

Managing Multiple Diseases in Cucurbits: Fungicide Update

Margaret Tuttle McGrath

Plant Pathology and Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research and Extension Center (LIHREC),
3059 Sound Avenue, Riverhead, NY 11901. mtm3@cornell.edu

Managing diseases is an important component of a successful production program for cucurbit crops. At a minimum powdery mildew will occur. Several other diseases can occur in the northeast. Powdery mildew always occurs due to the quantity of easily wind-dispersed spores that the pathogen produces and the breadth of conditions under which it can develop (no high moisture requirement). The downy mildew pathogen also can move long distances; its occurrence in the northeast varies yearly, especially on crops other than cucumber. Occurrence of other diseases varies among farms depending on whether the pathogen is in the soil (several including *Phytophthora* blight), surviving in alternative host plants including weeds (e.g. white mold, viruses), present in insect vectors (e.g. bacterial wilt) or present in/on crop seed (e.g. bacterial leaf spot), and also crop susceptibility (cucumber is more often affected by downy mildew and bacterial wilt than other cucurbits but less often affected by powdery mildew due to excellent host resistance). Infected crop at a near-by farm can also be a source of pathogens that move short distances such as during a rainstorm (e.g. *Plectosporium* blight). Most diseases are more severe during a rainy than dry season because wet leaves or soil are favorable conditions for most pathogens (exceptions include powdery mildew, bacterial wilt, and virus diseases).

Fungicides are an important tool for managing diseases. Cultural practices, which include resistant varieties, are valuable components of an integrated management program, but typically when used without fungicides will not achieve sufficient control to avoid a reduction in yield or fruit quality. Fungicides recommended routinely change as new products are registered and pathogens develop resistance to fungicides that have been in use for several years. Modern fungicides because of their targeted mode of action typically have medium to high risk for resistance to develop in the pathogen. These need to be used in alternation to delay development of resistance, avoid control failure when resistance develops, and comply with label use restrictions. Some targeted fungicides have narrow activity necessitating applying multiple products when more than one disease is occurring. This is especially true with the most common diseases, powdery mildew (caused by a fungus) and downy mildew and *Phytophthora* blight (caused by oomycetes).

Powdery mildew. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control. The pathogen has demonstrated ability to evolve and become less effectively controlled by both tools. Resistant varieties are now available in most crop groups with new varieties released most years. Resistance in cucumber is standard in modern varieties and is so strong it is easy to forget this cucurbit type is susceptible until an Heirloom type is grown. Cantaloupe with resistance to pathogen races 1 and 2 have exhibited excellent suppression. Resistance in other cucurbit crop types is not adequate used alone (without fungicide applications) to prevent impact of powdery mildew on yield. Alternate among targeted, mobile fungicides in the 4 chemical groups below (first 2 most important), and apply with protectant fungicide to manage resistance development. Begin very early in disease development (one older leaf out of 50 with symptoms). Fungicide efficacy and occurrence of pathogen resistant strains are studied every year at LIHREC.

Vivando or Prolivo (FRAC Group 50). Activity is limited to powdery mildew. They can be applied 3 times (4 for Prolivo at low label rate which is not recommended) with no more than 2 consecutive applications. REI is 12 and 4 hr, respectively. PHI is 0 days. Do not mix Vivando with horticultural oils. Less sensitive isolates have recently been detected.

DMI fungicides (FRAC 3) include Proline, Procure, and Rhyme (these considered most effective) plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Tebuzol, and TopGuard (also has FRAC 11 ingredient). Efficacy varies from good to excellent (Proline) in fungicide evaluations. Cevya is not as effective for powdery mildew on lower leaf surface as some others. Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Procure applied at its highest label rate provides a

higher dose of active ingredient than the other FRAC 3 fungicides. Five applications can be made at this rate. REI is 12 hr for these fungicides. PHI is 0 to 7 days. Powdery mildew is the only labeled cucurbit disease for some of these; see last section for additional labeled diseases.

Carboxamide fungicides (FRAC 7) include Luna fungicides (Luna Experience and Luna Sensation), Miravis Prime (also has FRAC 12 ingredient which targets other diseases), Fontelis, Endura, Pristine and Merivon. Powdery mildew pathogen strains resistant to boscalid, active ingredient in Endura and Pristine, have been detected since 2009 on Long Island and likely are the reason for poor efficacy in some fungicide evaluations. In laboratory assays boscalid-resistant strains exhibited sufficient cross resistance with Fontelis and Merivon that these are expected to be ineffective as well, but not with Luna fungicides. However, Luna Sensation failed in experiment at LIHREC in 2017. Luna Experience is the best choice. REI is 12 hr. PHI is 7. Maximum number of applications is 2-5, depending on rate used. Low rate is not recommended. Luna Experience also contains tebuconazole (FRAC 3), which needs to be considered when developing an alternation program. Luna Sensation is not recommended because it also contains trifloxystrobin (FRAC 11); resistance to this chemistry is very common. Limited use of Luna Experience is recommended. Less sensitive isolates have recently been detected.

Gatten (FRAC U13) was not as effective as Vivando when tested at LIHREC in 2018.

Switch (FRAC 9+12) ingredient with activity for powdery mildew (9) has greater activity for other labeled diseases and is recommended for powdery mildew when needed for others.

Resistance is a major issue. Recent testing of isolates from commercial crops in NY revealed a high percentage of isolates (67-100%) being resistant to Quintec from crops treated twice with Quintec even though a good fungicide program was used. Many isolates were also resistant to Torino (FRAC U6) and Endura (FRAC 7) although these or related fungicides were not applied. Almost all isolates tested were resistant to MBC fungicides (FRAC 1; Topsin M), although now in limited use, and QoI fungicides (FRAC 11; Quadris, Cabrio and Flint). Therefore, none of these are recommended. Occurrence of multi-fungicide resistant isolates is a concern.

There are several protectants for powdery mildew, including chlorothalonil, sulfur, copper, botanical and mineral oils, and several biopesticides. Sulfur is most effective.

Phytophthora blight. This destructive disease has more been severe recently in areas where there were intensive rainfall events, which created unusually favorable conditions. A key to successfully managing this disease is managing soil moisture to avoid saturated conditions. Achieving this is difficult when rainfall amounts are large. Another key has been fungicides registered in recent years with targeted activity for pathogens in this biological group (Oomycetes). Information about these follows section on downy mildew. These are considered the reason many growers have been effectively managing Phytophthora blight. A preventive fungicide program is considered essential. Ineffective control with fungicides has been associated with poor application timing in some fields (application missed when rain began before expected) while in others favorability of environmental conditions seemed to have been too great. Development of fungicide resistance is a concern with all targeted fungicides due to single site mode of action; therefore, alternation amongst chemistry is recommended. Resistance to Ridomil, Ranman and Presidio have been detected in the US. Protectant fungicides, such as coppers, are not sufficiently effective to be recommended alone for Phytophthora blight; however, they are useful tank-mixed with targeted fungicides to manage resistance.

Biopesticides There are several products (including Actinovate, AVIV, Bio-Tam, Companion, Howler, Regalia, SoilGard, Stargus, TerraClean 5) that can be applied to soil pre-transplant, at planting, and via drip to manage the blight pathogen, *Phytophthora capsici*, in the root and crown zone and to induce resistance (Regalia). Most of these biopesticides can also be applied to foliage. They are approved for organic production. Some other biopesticides are labeled for *Phytophthora* species causing root rot.

Downy mildew is primarily managed with fungicides. Cucumbers with a new source of resistance are now available. Those that performed well in variety evaluations are an experimental from Tokita (others, CU201AS and CU203AS, are now available), DMR 401, NY264, Brickyard and Citadel, a pickling type suitable for fresh market. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. Edisto 47, Planter's Jumbo, and Trifecta are resistant cantaloupe varieties. An

integrated program with fungicides applied to resistant varieties is recommended, and needed with the resistant cantaloupes to achieve adequate control.

The forecast website for this disease at <http://cdm.ipmpipe.org> is an important tool for determining when fungicide application is warranted and to what crops. Cucurbit plants are susceptible to downy mildew from emergence; however, this disease usually does not start to develop in the northeast until later in crop development when the pathogen is dispersed by wind into the region. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. The risk of downy mildew occurring throughout the eastern USA is forecast and posted three times a week. Forecasts enable timely fungicide applications. Label directions for some fungicides state to begin use before infection or disease development. The forecasting program helps ensure this is accomplished. Growers can subscribe to receive customizable alerts by e-mail or text message. Information is also maintained at the forecast web site of cucurbit crop types being affected by downy mildew. This is important because the pathogen exists as two main clades. First clade to appear each year infects cucumber and cantaloupe. Second infects squash, pumpkin, and watermelon. Forecast system success depends on knowledge of where downy mildew is occurring; therefore, prompt reporting of outbreaks by growers to extension staff or the website is critical.

While the pathogen has potential to produce oospores, which would enable it to survive cold winters, pattern of disease occurrence in the US suggests this obligate (can't survive on dead plant tissue) pathogen is only surviving over winter where cucurbits are growing (e.g. south FL). Additionally, the two mating types are being found on different crop types. Oospores are produced as a result of sexual reproduction, which requires pathogen isolates of different mating type to grow together. If the situation changes and oospores are produced, downy mildew will begin developing in the northeast much earlier in the growing season. Plants are susceptible from the cotyledon stage.

As with powdery mildew, fungicide resistance is also a concern with the downy mildew pathogen and therefore the fungicide program recommended is also targeted, mobile fungicides applied in alternation based on FRAC Code (see list below) on a weekly schedule and tank mixed with a protectant fungicide (chlorothalonil or mancozeb) beginning very early in disease development. With both diseases expect recommendations to change as pathogens develop resistance to additional chemistry and new fungicides become available. So far resistance has been associated with pathogen affecting cucumber and melon. Fungicides described below as being affected by resistance may still be effective for downy mildew in other types of cucurbits.

Fungicides for Phytophthora blight (PB) and/or downy mildew (DM):

Orondis (FRAC 49). The novel active ingredient, oxathiapiprolin, has exhibited excellent activity in fungicide evaluations. It is formulated with mandipropamid as Orondis Ultra (REI 4 hr; PHI 0 day) for both diseases, with chlorothalonil as Orondis Opti (REI 12 hr; PHI 0 day) for DM, and with mefenoxam as Orondis Gold applied once to soil at planting (REI is 0 or 48 hr depending on application method; PHI is 5 days) for PB. Either Orondis Gold or the formulations for foliar use are permitted used on a crop. Label use limits for other products are 33% of the applications when 3 or more applications are made or a maximum of 4 applications, whichever is fewer.

Elumin, Zing! and Gavel (FRAC 22). Zing! and Gavel are the only products that have a targeted fungicide and a protectant fungicide (chlorothalonil or mancozeb). All are labeled for DM; Elumin and Gavel are also labeled for PB. REI is 12 hr; 48 hr for Gavel. PHI is 2, 0 and 5 days, respectively. Apply no more than twice in succession. Total crop usage varies among products. The amount of chlorothalonil in an application of Zing! (1.18 lb/A) is less than the highest label rate of chlorothalonil fungicides for downy mildew (1.5 lb/A) and is below the range for other diseases including powdery mildew (1.5-2.25 lb/A). Increasing the amount of chlorothalonil applied is prudent for these diseases. To obtain an application rate of 1.5-2.25 lb/A chlorothalonil, tank mix Bravo WeatherStik at 0.43-1.43 pt/A with Zing!.

Omega (FRAC 29). REI is 12 hr. PHI is 7 days for squash/cucumber subgroup, which includes pumpkin, and 30 days for melons. Apply no more than 7.5 pts/A to a crop or 4 applications applied at highest label rate of 1.5 pts/A. Omega is more expensive than other fungicides.

Previcur Flex (FRAC 28). Activity is limited to DM. REI is 12 hr. PHI is 2 days. Label limit is 5 times in a season.

Phosphorous acid fungicides (FRAC P07, formerly 33). There are numerous products (e.g. Agri-Fos, Fosphite, K-Phite, Phostrol, ProPhyt, Rampart), all effective only for PB. They are recommended used at a low label rate tank mixed with the targeted PB fungicides listed above.

Fungicides with documented or suspected resistance in the US. Resistance to Ridomil, Ranman, and Presidio was detected in the PB pathogen; most testing was in the southeastern US. Resistance to other fungicides was detected in the DM pathogen affecting cucumber including in the northeastern US. These are no longer recommended for DM in cucumber and melon (caused by pathogen Clade 2) and recommended used sparingly (less than label limit) for DM in squash and pumpkins (pathogen Clade 1) and used for PB early in the season when DM is not a concern. Resistance has been confirmed based on laboratory testing of isolates.

Ranman (FRAC 21). Use organosilicone surfactant when water volumes are less than 60 gallons per acre. REI is 12 hr. PHI is 0 day. Apply no more than 6 times in a season with no more than 3 consecutive applications.

Presidio (FRAC 43). Must be applied with another fungicide. REI is 12 hr. PHI is 2 day. Apply no more than 4 times in a season with no more than 2 consecutive applications.

Revus (40) and Zampro (FRAC 40, 45). While in the same fungicide chemical group (40), there is indication they may have slightly different mode of action, thus there may be benefit to using one for the first application of a product in this group in a fungicide program and then switching to the other product later in the program. REI is 12 hr. PHI is 0 day. Apply no more than 3 times (4 for Revus) with no more than 2 consecutive applications (no consecutive with Revus). Revus must be applied with a spreading/penetrating type adjuvant. Revus is recommended used sparingly because of suspected resistance. Forum is no longer recommended; it has the same FRAC 40 ingredient as Zampro.

Ariston, Curzate or Tanos (FRAC 27). These have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). They can be a good choice when it was not possible to apply fungicide at the start of a high risk period when temperature is below 80 F. Apply another targeted fungicide 3-5 days later. Curzate and Tanos must be tank-mixed with a protectant; Ariston contains chlorothalonil. REI is 12 hr. PHI is 3 days. Apply no more than 4 times in a season (6-9 for Curzate depending on rate); no consecutive applications of Tanos are permitted. Ariston and Curzate aren't labeled for PB.

Recommended protectant fungicides. Chlorothalonil and mancozeb are the main protectant fungicides for DM and PB. Copper is also good for PB, but isn't as effective for DM.

Not recommended for downy mildew. Resistance to mefenoxam and metalaxyl (Ridomil) and to strobilurins (e.g. Cabrio) are sufficiently common that fungicides with these ingredients, which use to be highly effective, have been ineffective since 2004.

Other diseases that can affect cucurbits and labeled fungicides.

Alternaria leaf spot. Fontelis (FRAC 7), Inspire Super (3,9), Aprovia Top (3,7), Miravis Prime (7,12), Pristine (7,11), QoI fungicides (11), Reason (11), Switch (9,12), Tanos (27), Omega (29).

Anthrachnose. Aprovia Top (3,7), Inspire Super (3,9), Pristine (7,11), QoI fungicides (11), Tanos (27), Topguard (3,11), and Topsin M (1).

Bacterial leaf spot. Actigard (21) and copper (M1). Quintec applied for powdery mildew may apply some suppression of bacterial diseases.

Fusarium fruit and crown rot. Proline (3).

Gummy stem blight/Black rot. Fontelis (7)*, Aprovia Top (3,7), Inspire Super (3,9), Miravis Prime (7,12), Pristine (7,11)*, Proline (3), Rhyme (3), Switch (9,12), Omega (29), QoI fungicides (11)*, and Topsin M (1)*.

Plectosporium blight. Aprovia Top (3,7), Inspire Super (3,9), QoI fungicides (11), and Topguard (3,11).

* Resistance detected in the US.

See <https://www.vegetables.cornell.edu/pest-management/disease-factsheets/> for additional information about diseases of cucurbits and management including fungicides, plus photographs.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict due to label change or error. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.