

Managing Cucurbit Powdery Mildew Successfully in NY

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Effectively managing powdery mildew is essential for producing a high-quality cucurbit crop. This foliar, fungal disease is common wherever cucurbits are grown, including in the northeastern U.S. This is because the pathogen produces an abundance of asexual spores (the powdery growth) easily dispersed by wind, thus it can spread widely, and the pathogen can produce a sexual spore in fall that enables it to survive over winter. Leaves affected by powdery mildew die prematurely which results in fewer fruit and/or fruit of low quality (poor flavor, sunscald, poor storability).

Powdery mildew is managed with resistant varieties and fungicides. An integrated program with both management tools is the best approach for achieving effective control because the pathogen is adept at evolving new strains resistant to individual tools such as resistant varieties or a specific fungicide. It is more difficult for new pathogen strains to develop when an integrated program is used, and effective control is more likely. Powdery mildew management program often needs adjustments as the pathogen and management tools change.

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. Resistance in other cucurbit crop types is not adequate used alone (without fungicide applications) to prevent impact of powdery mildew on yield. Melon varieties with resistance to pathogen races 1 and 2 have exhibited very good suppression in experiments conducted at LIHREC until recently. Squash and pumpkin exhibit a moderate to low degree of resistance. Select varieties with resistance from both parents (homozygous resistance) when possible. This term is used in a few catalogues (for example Outstanding Seeds) whereas others use terms like 'high resistance' and 'intermediate resistance' or 'tolerance' to generally refer to homozygous and heterozygous resistance, respectively. Degree of disease suppression obtained with a variety also depends on modifying genes present. Plant breeders are actively searching for new sources of resistance to powdery mildew.

Fungicide program. The most important component of an effective management program is an effective fungicide program. And the key to that is using mobile fungicides targeted to powdery mildew. Mobile fungicides are needed for control on the underside of leaves. Because these fungicides have targeted activity, additional fungicides must be added to the program when there is a need to manage other diseases such as downy mildew and Phytophthora blight.

Alternate among targeted, mobile fungicides and apply them with a protectant fungicide to manage resistance development and avoid control failure if resistance occurs, and also to comply with label use restrictions (most mobile fungicides are not permitted used exclusively). The powdery mildew pathogen has a long history of developing resistance to fungicides (it was the first occurrence of resistance in the USA), thus a diversified fungicide program applied to resistant varieties when possible is critical for success. Always implement a resistance management program; do not wait until there is a problem. The goal is to delay development of resistance, not manage resistant strains afterwards.

When to apply fungicides. The action threshold for starting applications is one leaf with symptoms out of 50 older leaves examined. Examine both surfaces of leaves. Starting treatment after this point will compromise control and promotes resistance development. Powdery mildew

usually begins to develop around the start of fruit production. Protectant fungicides applied before detection will slow initial development. After detection, continue applying fungicides weekly. Conditions are favorable for powdery mildew throughout the growing season.

Recommended targeted fungicides. Alternate among targeted, mobile fungicides in the following five chemical groups (principally the first two), and apply with protectant fungicide to manage resistance development and avoid control failure if resistance occurs, and also to comply with label use restrictions. The first two products are the newest and thus are the most important ones to have in a fungicide program. The pathogen population has been subjected to more pressure to develop resistance to the other three fungicide groups, which are listed in order based on product efficacy in recent fungicide evaluations. The first three fungicides are the only ones in these chemical groups available in the USA. See “Mobile Fungicides for Mildews and Phytophthora Blight” for more information about these and other targeted fungicides. Federal pesticide labels can be viewed and downloaded at: <http://www.cdms.net/labelsmsds/lmdefault.aspx>. New York state labels are available at: <http://pims.psur.cornell.edu/ProductName.php>.

Vivando (FRAC Code U8) is a new fungicide with a new mode of action. Cucurbits are on a supplemental label. It has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. Do not mix with horticultural oils. It can be applied three times per year with no more than two consecutive applications. REI is 12 hr. PHI is 0 days.

Torino (FRAC Code U6) is a new fungicide with a new mode of action. It has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. It can only be applied twice to a field in a 12-mo period. Consecutive applications are not recommended. REI is 4 hr. PHI is 0 days.

Quintec (FRAC Code 13) has been consistently effective in fungicide evaluations. However, insensitivity to a high concentration of Quintec (similar to the dose when applied in the field) was detected in several of the pathogen isolates collected from fungicide-treated research and commercial fields at the end of the 2015 growing season. Therefore Quintec is now recommended used less than the label permits, which is a crop maximum of four applications. Aerial applications are not permitted and no more than two consecutive applications. Activity is limited to powdery mildew. It is the only mobile fungicide that does not move into leaves: it redistributes to foliage where spray was not directly deposited, including the underside of leaves, through diffusion and a continual process of absorption and desorption in the cuticular waxes of foliage. REI is 12 hr. PHI is 3 days.

DMI fungicides (FRAC Code 3) include Proline, Procure, Rally, and Inspire Super. Additional products are registered for use outside NY. Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Proline is thought to have the greatest inherent activity and Inspire Super the least. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr. PHI is 0 days, 7 days for Proline and Inspire Super. Powdery mildew is the only labeled cucurbit disease for Procure and Rally. Proline is also labeled for Fusarium blight and gummy stem blight. Inspire Super, which contains another active ingredient (Code 9), is also labeled for Alternaria blight, anthracnose, gummy stem blight, Plectosporium blight, and Septoria leaf spot.

Carboxamide fungicides (FRAC Code 7) registered in NY are Pristine and Merivon. Both also contain the same QoI fungicide (Code 11), which is no longer effective for powdery mildew. Only Pristine is permitted used on Long Island. Powdery mildew pathogen strains resistant to Pristine have been detected and likely are the reason its efficacy has varied. REI for Pristine is 12 hr and PHI is 0 days. Cross resistance was documented between Pristine and Merivon, but not Luna fungicides; therefore, Luna will be the best choice if registered for this use in NY.

Fungicide evaluations conducted each year on pumpkin at LIHREC include fungicides at risk for resistance tested alone (this is neither a labeled nor recommended commercial use pattern for these fungicides; it is done in efficacy evaluations to determine if resistance affects control). In 2016 Quintec and Procure were as effective as an alternation program while Pristine was substantially less effective. In 2015 Quintec, Pristine, and Vivando were as effective as an alternation program (69-78% control on lower leaf surfaces). Quintec and Vivando were the most effective of the targeted fungicides evaluated in 2014 (96 and 98% control); Pristine was moderately effective (54%); Procure was slightly but not significantly better (70%). In 2013 Quintec, Pristine, and Procure provided excellent control (93-99% control). In 2012 Pristine and Fontelis were ineffective (albeit treated pumpkins were numerically less severely affected by powdery mildew than the non-treated plots) while Quintec was very effective (96%) and Procure was moderately effective (57%). This documents year-to-year variation in the pathogen population.

No longer recommended. Resistant pathogen strains are sufficiently common to render the following fungicides ineffective: Topsin M (FRAC code 1; MBC fungicide) and QoI fungicides (Code 11), which include Quadris, Cabrio and Flint. Resistant strains continue to be detected commonly every year on Long Island where monitoring is being conducted.

Recommended protectant fungicides. Many fungicides have contact activity for powdery mildew; mancozeb is an exception. They include chlorothalonil, sulfur, copper, oils (mineral and botanical), potassium bicarbonate, and biologicals. Many of these products are approved for organic production (see list below). Sulfur is one of the most effective and least expensive products. Its activity is limited to powdery mildew, thus it is especially useful early in disease development when other diseases are not a concern, including as a preventive application. Melons are sensitive to sulfur especially when hot; there are tolerant varieties.

Organic fungicides. Products labeled for cucurbit powdery mildew, in addition to several formulations of copper and sulfur, include:

Actinovate AG. 0.0371% *Streptomyces lydicus* strain WYEC 108. For best results with applications to foliage, label indicates to use a non-ionic spreader-sticker. OMRI-listed. EPA Reg. No. 73314-1. Monsanto BioAg.

BacStop. 2.0% thyme, 2.0% clove & clove oil, 1.5% cinnamon, 1.0% peppermint & peppermint oil, and 1.0% garlic oil. Recommended used with EF400. Exempt from EPA registration. USAgriTech, Inc.

Companion. 0.03% *Bacillus subtilis* strain GB03. EPA Reg. No. 71065-3. Growth Products, Ltd.

Double Nickel 55 LC and WDG. *Bacillus amyloliquefacinens* strain D747, 98.8% and 25%, respectively. OMRI-listed. EPA Reg No. 70051-107 and 108, respectively. Certis USA, LLC.

EF400. 8.2% clove, 8.1% rosemary, and 6.7% peppermint. Exempt from EPA registration. No Ag Label. USAgriTech, Inc.

JMS Stylet-oil. 97.1% paraffinic oil. OMRI-listed. EPA Reg. No. 65564-1. JMS Flower Farms, Inc.

Kaligreen. 82% potassium bicarbonate. OMRI-listed. EPA Reg. No. 11581-2. Arysta LifeScience North America LLC.

KeyPlex 350 OR. 0.063% yeast extract hydrolysate from *Saccharomyces cerevisiae*. Combination of defensive proteins (alpha-keto acids) and secondary and micronutrients. Elicits systemic acquired resistance in plants against fungal and bacterial pathogens. Labeled

for general disease control in vegetables with specific mention of bacterial leaf spot in tomato. EPA approval for organic production. EPA Reg. No. 73512-4. KeyPlex.

Mildew Cure (formerly GC-3 Organic fungicide). 30% cottonseed oil, 30% corn oil, 23% garlic extract. OMRI-listed. Exempt from EPA registration. JH Biotech, Inc.

MilStop. 85% potassium bicarbonate. OMRI-listed. EPA Reg. No. 70870-1-68539. BioWorks, Inc.

Organocide. 5% sesame oil. OMRI-listed. Exempt from EPA registration. Organic Laboratories, Inc.

OxiDate. 27% hydrogen dioxide. OMRI-listed. EPA Reg. No. 70299-2. BioSafe Systems, LLC.

Procidic. 3.5% Citric acid. NOP compliant; registered for use in organic agriculture with Washington State Dept of Ag. Exempt from EPA registration. Greenspire Global, Inc.

Promax. 3.5% Thyme oil. OMRI-listed. Exempt from EPA registration. Bio Huma Netics.

Regalia. 5% Extract of *Reynoutria sachalinensis*. OMRI-listed. EPA Reg. No. 84059-2. Marrone Bio Innovations, Inc.

Serenade ASO. 14.6% *Bacillus subtilis* strain QST 713. OMRI-listed. EPA Reg. No. 264-1152. Bayer CropScience.

Serenade Opti. 26.2% *Bacillus subtilis* strain QST 713. New formulation; see above products. OMRI-listed. EPA Reg. No. 264-1160. Bayer CropScience.

Sonata. 1.38% *Bacillus pumilus* strain QST 2808. OMRI-listed. EPA Reg. No. 69592-13. Bayer CropScience.

Sporatec AG. 18% rosemary oil, 10% clove oil, and 10% thyme oil. OMRI-listed. Exempt from EPA registration. Brandt Consolidated, Inc.

Thyme Guard. 23% thyme oil extract. Determined to be NOP compliant by Washington State Dept of Ag. Exempt from EPA registration. Agro Research International.

Trilogy. 70% clarified hydrophobic extract of neem oil. OMRI-listed. EPA Reg. No. 70051-2. Certis USA, LLC.

TriTek. 80% mineral oil. OMRI-listed. EPA Reg. No. 48813-1. Brandt Consolidated, Inc.

Before purchase for organic production, confirm product is acceptable for agricultural use with your certifier or your NYS DEC regional office.

In summary, to manage powdery mildew effectively in cucurbit crops: 1) select resistant varieties, 2) inspect crops routinely for symptoms beginning at the start of fruit development, and 3) apply targeted fungicides weekly with protectant fungicides and alternate amongst available chemistry based on FRAC Group code, starting at the action threshold of 1 affected leaf out of 50 older leaves. Add new fungicides to the program when they become available; substitute new for older product if they are in the same FRAC group.

Please Note: The specific directions on fungicide 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 in NY. Check state registration for all products and approval with certifier for organic products. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.