



Managing Resistance in the Greenhouse

Managing pests and diseases in the greenhouse can be a challenge for even the most experienced grower. When resistance is thrown into the mix, new growers are often overwhelmed.

FUNGICIDE RESISTANCE

Fungicides should be used intelligently to prevent the loss of effectiveness by resistance development. Table 1 lists fungicides and their chemical classes that are most likely to develop pathogens with resistance. Do not make repeated applications of any of these materials. Rather, rotate them with materials outside of their chemical class. For example, you can rotate Cleary's 3336 with Chipco 26019 but not with Fungo Flo. Once resistance to one fungicide in a chemical class occurs, all of the fungicides in that class will be ineffective against the resistant disease.

A survey of 13 different greenhouses in Pennsylvania found that all of them had Botrytis with resistance to benzimidazoles, and six had Botrytis with resistance to dicarboximides. In Connecticut, 75 percent of Botrytis strains in six greenhouses were resistant to benzimidazoles, and 40 percent were resistant to both classes of fungicide. In South Carolina, 35 greenhouses were surveyed, and 65 percent of the Botrytis strains were found to be resistant to both benzimidazoles and dicarboximides. In some cases, participating greenhouses used little if any of these chemicals; however, they probably brought the resistant strains into the greenhouse on plant material.

Closer to home, I have been examining Pythium resistance to metalaxyl (mefenoxam). In 1997, about 30 percent of isolates recovered from greenhouses were resistant. Currently, our collection shows about 50 percent of the isolates from greenhouses are resistant. Isolates from field soil tend to be sensitive, presumably because they are not exposed to metalaxyl on a frequent basis.

Metalaxyl has always been our best fungicide for Pythium and Phytophthora. The late blight fungus, *Phytophthora infestans*, and the tobacco blue mold fungus, *Peronospora tabacina*, have widespread resistance to metalaxyl. Now that many greenhouse strains of Pythium are resistant to metalaxyl, I am reluctant to recommend the use of this material until we carry out resistance tests in the lab.

Not all fungicides will produce resistance in pathogens. For example, chlorothalonil (Daconil, Exotherm, Bravo) and Mancozeb have not resulted in resistance. Fungicides that usually result in

resistance typically have a "single site" mode of action against the fungus. For example, the fungicide may inhibit an important enzyme. When the fungus is subjected to these kinds of toxins, they find new ways to carry out their metabolic needs and, in the process, become resistant.

The fungicides in the chemical classes listed in Table 1 tend to result in resistance. They are all excellent fungicides so the temptation is to use them repeatedly. This is a mistake. Once the fungi become resistant, they may not revert to being susceptible (although some will). Rotate fungicides from these classes with materials in a separate class. Make sure the class of fungicides you choose to rotate with is effective against the target pest. Other fungicides not listed here should also be considered. Subdue can be rotated with Banol Truban, Aliette and Terrazole.

PEST RESISTANCE

Relying entirely on rotating insecticide appli-

Table 1. Fungicides and their chemical classes most likely to develop resistant pathogens.

Trade name	Common name
STEROL INHIBITORS	
Rubigan	fenarimol
Strike	triadimefon
Systhane	myclobutanil
Terraguard	triflumizole
BENZIMIDAZOLES	
Cleary's 3335	thiophanate methyl
Fungo Flo	thiophanate methyl
DICARBOXIMIDES	
Chipco 26019	iprodione
Vorlan	vinclozolin
STROBILURINS	
Compass	trifloxystrobin
Cygnus	kresoxim-methyl
Heritage	azoxystrobin
PHENYLAMIDES	
Subdue Maxx	mefenoxam*

* Earlier formulations of Subdue (metalaxyl) are chemically related to mefenoxam. Subdue can be rotated with Banol, Truban, Aliette and Terrazole.

cations will only delay resistance, not stop it. This makes managing insecticide resistance in the greenhouse more challenging than managing fungicide resistance. In addition to rotating insecticides, growers should consider several other strategies when coordinating an effective resistance management program.

Resistant Cultivars. When possible, choose those cultivars that are resistant to infestation and/or damage by the target pest.

Sanitation. One of the best ways to keep insects from infesting plants is to not provide opportunities for them to become established. Clean up weeds, nonessential plants and crop debris. It may be possible to schedule a plant-free period or crop rotation to break an insect cycle in individual greenhouses.

Inspecting, scouting and trapping. Inspect all incoming plant material for evidence of infestation. If present, isolate and treat. Also, scout existing plant material for insects and utilize sticky trapping for pests such as leafminers and thrips.

Exclusion. Use screens or barriers to prevent insects from migrating indoors and/or between greenhouses.

Biological Control. When possible, use insecticides that are soft on beneficials and/or time applications to minimize effects on the beneficials. This can also be accomplished by spot treating the areas of severe infestation rather than a broadcast treatment of an entire greenhouse.

Judicious use of pesticides. To be effective, each class of insecticide should be used for a period of time sufficient to cover at least one generation of insects before switching chemical classes. Avoid making short-term rotations and/or tank-mix applications. Both of these practices can result in contact of more than one insecticide to the same generation of insects, which will kill the susceptible pests and yet leave insects that resist both chemicals. Using longer rotation ensures that the insecticide will affect one complete generation of the pest. GPN

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