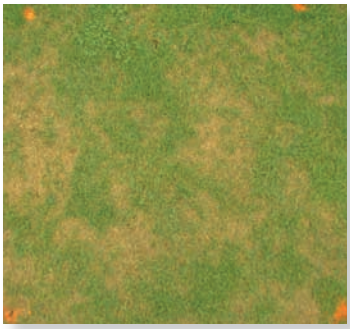
# Update on fungicide resistance in gray leaf spot

Superintendents in areas where fungicide resistance has not developed may still use $Q_o$I fungicides for gray leaf spot control.



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Gray leaf spot is the most destructive disease of perennial ryegrass (*Lolium perenne* L.), and it is one of the most devastating turfgrass diseases known (5). Turf-infecting strains of the fungus *Pyricularia oryzae* (= *Pyricularia grisea*) infect leaves to produce spots and blight that, when severe, can result in sudden and widespread death. Perennial ryegrass varieties developed over the past 30-40 years typically are highly susceptible to the disease. Although recent breeding efforts are beginning to provide varieties with significant resistance to gray leaf spot (2), almost all swards currently in existence are susceptible. In these swards, cultural practices can reduce disease pressure to a modest degree, but fungicides are essential to maintain the grass during an epidemic.

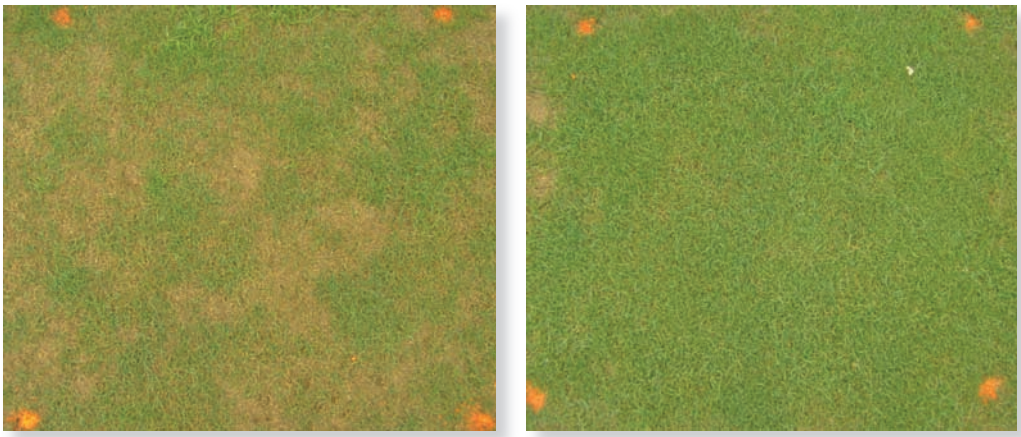
Several fungicides with different modes of action are currently labeled for gray leaf spot control (Table 1). The available fungicides vary considerably in their efficacy for controlling the disease (Table 2). Research trials have indicated that the most effective products fall in two fungicide families: the $Q_o$I group (also called strobilurins), which includes azoxystrobin, pyraclostrobin and trifloxystrobin, and the benzimidazole group, of which one representative — thiophanate-methyl — is labeled for gray leaf spot (5).

Unfortunately, the very best fungicides against gray leaf spot also are those with the most risk of fungicide resistance. Although the risk that thiophanate-methyl resistance will eventually occur in *P. oryzae* is considered high, the good news is that, to our knowledge, it has not yet been reported anywhere in the world where perennial ryegrass is grown. The news is not so good with the $Q_o$I fungicides, because resistance to this family has been reported in *P. oryzae* isolates collected at scattered locations throughout the United States, including Rhode Island, Kentucky, Indiana, Maryland, Illinois, Virginia and Ohio, among others (3,6).

## Two mutant types

Two types of $Q_o$I-resistant *Pyricularia oryzae* strains have been found in diseased perennial ryegrass. These are referred to as G143A mutants and F129L mutants (3), based on the positions of certain mutations in the cytochrome *b* protein — the molecular target of the $Q_o$I fungicides.

Although the occurrence of either mutant on a golf course complicates a gray leaf spot management program, research suggests that the G143A mutants are a greater problem. First, G143A mutants are highly resistant to both azoxystrobin and trifloxystrobin, being roughly 700-1,300 times less sensitive to these fungicides than wild-type strains of *P. oryzae* (3,6). F129L mutants, on the other hand, are just moderately resistant to azoxystrobin (140-fold less sensitive than wild-type), and only mildly resistant to trifloxystrobin and pyraclostrobin (difference is about 30-fold) (6; unpublished data, Vincelli and Farman). This suggests that trifloxystrobin and pyraclostrobin may, in some circumstances, still be somewhat effective in sites where the F129L mutant is



The plot on the left was treated with Heritage (azoxystrobin), which was not effective in treating perennial ryegrass infected with a $Q_o$I-resistant strain of *P. oryzae*. On the right, gray leaf spot was controlled with a full fungicide program. **Photos by P. Vincelli**

the only mutant that occurs. Unfortunately, the G143A mutation appears to predominate in most locations (3; Y.-S. Kim and M. Farman, unpublished data).

Field testing at sites where $Q_o$I resistance has already developed indicates that not only do $Q_o$I fungicide applications fail to control gray leaf spot, but also they can sometimes make the disease worse than spraying water alone (7). This enhancement of disease when a fungicide is used against strains that are highly resistant to that chemical has been observed in numerous situations in turfgrass and other crops. It is thought to be similar to a phenomenon that toxicologists call "hormesis" (1). A hormetic response occurs when a chemical that is normally toxic to a microorganism can actually *stimulate* the microorganism at a very low dose. Think about it: If a mutant is highly resistant to a fungicide, then the normal field rate of that fungicide is essentially the same to that mutant as a very low dose of that fungicide to a sensitive strain.

## Are they fit?

Whenever fungicide-resistant strains develop, regardless of the crop or disease, one hopes that the resistant strains have what biologists call *reduced fitness*. This means that resistant strains are genetically weaker in some way as compared to the wild-type. Strains with reduced fitness might require longer periods of leaf wetness in order to infect; they might grow more slowly or produce fewer spores. Alternatively, they might die more easily in winter, and so on. If this were the case, one might be able to build a management program around such situations. For example, if fungicide-resistant strains have reduced fitness, it might be possible to withhold that fungicide for a year or two, allowing the mutant to die out sufficiently, and then use the fungicide effectively again once or twice before the resistant strain begins to build up. This sometimes happens with plant pathogens as well as human pathogens (4).

A nice set of lab and field studies testing the fitness of resistant strains was conducted by University of Kentucky scientists. To monitor fitness effects in the field, an area of a golf course fairway with $Q_o$I-resistant strains was left untreated with any kind of fungicide for three years. Each year, a large number of isolates was collected and screened for the presence of the G143A and F129L mutations. All the isolates collected in the first year without fungicide applications were resistant. In the second and third years, wild-type isolates were detected, but resistant isolates were also collected, and 92% of the isolates collected in the third year were resistant. Interestingly, the proportion of

## Fungicides vs. gray leaf spot

| Fungicide | Mobility within plant | Fungicide group | FRAC code* | Risk of resistance | Examples of product names† |
|---|---|---|---|---|---|
| Azoxystrobin | systemic | $Q_o$I | 11 | high | Heritage 50WG |
| Chlorothalonil | protectant | multisite inhibitor‡ | M | NS§ | Daconil Ultrex |
| Propiconazole | systemic | DMI// | 3 | moderate | Banner MAXX |
| Pyraclostrobin | mesostemic# | $Q_o$I | 11 | high | Insignia 20WG |
| Thiophanate-methyl | systemic | benzimidazole | 1 | high | Cleary's 3336 Fungo 50WSB |
| Triadimefon | systemic | DMI | 3 | moderate | Bayleton 50 |
| Mancozeb | protectant | multisite inhibitor | M | NS | Fore Rainshield |
| Trifloxystrobin | mesostemic | $Q_o$I | 11 | high | Compass 50WG |

*Codes used by the international Fungicide Resistance Action Committee to identify different fungicide groups.
†Products that are pre-mixes of two active ingredients, such as MANhandle and Spectro 90, are not listed in this table.
‡Multisite inhibitors have no significant risk of resistance.
§NS, not significant
//Demethylation-inhibitor, a sterol-inhibitor fungicide.
#Enters into plant tissue but does not translocate in vascular tissues.

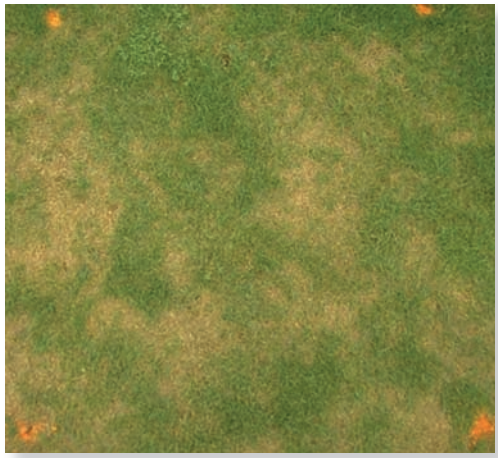
**Table 1.** Some fungicidal materials for control of gray leaf spot of perennial ryegrass.

strains carrying the F129L mutation progressively increased over time, but G143A isolates were the most abundant in each of the three years (unpublished data, Y. Kim and M. Farman). Altogether, these results suggest that once resistance to $Q_oI$ fungicides develops on a golf course, it is likely to persist for a long time, perhaps indefinitely.

## Management do's and don'ts

*Don't* stop using $Q_oI$ fungicides against gray leaf spot (unless they fail on your particular site). Fortunately, $Q_oI$-resistant strains of *Pyricularia oryzae* are not yet prevalent in those states where they occur (although we do suspect that they could become more common if we have another pandemic year like 1998). $Q_oI$ fungicides should be part of your spray arsenal for as long as they work because if you stop using them for fear of resistance, you will have to rely more on other fungicides that also have a risk of resistance. As mentioned above, thiophanate-methyl carries a significant risk of resistance, and there is also some risk of resistance to DMI fungicides (propiconazole, triadimefon and myclobutanil).

*Do* monitor swards treated with $Q_oI$ fungicides. Although the chance of resistance popping up on your course at any given moment is low, the risk is real. If you have a control failure, you will want to catch it early so you can spray something else in time to save the grass. The good news is that $Q_oI$-resistant strains are still sensitive to other fungicides labeled for gray leaf spot.



This turf plot infected with gray leaf spot was treated only with water.

*Do* save the $Q_oI$ fungicides for "crunch time" (8). In Kentucky, the disease can occur anywhere from mid-July until mid-October, but the most severe disease pressure is typically from early August through early September. If a superintendent wants to have an "insurance spray" in place before August, we suggest using one of the less effective fungicides or tank-mixes. These will still provide adequate control under moderate pressure without putting any selection pressure toward $Q_oI$ resistance. Likewise, once autumn weather and shorter nights reduce disease pressure, one should stop using the $Q_oI$ fungicides and substitute other fungicides if a spray is needed.

*Do* rotate away from $Q_oI$ fungicides at each spray. Rotation to another active ingredient after just one spray is probably better than using a $Q_oI$ fungicide two to three times before switching to another mode of action. The less they are used, the longer they will last.

*Do* mix $Q_oI$ fungicides with contact fungicides like chlorothalonil or mancozeb. Although the $Q_oI$ fungicides will hold their own against the disease, mixing them with a contact fungicide with no significant risk of resistance actually helps reduce the risk of resistance to the $Q_oI$. If a resistant mutant pops up, there is a chance that the contact fungicide will kill it before it has a chance to multiply.

You cannot prevent $Q_oI$ resistance from developing on your course; all you can do is reduce the risk. But we know the risk is real, so it makes sense to take precautions that help reduce your chances

## Fungicide efficacy

| Efficacy category | Product | Rate* | Application interval (days) |
|---|---|---|---|
| Excellent under *high* disease pressure | Heritage 50WG | 0.4 ounce | 21 |
| | Cleary's 3336 50WP | 4 ounces† | 14 |
| | Fungo 50WSB | 4 ounces | 14 |
| | Insignia 20WG | 0.5 ounce | 14 |
| | | | |
| Good under *high* disease pressure | Compass 50WG | 0.2 ounce | 14 |
| | Fore Rainshield NT 80WP + Daconil Ultrex | 8.0 ounces 3.2 ounces | 14 |
| | Heritage 50WG + Daconil Ultrex | 0.2 ounce + 3.2 ounces | 14 |
| | Banner MAXX + Daconil Ultrex | 1.0 fluid ounce + 3.2 ounces | 14 |
| | Bayleton 50WP + Daconil Ultrex | 1.0 fluid ounce + 3.2 ounces | 14 |
| | MANhandle 62.25WP | 10.0 ounces | 14 |
| | Spectro 90 WDG | 5.76 ounces | 14 |
| | | | |
| Good under *light to moderate* disease pressure | Daconil Ultrex | 3.2 ounces | 7-10 |
| | Banner MAXX | 2 fluid ounces | 14 |
| | Bayleton 50 | 1.0 ounce | 14 |
| | Fore Rainshield NT | 8.0 ounces | 14 |

*Metric equivalents: 1 fluid ounce = 29.6 milliliters; 2 fluid ounces = 59.1 milliliters; 0.2 ounce = 5.7 grams; 0.4 ounce = 11.3 grams; 0.5 ounce = 14.2 grams; 1 ounce = 28.3 grams; 3.2 ounces = 90.7 grams; 4 ounces = 113.4 grams; 5.76 ounces = 163.3 grams; 8 ounces = 226.8 grams; 10 ounces = 283.5 grams.

†Maximum allowable application rates of thiophanate-methyl on fairways recently were reduced by the U.S. EPA. Most of the data on efficacy of thiophanate-methyl against gray leaf spot have been obtained at higher application rates than are currently labeled. However, limited studies available to date suggest that the 4.0-ounce rate of Cleary's 3336 50WP (or an equivalent rate of a similar product), which is labeled for golf course fairways, performs as well as higher rates. The 2-ounce rate, labeled for residential and public areas, is probably inadequate for complete control.

**Table 2.** Efficacy of fungicides against gray leaf spot.

Griffin Gate Marriott Resort and Golf Club, Lexington, Ky., suffered from the gray leaf spot pandemic of 1995 (shown here). For eight years Marriott's Griffin Gate provided land for critical field research that has helped guide management recommendations for gray leaf spot control throughout the country.

of having another disease management headache.

### Funding and disclosure statement

With the exception of the fitness study (funded by Syngenta Corp.), no industry funding was received for the fungicide resistance work reported herein. Listing of fungicidal products implies no endorsement by the University of Kentucky nor its representatives. Criticism of products not listed is neither implied nor intended.

### Acknowledgments

Space for several years of field tests — including unsprayed in-play fairway areas — was graciously provided by Griffin Gate Marriott Resort and Golf Club in Lexington, Ky. We thank our cooperators, Ken Rue and Scott Bender. The excellent technical support of Ed Dixon is gratefully acknowledged.

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## The research says

→ The $Q_o$I group (strobilurins) and thiophanate-methyl in the benzimidazole group are the most effective fungicides for controlling gray leaf spot, but two mutants of the pathogen that causes gray leaf spot are resistant to members of the $Q_o$I group, and thiophanate-methyl is at high risk for resistance.

→ Where $Q_o$I resistance has already developed, $Q_o$I fungicide applications fail to control gray leaf spot, and they also can sometimes make the disease worse than spraying water alone.

→ Continue using $Q_o$I fungicides against gray leaf spot on sites where resistance has not developed, and mix the $Q_o$I fungicides with contact fungicides like chlorothalonil or mancozeb.

→ Wait until disease pressure is most severe to use the $Q_o$I fungicides, and then rotate to another active ingredient after just one spray.

→ Monitor turf treated with $Q_o$I fungicides so that control failures can be caught early and the turf can be saved.