MANAGING DOWNY MILDEW OF CUCURBITS

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Cucurbit downy mildew is a potentially very devastating disease that can develop any time during the growing season. Young seedlings are especially susceptible. In the past, downy mildew occurred sporadically in the northeastern USA, usually appearing late enough in the growing season that cucurbit yields were seldom impacted. However, since 2004 this disease has appeared earlier during the year causing extensive defoliation on some cucurbits when not properly managed with fungicides. Also, QoI (aka strobilurin) fungicides (FRAC code 11) are no longer highly effective and cucumber crops in particular have been severely affected despite genetic resistance which is a common feature of most slicer and pickling varieties marketed today. These recent changes indicate that a new strain of the pathogen most likely has developed.

The downy mildew pathogen exists as pathotypes that vary in their ability to infect the different cucurbit crops. Certain pathotypes can infect all cucurbits while others are able to infect only cucumber and cantaloupe but not watermelon, squash or pumpkin. Races and strains have been described within pathotypes based on variation in virulence and fungicide sensitivity. Races and strains often develop in response to selection pressure from management practices. Cucumber, when not improved by breeding, is susceptible to all pathotypes. The impetus for previous resistance breeding started in the 1930's was the great impact downy mildew was having on cucumber production. This work resulted in varieties highly suppressive to the pathogen strains present in the USA at that time.

Only cucurbit leaves can become infected by the downy mildew pathogen. Initially spots are pale green, then yellow before infected tissue dies. Spots become angular and are often delineated by leaf veins. Often several spots occur together in a coalesced group. Affected tissue in pumpkin can be more orange than yellow. On the underside of leaves, spots appear water-soaked at first. Extensive defoliation can occur rapidly when conditions are favorable. Leaf petioles often

remain green and upright after the leaf blade has died and drooped giving the appearance of limp rags on sticks. In contrast with powdery mildew, spores of the downy mildew pathogen are darker (purplish gray) and develop only on the underside of leaves. Spores are not always present (they are most visible on humid mornings) and symptoms can vary greatly based upon variety and/or crop, thus diagnosis can be challenging. Photographs are posted at http://vegetablemdonline.ppath.cornell.edu. There is an article at this site on 'Identifying initial downy mildew symptoms in cucurbits is critical for successful management'.

Premature death of leaf tissue results in reduced fruit quality and quantity. Loss can be quite extensive in cucumber as fruit production declines substantially in severely affected plants and much of the fruit produced is misshapen. As with powdery mildew, premature loss of leaves can result in reduced market quality because fruit may become sunburned, have poor color, or have low sugar content due to premature or incomplete ripening. Fruit, such as melon and winter squash, with low sugars has poor flavor and poor storability. The handles of pumpkin fruit on infected plants may be shriveled or rotten in addition to fruit being paler orange in color.

Management of downy mildew can be accomplished by planting resistant varieties when available, minimizing conditions favorable for disease development, monitoring forecasts of disease occurrence and weather, scouting crops for symptoms weekly, and applying broad-spectrum protective fungicides before detection and mobile narrow-spectrum fungicides when downy mildew occurs early in crop production. Currently, fungicides are the main tool for managing downy mildew due to greater relative efficacy.

Breeding for resistance to downy mildew has been ongoing since the 1930's. These breeding programs produced many cucumber varieties and a few melon varieties that had resistance to strains of downy mildew present in the U.S. This resistance, which was developed for the previous pathogen strains, is only minimally effective against the new strain(s). These varieties however, may still provide some contribution to downy mildew management. However, even the best resistance is not expected to provide adequate suppression when used in the absence of fungicides. Cucumber variety evaluations conducted each year in North Carolina have included downy mildew ratings since 2005. Differences have been detected in resistance to the new strain(s) of downy mildew. Reports are available at http://cuke.hort.ncsu.edu/cucurbit/cuke/cukemain.html. Scroll down the page to 'Cucumber Trials Summary'. Within each summary scroll down to find the table with the downy mildew ratings. Performance has varied from test to test and year to year, therefore several trial results should be considered when selecting a variety. These results have been compiled in a table posted in the 'Resistant Variety' section at http://vegetablemdonline.ppath.cornell.edu. Best slicer type varieties include Dasher II and Poinsett 76. Best pickle types are Calypso, Vlaspik, and Johnston. Some cucumber varieties like Rockingham have such a vigorous vine they appear to provide tolerance. A search for new sources of resistance is underway at North Carolina State University.

Choose planting sites with good air movement and full sun (no shading) to minimize leaf wetness periods. Disease development may be slowed in trellised cucumbers compared to ground culture. Avoid overhead irrigation in early morning when leaves are wet from dew or late in the day when leaves will not have an opportunity to dry before dew forms. Maintain ample but not excessive nitrogen fertility. These cultural practices should be used with a good

fungicide program to achieve effective control. Producing crops under tunnels has been suggested for organic production as a means to protect plants from spores and to reduce leaf wetness periods that are favorable for pathogen infection; however, downy mildew has developed in tunnels and greenhouses, thus this practice is not expected to be as successful as high tunnels are for some tomato foliar diseases.

The downy mildew pathogen does not survive winter in cold climates. Therefore, except when fields are planted with infected transplants, downy mildew only occurs in northern states when conditions favor spore production, release, and movement by wind from where the disease is occurring. Also, favorable environmental conditions for disease development need to be present where spores land. A forecasting system has been developed to predict where downy mildew will occur in the eastern USA based on forecasted wind trajectories and weather from spore production through infection. Forecasts are posted at a North Carolina State University web site (www.ces.ncsu.edu/depts/pp/cucurbit/). Even when the forecasting program is not funded, as in 2004, a map of the current active sources and a table describing each is maintained at this web site. Click on 'Current Forecasts' on the left side of the home page. The calendar on the right side can be used to look at previous year's forecasts. Considering the potential for spores to be dispersed to northern states at any time during the cucurbit growing season, the destructive potential of this disease, and the fact these crops are susceptible from the cotyledon stage, regularly checking the forecast is a critical component of downy mildew management. This web site also has fungicide evaluation results and photographs of symptoms.

Direct seed crops or produce your own transplants if possible to avoid introducing the pathogen on infected transplants. Avoid transplants from greenhouses producing winter cucumbers or from southern areas where downy mildew can persist in the winter.

Growers in northern states may attempt to avoid the disease by concentrating production early in the growing season when downy mildew is less likely to occur.

Fungicides that have broad-spectrum contact and protectant activity (Bravo, Maneb, Dithane, copper) provide some downy mildew control. They are not as effective as mobile fungicides which can move to the under side of leaves. They should be used alone to provide protection before disease onset in a production area, and in combination with mobile products when downy mildew is present to manage resistance. Researchers in NC regularly conducting fungicide evaluations for downy mildew rated chlorothalonil efficacy higher than the EBDC fungicides mancozeb and maneb (4 vs. 3), which rated higher than copper (rated 1). Therefore, while EBDC fungicides are often recommended because they cost less than chlorothalonil products; chlorothalonil should be used when powdery mildew also is developing.

Applications of mobile (systemic, translaminar) fungicides, which have an active ingredient that specifically targets oomycete fungi, are recommended beginning when downy mildew is forecasted to occur in the area or symptoms are observed. It is critical to initiate treatment promptly because delaying fungicide application until after disease onset increases selection pressure for resistance development and greatly decreases the degree of control achieved. Apply fungicides every 5-7 days depending on weather. The downy mildew pathogen is prone to developing fungicide resistance and also all mobile fungicides are at risk for resistance due to their specific mode of action. Therefore it is important to minimize the opportunity for resistance

development by alternating among mobile fungicides that are in different chemical classes and tank-mixing with protectant fungicides when the mobile fungicide is not formulated with a protectant. Fortunately several effective mobile fungicides are now available. In university fungicide efficacy experiments, Ranman and Presidio have performed slightly better than Previcur Flex, followed by Tanos and Curzate, which are considered slightly better than Forum, Revus, Gavel, and phosphorus acid fungicides. Most treatments tested were fungicide programs with mobile fungicides tank-mixed with protectants and used in alternation with other mobile fungicides. Several different programs with combinations of mobile fungicides have provided similar control. Therefore growers have many options. Revus has exhibited variable efficacy with different cucurbit crop types, suggesting that it might not be equally effective for all downy mildew pathotypes. For example, downy mildew was more effectively controlled in pumpkin than cucumber in two experiments at the same location. Most mobile fungicides for downy mildew are also labeled for Phytophthora blight, but they are not effective for powdery mildew.

Presidio (fluopicolide; FRAC Code 43) received EPA registration in February 2008. It is labeled for use at 3-4 fl oz/A with no more than two sequential applications. It is rainfast in 2 hours. Crop limit is 4 sprays or 12 fl oz. PHI is 2 days. REI is 12 hours.

Ranman (cyazofamid; Code 21) is labeled for use at 2.1-2.75 fl oz/A on a 7-10 day schedule for a maximum of 6 applications (16.5 fl oz) with no more than 3 consecutive applications followed by at least 3 applications of fungicide in another FRAC group. It has a 12 hr REI and 0 day PHI. Ranman should be tank-mixed with a protectant fungicide. Cost of product per application is about $16.76/A for the highest label rate which is the label rate for Phytophthora blight.

Previcur Flex (propamocarb, Code 28) is labeled for use at 1.2 pts/A on a 7-14 day schedule for a maximum of 6 pts. PHI is 2 days. REI is 12 hours. Previcur Flex should be tank-mixed with a protectant fungicide. Cost of product per application is about $11.10/A.

Curzate and Tanos both contain cymoxanil, a Code 27 fungicide. Both have a 12 hr REI and 3 day PHI. They are rainfast in 2 hours. Curzate is labeled for use at 3.2 oz/A on a 10-14 day schedule for a maximum of 9 applications. Cost of product per application is about $8.50/A. Tanos also contains famoxadone (Code 11). It is labeled for use at 8 oz/A, tank-mixed with protectant fungicide, on a 5-7 day schedule. There is a crop maximum of 4 applications of Code 11 fungicides which includes Tanos. Cost of product per application is about $10.31/A. Curzate or Tanos is a good choice for the first application of a mobile fungicide to a crop after detecting downy mildew. They have poor residual activity thus another mobile fungicide should be applied within a week.

Forum (dimethomorph, Code 40), a new formulation replacing Acrobat, is labeled for use at 6 oz/A tank-mixed with protectant fungicide on a 5-10 day schedule for a maximum of 5 times with no more than 2 sequential applications. PHI is 0 days. REI is 12 hours. Tank-mix with protectant fungicide. Cost of product per application is about $8.91/A.

Revus (mandipropamid, Code 40) received EPA registration in February 2008. It is labeled for use at 8 fl oz/A on a 7-10 day schedule for a maximum of 4 sprays (32 fl oz). Revus must be tank-mixed with another fungicide and it cannot be applied more than once before switching to another fungicide. PHI is 0 days. REI is 12 hours.

Gavel (mancozeb and zoxamide, Codes M3 + 22) can be used on cucumber, melon, summer squash, and watermelon but not currently on pumpkin and winter squash because it contains mancozeb. Gavel is labeled for use at 1.5–2.0 lb/A, every 7 to 10 days or when conditions are favorable for disease for a maximum of 8 applications. Cost of product is about $7.73-10.30/A. PHI is 5 days. REI is 48 hours.

New phosphorus acid fungicides (Phostrol, ProPhyt, and Fosphite)(phosphonates; Code 33) are more effective than Aliette, an older product in this group, but they are not as effective as other mobile fungicides for downy mildew in cucurbits, which is in contrast with their efficacy for some other downy mildew diseases. They have a 12 hr REI and can be applied to all cucurbits at 2.5-5 pt/A, which will cost about $12.50-25.00/A, on a 7-14 day interval up to 6-7 times/crop. Phosphite ion, the active ingredient for these fungicides, effects fungal pathogens directly and promotes the plant's defense system.

Forum, Ranman, Gavel, Tanos and phosphorus acid fungicides are also labeled for Phytophthora blight, which is caused by a pathogen related to the downy mildew fungus.

Reason (fenamidone) is labeled for cucurbit downy mildew, but not recommended at this time because other products available now contain more effective chemistry.

Fungicides with mefenoxam (Code 4) or with QoI fungicides (Code 11) are no longer recommended for downy mildew because of resistance. Products with this chemistry provided little or no control of downy mildew when tested alone in several university experiments conducted recently, which is in sharp contrast to their previous performance. Products include Ridomil Gold Bravo, Ridomil Gold Copper, Quadris, Amistar, Cabrio, Flint, and Pristine. Tanos is one Code 11 fungicide that is still recommended because it contains an additional active ingredient, cymoxanil.

Downy mildew is very challenging to manage in organically-produced crops due to current lack of adequately effective resistant varieties, cultural practices and approved products. Serenade and Sonata have not been effective when tested in fungicide efficacy experiments with conventionally managed crops. Copper fungicides provided limited to no control.

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