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Alternaria leaf spot on brunnera.

Mode of Action Group 3: DMI fungicides

By A.R. Chase

This is the third of a 6-part series detailing mode-of-action groups for disease control comparing relative efficacy, resistance and phytotoxicity characteristics.

The mode-of-action group 3 (demethylation inhibitors, also called sterol biosynthesis inhibitors) fungicides were first introduced in the mid 1970s and products continue to be introduced. There are over 30 active ingredients in this group with only a few currently registered for ornamentals. The majority have been developed for other markets including grains, vines and fruit crops.

Some of the first group 3 fungicides to be registered for ornamentals included triadimefon (Bayleton and Strike) in 1975, propiconazole (Banner MAXX) in 1979 and myclobutanil (Systhane, Eagle and Hoist) in 1984. These examples represent the largest sub-group, the triazoles, which are often described as being both protective and curative as well as having contact and systemic properties, in some cases. Other sub-groups include piperazines (triforine, which is no longer registered on ornamentals) and imidazoles (imazalil the active ingredient in Fungaflor TR, which was introduced in 2007 as a total release product) and triflumizole (Terraguard) introduced in 1982.

Cercospora leaf spot on Kentia palm.

Resistance management

Resistance development to these fungicides is variable but overall described as medium with cross-resistance possible. Thus resistance to propiconazole might confer resistance to other triazoles like myclobutanil. Rotating a mode-of-action group 3 fungicide with another mode-of-action group is therefore the best approach to minimizing development of fungicide resistance.

Resistance management with DMI fungicides is different than with some other types of fungicides such as the strobilurins. DMI fungicide resistance is not complete or qualitative but rather due to a series of more than one mutation and therefore qualitative. This means that while resistance may be present, not all of the fungi in a given greenhouse have the same level of resistance. The instinct to use a higher rate of a fungicide when an application has failed can actually work with DMI resistance. Starting with a lower rate of a DMI fungicide and having unsatisfactory results can lead directly to applying a higher labeled rate with much better results. This does not work with some other fungicide groups like the strobilurins where using any rate results in no control when resistance to one has developed.

Application methods

Nearly all of the mode-of-action group 3 fungicides are applied as foliar sprays to ornamentals (or seed treatment in other crops) with only a few being effective and registered as soil drenches. Terra-

guard is effective as a drench and foliar spray depending on the pathogen target.

Most if not all DMI fungicides have some plant growth regulator effect. This can be extreme or minor and application site (foliar or root zone) is often a reflection of this characteristic. Sensitive plants are darker green, shorter and sometimes have glossy leaves when treated with DMI fungicides. For instance Banner MAXX is registered for outdoor use only and indeed has a moderate growth regulator effect on sensitive greenhouse crops. Representing the other end of the spectrum is Terraguard, which is registered for greenhouse use and can be applied as a drench. Some of these products are labeled for nursery or outdoor use only (e.g. Banner MAXX).

DMI fungicides are also variably labeled for application method with only Eagle or Hoist and Terraguard legal for chemigation according to the labels reviewed. Total release DMI Fungaflor TR is labeled for use in structures only and cannot be applied by chemigation.

I have been working with DMI fungicides since Terraguard was studied in the mid 1980s. My research at the time focused on foliage plants. Other crops were added when Chase Horticultural Research began operating in 1996. Since then we have worked on many of the products listed in Table 2 including the total release Fungaflor TR and the two newest triazoles Trinity and Tourney. Information on these two new products was included even though they are not currently registered for ornamentals, label approval is expected to occur in the near future.

Diseases controlled

There are many uses for the DMI fungicides (see Table 2). All of them ap-

Table 1. Comparison of DMI fungicides labeled for ornamentals*

Fungicide	Manufacturer/ source	Active ingredient	Drench permitted	Chemigation permitted	REI hour
Banner MAXX	Syngenta Professional Products	Propiconazole	No	No	12
Eagle (Systhane), Hoist	Dow AgroSciences and PROKoZ	Myclobutanil	No	Yes	24
Fungaflor TR	BASF Corp.	Imazalil	No	No	24
Rubigan A.S.	Gowan	Fenarimol	No	No	12
Strike 50WDG	OHP	Triadimefon	No	No	12
Terraguard 50WP	OHP (through Chemtura)	Triflumizole	Yes	Yes	12

* Based on label descriptions.

Table 2. Summary of efficacy of some copper fungicides for ornamental diseases*

Disease/pathogen	Banner MAXX	Eagle, Hoist	Fungaflor TR	Rubigan	Strike	Terraguard	Trinity**	Tourney**
Alternaria	Fair to							
Very good	Good to excellent	Very good to excellent		Very good	Good to excellent	Very good to excellent		
Botrytis			Some to very good		Good	None to very good	Very good to excellent	
Cercospora	Good to very good	Very good to excellent		Very good		Very good		Very good to excellent
Colletotrichum		None to very good				None to very good	Some to very good	Very good to excellent
Cylindrocladium						Good to very good	Some	
Downy mildew			Some to very good		Poor to excellent			Some
Fusarium	Good					Good	Some to good	
Myrothecium	Good	Some to good				Very good		
Phyllosticta	Some to good	Very good to excellent				None		
Powdery mildew	Very good to excellent	Very good to excellent	Very good	Very good to excellent	Good to excellent	Very good to excellent	Excellent	Excellent
Rhizoctonia		Very good			Fair	Fair to very good	Very good to excellent	Very good to excellent
Rust	Good to excellent	Very good to excellent		Very good	Good to excellent	Good to excellent	Excellent	
Scab (Sphaceloma)		Very good to excellent		Very good		Very good to excellent		

* Most of the research performed at Chase Horticultural Research, 1996-2009.

** Trinity and Tourney are currently not labeled for ornamental use in the United States.

pear to provide very good to excellent control of powdery mildew and rust diseases and miscellaneous fungal leaf spots including Cercospora, Alternaria and scab (Sphaceloma).

Some of the less likely target diseases include Botrytis blight, anthracnose (Colletotrichum) and downy mildew. Control of downy mildew can be poor to excellent depending on the plant type and active ingredient. This control variability may indicate that unless treatments are preventive they might not be effective. It may also indicate variable levels of sensitivity in the pathogen populations to different active ingredients in the DMI group.

The most effective DMI fungicide is Terraguard. It is not a triazole but rather an imidazole and can be very effectively used on a wide range of some very tough soil-borne fungi.

My first experience with Terraguard was during the 1980s when I worked with foliage plants. It was tested against Cylindrocladium root and petiole rot on spathiphyllum. Terraguard had the best results of all fungicides that were trialed. It also showed good results on other Cylindrocladium diseases (cutting rot on azalea and rose and crown rot on myrtle and other cut foliage crops). Additional studies have shown Terraguard provides good control of Fusarium wilt on cyclamen with many reports of similar results on other Fusarium ornamental diseases.

Terraguard also provides fair to very good control of Rhizoctonia. Rhizoctonia is often an aerial disease in the warmer, wet climates of the southern United States. Fungicide sprays (not drenches) can be an excellent method for control of Rhizoctonia web blight, leaf spot and aerial blight. While some other DMI fungicides have been evaluated for soil-borne diseases, they are not registered for this use. The results reported for Rhizoctonia were obtained on damping-off of celosia and cutting rots on poinsettia and hydrangea. These trials were performed using a sprench application (a spray application that provides some runoff into the growing medium).

Rotating applications

DMI fungicides (Group 3) are a natural rotation partner with strobilurin fungicides (Group 11) for many foliar diseases, especially powdery mildews and rusts. DMI fungicides offer unique application opportunities with chemigation (Eagle, Hoist and Terraguard), total release (Fungaflor TR) and drenching (Terraguard). Remember to always use products only according to their current labels.

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