

Gray leaf spot in the West

A new disease of perennial ryegrass and kikuyugrass has become established in California and Nevada.

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In 2003, the California turf industry was affected by the widespread emergence of gray leaf spot caused by the fungus *Pyricularia grisea* as a new disease of perennial ryegrass (*Lolium perenne*) and kikuyugrass (*Pennisetum clandestinum*). Since the 1970s, the disease had been found in California on St. Augustinegrass (*Stenotaphrum secundatum*) (5), but it was not reported on perennial ryegrass until 2001 (8) and only reported on kikuyugrass in 2003 (11). Within the span of five years, gray leaf spot appears to have established itself strongly within California and has now been found in the neighboring state of Nevada.

Gray leaf spot on the West Coast

Origins of the invasion

Gray leaf spot was first seen in California in 1972, when K. Mueller, a University of California Cooperative Extension Farm Advisor, had noticed its presence on St. Augustinegrass in Orange County and other parts of Southern California (5). Because the weather in Southern California is relatively dry and mild compared with the southeastern United States, where gray leaf spot has been more of a problem on St. Augustinegrass, the disease was considered a very minor threat and likely to be a problem only on heavily irrigated and overfertilized St. Augustinegrass lawns.

In 1996, rice blast, a serious disease of cultivated rice, also caused by *Pyricularia grisea*, appeared for the first time in California in Sacramento Valley rice fields (1). Five years

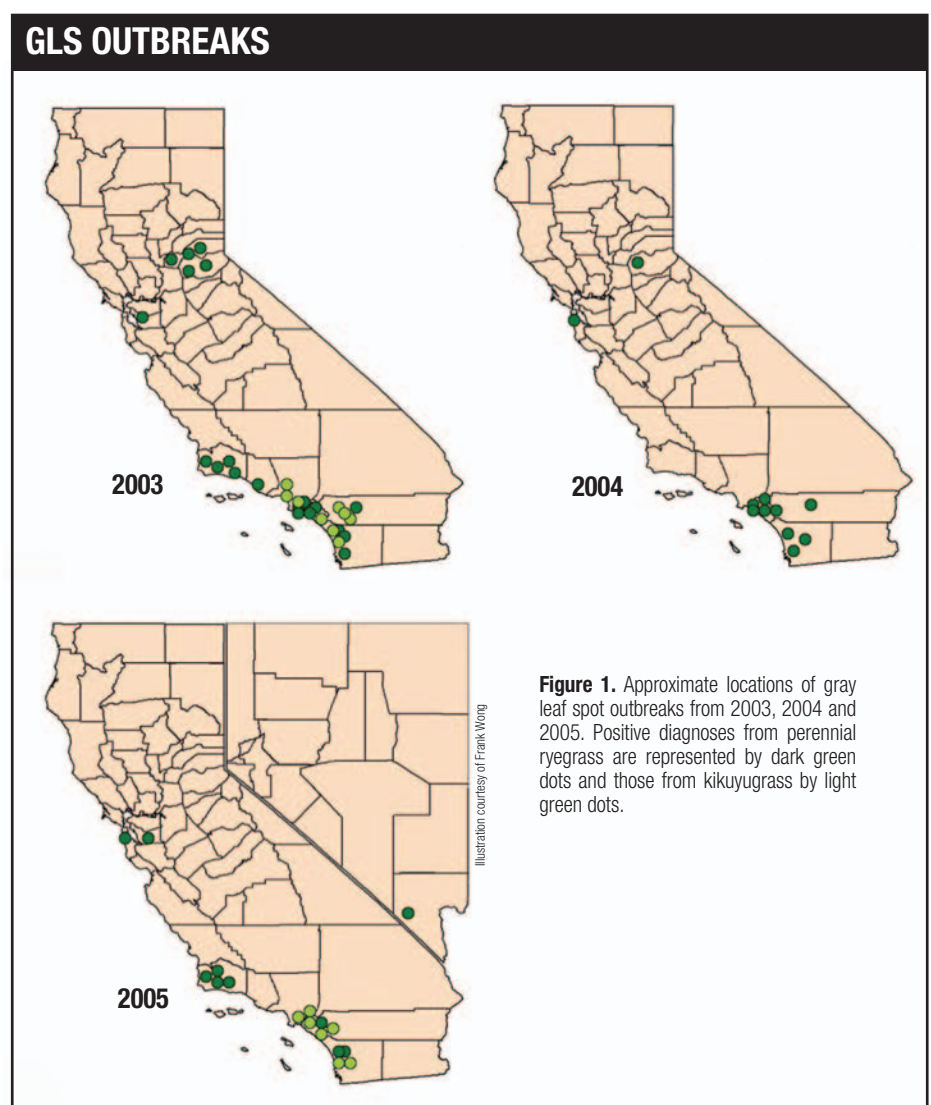


Figure 1. Approximate locations of gray leaf spot outbreaks from 2003, 2004 and 2005. Positive diagnoses from perennial ryegrass are represented by dark green dots and those from kikuyugrass by light green dots.

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later in 2001, gray leaf spot was detected in Southern California on perennial ryegrass in a Los Angeles sports stadium (7). That same year Larry Stowell, Ph.D., diagnosed the disease on two golf courses, one in the San Diego area and the other in the Sacramento area.

Subsequent research by pathologists from the University of California–Davis indicated that the rice blast isolates from Northern California were unable to infect perennial ryegrass and St. Augustinegrass, and it seemed that the appearance of the fungus in two different crops, rice and turfgrass, was not related. In 2002, no gray leaf spot diagnoses were made on turfgrass in California, suggesting perhaps that the appearance of the disease was an anomaly and that gray leaf spot was not going to be a problem for turfgrass in the state.

Establishment and a new host

In 2003, brief but sudden thunderstorms in the Sierra Nevada foothills in July with air temperatures near 90 F brought the appearance of a blight on a number of newly established perennial ryegrass approaches on a golf course in Meadow Vista, Calif., roughly 45 miles northeast of Sacramento. Northern California Golf Association agronomist Mike McCullough suspected the damage was caused by gray leaf spot, and samples

were subsequently sent to the University of California–Riverside, where the presence of the fungus was confirmed. McCullough's site visits to neighboring locations revealed that perennial ryegrass fairways and roughs on four other courses in the area had also been affected by the disease.

A joint effort was made by the Northern California Golf Association, the University of California–Riverside and PACE Consulting to inform the industry of the risk of gray leaf spot, hoping that the disease would be limited to the Sierra Nevada foothills area. Shortly after the information was passed to the golf industry, David Major, CGCS at Shady Canyon Golf Club in Irvine, contacted the University of California–Riverside with perennial ryegrass samples he suspected of having gray leaf spot. The samples were positive. Therefore, it appeared that near-simultaneous outbreaks of gray leaf spot had occurred on perennial ryegrass in both Northern and Southern California.

At about the same time, Stowell received samples from a kikuyugrass fairway in downtown Los Angeles that was showing signs of blight similar to *Rhizoctonia* blight, brown patch or *Pythium* blight. The sample showed profuse sporulation and damage from gray leaf spot; for the first time the disease had appeared on kikuyugrass in the United States (11).

From July to November 2003, gray leaf spot was diagnosed at 30 locations by labs at the University of California–Riverside and PACE Consulting (Figure 1). Twenty-two samples were from perennial ryegrass and 10 from kikuyugrass; one location had gray leaf spot on both turf species. The extended period over which positive diagnoses were being made reflected both the temperate climate in California and the diverse geography and climates in the state that allowed the disease to develop.

Gray leaf spot was most prevalent on coastal golf courses in Southern California, and damage in some cases was very severe (Figure 2). In Northern California, it appeared to be limited to the Sierra Nevada foothills; although one diagnosis was made from a course in the East Bay area near San Francisco. Although the disease was found as far inland as Calimesa (approximately 90 miles inland), no courses in the Coachella Valley (Palm Springs) area appeared to be affected.

Gray leaf spot spreads in the West

In 2004, gray leaf spot was diagnosed from only 11 locations (Figure 1), all on perennial ryegrass. It appeared that the turf industry had responded to the disease and was taking steps to prevent its development. Of significance was the detection of the disease at a course in Menlo Park, another San Francisco Bay Area location, indicating that gray leaf spot was now established in three major metropolitan areas of the state.

In 2005, the disease was diagnosed from 17 locations, with seven diagnoses on kikuyugrass and 10 on perennial ryegrass. Above-average winter rainfall in many parts of the state likely created favorable conditions for the survival of gray leaf spot through the winter, resulting in a rise in gray leaf spot incidence as compared to 2004.

In August 2005, gray leaf spot surprisingly appeared on perennial ryegrass fairways on at least one golf course in Las Vegas (Figure 3). The course had 100% perennial ryegrass fairways, and the disease appeared after two weeks of temperatures above 90 F (32.2 C) and two days of showers on Aug. 9 and 14. The discovery of gray leaf spot in Las Vegas was shocking, but given the high summer temperatures, humid weather and the amount of irrigation needed to maintain a cool-season grass in hot, arid conditions, it was clearly possible. Other courses in the Las Vegas area and in St. George, Utah, also



Photos courtesy of Frank Wong

Figure 2. Gray leaf spot damage in 2004 on a perennial ryegrass fairway in Newport Coast, Calif.

reported gray leaf spot-like symptoms on perennial ryegrass in 2005, but the disease was not confirmed in those cases. With the appearance of gray leaf spot in California and Nevada, it is safe to say that this disease is firmly established in the West (Figure 1).

Tracking the pathogen

Since the appearance of gray leaf spot in the United States on perennial ryegrass in 1991 in Pennsylvania, the disease has spread steadily along the East Coast and into the Midwest. Gray leaf spot is able to move long distances by wind or splash dispersal of spores. *Pyricularia grisea* can also survive in debris and old plants as well as in seed, although seed-borne gray leaf spot is unlikely to have played a role because gray leaf spot has not yet been found in any of the seed-producing regions in the Pacific Northwest. The wind could have carried the disease into California; the disease could have been brought in on debris from the eastern United States; or it could have spontaneously arisen from native populations already in the state. Currently, the turf pathology programs at University of California–Riverside and Penn State are using molecular analyses of the DNA of isolates recovered from California to determine how closely western gray leaf spot populations are related to those from the East.

Because the pathogens for rice blast and gray leaf spot are very similar biologically, it is helpful to draw comparisons between the two systems. In previous work describing the threat of rice blast to California (2), it was determined that California had permissive, but not conducive, conditions for the development of the fungus in the northern Central Valley. Spore release was usually maxi-



Figure 3. Gray leaf spot damage in 2005 on a perennial ryegrass fairway in Las Vegas.

mal near 6 a.m., with leaf wetness periods lasting only from 8 to 9 p.m. until 10 a.m. to noon, meaning that generally, there were only four to six hours of leaf wetness when the fungus could infect plants. Thus, it was generally assumed that this fungus would not be able to survive in the warm, arid conditions of the West.

However, unlike the Central Valley, which tends to have clear summer nights, the coastal areas and inland microclimates where turf is grown frequently have summer cloud cover. Nighttime cloud cover has been known to increase the release of *P. grisea* spores and

likely increase the potential infection periods in these areas (3).

By extending periods of leaf wetness, the frequent irrigation of turfgrass to meet plant needs in summer has also likely led to the development of gray leaf spot in turf. For perennial ryegrass and kikuyugrass, other irrigation-related diseases can also play a part in the summer stress complex that leads to gray leaf spot development. *Bipolaris* leaf spots are common on both turf types in the summer and more frequent on heat- and drought-stressed turf. For kikuyugrass, many locations are affected by kikuyugrass

GRAY LEAF SPOT VS. TURF

Isolate	Origin	Reaction on kikuyugrass*	Reaction on perennial ryegrass*
CCCC-1	kikuyugrass	+++	—
OSGC-1	kikuyugrass	+++	—
SRCC-1	perennial ryegrass	—	+++
SRCC-2	perennial ryegrass	—	+++

*+++ = development of disease; — = no disease development.

Table 1. Host specificity of four gray leaf spot isolates to kikuyugrass and perennial ryegrass. Six-week-old seedlings of either kikuyugrass variety AZ-1 or perennial ryegrass (a blend of Kokomo, Cabo and Secretariat) were inoculated with a spore suspension of 1×10^5 conidia/milliliter and incubated for seven days at 86 F (30 C) and 100% relative humidity. Six pots of plants were used for each experiment, which was repeated three times.

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decline, caused by *Gaeumannomyces graminis* var. *graminis*. Superintendents tend to over-irrigate to reduce the effects of both *Bipolaris* leaf spot and kikuyugrass decline, but, by doing so, they can be setting themselves up for gray leaf spot.

Research results so far

Host-specificity of gray leaf spot strains

So far, it appears as if isolates of gray leaf spot that infect perennial ryegrass cannot infect kikuyugrass and vice versa. Isolates OSGC-1 and CCCC-1 obtained from infected kikuyugrass and SRCC-1 and SRCC-2 obtained from perennial ryegrass were used in pathogenicity testing. OSGC-1 and CCCC-1 were able to infect kikuyugrass seedlings but not perennial ryegrass. SRCC-1 and -2 were able to infect perennial ryegrass but not kikuyugrass (Table 1). Work is continuing to determine whether these isolates can infect St. Augustinegrass or fescue (*Festuca* species). Since the temperature and leaf wetness optima for gray leaf spot on Ital-

ian and perennial ryegrass and tall fescue appear to be very similar (7), it is likely that disease development on kikuyugrass would also take place at the same leaf wetness and temperature range (79-84 F [26.1-28.8 C]).

The risk of resistance

Fungicide resistance development for gray leaf spot has been a concern since resistance to the QoI fungicides (Heritage, Insignia, Compass) was detected in the eastern United States (4,10). In 2003 and 2004, 74 isolates of gray leaf spot were collected from nine California locations, and in 2005, 46 isolates were collected from nine locations and tested for sensitivity in the laboratory against the QoI fungicide azoxystrobin, the active ingredient in Heritage.

The majority of the isolates collected in 2004 were highly sensitive to azoxystrobin, with the exception of four isolates from a single location in Northern California that showed some tolerance to azoxystrobin. Those four isolates were approximately 144 times less sensitive to azoxystrobin. Cyto-

chrome *b*, the fungicide target gene from the pathogen, was sequenced for these four isolates using previously published information (4). For these isolates, a mutation was characterized as an amino acid substitution at position 129, changing phenylalanine to lysine (F129L). The F129L mutation in the population was typical of the partial-resistance phenotype previously described (4); these isolates are only partially controlled by labeled rates of QoI-fungicides.

In 2005, a number of isolates showed some amount of tolerance to azoxystrobin when tested at the discriminatory doses of 8 parts per million, a dose at which it appeared tolerant isolates could be detected. Compared to isolates collected in 2004, there appeared to be a larger shift in tolerance in the tested isolates, with at least three of them appearing highly tolerant to the fungicide (Figure 4). These isolates are being characterized further as being tolerant or immune in laboratory assays.

For all 120 isolates tested in 2004 and 2005, none appeared to be resistant to the benzimidazole fungicide thiophanate-methyl. On the courses, there appeared to be no performance issues with products that contain this active ingredient (Cleary's 3336, Fungo).

Work in progress and future objectives

One of the major issues with regard to the management of gray leaf spot in the West is that Western superintendents traditionally do not apply fungicides to control diseases in fairways. The high costs of a summer-long spray program would be impossible for some locations to afford. Because the climate is drier, the disease pressure in California is generally lower, and it was hypothesized that fungicide programs could be reduced. Experimental test plots have been established to test the possibility of using a reduced spray program combined with a perennial ryegrass variety that tolerates gray leaf spot. Although data from the first year should be considered with caution, they hold some promise, and future work on the use of gray leaf spot-tolerant varieties is planned.

The origin of the isolates causing gray leaf spot on perennial ryegrass and kikuyugrass (Figure 5) in the West are still unknown, but a number of molecular techniques can help solve the puzzle (9). In collaboration with Wakar Uddin, Ph.D., from Penn State

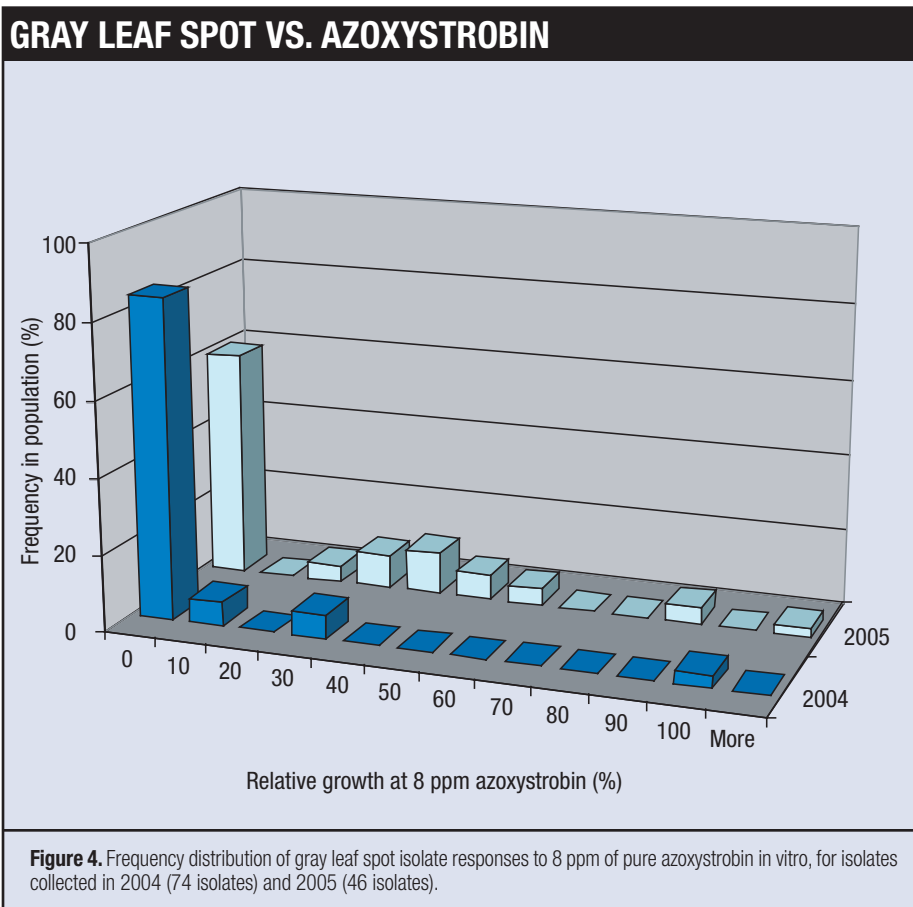


Figure 4. Frequency distribution of gray leaf spot isolate responses to 8 ppm of pure azoxystrobin in vitro, for isolates collected in 2004 (74 isolates) and 2005 (46 isolates).

University, we will compare 84 isolates collected from 2003 through 2005 to known isolates from the East Coast using amplified fragment-length polymorphism analysis, which has been used successfully to characterize populations of the pathogen in other studies (6).

Future work will also focus on determining the epidemiology and susceptibility of kikuyugrass to the disease, evaluating gray leaf spot-tolerant perennial ryegrass varieties in western climates, and creating sound gray leaf spot management programs with reduced fungicide inputs.

Conclusions and outlook

Gray leaf spot on perennial ryegrass appears to have become established in California and likely other parts of the western United States with outbreaks in 2003, 2004 and 2005 since its initial discovery on turfgrass in California in 1999. Frequent and preventive fungicide applications are recommended for its control, starting approximately in the first week of July and lasting until September or October. We have already seen the development of some QoI resistance, although performance at other locations appears to be acceptable. For resistance management, superintendents need to rotate the chemical classes used and tank-mix systems with contact fungicides. Much work still remains. Determining the origin of the pathogen remains a top priority, and future research should help answer this question.

Funding

Funding for this research was provided through The Environmental Institute for Golf and a cooperative chapter grant from the California GCSA, GCSA of Central California, GCSA of Northern California, GCSA of Southern California, Hi-Lo Desert GCSA, San Diego GCSA and Sierra Nevada GCSA.

Acknowledgments

I would like to thank all of the superintendents and their staff who have assisted in these studies, in particular the cooperators in this research: David Major, CGCS; Scott Dey; David Karp; Steve Thomas; Matt Marsh; Mike Rothenburg; Kevin Iverson; Tim Sedgley, CGCS; Wendy Gelernter, Ph.D., and Larry Stowell, Ph.D., of PACE Consulting; Mike McCullough of the Northern California Golf Association; and Wakar Uddin, Ph.D., Penn State University.

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says . . .

- **Gray leaf spot** was first reported in California in 1972 on St. Augustinegrass, but between 2001 and 2005, it was reported on perennial ryegrass and kikuyugrass in California and perennial ryegrass in Nevada.
- **Frequent irrigation** in summer and overirrigation to reduce the effects of drought stress and other summer diseases may set the stage for gray leaf spot.
- **It appears that** different isolates of gray leaf spot infect perennial ryegrass and kikuyugrass.
- **Gray leaf spot** resistance to QoI fungicides may be developing in California, but none of the 120 isolates tested appeared to be resistant to benzimidazoles.
- **Work continues on** establishing the origin of the gray leaf spot pathogen in California, determining the epidemiology and susceptibility of kikuyugrass, evaluating tolerant perennial ryegrass varieties in the West, and creating sound management programs with reduced fungicide use.

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Figure 5. This kikuyugrass fairway in Southern California has symptoms of gray leaf spot.