Fungicide Resistance in Turfgrass – Future Trends and Possible Problems

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Author's note: This is the third in a three-part series looking at fungicide resistance in turfgrass.

Organisms resistant to chemical control have become commonplace in national news stories. Antibiotic resistant tuberculosis has been around for years, and just a few months ago several outbreaks of drug-resistant staph infections in high school locker rooms caused widespread panic. While the nationwide panic over the development of fungicide resistance in turfgrass diseases promises to be comparatively subdued, the threat to our ability to control disease is just as real. In two previous issues of *The Grass Roots* I have written about the history of fungicide resistance as it pertains to turfgrass, as well as some recent resistance research done here at the University of Wisconsin (Koch, 2007a; Koch 2007b). While great strides have been made in deepening our knowledge of fungicide resistance, much is still unknown. More troubling is that reports of fungicide failure due to resistant isolates of *Sclerotinia homoeocarpa* (dollar spot), *Pyricularia grisea* (gray leaf spot), and *Colletotrichum cereale* (anthracnose) are on the rise.

There is no singular explanation for the increase in nationwide resistance reports. Rather a myriad of factors appear to be increasing the buildup of resistant organisms in fungal populations faster than ever before. More selective fungicides are continually being developed to minimize non-target effects in response to environmental concerns, but these newer fungicides often have single-site modes of action that can be overcome by a single fungal mutation (Eckert, 1988). Lower fungicide rates and extended spray intervals

are touted as ways to reduce application costs and environmental contamination, but certain research has shown these strategies may allow resistant organisms to build up in a population (Koch 2007b). Repeated fungicide applications within a single class may be an obvious factor in resistance development to many superintendents, but there is still a remarkably large number who apply propiconazole four to five times in a season for their disease control program. With some of our fungicides, the DMIs in particular, time appears to be a large factor in the development of resistance. Unlike the benzimidazoles or strobilurins, resistance to the DMI fungicides takes years to develop even with repeated applications (Smith *et al.*, 1991). Since many golf courses have been applying DMI fungicides for 15 to 20 years, it is possible that resistant fungal isolates at these sites finally make up a significant enough percentage of the overall population to affect control.

A factor outside of the superintendent's control that is making resistance management more difficult is the lack of new fungicides from different chemistries being brought to the turfgrass market. While several new fungicides have been brought to market in recent years, most of them have either been combinations of older fungicides (Headway® is propiconazole and azoxystrobin, Tartan® is triadimefon and trifloxystrobin) or new active ingredients within an older class of fungicides (Trinity® in the DMIs, Disarm® in the strobilurins). While these new products often provide convenience or expanded disease control, they do not aide in preventing the buildup of resistant fungal isolates. Likely the major reason behind the lack of new products is the immense cost in terms of time and money to the chemical companies to discover and develop a molecule and bring it to market. Upwards of ten years and 100 million dollars is probably a conservative estimate for the time and money it takes to complete this process. The lack of new chemistries being developed for disease control in turfgrass, coupled with the increasing governmental regulation of some of our older and more effective chemistries (i.e. chlorothalonil), has made control of fungicide resistant organisms difficult for both superintendents and researchers alike.

With all the uncertainty surrounding fungicide resistance, what can you as a superintendent do to prevent resistance from becoming a serious problem at your course? Or if you believe resistance already is a serious problem on your course, what can you do to minimize or even reduce it? The answers to these questions are going to be specific to each individual golf course based on the fungicides in question, but

there are some overall strategies every superintendent can use to prevent or limit the development of fungicide resistance.

As with many things, preventing something from happening is oftentimes much easier to accomplish than reversing it once it has already occurred. The same concept applies to fungicide resistance, even though it is debatable how easy it is to prevent the development of resistance. The first thing to do when trying to combat resistance is to understand the basic chemical classes that house the major turfgrass fungicides (Table 1). Understanding the chemical classes is critical to developing a fungicide program that alternates properly amongst classes and is effective in preventing or delaying the onset of resistance. Once a basic understanding of the chemistry has been attained, a plan for effectively controlling all the major diseases seen in a typical growing season can be developed. Care should be taken to rotate amongst classes every second or third application to expose the fungal population to different modes of action. Not only are the fungicides themselves important in managing fungicide resistance, but the manner in which they are applied is important as well. Courses that strictly followed label recommendations for spray rate and interval had lower resistance levels to the DMI fungicide propiconazole in research done at the University of Wisconsin in the summer of 2006 (Koch 2007b). Following these basic recommendations (Table 2) will not guarantee the prevention of fungicide resistance at your course, but at the very least should significantly delay the onset years into the future.

Those superintendents who believe they already have a significant degree of fungicide resistance at their golf course may be contemplating a major shift in management strategy. Before changes are made, though, confirmation of resistance should be done through *in vitro* laboratory testing to confirm resistance is a problem. Labs such as the University of Wisconsin's Turfgrass Diagnostic Lab can complete a resistance test for *S. homoeocarpa* with regards to benzimidazole and DMI fungicides in approximately two weeks, giving the superintendent a much clearer picture of the role resistance is playing in the failure of disease control. If indeed a significant amount of resistance is observed from laboratory testing, changes should be made immediately to the fungicide program. Most scientific research indicates that resistance to thiophanate-methyl is non-reversible, meaning a high proportion of thiophanate-methyl resistant isolates could result in the permanent loss of that fungicide for the control of that particular disease (Koenraadt *et al.*, 1992). Research is more variable on the persistence of DMI resistant isolates in the environment, but there is

Table 1. Common fungicide classes, active ingredients, and their risk of developing resistance as measure by the Fungicide Resistance Action Committee (FRAC).

Fungicide Class	Active Ingredients	Resistance Risk
Benzimidazoles	Thiophanate-methyl, Propamocarb	High: Resistance Common
Strobilurins (QoI)	Azoxystrobin, Pyraclostrobin, Trifloxystrobin, Fluoxastrobin	High: Widespread resistance documented
Phenylamides	Mefenoxam, Metalaxyl	High: Resistance documented in Pythium
Demethylation Inhibitor (DMI)	Propiconazole, Myclobutanil, Triadimefon, Fenarimol	Medium: Resistance documented in turf
Dicarboximide	Iprodione, Vinclozolin	Medium: Resistance documented in turf
Carboximides	Boscalid, Flutoloanil	Medium: No resistance documented in turf
Phosphonates	Fosetyl-Al, phosphonates	Low: No resistance documented in turf
Nitrile	Chlorothalonil	Low: No known cases of resistance

Source: PACE Turfgrass Research Institute

evidence that over time in the absence of DMI fungicides the level of resistance drops (Sisler, 1988). The length of time it takes to regain a DMI sensitive population is unclear, but trying to develop a spray program in Wisconsin without the use of DMI fungicides for any length of time is very difficult. Instead of a program that eliminates DMI fungicides for a period of time I would recommend a program that instead rotates heavily amongst different fungicide classes, strictly follows label rates and spray intervals, limits the bulk of the DMI fungicide applications to times of the season when disease pressure is not as severe, and includes a low resistance risk fungicide such as chlorothalonil in the tank with every DMI application (Table 3). This program will not be an instant cure to your resistance ailments, but it should prevent or greatly slow the continued buildup of resistant isolates in the fungal population and may lower the overall resistance to the fungicide in question over time.

Much has been learned in over 40 years of research on fungicide resistance. But for all that research, relatively little is known about the genetic basis for resistance and the methods for managing fungicide resistance. More research needs to be conducted to determine the most effective methods for both preventing fungicide resistance as well as reducing the resistance already present at some golf courses. In the meantime, while we wait for those research results, format your plan for managing resistance at your golf course now...before it's too late.

References:

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Table 2. Recommendations for preventing or delaying the onset of fungicide resistance.

1)	Learn or own reference on common turfgrass fungicide classes.
2)	Include fungicides from two to three different classes in your spray program every season.
3)	Follow label recommendations for fungicide rate and spray interval.
4)	Include chlorothalonil, a low resistance risk fungicide, in a tank-mix with other penetrant fungicides during times of severe disease pressure.

Table 3. Recommendations for halting or decreasing fungicide resistance.

1)	Have isolates tested for degree of fungicide resistance.
2)	Follow strict chemical class rotations every application.
3)	During times of heavy disease pressure, apply fungicide closer to the higher labeled rate or closer to the lower recommended spray interval, or both.
4)	If DMI or dicarboximide resistance is documented, limit DMI/dicarboximide fungicide applications during times of severe disease pressure.