OVERCOMING RESISTANCE

Low-risk, broad spectrum fungicides will lessen resistance to popular systemics.

In the late 1960s, a new generation of systemic fungicides emerged that represented a breakthrough in fungicide technology.

Initially, some predicted that these new fungicides would replace older, preventive contact fungicides because they offered systemic action, curative ability, and lower dose rates for optimum disease control.

The high efficacy of these new agents unfortunately led to over-re-

liance, exclusive use for control of certain diseases and to resistance problems unlike any previously encountered by golf course superintendents and turf care professionals.

Resistance problems

Resistance problems first observed with systemics demonstrated that their greatest strength—highly selective single-site action—could rapidly become a weakness in the presence of resistant fungal strains.

For this reason, fungicides with single sites of action, whether contact or systemic, have come to be known as "at-risk" fungicides. These fungicides contrast with most conventional contact fungicides that have multi-site action and, therefore, a lower risk of resistance.

Single-site fungicides are prone to resistance because they act on only one enzyme or enzyme site in a fungus. Repeated use of these chemicals exerts high selection pressure.

Single-site fungicides rapidly kill all susceptible fungi, leaving only resistant fungi that, through random mutations, rely on other enzymes to exist. Thus, it is possible for an at-risk fungicide to provide excellent disease control at first, which is then followed by catastrophic fungicide failure when resistant fungi become predominant.

Reduce selection pressure

Recent research makes it clear that disease prevention and resistance management strategies must rely more on treatments that reduce selection pressure, through the use of low-risk, multi-site contact fungicides. At-risk agents can then be used on an as-needed basis, when their powerful effects can be maximized without undue threat of resistance.

Through the increased use of low-risk, broad-spectrum fungicides such as chlorothalonil, mancozeb, anilazine and others, the effectiveness of valuable systemic agents can be preserved against resistance problems, perhaps indefinitely.

Resistance occurs whenever genetic changes in a fungal cell allow it to survive using enzymes other than the one that is attacked by the fungicide.

Whether resistance is based on changes to a single gene (monogenic) or to several genes (polygenic), resistant fungi almost always exist naturally in a population, though in small numbers.

Resistance strength

Monogenic resistance is usually easier for a fungus to achieve; consequently, it tends to occur more often and much more quickly. Polygenic resistance seems to occur much more slowly, making it somewhat easier to combat.

Polygenic resistance is evidenced by a gradual decline in fungicide effectiveness, rather than a sudden, disruptive loss of control. As a single-site fungicide removes susceptible individuals, the population balance shifts toward those that are resistant, because they are the only ones genetically capable of surviving.

If the same treatment is used repeatedly, the resistant individuals are likely to become predominant as competition provided by the susceptible strains is eliminated.

Pressure behind resistance

The frequency, uniformity of placement, and timing of at-risk fungicide application are factors determining the degree of selection pressure exerted on the fungal population. Together with the mode of action of the chosen fungicide and the reproductive rate of the fungus, selection pressure determines the speed at which resistance can occur.

By reducing the selection pressure on target populations, turfgrass managers can minimize the emergence of resistant strains, prolong the use of powerful but resistance-prone at-risk fungicides, and achieve the goal of attractive, disease-free turf.

The Fungicide Resistance Action Committee (FRAC) North American Working Group suggests two general strategies for reducing selection pressure exerted by at-risk fungicides:

1. Alternate or mix high-risk fungicides with other fungicides not having a cross-resistance potential. This normally involves the use of a broad-spectrum, multi-site contact fungicide with little resistance risk or an at-risk fungicide from a different chemical class.

2. Restrict use of the high-risk

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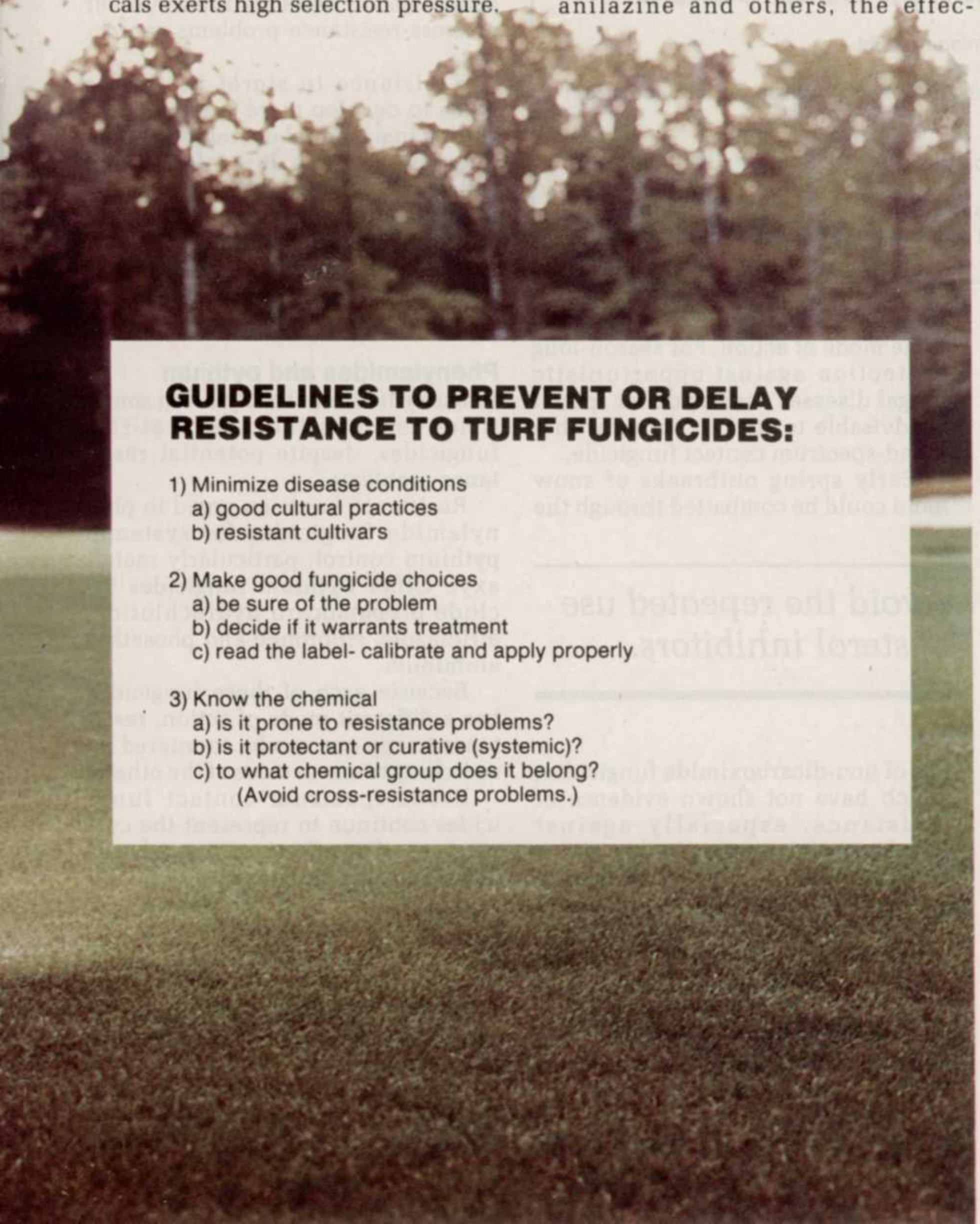

GUIDELINES TO PREVENT OR DELAY RESISTANCE TO TURF FUNGICIDES:

1) Minimize disease conditions
  a) good cultural practices
  b) resistant cultivars

2) Make good fungicide choices
  a) be sure of the problem
  b) decide if it warrants treatment
  c) read the label- calibrate and apply properly

3) Know the chemical
  a) is it prone to resistance problems?
  b) is it protectant or curative (systemic)?
  c) to what chemical group does it belong? (Avoid cross-resistance problems.)

TURF FUNGICIDE CHEMICAL GROUPS SUBJECT TO RESISTANCE PROBLEMS

1) DICARBOXIMIDES- MODERATE RISK
examples: iprodione (Chipco 26019)
vinclozolin (Vorlan)

resistance can appear suddenly, but appears unstable

Cross-resistance within the group and also to chloroneb (Terremec SP)

2) BENZIMIDAZOLES - HIGH RISK
examples: benomyl (Tersan 1991)
thiophanate-methyl (Fungo 50, Spot Kleen)
thiophanate-ethyl (Cleary's 3336)

resistance can appear suddenly, seems to remain stable: cross-resistance within the group

3) STEROL BIOSYNTHESIS INHIBITORS (SIs) (SBIs) (DMIs) LOW RISK
examples: fenarimol (Rubigan)
triadimefon (Bayleton)
propiconizol (Banner)

resistance may appear gradually and may shift back to sensitivity with time

Cross-resistance within the group (where studied).

4) PHENYLAMIDES- HIGH RISK
example: metalaxyl (Subdue)

resistance can appear suddenly and seems to remain stable

Source: Gail Schumann, Assistant Professor, Dept. of Plant Pathology, University of Massachusetts.

CHOOSING COMPANION COMPOUNDS

1) Curative use needs a curative companion product.

2) Intervals should not exceed the limits of protection given by the companion product.

3) Systemic disease requires systemic partners.

4) Rates: for alternation: use FULL rates
for mixing: it may be possible to use reduced rates but this must be tested by researchers

product to just one or two periods in a season when its utility will be greatest.

Tank mixes that incorporate multi-site contact fungicides with the at-risk fungicide minimize the chance of sudden, disruptive loss of disease control. For treatment of fungi such as pythium, alternating applications of effective fungicides with different modes of action should be used.

Strategies by groups

Resistance has been documented in four major classes of fungicides: the dicarboximides; the benzimidazoles; the sterol demethylation inhibitors; and the phenylamides. Note that while the last three classes mentioned are systemic fungicides, the dicarboximides are contact fungicides that are resistance-prone due to their single-site action.

In the dicarboximide class, the single-site, contact fungicides iprodione and vinclozolin often provide excellent protection, but resistance to iprodione has been observed for dollar spot in Michigan and pink snow mold in Washington.

Cross-resistance to vinclozolin could also be predicted, since both iprodione and vinclozolin have the same mode of action. For season-long protection against opportunistic fungal diseases such as dollar spot, it is advisable to start in spring with a broad-spectrum contact fungicide.

Early spring outbreaks of snow mold could be combatted through the use of non-dicarboximide fungicides, which have not shown evidence of resistance, especially against *fusarium nivale* strains. In this case, a broad-spectrum contact fungicide such as chlorothalonil could be used as a preventive, with additional curative power added by a benzimidazole, such as benomyl, when needed.

Avoid the repeated use of sterol inhibitors.

Powdery mildew resistance

Benzimidazoles were once market-leading products due to their excellent control of dollar spot and brown patch, until resistant strains of dollar spot developed in the late 1970s.

Resistant strains of powdery mildew and fusarium patch have also been observed with the benzimidazoles.

To extend the life of these valuable agents and keep resistant strains in line, application of a broad-spectrum contact fungicide can be recommended.

Applications of broad-spectrum contact fungicides kill resistant fungal strains and help to keep the overall balance of susceptible and resistant strains intact.

Inhibitors are selective

Due to their selective, single-site action, sterol inhibitor fungicides, including triadimefon, propiconazol, and fenarimol, are likely to select resistant strains which will remain present in the resulting population.

Because all of these fungicides have the same mode of action, they cannot be alternated with each other or cross-resistance problems can occur.

Resistance to sterol inhibitors tends to develop more gradually, resulting in a gradual decrease in effectiveness over time. It is inferred that resistance to these agents is polygenic, requiring multiple gene changes over an extended period of time.

To keep potentially resistant strains in balance, the repeated use of sterol inhibitors should be avoided.

Phenylamides and pythium

Effective treatment of Pythium sometimes requires the use of at-risk fungicides, despite potential resistance problems.

Resistance has been noted in phenylamide fungicides for systemic pythium control, particularly metalaxyl. Other Pythium fungicides include propamocarb hydrochloride, etridiazole, chloroneb and phosethyl aluminum.

Because each of these fungicides has a different mode of action, resistance to any one can be countered by switching to one or more of the others.

Broad-spectrum contact fungicides continue to represent the cornerstone of an effective, low-risk turf disease control program.

Intelligent use of broad-spectrum contact agents opens the door for more effective and timely use of powerful but resistance-risk fungicides, which can then be used at times when they are likely to do the most damage to the fungus.

In this way, their long-term efficacy can be preserved against the threat of resistance. **LM**