Reducing the Risk of Fungicide Resistance

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Fungicide resistance occurs when a fungus changes genetically and is no longer sensitive to the toxic effects of a fungicide. Resistance can build up to some fungicides used commonly in turf. The main concern with resistance is that the fungicide, and all those with a similar active ingredient, will then no longer be available as a tool for disease management.

What actually happens when a fungicide is no longer effective is that a new population of the pathogen has built up on the site of repeated fungicide application. Before a fungicide program is implemented, nearly all members of the target pathogen population are sensitive to the toxic effects of the fungicide. As time goes on, however, the sensitive members of the population die out and the (once very small) population that is resistant, either from genetic mutations or from natural resistance, starts to build up. Soon the population is predominately the resistant type and at this point the fungicide no longer works.

Sometimes these resistant strains die out again because they are weaker organisms in general. If this is the case, then the fungicide may work again in a year or two. This has been known to occur on occasion with fungi that became resistant to sterol-inhibiting fungicides. However, resistance to other fungicide groups, such as the benomidazole fungicides, can be more or less permanent because the resistant types are strong and stable.

Development of fungicide resistance occurs most quickly in those fungicides that act on a fungus in a very specific way. Most of the systemic fungicides that were introduced in the 1960's and early 1970's have very specific modes of action. For example, fungicides containing benzimidazole (benomyl) as an active ingredient are toxic to fungi because they disrupt a very specific event during cell division (growth of the fungus). Sterol-inhibiting fungicides interfere with a very specific step in a biochemical pathway as the fungus is forming basic compounds it needs to grow. Although fungicides with specific modes of action are excellent fungicidal compounds in many ways, the development of resistance continues to be a concern.

Also, certain fungi are more likely to become resistant to fungicides than others. Fungi that are heavily dependent on the pathogenic way of life are more likely to change genetically in order to continue to be able to infect the plant. In turf these include fungi that cause rust, powdery mildew, downy mildew, dollar spot and Fusarium patch (pink snow mold). Dollar spot is probably of greatest concern to golf course superintendents. Other fungi are perfectly well adapted to living most of their life as saprophytes on decaying organic matter and are under less "pressure" to change genetically if fungicides prevent pathogenic activity. *Rhizoctonia* (brown patch) and *Colletotrichum* (anthracnose) are examples of this type of fungus, which are not likely to develop fungicide-resistant populations very easily.

What can be done to manage resistance? There are several strategies that a turf manager should adopt to prevent resistance to some of the more vulnerable pathogens, especially dollar spot. One approach that many already use is to rotate fungicides with different chemical modes of action. For example, not using the same fungicide more than 3 successive applications before switching to one with a different mode of action. This requires information on the biochemistry of the fungicide, since many fungicides share the same basic active ingredient. Some of the more common turf fungicides are grouped by their biochemical activity in Table 1.

Rotating fungicides on a yearly basis is another option. Dr. Joe Vargas has worked out an example of this approach in a resistance management program for dollar spot. In this program, fungicides with different modes of action are rotated over a 3-year cycle (Table 2). Since the most danger of fungicide resistance is with the sterol-inhibiting (DMI) fungicides, the use of this group of fungicides is restricted during the time when the population of dollar spot fungi is at it's peak (usually late summer). This way, DMI fungicides can still be used, but much of the population will not be exposed.

Another approach to managing fungicide resistance is to use combinations of systemic fungicides with different modes of action at reduced rates. Work at Penn State University has showed successful prevention of resistance in Pythium blight to metalaxyl fungicides (Subdue) by combining Subdue at half-rate with half rates of Banol or Aliette or one-third rates of Subdue-Banol-Aliette.

Managing fungicide resistance will always be a part of using fungicides. Fungicides that act in a very specific way will continue to be developed and used for several reasons. One is because they are excellent fungicides. A second reason is that their very specificity also makes them less likely to harm beneficial microorganisms in the turf and soil. As long as we remain aware of the potential for resistance, and plan long-term fungicide programs accordingly, these excellent compounds are likely to remain effective tools for a long time.

Table 1. Biochemical groups of common turf fungicides and potential for development of resistance.

Biochemical Group	Resistance potential	Example Trade Names
Systemic fungicides		
Benzimidazoles: benomyl, thiophanate methyl	high	Cleary's 3336, Tersan 1991, ProTurf Systemic Fungicide, Fungo 85
Dicarboximides: iprodione, vinclozin	moderate	Chipco 26019, Vorlan, ProTurf Fungicide X, Rovral
Phenylamides: metalaxyl	high	Subdue, ProTurf Pythium Control
Sterol inhibitors (demethylation inhibitors or DMI): fenarimol, triademifon, propiconazole	high	Rubigan, Bayleton, ProTurf Fungicide VII, Banner , Sentinel
Contact fungicides		
Dithiocarbamates: maneb, mancozeb	low	Manzate 200, Fore
Ethazoles	low	Koban, Terrazole
Phosphonates: fosetyl Al	low	Aliette
Substituted aromatic compounds: PCNB, chlorothalonil, chloroneb	low	Daconil 2787, Proturf Fungicide and Fertilizer II, Pennstar, Terraclor 75
Thiram	low	Spotrete, Tersan 75

Table 2. Fungicide program to delay development of DMI-resistance in dollar spot fungi.

Spring-Early Summer	Mid-summer	Late summer-Fall
DMI fungicides	Year 1: Contacts Year 2: Contacts and Benzimidazoles Year 3: Benzimidazoles and Dicarboximides	Year 1: DMI's Year 2: Dicarboximides Year 3: Contacts

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