that, under severe disease pressure, all commercial perennial ryegrass varieties are susceptible to gray leaf spot and can suffer extensive turf loss. There is limited data (one site, one year) showing that some varieties are less susceptible than others under conditions of light to moderate pressure. These data are available through the National Turfgrass Evaluation Program. Superintendents may wish to consider these data when selecting varieties, but realize that all varieties of perennial ryegrass have the potential to be severely affected by the disease under high disease pressure.

Nitrogen Fertilization

Numerous studies on *P. grisea* have shown that grasses are typically more susceptible to infection and disease development with increasing levels of nitrogen fertilization. Studies conducted thus far at Rutgers University and the University of Kentucky indicate that this trend holds true for gray leaf spot on perennial ryegrass. Keep nitrogen levels low during the summer to reduce susceptibility. If fertilizing during the period of June through August, foliar-feed with a total of no more than 0.1 to 0.25 lb. soluble nitrogen/1000 ft^2.

An interesting and unexpected result in the study at Rutgers University, conducted by Saul Vaiciunas and Dr. Bruce Clarke, was that, in one season (1997), perennial ryegrass exhibited less gray leaf spot damage with increasing nitrogen rates. The researchers stressed that the 1997 outbreak was unusual, in that disease pressure was light and the outbreak developed later than usual, occurring in September instead of August. They speculated that the plots receiving increased nitrogen in the autumn outgrew the leaf blighting more quickly than plots receiving little to no nitrogen.

In 1998, a year of high disease pressure, increasing nitrogen rates were associated with increasing disease severity in the Rutgers study. Thus, the Rutgers research emphasizes the need to keep nitrogen levels low during the summer, so as to not enhance susceptibility of the grass should disease pressure become high. However, the Rutgers researchers suggest that their results in 1997 indicate that nitrogen fertilization in late summer and early fall may help the turf outgrow damage as long as disease severity is light to moderate.

Questions also arise regarding how the source of nitrogen might influence gray leaf spot development. Relatively little research addressing this issue has been conducted in turfgrass hosts of *P. grisea* as a whole. No such tests have been conducted in perennial ryegrass and are sorely needed.

Mowing

Mowing height: Many observers have noticed that gray leaf spot often develops earliest and most severely in tall-cut peren-

nial ryegrass. In a two-year study at Rutgers, disease severity on perennial ryegrass increased greatly as mowing height increased. The study compared mowing heights ranging from 0.5 inch to 3.5 inches.

Dr. David Williams began a similar field study at the University of Kentucky in 1998, but the results were less clear. The disease developed more quickly in perennial rye mowed at 0.75 inch through most of August. However, disease development at 2.5 inches surpassed that of the shorter turf by the end of August and turfgrass recovery by early October was greater at 0.75 inch than at 2.5 inch. Thus, continuing studies on the effects of mowing height on gray leaf spot are needed.

Mower passes: Some superintendents have noted that the gray leaf spot is sometimes associated with mower passes, much like Pythium cottony blight. Based on these observations, some turfgrass pathologists recommend mowing when the foliage is dry. It is possible that early-morning mowing when turf is wet may disperse spores and create wounds that allow infection into freshly-mowed blades. It is also possible that freshly-wounded leaves are more aggressively colonized by *P. grisea* than unwounded leaves. This is another area where controlled research is needed.

Clipping removal: One study in St. Augustinegrass showed that removing clippings reduced gray leaf spot damage when disease pressure was low, but had no effect when disease pressure was high. A study at Rutgers showed a similar effect on some, but not all, entries of perennial ryegrass and tall fescue. Based on field observations, some turfgrass scientists have suggested that clipping removal on greens collars and approaches may reduce infection activity when disease pressure is light to moderate.

Other Practices

Foliar diseases caused by fungi are commonly enhanced when turf is irrigated at dusk as opposed to early morning. Irrigating at dusk allows long periods of leaf wetness that favor infection by foliar pathogens. In contrast, irrigation near sunrise can help reduce disease pressure. Even though early morning irrigation adds water to the turf ecosystem, it actually can speed drying of the turfgrass foliage, because the impact of irrigation water knocks many of the dew and guttation droplets from the leaves. So schedule irrigation near sunrise whenever possible.

Many observers have noticed that gray leaf spot often develops earliest and most severely in tall-cut perennial ryegrass.

A serious deficit exists in our understanding of the factors that predispose perennial ryegrass to explosive outbreaks of gray leaf spot. There is some speculation, based on field observations, that applications of plant growth regulators and postemergence herbicides may enhance susceptibility of perennial ryegrass to this disease. Testing the effects of such products have been limited, but in one year of testing, no disease enhancement was observed from Acclaim Extra on perennial ryegrass (University of Kentucky) nor from Primo on tall fescue (University of Georgia). This is an additional area that needs more research attention.

Fungicidal Management

There is a widespread consensus that, in areas with a substantial risk, most superintendents are faced with need to use fungicides preventively on perennial ryegrass. When the logarithmic phase (the period of rapid disease increase) kicks in, this disease is rapid and extremely destructive. Those who have direct experience with this disease know that fungicidal protection is needed against this disease before it "explodes" into a full-scale epidemic.

This is not to suggest that all perennial ryegrass should be treated aggressively for gray leaf spot. It has not been reported in all areas where perennial rye is grown. Furthermore, some growing seasons are not conducive for epidemics of gray leaf spot. However, it is a dynamic and emerging problem. Some areas, such as southern Connecticut, Rhode Island, Iowa and eastern Nebraska, developed the disease for the first time last year.

We understand very little about the conditions that lead to the logarithmic phase in natural turfgrass swards. Given our current

state of knowledge, no one can positively identify those locations nor forecast those seasons when superintendents can safely withhold all preventive sprays.

Learn as much as you can about disease development in your area, and be informed about what turfgrass scientists know about the disease for your region. Also, scout for the disease, so as to get optimal protection from the fungicides used.

Timing and Efficacy

Research-based comments regarding the timing and efficacy of labeled fungicides are obviously important for readers. This article provides comments based on a careful study of available research, much of which can be found in recent and forthcoming volumes of the journal *Fungicide and Nematicide Tests*, published by APS Press. The comments provided are consistent with the labels of products mentioned. However, fungicide labels do change, and the only valid guides regarding legal rates and timing of fungicides are the product labels themselves.

Seedings made in mid- to late-summer might need preventive fungicide protection from emergence until near the first frost.

On established perennial ryegrass, preventive fungicide protection is needed prior to the logarithmic phase of the disease. The first lesions of gray leaf spot may appear six weeks or more prior to this phase, but the logarithmic phase is the time when protection is critical. In many areas, this phase commonly occurs sometime during the first three weeks of August.

However, in some locations, such as eastern and central Maryland, the logarithmic phase can occur as early as mid-July. In other locations, especially at the more northern range of occurrence, this phase may not develop until around, or after, Labor Day. Again, this reinforces the value of scouting your own course.

Seedlings are more susceptible to gray leaf spot than is established turf. Seedings made in mid- to late-summer may need preventive fungicide protection from emergence until near the first frost.

Azoxystrobin (Heritage) and thiophanate-methyl (Cleary's 3336) are the only labeled fungicides shown to be effective against gray leaf spot under high disease pressure (Table 1).

Heritage 50WG at 0.4 oz. can be expected to provide a minimum of three weeks of protection under high disease pressure. Heritage 50WG at 0.2 oz. at 2 to 3 week intervals also has worked very well in several tests, although some loss in disease control has been observed in some studies.

Cleary's 3336 F at 6 fl. oz. at a two-week spray interval has provided excellent control in almost all studies, although control slipped slightly at the end of the two-week interval in one study at the University of Maryland. The 8 fl. oz. rate of Cleary's 3336 F applied at a maximum of two-week intervals may be necessary for assuring excellent disease control in all circumstances. Given the research to date, stretching the spray interval for Cleary's 3336 F beyond two weeks not only exceeds the instructions on the label, but also is unwise in the event that disease pressure becomes intense.

Studies to date suggest that several labeled fungicides would fall into the "second tier" for gray leaf spot control. These are products that, in my opinion, can be expected to provide adequate disease control under low to moderate pressure, but inadequate disease control under high disease pressure. Products which fall into this category include: those containing chlorothalonil (Daconil and related products), propiconazole (Banner) and cyproconazole (Sentinel). In fairness, it is important to note that Daconil products have only been tested at two-week spray intervals, whereas the labeled spray interval for gray leaf spot is actually 7-10 days. Thus, studies are needed to evaluate chlorothalonil at a shorter spray interval. However, until such studies are conducted, I opt for the conservative approach and consider it a Tier II product based on the best data available to date.

It is noteworthy that iprodione (Chipco 26GT) and flutolanil (Prostar) — fungicides commonly used for brown patch control on perennial ryegrass — are ineffective against gray leaf spot.

Fungicide Resistance

Azoxystrobin and thiophanate-methyl are clearly key players for gray leaf spot control. However, superintendents are advised not to rely exclusively on these products for gray leaf spot control. Azoxystrobin and thiophanate-methyl are systemic fungicides with a significant potential for resistance development.Both chemicals are toxic to fungi by different biochemical modes of action and strains of *P. grisea* resistant to one fungicide would not be expected to be resistant to the other. Yet, *P. grisea* is remarkably adaptable to new control strategies, so I have great concern that repeated, widespread use of these fungicides could lead to a buildup *P. grisea* strains resistant to both fungicides in a short time. Therefore, superintendents across the nation would be well-advised to practice appropriate resistance management strategies. Such strategies would include using all reasonable cultural practices to reduce disease pressure and avoiding exclusive use of fungicides with a similar mode of action.

Based on my assessment to date, it seems that the most sensible use of azoxystrobin and thiophanate-methyl is to apply them during the period of greatest risk — the period when logarithmic disease increase is likely — and to use Tier II products when the risk of disease is low to moderate. This balances the need for excellent disease control with concerns about fungicide resistance as well as cost of the Tier I products (Table 2).

In 1999, we will conduct studies at Griffin Gate Golf Club in Lexington to evaluate the efficacy of fungicide programs designed for resistance management. For example, in central Kentucky logarithmic disease increase in established perennial ryegrass usually occurs sometime during the first two weeks of August. However, substantial disease activity can occur through the end of September and possibly later for seedlings. Thus, one of the treatment programs we'll be testing is Daconil applied in mid-July, followed with Heritage sometime during the first week of August and then Banner or Daconil in mid-September.

TABLE 1. EFFICACY OF FUNGICIDES FOR GRAY LEAF SPOT

Product	Active ingredient	Fungicide Group[2]
Tier I[1]		
Heritage	azoxystrobin	Strobilurin
Cleary's 3336	thiophanate-methyl	Benzimidazole
Tier II[1]		
Daconil Ultrex	chlorothalonil	Multisite contact
Banner	propiconazole	DMI
Sentinel	cyproconazole	DMI
No meaningful efficacy		
Chipco 26019	iprodione	Dicarboximide
Prostar	flutolanil	Benzamide

1. Tier I fungicides are those that, in studies to date, have generally provided good to excellent disease control under severe disease pressure. Tier II fungicides are those that, to date, provide good to excellent control under low to moderate pressure but unacceptable disease control under high disease pressure.

2. Fungicides in the same fungicide group have a similar biochemical mode of action. Superintendents are advised to rotate among (or tank-mix) systemics and contacts or among systemics in different fungicide groups.

Why Is Gray Leaf Spot an Emerging Disease?

Although there are still many unanswered questions, I believe a reasonable explanation for the emergence of gray leaf spot in recent years is analogous to a predator/prey relationship: a steady increase in the use of perennial ryegrass has allowed the buildup of prg/tf strains of *P. grisea*.

A steady increase in the geographic range of P. grisea on perennial ryegrass has been reported each year since 1995.

In the late 1960s, varieties of perennial ryegrass suitable for use on golf courses became commonly available. In the 1980s and early 1990s, acreage of golf turfs sown to perennial ryegrass grew steadily, because of the many agronomic advantages of this grass. The first report of serious damage came as early as 1986, on a golf course in Maryland.

In 1991, as the fungus spread, more frequent reports occurred from several areas in the transition zone, including Pennsylvania, Maryland, and Kansas. Prg/tf strains of *P. grisea* had spread throughout much of the transition zone by 1995 and, with the hot, humid summer that year, an epidemic developed in many areas across the transition zone. A steady increase in the geographic range of *P. grisea* on perennial ryegrass has been reported each year since then. The molecular genetics studies of Dr. Farman's support this explanation: the lack of significant genetic diversity of the prg/tf strains from across the U.S. suggests that these strains originated and spread from some single, unidentified source.

No matter where *P. grisea* originated from, it is clear that the disease is well-established in the transition zone and may constitute an endemic threat to areas further north. Learn what you can about the disease, watch for new research developments and consider the possibility of changing to other suitable species of turfgrasses if the opportunity arises.

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TABLE 2. FUNGICIDE COSTS FOR GRAY LEAF SPOT

Product	Rate	No. Appl.	Cost ($) Per appl.	Cost ($) per season
Heritage 50 WG	0.4 oz	2	11,108	22,215
Cleary's 333650WP	6 oz	4	9,287	37,146
Daconil Ultrex	3.7 oz	6	2,691	16,145
Banner MAXX	2 fl oz	4	5,084	20,337

Assume: preventive treatment for 8 wk (26 Jul - 20 Sep)
30 acres of fairway\par
Prevailing prices in Lexington in March 1999