

# Classification of Turfgrass Fungicides

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**T**HINK back for just a moment. If you were a golf course superintendent ten years ago and *Pythium Blight* was creeping across your championship course, what fungicide choices did you have? Not many! Approximately 50% of the currently available turfgrass fungicides have been registered only since 1979. Now that a superintendent has an expanded fungicide inventory, how many know *why* they select a particular fungicide for one disease but not another?

Fungi are organisms that have no chlorophyll, the substance that makes plants green and able to produce their own energy for growth. Because fungi cannot produce their own energy, they must rely on living or dead hosts for energy and growth. Some fungi are totally harmless, like mushrooms in the grocery store, while others cause plant diseases.

Fungi are composed of mycelia, thread-like bodies that usually branch as they grow in length, and reproduce by developing spores. These spores are small, independent fungal bodies which germinate to produce mycelia. A very generalized fungal life cycle alternates between mycelia and spores. Both structures can infect a plant to cause disease. In Florida, four major fungal diseases of golf course turfgrass that may be controlled with fungicides are Brown Patch, Dollar Spot, *Helminthosporium* Leaf/Crown Complex, and *Pythium* Blight/Root Rot.

Fungicides, chemicals that inhibit fungi, have two different types of names. Each fungicide has one common chemical name, but may have many brand names. The number of brand names depends on the number of companies which market that particular fungicide. When fungicides are

mentioned in this article the common name will be listed first with a brand name in parenthesis. This is not meant as an endorsement but rather a method to associate the common name with a familiar brand name.

Membranes are essential for life because they protect organisms from the outside environment; sterols are a necessary component of a membrane, any membrane. For example, cholesterol is the essential sterol in human membranes while most fungal membranes contain ergosterol. *Pythium* species are the exception since their membranes do not contain ergosterol. The EBI fungicides are systemic fungicides that inhibit the production of ergosterol. Thus, they are effective compounds when used to control ergosterol-containing fungi, such as the causal agents of Brown Patch, Dollar Spot and Helmin-

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thosporium Leaf Spot, but do *not* control Pythium diseases.

The three EBI fungicides utilized for turfgrass disease control are fenarimol (Rubigan), propiconazol (Banner) and triadimefon (Bayleton). All three systemic chemicals have curative and protective action. Bayleton has been registered for use on turfgrass in Florida for a number of years. However, Banner is newly registered for warm-season turfgrass disease control this year. Since Banner is new, be sure to read the Banner label carefully for precautionary statements.

Golf course superintendents may be more familiar with Rubigan as a herbicide for *Poa annua* control than as a fungicide. A side effect of EBI fungicides is their plant growth regulation property. This property has been exploited with Rubigan which also inhibits the production of gibberellin, a plant hormone which regulates plant cell elongation and growth. At recommended rates, *Poa annua* is sensitive to Rubigan but bermudagrass and perennial ryegrass are not.

#### GENERAL FUNGICIDE GROUPS

Fungicides are divided into different groups based on: 1.) general activity - pro-

TECTIVE OR CURATIVE; and 2.) location of that activity - contact or local systemic or systemic. A protective fungicide does not cure or eradicate fungal pathogens that have already infected the plant but does protect the plant against future pathogen activity. For example, fungal spores which are released on a leaf after a protective fungicide has been applied will be prevented from infecting that leaf. A curative fungicide, however, is capable of eradicating a fungal pathogen which has already established itself in a host plant and initiated a disease.

Contact fungicides remain on the plant surface and do not penetrate into the plant. These fungicides are normally only protective. Local-systemic fungicides remain on the plant surface but also penetrate the plant surface and move very short distances within the plant. They are also protective fungicides.

Systemic fungicides do penetrate plant surfaces (or seed coats) and then translocate (move) inside the plant. Systemic fungicides are translocated via xylem or phloem tissue. Xylem is formed from plant water conducting tubes so compounds in the xylem move in an upward direction with the water system. Phloem is

formed from tubes which move photosynthates (plant products) from leaf tissue to other plant organs (i.e. upward and downward directions). Except for fosetyl-A1 (Aliette) which is translocated in xylem and phloem, systemic fungicides are xylem-limited. In general, systemic fungicides have curative and protective activities. They often have extended residual activity. Table 1 lists the currently registered turfgrass fungicides in Florida.

#### CHEMICAL FUNGICIDE GROUPS

In addition to the general groups of fungicides discussed above, fungicides are divided into groups based on their chemical properties. Discussed below are the chemical groups of turfgrass fungicides.

##### *Benzimidazole Fungicides* (Systemic; Curative and Protective)

A second group of systemic fungicides which control turfgrass diseases other than *Pythium* is the benzimidazole (BZD) fungicides. These chemicals include benomyl (Tersan 1991) and thiophanate methyl (Fungo). BZD fungicides control plant diseases by inhibiting development of the fungal skeleton (i.e. support structures of the fungus). Like the EBI fungicides, BZD fungicides are both protective

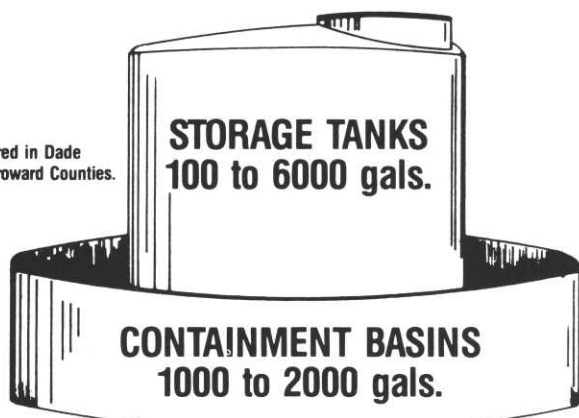
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and curative. They bind tightly to plant surfaces and degrade slowly, and therefore directly protect the plant from fungal attack via residual activity. However, BZD fungicides also penetrate plant surfaces and translocate in the xylem to provide systemic, curative action against established pathogens.

### PYTHIUM FUNGICIDES

As indicated previously, *Pythium* is a very different fungus from the other fungi that cause turfgrass diseases. A major difference is the lack of ergosterol in *Pythium* cell membranes. The five fungicides recommended for controlling *Pythium* diseases fall into three general groups based on location of activity - contact, local-systemic and systemic fungicides.

The contact fungicides are chloroneb (Terraneb) and ethazol (Koban) which were discussed previously with the aromatic hydrocarbon fungicides. They are protective compounds only, since they inhibit fungal mycelia and spores on the plant surface. The local-systemic fungicide propamocarb (Banol) does penetrate the plant surface but is degraded rapidly inside the plant so systemic effects are localized and short in duration. Metalaxyl (Subdue, Apron) and foestyl-AI (Alette)

are both systemic fungicides. Their activities, however, are very different.

Metalaxyl is formulated as Subdue for foliar applications and Apron for seed treatments. Metalaxyl easily penetrates the plant surface or seed coat and is rapidly translocated in the xylem (i.e. upward with the water stream). It has curative and protective activity and, since it moves in the xylem, protects new plant growth better than old plant tissue. Metalaxyl also has extended residual activity in plant tissue which allows you to extend the interval between spray applications.

### Aromatic Hydrocarbon Fungicides (Contact; Protective)

Aromatic hydrocarbon (AH) fungicides are contact fungicides that destroy fungal membranes inside a fungal cell. This stops the fungus from growing and spreading to more plants. Therefore, AH fungicides are classified as protective and not curative fungicides. Examples are chloroneb (Terraneb), ethazol (Koban, Terrazole) and PCNB (Terraclor). These compounds evaporate quickly (high volatility) or are sensitive to ultraviolet sunlight. Thus, they are best used as soil incorporated fungicides since the soil will provide some chemical stability.

### Dicarboximide Fungicides (Contact; Protective)

Two dicarboximide fungicides available for broad-spectrum turfgrass disease control are iprodione (Chipco 26019) and vinclozolin (Vorlan). The mechanism of action of these compounds is not entirely clear, although they appear to destroy fungal membranes and interfere with DNA synthesis. Since they stop fungi from spreading, these contact fungicides are protective in action. Although dicarboximide fungicides alone have a broad spectrum of activity, they are often mixed with other fungicides to enhance disease control.

### Ethylenebisdithiocarbamate (EBDC) Fungicides (Contact; Protective)

These contact fungicides include maneb (Tersan LSR), mancozeb (Fore) and zineb (Zineb). The EBDC fungicides are protective compounds and have been available for many years. They have no specific mechanism of action nor site of action and are active against many fungal plant pathogens. Thus, they can help to prevent the spread of many turfgrass diseases and are often combined with other fungicides to enhance disease control.

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*Miscellaneous Contact Fungicides*  
(Protective)

Two contact fungicides which do not fall into the above chemical groups are anilazine (Dyrene) and chlorothalonil (Daconil 2787). Both are broad spectrum, protective leaf fungicides. Anilazine is quickly and strongly absorbed by fungal spores present on the leaf and then inhibits a variety of spore functions. Chlorothalonil, which is also an algicide, does have more specific mechanisms of action. It reacts with glutathione to disrupt regulation of cell functions and it also inhibits sulfur-dependent enzymes in the cell.

*Ergosterol Biosynthesis Inhibiting (EBI) Fungicides* (Systemic; Curative and Protective)

Metalaxyl controls *Pythium* by inhibiting RNA synthesis, an essential process for cell growth. The sensitive fungal stages are mycelia and spore production. It does not inhibit spore germination, zoospore release or plant penetration by the fungus.

Therefore, metalaxyl primarily inhibits growth of fungal mycelia after plant penetration. In other words, it is killing the mycelia already inside the plant and mycelia that enter the plant. This is why metalaxyl is often mixed with contact, protective fungicides such as mancozeb (Fore). The mancozeb inhibits spore germination and initial penetration by *Pythium* on the leaf surface but does not effect fungal growth within the leaves; the metalaxyl will eradicate mycelia which has penetrated the plant surface. Because metalaxyl is both systemic and persistent, most of the disease control achieved from the mixture is from metalaxyl but the mancozeb provides an additional measure of control.

Fosetyl-AI (Aliette) is also systemically active against *Pythium* diseases - *Pythium* Blight and *Pythium* Root Rot. It is a unique systemic fungicide because it moves *both* in xylem and phloem. Therefore, foliarly applied fosetyl-AI will move down to the roots to protect against *Pythium* Root Rot. The other systemic fungicides

that have been discussed are not translocated in the phloem. If they are to protect plant roots, they must be absorbed by the roots.

Fosetyl-AI has weak curative activity of *Pythium* but is excellent at protecting new plant growth. Like metalaxyl, it inhibits mycelia and spore production. How fosetyl-AI controls *Pythium* is not entirely clear, yet. It is known that fosetyl-AI is degraded in the plant tissue to phosphoric acid and it is this latter compound which produces the antifungal activity, either directly on the fungus or indirectly by triggering defense reactions of the plant.

**SUMMARY**

Fungicides have been and will continue to be a major component of an integrated disease control program. As indicated in this article, there is a wide variety of chemicals available for turfgrass disease control. Knowing how to select fungicides based on their general activity and location of that activity will allow you to be a better manager of golf course turfgrass. ■

Table 1. Turfgrass fungicides registered in Florida.

Common Name of Fungicide	General Fungicide Group					Disease Control			
	Location			Action		Brown Patch	Dollar Spot	Helminthosporium	Pythium
	Contact	Local-Systemic	Systemic	Protective	Curative				
Anilazine	+	-	-	+	-	+	+	+	-
Benomyl	-	-	+	+	+	+	+	-	-
Chloroneb	+	-	-	+	-	-	-	-	+
Chlorothalonil	+	-	-	+	-	+	+	+	-
Ethazol	+	-	-	+	-	-	-	-	+
Fosetyl-AI	-	-	+	+	+	-	-	-	+
Fenarimol	-	-	+	+	+	+	+	-	-
Iprodione	+	-	-	+	-	+	+	+	-
Maneb	+	-	-	+	-	+	+	+	-
Mancozeb	+	-	-	+	-	+	+	+	-
Metalaxyl	-	-	+	+	+	-	-	-	+
PCNB	+	-	-	+	-	+	-	-	-
Propamocarb	-	+	-	+	-	-	-	-	+
Propiconazol	-	-	+	+	+	+	+	+	-
Thiophanate Methyl	-	-	+	+	+	+	+	-	-
Thiram	+	-	-	+	-	+	+	-	-
Triadimefon	-	-	+	+	+	+	+	-	-
Vinclozolin	+	-	-	+	-	-	+	+	-
Zineb	+	-	-	+	-	-	-	+	-