

# Greenhouse Disease Control Update

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**Botrytis Blight.** The fungus *Botrytis cinerea* causes disease on greenhouse ornamental and vegetable crops including leaf spots, blighting, stem cankers, and damping-off. *Botrytis* produces large masses of gray conidia or spores (hence the name “gray mold”) that are carried on air currents to healthy plants where blight can become established. Infection can start as a small leaf spot that can quickly coalesce into a large necrotic area or infect the cut stem surface of stock plants and progress downward, causing a dieback of the entire plant. On bedding and stock plants, *Botrytis* typically becomes established and produces conidia on older lower leaves that are near the moist soil surface and under the plant canopy. *Botrytis* can also infect dead plant tissue in the pot or on the greenhouse bench or floor, which can be a source of future infections.

When the weather is moist and humid, susceptible plants may need to be protected from *Botrytis* infection. Plants may also be susceptible if they become wet from water dripping from overhead, dew, or condensation. Water allows the *Botrytis* conidia to germinate and penetrate the plant. Watering in the morning so that the foliage can dry rapidly is one way to minimize *Botrytis*. Reducing relative humidity by spacing plants further apart and providing good air circulation can be helpful. Reduce the relative humidity for a minimum of 24 hours immediately following the harvesting of cuttings to help “dry” the wounded stems and thereby limit stem blight. Finding the beginnings of brown/gray fuzziness on lower leaves can signal the need for disease control measures. Sanitation is an important first step to reduce *Botrytis* in your greenhouse. If you have dead plant tissue on your greenhouse bench, it is likely supporting sporulating *Botrytis*! The table below shows that even the best treatments do not completely prevent infection; however, they are often necessary partners in a successful management program that includes environmental control and sanitation.

This table shows the results of a trial conducted on geraniums inoculated with *Botrytis*. Fungicides were applied and allowed to dry prior to introducing *Botrytis*. Newly registered product

Tourney 50WDG was highly effective and resulted in similar % leaves with *Botrytis* sporulation when compared to the industry standard Affirm WDG. A newly registered fludioxonil formulation, Emblem, was highly effective and will be included in future studies to confirm the results of this experiment. Although the biocontrol product Proud 3 statistically lowered the % of leaves with *Botrytis* sporulation compared to the untreated control, it should be noted that levels were at levels unacceptable for greenhouse production. The experimental product BAS 703 01F was very effective and is expected to be registered for greenhouse use in 2016.

Treatment and rate/100 gal, applied at 14-day intervals	Disease severity		Leaves with <i>B. cinerea</i> sporulation (%)
	1=healthy 10=dead		24 Jun
Untreated control	4.8	i**	39.4 d
BAS 703 01F 8 fl oz	1.6	ab	7.3 ab
Proud 3 4 qt	3.6	f-h	20.6 a-c
F9110 24 fl oz	4.2	g-i	31.6 cd
Pageant 38WG 14 fl oz	3.0	d-f	17.2 a-c
Tourney 50WDG 4 oz	1.8	a-c	9.0 ab
Emblem 4 fl oz	2.2	b-d	7.5 ab
Emblem 8 fl oz	1.4	ab	3.5 a
Affirm WDG 8 oz	1.2	a	7.0 ab

**Botrytis 'A' Team**

Daconil Weatherstik SC	chlorothalonil
Decree 50DF	fenhexamid
Chipco 26019 WDG, 26GT F	iprodione
Pageant 38WG	pyraclostrobin/boscalid
Affirm WDG	polyoxin D zinc salt

**Botrytis 'B' Team\***

Compass O WDG	trifloxystrobin
Heritage WDG	azoxystrobin
Insignia WG	pyraclostrobin
Palladium WDG	cyprodinil/fludioxonil

\*Not recommended when disease pressure is high.

**Downy Mildew.** Downy mildew occurs sporadically on some crops, but can be a predictable pest on others. There are many different pathogens that cause the downy mildew diseases and most are restricted to only one or a few plant crops. The downy mildew pathogen that infects rose is specialized and does not cause disease on other ornamentals, so if you've been struggling with downy mildew on coleus, snapdragon or impatiens, the rose downy mildew pathogen is not the culprit! Downy mildew can occur on all aboveground plant parts, blighting the leaves and stems. Sometimes the first symptoms of downy mildew are confused with a nutrient deficiency or spray injury. On the leaves, spots may be purplish or brown and appear square since they may be limited by the larger veins. Downy mildew that infects some plants, such as roses, doesn't always produce a fuzzy mat on the underside of the leaf that is noticeable without magnification. On other species, such as impatiens and coleus, sporulation may be observed easily on the underside of an infected leaf. When the infection is severe enough, leaves may drop from the plant, leaving the plant nearly devoid of foliage. Once the diseased leaves start dropping, the downy mildew is advanced and stopping it becomes very difficult. Since the downy mildew pathogen can lay quiet in tissue without noticeable blighting, it is possible to receive plants that appear healthy only to have symptoms develop later. It is also possible for the downy mildew pathogen to persist in a greenhouse or production facility, causing disease from one season to the next. A specialized spore (oospore) can remain dormant in infected plant debris and soil, surviving harsh weather conditions and allowing the downy mildew pathogen to survive between crops.

Downy mildew is very responsive to weather cues; when the weather is favorable, downy mildew symptoms can explode almost overnight. Wet weather, high relative humidity, and overcast conditions are triggers to downy mildew disease. In outdoor growing facilities fog provides nearly the perfect weather for an outbreak. During wet weather, a fuzzy mat of fungal threads can coat the underside of the leaf. This is where the downy mildew pathogen reproduces via a spore type called a sporangium. Sporangia develop and ripen during the night as long as there is darkness and at least 6 hours of continuous moisture. When the environment begins to dry in the early to mid-morning hours, the air currents or splashing water pluck the sporangia from their spore stalks and carry them to nearby healthy foliage. Downy mildew is most favored at temperatures around 60-65°F. Temperatures that are too warm (80°F and above) or too cold (40°F and below) stop the disease. If the weather becomes hot and dry, the downy mildew pathogen will be halted at least for a while, but it is possible for it to lay quiet in infected tissue and wait for cooler weather. MSU research tested the effect of temperature on the ability of *Peronospora* sp. to infect coleus at different temperatures. Infection was greatly reduced when temperature reached 77°F and did not occur at 86°F. A similar study was conducted to determine temperature effect on sporulation. Again, when temperatures reached 77-86°F sporulation was significantly reduced.

Once the plant is infected with downy mildew, there is no fungicide that can "cure" it. Fungicides may be needed to protect crops from downy mildew. Greenhouse and landscape studies conducted over the last few years have greatly increased our knowledge of efficacy and residual control of the various fungicides available for use against downy mildew. Systemic products that can be applied as a drench offer the best control and the longest residual. In particular, drenches of Adorn and Subdue MAXX have provided control against downy mildew for >30 post-treatment days in greenhouse and landscape studies. Due to pathogen resistance concerns associated with systemic products, it is important

to tank-mix and rotate with other products that can be applied as a drench, such as Alude and Heritage. Greenhouse studies have shown that preventive foliar applications of Micora, Orvego, Segway, FenStop, and Stature offer protection against downy mildew. These foliar applications, however, do not provide disease control for an extended period and should only be part of an overall program. A study was conducted at MSU to determine if



greenhouse applications of effective fungicides to bedding impatiens could provide season lasting downy mildew control in the landscape. Results from this study provided some confirmation of previous studies, that an extended downy mildew fungicide control program applied in the greenhouse provides >90 days of protection in the landscape. The most effective programs included drench applications of Subdue MAXX, Alude, and Adorn rotated with foliar applications of Segway and Micora. The final drench application of Subdue MAXX + Adorn seems to be especially important as both products offer long-term systemic protection. In the MSU downy mildew trials the experimental product oxathiapiprolin has been especially effective. This photograph (above) from September 2015 shows that impatiens treated with the most effective fungicides are still healthy 90 days after transplanting while the impatiens that were left untreated or treated with ineffective products are diseased or dead.

#### Downy Mildew 'A+' Team

Adorn SC	fluopicolide
Subdue MAXX EC	mefenoxam

#### Downy Mildew 'A-' Team

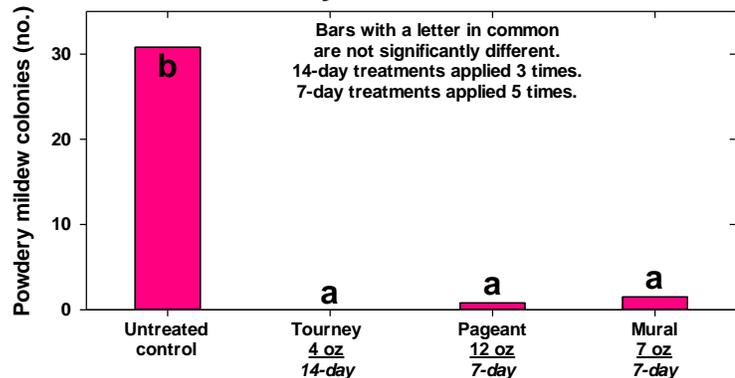
FenStop SC	fenamidone
Micora SC	mandipropamid
Orvego SC	ametototradin/dimethomorph
Segway SC	cyazofamid
Stature SC	dimethomorph

#### Downy Mildew 'B' Team

Compass O WDG	trifloxystrobin
Disarm O	fluoxastrobin
Heritage WDG	azoxystrobin
Insignia WG	pyraclostrobin
Pageant 38WG	pyraclostrobin/boscalid
Protect DF	mancozeb
Alude/OxiPhos/Vital	phosphorous acid

**Powdery Mildew.** The white talcum-like colonies of powdery mildew start small but can rapidly blight the leaves, stems, and flowers of susceptible crops. Some powdery mildews can be specific to one type of plant while other powdery mildews, such as *Erysiphe cichoracearum*, can infect many different annual and perennial flowers and vegetables. The abundant conidia (spores) give a white, powdery or fluffy appearance. There are times when identifying the disease can be difficult as infection sometimes only causes

#### Powdery Mildew on Phlox



yellowing and withering of leaves and stunted plant growth. High relative humidity can prompt epidemics. Some plant species such as gerbera daisy, calibrachoa, asters, and verbena are very susceptible and should be sprayed more frequently with the most effective fungicides. Other plant species may not need frequent applications but should be scouted regularly for signs of the disease. It should be noted that certain cultivars of a plant species may be more susceptible than others.

Growing crops susceptible to powdery mildews can be a challenge, and fungicides have typically played a key role. Powdery mildews are tricky and have been known to genetically adapt to overcome some of the most effective fungicides. If you are growing an especially susceptible crop or are starting with plants already showing signs of powdery mildew infection, you should start out with the most effective products, such as Eagle, Tourney, and Terraguard. In one study looking at powdery mildew control on phlox, applications of Tourney and Pageant were highly effective and resulted in little to no infection. The introduction of these newer products in recent years will allow growers to rotate more active ingredients into their powdery mildew control programs without compromising efficacy.

Powdery Mildew 'A' Team		Powdery Mildew 'A-/B+' Team	
Eagle EW/WP	myclobutanil	Compass O WDG	trifloxystrobin
Terraguard SC	triflumizole	Heritage WDG	azoxystrobin
Tourney 50WG	metconazole	Insignia WG	pyraclostrobin
		Pageant 38WG	pyraclostrobin/boscalid
		Palladium WDG	cyprodinil/fludioxonil

**Pythium Root Rot.** *Pythium* crown and root rot is a common and persistent disease in the greenhouse industry. *Pythium* is a water mold that can “nibble” the feeding roots of plants, resulting in stunted growth. *Pythium* also causes severe symptoms, such as crown rot, that can result in plant death. *Pythium* favors wet, saturated soil conditions, such as overwatered media. The persistence of this pathogen can be traced to its ability to ‘hibernate’ on dirty plant containers, benches, hoses, and greenhouse walkways, ready to become activated by the right crop and weather conditions. Although *Pythium* can be a problem on almost any greenhouse crop, plants like geranium, poinsettia, and snapdragons are often the most affected. Sanitation is especially important in limiting root rot. Conditions that favor good plant growth and minimize stress make the plant less vulnerable to attack by a root rot. Use a pressure washer with soap and water when cleaning walkways, benches, etc. You can follow this with a disinfectant to remove any remaining *Pythium*. If you’ve done everything right and still find yourself with a *Pythium* problem, choosing the right fungicide tools can minimize your losses.

Scouting is an important first step in controlling *Pythium* root rot. If *Pythium* has a significant head start, the root system of some plants will be too rotted and the fungicides will not be able to rescue them. If Subdue MAXX has been the only or primary fungicide used over the years, and *Pythium* continues to be an issue in your greenhouse, it is possible that the *Pythium* has become resistant and is no longer affected by this fungicide. To know for sure, the *Pythium* present in your greenhouse must be tested in a diagnostic lab. To avoid the development of resistance, rotate among the different active ingredients available among fungicide products.

If *Pythium* has not been a major issue in your greenhouse, a fungicide such as Banrot 40WP is a mixture of two different active ingredients and targets all three common greenhouse root rots. If *Pythium* is diagnosed as the problem, choosing a fungicide that is specific for *Pythium* is important. Products effective against *Pythium* include Subdue MAXX (also available as Mefenoxam 2), Truban, Terrazole, and FenStop. If you have *Pythium* resistant to Subdue MAXX in your greenhouse it is recommended that Truban or Terrazole be used as they have been shown to be the most effective products in our greenhouse trials. Since Truban and Terrazole have the same active ingredient, rotating between these two fungicides is not recommended. Alude, Captan, Empress Intrinsic, FenStop, Heritage, and Segway are tools for *Pythium* control that can be helpful if used early and if the disease is not severe. Biocontrol products such

as Actinovate and RootShield can also be helpful; however, they must be applied prior to *Pythium* symptoms being observed. Several of our studies indicate that Actinovate offers suppression of *Pythium*. For the best control, the time between fungicide applications should not be stretched beyond the minimum interval listed on the label. Only drench applications, not spray applications, are effective in controlling *Pythium* root rot. Although several new effective *Phytophthora* control products, such as Micora, Orvego, and Adorn, have recently been labeled for the greenhouse, studies have shown that this efficacy does not always extend to *Pythium*.

***Pythium* ‘A’ Team\***

Terrazole WP/Truban WP	etridiazole
Subdue MAXX EC	mefenoxam

\*Watch for pathogen resistance.

***Pythium* ‘B/B-’ Team**

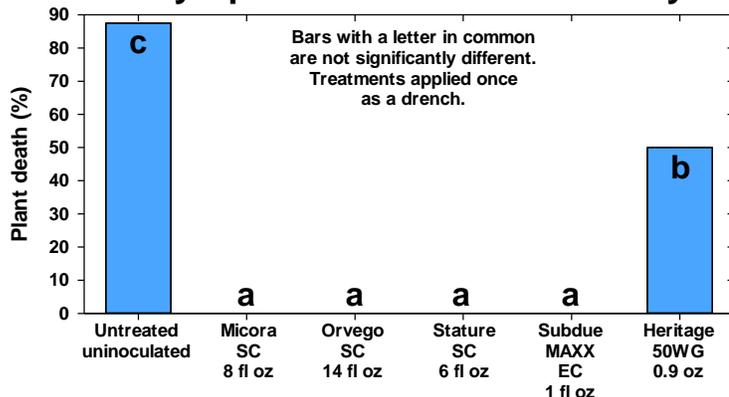
Captan WDG	captan
Empress SC	pyraclostrobin
FenStop SC	fenamidone
Heritage WDG	azoxystrobin
Segway SC	cyazofamid
Alude/OxiPhos/Vital	phosphorous acid

***Phytophthora* Root Rot.** *Phytophthora* is a water mold (like *Pythium*) and can be a particularly devastating and difficult-to-control problem. It can spread quickly in a greenhouse, especially in flood floor and hydroponic systems. Two species of *Phytophthora* (*Phytophthora nicotianae* and *Phytophthora drechsleri*) are usually found infecting floriculture crops and can cause root, crown, and foliar blights. *P. nicotianae* can infect snapdragon, fuchsia, verbena, vinca, African violet, and dusty miller to name a few. *P. drechsleri* may infect poinsettias, million bells/calibrachoa, and pansies. Losses can be especially severe where ample water and warm temperatures favor disease epidemics. Symptoms include brown-black cankers at the soil line and diseased roots. Infected foliage will have a water-soaked, dark necrotic area. In some cases, the crowns will be the first plant part to become infected, after which the infection will move up the stem into the foliage near the petiole. This type of symptom is especially noticeable on English ivy and African violets.

Controlling the spread of *Phytophthora* spp. can be difficult. First, *Phytophthora* must be kept out of the production site. This is particularly difficult with floriculture crops because of the widespread distribution of prefinished plants. Also, plants may not exhibit obvious symptoms until the infection is well established or the plant becomes stressed (e.g., over- or underwatered). Infected plants treated with fungicides may appear healthy until the fungicides wear off and *Phytophthora* increases. The second challenge is eradicating *Phytophthora* once it has been introduced. Sanitation can limit disease and includes removing plant debris and disinfesting production surfaces. Power washing benches and replacing floor mats are important steps to take to reduce inoculum for future crops.

If fungicides, such as the standard Subdue MAXX, are used to control *Phytophthora*, rotate it with other effective products. Adorn, Micora SC, Orvego SC, and Stature have been effective in controlling various *Phytophthora* species in greenhouse studies. Phosphorous acid products, such as Alude and Vital, may limit disease, however, due to their lack consistency, they should not be relied upon for *Phytophthora* control. Other fungicides such as FenStop, Empress, Heritage, Terrazole/Truban, Segway, and Aliette, may offer help if the disease pressure is not too severe. Some

**Phytophthora Root Rot on Pansy**

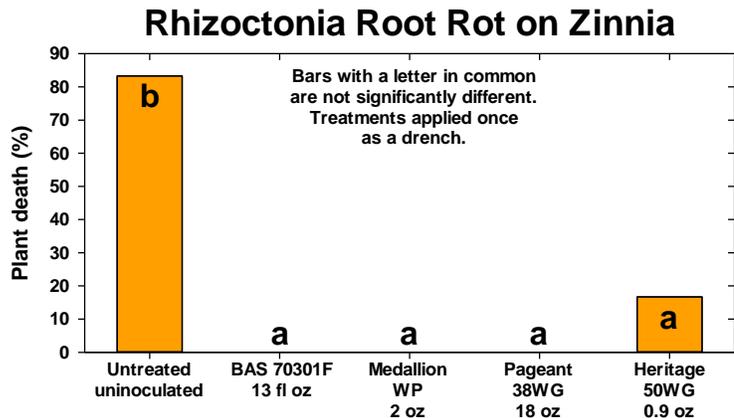


products have performed well on one crop but failed on another, so care must be taken to use a fungicide program that effectively rotates products to maintain disease control and minimize the chance of fungicide resistance developing in *Phytophthora*.

<i>Phytophthora</i> 'A' Team		<i>Phytophthora</i> 'B' Team	
Adorn SC	fluopicolide	Aliette WDG	fosetyl-al
Micora SC	mandipropamid	Captan WDG	captan
Subdue MAXX EC	mefenoxam	FenStop SC	fenamidone
		Orvego SC	ametoctradin/dimethomorph
		Segway SC	cyazofamid
		Stature SC	dimethomorph
		Terrazole WP/Truban WP	etridiazole
		Alude/OxiPhos/Vital	phosphorous acid

**Rhizoctonia Root Rot.** The *Rhizoctonia solani* fungus typically causes a dull brown to dark brown rot on lower plant stems. In severe cases it can also destroy the root system of an infected plant. This pathogen can thrive in wet/dry or warm/cool conditions. Sanitation is an important method of limiting the pathogen as it is most likely to spread via contaminated soil, flats, or pots. Terraclor, Terraguard, Cleary's 3336/OHP 6672, and Medallion applied as a drench have been important tools in preventing *Rhizoctonia* and halting its spread. Newer products Pageant 38WG and Tourney WG have shown excellent efficacy in recent studies and could be included in effective control programs. Repeated studies with the biopesticide Affirm WDG have shown it to be a very effective product against *Rhizoctonia*. Biocontrol agents are becoming more widely available for use in controlling damping-off fungi such as *Rhizoctonia*. Soil applications of the fungicides are the most effective method of applying the various products when dealing with a *Rhizoctonia* infestation.

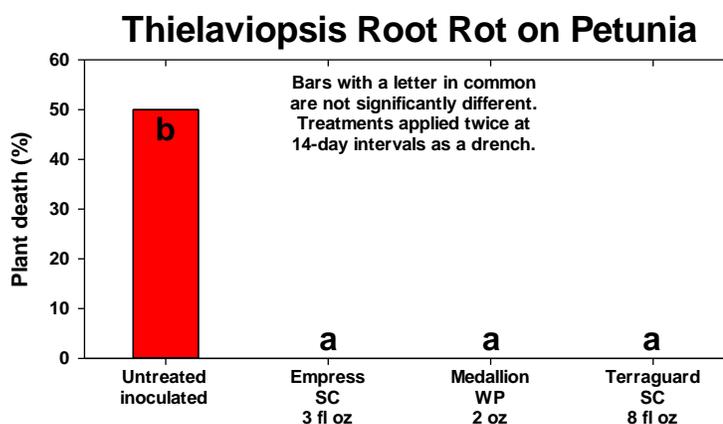
Growing mixes that are naturally suppressive to damping-off soilborne fungi are also available to growers. A "suppressive" medium is one that represses, restrains, or checks the growth of damping-off fungi. Initially, interested growers may want to test the usefulness of suppressive media in their growing system by planting a small portion of their crop in suppressive media. Communication with sales representatives and extension personnel may be helpful to evaluate and perhaps modify growing systems using suppressive media to achieve the best results.



<i>Rhizoctonia</i> 'A' Team		<i>Rhizoctonia</i> 'B+' Team	
Affirm WDG	polyoxin D zinc salt	Captan WDG	captan
Medallion WG	fludioxonil	Cleary's 3336 WP/OHP 6672 FL	t-methyl
Pageant 38WG	pyraclostrobin/boscalid	Heritage WDG	azoxystrobin
Terraclor 400 WP	PCNB		
Tourney 50WG	metconazole		

**Black Root Rot.** Black root rot, caused by the fungus *Thielaviopsis basicola*, is a serious threat to pansies, petunias, and vinca. It may also infect cyclamen, calibrachoa, poinsettia, primula, impatiens, snapdragon, verbena, phlox, begonia, and nicotiana. Symptoms of black root rot are often mistaken for nutrient deficiencies. Leaves may turn yellow and the youngest leaves become stunted and tinged with red. In mild infections, older leaves are yellow-green with the veins retaining their green color.

Sanitation is the best preventive measure against black root rot. This pathogen produces a spore that can persist on floor mats, greenhouse benches, or flats/pots. It is not recommended to reuse plug trays for crops that are susceptible to *Thielaviopsis*. University studies have shown that fungus gnats and shore flies can move this pathogen around a greenhouse by eating the spores and excreting them into nearby pots. If you have a *Thielaviopsis* problem and a fungus gnat problem then you will have a quickly spreading epidemic! Based on MSU studies, fungicides that have thiophanate-methyl as the primary active ingredient (Cleary's 3336 F is an example) should be used frequently. Good rotational products include Terraguard and Medallion since they have a different mode of action and were shown to be effective in MSU studies against black root rot. In one greenhouse study conducted at MSU, the newly registered product Empress (pyraclostrobin) was highly effective against *Thielaviopsis*, however, more studies are needed to determine if it should be recommended to growers. Choosing an effective fungicide to control black root rot is critical because a misstep early in the disease epidemic may result in an unsalable crop. It is recommended to use the highest labeled rate of each treatment with close reapplication intervals.



***Thielaviopsis* 'A' Team**

Cleary's 3336 WP/OHP 6672 FL	t-methyl
Medallion WG	fludioxonil
Terraguard SC	triflumizole

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