CUCURBIT DOWNY MILDEW: WHAT TO LOOK FOR AND HOW TO CONTROL IT!

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Knowing what the initial symptoms of a disease look like and knowing when the disease can start to develop are important for effectively managing a disease with fungicides. These can be even more important than implementing the most efficacious fungicide program! This is because most fungicides are effective during the infection process with limited if any activity after infection. It can be impossible to slow disease development once well established in a crop, which cucurbit downy mildew can do quickly.

Early symptoms of downy mildew are tiny spots on leaves. Other plant parts are not susceptible. Images are posted at: http://www.longislandhort.cornell.edu/vegpath/photos/index.htm and at http://cdm.ipmpipe.org. Initially spots are wilted or water-soaked. The color becomes yellow on most cucurbits, spots can be yellow-orange on Halloween pumpkin, whereas they are dark brown to black on watermelon. Spots develop an angular appearance as they enlarge because the pathogen cannot move through veins in the leaf. The bacterial disease angular leaf spot has symptoms most similar to downy mildew and thus is most likely to be confused for downy mildew. One way to distinguish the two is to look for the characteristic growth of the downy mildew pathogen on the underside of the spots. A hand lens or magnifying glass will probably be needed to see this growth, which is the pathogen's spores and the tree-like structures they form on (aka sporulation). This growth will usually be a dark brown unless there are no spores present. Early morning is the best time to see this growth because spores are produced over night and released in the morning as the humidity changes and wind speed increases. If growth is not found, favorable conditions for pathogen growth can be provided by putting leaf tissue with symptoms up-side-down on wet paper towel in a plastic bag with some airspace before sealing it shut. Put a box over the bag to keep it in the dark. Examine the leaf again 12 – 24 hours later. Don't leave the leaf a lot longer as saprophytic fungi will start to grow and could be confused for downy mildew. Finding characteristic growth of the downy mildew pathogen confirms the spots are the result of this disease; however, not finding this growth does not mean it is not downy mildew! Amount of sporulation varies with crop type. It is easiest to find on cucumber and butternut squash leaves. It can be very hard to find on watermelon and giant pumpkin (*Cucurbita maxima*), and sometimes also difficult on cantaloupe, Halloween pumpkin (*Cucurbita pepo*) and summer squashes.

Cucumbers usually become affected by downy mildew before other cucurbit crops. Therefore this is the crop to focus most attention on when scouting for symptoms. Downy mildew occurs more sporadically on the other crops, especially watermelon and giant pumpkin. This is because the pathogen exists as pathotypes varying in ability to infect the different types of cucurbits with cucumber susceptible to all. Downy mildew is of minor concern in crops being treated routinely for Phytophthora blight with targeted fungicides because most are effective for both of these oomycetes. About one week after rain is a good time to look for symptoms because rain is an important way that spores are moved from air currents down onto crops.

Cucurbit crops are susceptible to downy mildew from the cotyledon stage, thus this disease is a concern throughout production. In contrast, field-grown cucurbits are not susceptible to powdery mildew until fruiting. Without knowledge of when the downy mildew pathogen is present, a lot of time can be spent on weekly scouting for symptoms and a lot of fungicide applications can be made to protect the crop.

Downy mildew almost always starts to develop on a crop in the northeast after spores are successfully dispersed there by wind from another affected crop. The pathogen cannot survive very long when not growing inside living host plant tissue (it is an obligate pathogen). Unlike

some other downy mildew pathogens, it does not produce a resting spore (oospore, which is the product of sexual reproduction) to enable it to survive in soil between seasons and it cannot be seed-borne. The spore produced (asexually) on the underside of leaf spots can be dispersed by wind many miles. Another possible way that the downy mildew pathogen can be brought onto a farm is on cucurbit transplants produced in an area where the disease is developing near-by.

The *ipm*PIPE forecasting system is a valuable tool for determining when downy mildew is likely to begin developing on a farm and what crops are most likely to be affected. This is a unique forecasting system because unlike others, it is predicting spore movement as well as when conditions are favorable for infection. Only environmental conditions favoring disease development are considered with other systems, including Tomcast, Blitecast, and Simcast. The *ipm*PIPE website has these forecasts and additional information about cucurbit downy mildew useful for its management. The website is at http://cdm.ipmpipe.org. Forecasts are produced and posted online at least twice (usually three times) a week during the growing season by a trained meteorologist. A disease alert system was developed in 2010 to provide growers customized, real-time information on status of downy mildew, disease forecasts, and occurrence of new outbreaks near their farm. Growers can sign up at the website to receive text or e-mail alerts. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. Knowing when a pathogen is likely to first infect a crop enables ideal timing of fungicide applications and other protective measures. Fungicides perform best when applied before infection. Equally important, the forecasts indicate when there is no risk of downy mildew. This can be especially useful for reducing unneeded fungicide applications when conditions are expected to be favorable (rainy weather forecast when downy mildew is present in a nearby region) but wind trajectories are predicted to go in a different direction. By using the forecasting system, reduction of 2 to 3 fungicide applications has been reported for growers in Georgia, North Carolina, and Michigan. With about 122,000 acres of cucurbits in the three states and at an average cost of $25/acre for each fungicide application, this equates to more than $6 million in savings to producers in these states. The website also has resources including information about the biology of the pathogen and current disease control recommendations.

Information about the type of cucurbit crop found affected is an important component of the status of downy mildew provided at the website. The various pathotypes affect different cucurbit crops. So if downy mildew has only been found affecting cucumber and cantaloupe at potential source areas for pathogen spores, a grower would not need to apply fungicide to protect pumpkin or watermelon crops despite a high risk forecast for downy mildew in his area.

While most growers use the forecasting system to optimize fungicide applications, one innovative grower uses it to determine when to operate his Spore Exclusion Tunnels. Lou Lego, Elderberry Pond Farm, designed and built low and high tunnels with low-cost air filtration system capable of blocking pathogen spores from entering. The system contains standard allergen reduction filters. It was completely successful: downy mildew did not develop on cucumber plants inside the Spore Exclusion Tunnels while plants were killed in outdoor and conventional high tunnel plantings.

Success of the forecast system depends on knowledge of where downy mildew is occurring; therefore prompt reporting of outbreaks by growers is critical. Growers can log a report directly at the website, or notify vegetable extension faculty or educators who will log a report.

Fungicides. There are several fungicides now registered with targeted activity for oomycete pathogens like the one causing cucurbit downy mildew. They are highly effective and rainfast because of their mobility in plants. Therefore they are excellent choices for managing downy mildew. The forecasting system is especially valuable for determining when to apply these fungicides because of their narrow-spectrum activity. Phytophthora blight is the only other disease most of these fungicides control. Use them in alternation and tank mixed with a protectant fungicide. Label directions for some state to begin use before infection or disease development. The forecasting program helps ensure this is accomplished.

Presidio (FRAC Code 43). This was the most effective fungicide. However, it has provided little to no suppression in fungicide efficacy trials conducted recently in the eastern USA suggesting that resistance may have developed (ineffective on Long Island in 2013). In contrast, Presidio has continued to be effective in the mid-western US. The pathogen population is different in the two regions. Cucurbit crops in NYS could become infected by strains of the pathogen originating from crops growing to the south or the west. Maps at the forecasting website indicate where wind trajectories potentially transporting spores are moving. Thus a grower can use the forecasts to decide whether it is worthwhile to consider using Presidio. It is prudent to use Presidio judiciously in a good rotation program. It has a long rotational interval of 18 months for non-labeled crops, which can be a constraint on production. The label has been expanded and now includes all cucurbits, fruiting vegetables, leafy vegetables, brassica (head and stem), bulb vegetables, sweet potatoes and root vegetables (except carrot, sugar beet, potato). REI is 12 hr. PHI is 2 days. Apply no more than 4 times in a season with no more than 2 consecutive applications. Presidio must be applied with another fungicide.

Zampro (40, 45) or Forum (40) and Revus (40). Zampro contains armetoctradin (FRAC Code 45) plus dimethomorph (Code 40), the active ingredient in Forum. It is not yet registered in NYS. It will be recommended used in place of Forum. While the active ingredient in Forum and Revus are in the same fungicide chemical group, 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) in a season with no more than 2 consecutive applications (none with Revus). Revus must be applied with a spreading/penetrating type adjuvant.

Ranman (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.

Previcur Flex (28). This fungicide is more systemic than others and has good activity for downy mildew, but it is not effective for Phytophthora blight, which usually is also a concern in cucurbit crops. REI is 12 hr. PHI is 2 days. Apply no more than 5 times in a season.

Curzate or Tanos (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. Both must be tank-mixed with a protectant. 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. Curzate is not labeled for Phytophthora blight.

Gavel (22). This is the only product that consists of a targeted fungicide and a protectant fungicide (mancozeb). REI is 48 hr. PHI is 5 days. Apply no more than 8 times in a season. Some cantaloupe varieties are sensitive to Gavel. Workers must be notified that a dermal sensitizer was applied both orally and by posting at entrance to treated area for 4 days.

No longer recommended. Resistance to mefenoxam and metalaxyl and to strobilurins is sufficiently common that fungicides with these active ingredients (e.g. Ridomil and Cabrio), which use to be highly effective, are now ineffective.

Recommended protectant fungicides. Chlorothalonil and mancozeb are the main protectant fungicides for downy mildew. Copper is not as effective. Dithane now has a supplemental label that includes pumpkin, winter squash and gourd.

There are several biopesticides labeled for managing cucurbit downy mildew, including Actinovate, Double Nickel 55, EF400, Milstop, Organocide, Oxidate, Regalia, Serenade, Sonata, Sporatec, and Trilogy. They are approved for organic production.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Note that some products mentioned are not yet registered for use on cucurbits. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.