MANAGEMENT OF FUNGICIDE RESISTANCE

Patricia L. Sanders
Plant Pathology Department
Penn State University
University Park, PA

Fungicides can be divided into two groups according to where they act to protect plants. CONTACT or PROTECTANT FUNGICIDES are those that stay on plant surfaces and provide a barrier against the fungi that cause disease. ERADICANT or SYSTEMIC FUNGICIDES are absorbed by plants, and thus can work to protect plants from within, in the same way that antibiotics act to eradicate "germs" inside human bodies. Most systemic fungicides also have protectant properties in that they can provide barriers to fungi on plant surfaces. Systemics have the advantage of long residual action, protection of plant crowns and roots, movement within plants to protect newly-formed tissues, eradication of fungi already inside plants, and protection from washoff and weathering.

The chief disadvantage of systemic fungicides has been the problem of resistance to these fungicides in many important turf pathogens. Resistance in fungi to systemic fungicides occurs because these fungicides generally poison fungi at only a single location in their growth and development cycles. It is, therefore, relatively likely that some individuals will be present in populations of disease-causing fungi that are able to circumvent or short-circuit the poisoned site. These individuals will be able to grow and increase in the presence of the fungicide. With repeated, continuous application of the same systemic fungicide, the naturally-resistant individuals in a fungal population will multiply until the population is composed primarily of fungicide-resistant individuals, and disease control fails. This has happened in countries all over the world where systemic fungicides have been used. In the U.S.A., most of the disease control failures from resistance to systemic fungicides have occurred on turfgrass. There are published reports of resistance control failures of Tersan 1991 on dollar spot, Subdue on Pythium blight, and Chipco 26019 on dollar spot and pink snow mold.

Identification and development of new fungicides is costly and time-consuming. Therefore, we must learn to use systemics in ways that will prolong their useful lives. In order to prevent or delay fungicide resistance in populations of disease-causing fungi, it has been suggested that systemic fungicides should be alternated or used in mixtures. However, there are very few published research studies on which recommendations for preventing or delaying fungicide resistance can be based. Alterations will be effective in cases where the resistant individuals in the population are not as competitive as sensitive individuals. Thus, the population will fluctuate; the resistant component increasing when the resistance-prone fungicide is applied, and the more vigorous sensitive component increasing

when the fungicide selection pressure is not present and the alternate fungicide is being used. Unfortunately, many times the resistant individuals in fungal populations are just as competitive and vigorous as the sensitive ones. In such cases, an alternating program will result in a steady increase in proportion of resistant members, until finally the population is predominantly resistant - a condition we are trying to avoid. In populations of equally-fit resistant and sensitive components, mixtures have been found to be effective in keeping resistant proportions stable in experimental populations.

Assuming that fungicide mixtures are able to keep resistance levels stable in fungus populations, they must be effective in controlling disease. Obviously, we cannot use full rates of fungicides in mixtures, because to do that would increase financial and environmental costs. We need to be sure that reduced rates of fungicides in mixtures will give satisfactory field control of diseases. Field and greenhouse studies have shown that reduced-rate mixtures can give disease control equal to, and sometimes greater than, the additive control of the individual mixture partners alone at the reduced rate. Although much more research is needed, it appears that reduced-rate mixtures can give acceptable field disease control, as well as delaying problems with resistance.

There are several important things to consider when selecting fungicides for use in alternations or reduced-rate mixtures. First, only fungicides with different ways of controlling the target fungus can be used in alternations or mixtures to delay or prevent control failures resulting from fungicide resistance in fungal populations.

The three systemic fungicides registered for Pythium blight control (Banol, Aliette, and Subdue) have different modes of action, and therefore, can be used in alternations or two-component, half-rate mixtures for resistance management and disease control. Three-component, third-rate mixtures of Banol/Aliette/Subdue may also be effective for these purposes, but research to test this is not completed.

The broad-spectrum systemic fungicides that control other turf diseases fall into three groups according to their mode of action: the benzimidazoles (Tersan 1991, Fungo 50, CL 3336), the dicarboxymides (Chipco 26019, Vorlan), and the sterol inhibitors (Banner, Bayleton, Rubigan). Any fungus that is resistant to one of the benzimidazole fungicides will be resistant to them all. The same is true within the dicarboxymide and sterol-inhibitor groups of fungicides. Therefore, for resistance management, broad-spectrum systemic fungicides must be mixed or alternated BETWEEN but not WITHIN groups. Systemic fungicides may also be mixed or alternated with any contact fungicide that will give the disease control desired.

In addition to mode of action differences, the length of disease control provided by mixture components must be matched to

avoid resistance selection. If a short-residual fungicide is included in a mixture for delaying resistance, an interspray of the short-residual chemical probably will be necessary.

If they are available, it is probably much better to use systemic fungicides in mixtures for resistance management. The reason is that the turfgrass plant itself can "unmix" mixtures of contact and systemic fungicides. If you apply a contact/systemic mixture, the mixture will be present on plant surfaces, but the systemic fungicide will be present alone inside the plant. As an example, in the case of a Subdue/Fore mixture, Subdue alone will be acting against Pythium that already has invaded the plant. For this reason mixtures of systemics are safer for resistance delay than contact/systemic mixtures.

The management of fungicide resistance in populations of disease-causing fungi is an area where much more research is needed. Additive, synergistic, or antagonistic effects may be possible with particular fungicide mixtures. It is, therefore, important that alternations and mixtures of various fungicides be tested, both for disease control and for resistance delay, in as many use settings and turfgrass/pathogen systems as possible.

Although there is much more we need to know about how we can best use systemic fungicides to avoid disease control failures from fungicide resistance in fungal populations, one thing is clear. We cannot safely use any systemic fungicide repeatedly and exclusively for disease control. Sensible and prudent use of systemic fungicides dictates diversity in chemicals used. Turf managers should be very skeptical of recommendations suggesting that any systemic fungicide can be used alone and continually without risk of resistance problems.