

Managing Cucurbit Powdery Mildew Successfully in 2020

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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 (prone to sunscald, poor flavor, 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 conventional 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. Watermelon is infrequently affected in the northeast. 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. Resistant melon, squash and pumpkin varieties exhibit 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. Tables of resistant varieties are at <http://vegetablemdonline.ppath.cornell.edu/Tables/TableList.htm>.

Fungicide program. The most important component of an effective management program for powdery mildew is an effective fungicide program. The challenge is getting fungicide to the lower surface of leaves where the pathogen develops best. Most fungicides approved for organic production have contact activity. Sulfur and oil have demonstrated some ability to control powdery mildew on the lower surface indicating some ability to redistribute. Sulfur is volatile. Organic fungicides are listed below. For conventionally managed crops there are mobile fungicides able to move through leaves with targeted activity for powdery mildew. Because these fungicides have targeted activity, they are prone to resistance development and additional fungicides must be added to the program when there is a need to manage other diseases such as downy mildew and Phytophthora blight.

For conventionally managed crops, 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 U.S.), 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; this pathogen does not need a period of leaf wetness to infect.

Recommended targeted fungicides. Alternate among targeted, mobile fungicides primarily in the following three 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. All targeted fungicides are at risk of resistance developing; FRAC Code 50 (formerly U8) and U13 are the only chemistries that resistance has not yet been detected to. 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/Label-Database>. New York state labels are available at: <http://www.dec.ny.gov/nyspad/products?0> (enter product name under ‘Names’ in center of page, then click on Search at bottom of this section).

Vivando (FRAC Code 50, formerly U8) has exhibited excellent control in fungicide evaluations. Activity is limited to powdery mildew. It is recommended used with a silicon adjuvant. 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. Proливо is a new fungicide with a new active ingredient in this FRAC group registered in NY April 2018. It was not as effective as Quintec for managing powdery mildew on lower leaf surfaces in a fungicide evaluation conducted at LIHREC in 2016 in which Vivando was not included.

DMI fungicides (FRAC Code 3) include Proline*, Procure, Luna Experience*, and Rhyme* (these considered most effective) plus Aprovia Top*, Inspire Super*, Mettle, and Rally. 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. 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 for DMI fungicides. PHI is 0 days for some including Procure; 7 days for others including Proline. not labeled for use on Long Island. *Fungicides labeled for additional cucurbit diseases; see section on other diseases. Inspire Super (FRAC Code 3 and 9) is recommended for other labeled diseases. It is expected to provide some control of powdery mildew. but there are other FRAC 3 fungicides with greater intrinsic activity for powdery mildew that are better choices when this is the only disease developing. TopGuard is labeled but not recommended because it has Code 11 ingredient plus same DMI ingredient in Rhyme. Additional products are registered for use outside NY.

Gatten (Code U13) is the newest fungicide; it was introduced in 2018 and registered in NY in 2020. REI is 12 hr. PHI is 0 days. Activity is limited to powdery mildew. In NY, Gatten can only be applied twice (five times elsewhere) and it is not allowed used on Long Island. It was as effective as Vivando for managing powdery mildew on lower leaf surfaces in a fungicide evaluation conducted at LIHREC in 2019 but not in 2018.

Recommended used sparingly:

Quintec (FRAC Code 13) was consistently effective in fungicide evaluations conducted on Long Island until 2019 when it was significantly less effective than Vivando for the first time in the fungicide evaluation conducted annually on Long Island. This was not surprising because insensitivity to a high concentration of Quintec (similar to the dose when applied in the field) has been detected in some pathogen isolates collected from commercial fields and/or fungicide-treated research fields at the end of the growing season on Long Island since 2015. Resistant isolates evidently were sufficiently uncommon most of the season in 2015-2018 not to impact Quintec efficacy. Because resistance has developed, Quintec is now recommended to be 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. Labeled for use on non-edible peel crops: melons, pumpkin, and winter squash. REI is 12 hr. PHI is 3 days.

Carboxamide aka SDHI fungicides (FRAC Code 7) registered in NY are Luna fungicides*, Aprovia Top, Miravis Prime*, Endura, Pristine and Merivon* (* not allowed used on Long Island). Last two also contain the same QoI fungicide (Code 11), which is no longer effective for powdery mildew. Resistance to boscalid, the FRAC Code 7 active ingredient in Endura and Pristine has been detected routinely on Long Island since 2009 and likely is the reason their efficacy has varied in fungicide evaluations. Full cross resistance was documented between several carboxamides, including those in Pristine, Merivon and also Fontelis (not registered for use in NY), but not Luna fungicides, through laboratory assays conducted with pathogen isolates resistant and sensitive to boscalid. However, Luna Sensation has exhibited limited control in fungicide evaluations conducted in 2017-2019 on Long Island. Luna Experience is the best choice because it also contains tebuconazole (Code 3), which needs to be considered when developing an alternation program. Luna Sensation is not recommended because it also contains trifloxystrobin (Code 11); resistance to this chemistry is very common. Aprovia Top, Luna Experience, and Miravis Prime are the only Code 7 fungicides recommended. Limit use. Aprovia Top and Luna Experience have the advantage that they contain a second active ingredient with activity for powdery mildew (Code 3). All have 12 hr REI. PHI is 0, 7, and 1 day respectively. Maximum number of applications is 2-5, depending on product and rate. Low rate isn't recommended.

Recommended used sparingly if at all:

Torino (FRAC Code U6) exhibited excellent control in fungicide evaluations until recently. It failed in an experiment in North Carolina in 2016 and on Long Island in 2017, where resistance to Torino was detected in pathogen isolates. Torino resistance was also detected in 2018. 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.

Fungicides classified for “Restricted Use” in New York: Aprovia Top, Gatten, Miravis Prime, and Procure.

No longer recommended. Resistant pathogen strains are sufficiently common to render the following fungicides ineffective: Topsin M (FRAC Code 1; MBC fungicide), QoI fungicides (Code 11), which include Quadris, Cabrio and Flint, and SDHI fungicides (Code 7) containing boscalid (Endura and Pristine) or an active ingredient that has exhibited full cross resistance in laboratory testing of pathogen isolates (Merivon). Resistant strains continue to be detected very 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, mineral oil, and several biopesticides. 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. Microencapsulated formulations are recommended. Melons are sensitive to sulfur especially when hot; there are tolerant varieties.

Fungicide evaluations conducted each year on pumpkin at LIHREC on Long Island 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). Not every fungicide chemistry prone to resistance is tested every year. In 2019 Vivando was the most effective single product tested providing control statistically similar to the alternation program (Vivando, Quintec, Proline), albeit numerically lower control (75 and 92% control on lower leaf surfaces). Gatten was as effective as Vivando (65%); Luna Sensation and Quintec were less effective (47 and 40%). In 2018 Vivando was most effective albeit not significantly better than Quintec, which was not significantly better than Luna Sensation (54, 42, and 28%). In 2017 Torino, Pristine, and Luna Sensation were ineffective, while Vivando was most effective (80%) albeit not significantly better than Quintec (72%) or Procure (54%). In 2016 Quintec and Procure were as effective as an alternation program (98, 91, and 97%) while Pristine was substantially less effective (43%). In 2015 Quintec, Pristine, and Vivando were as effective as an alternation program (69-78%). Quintec and Vivando were the most effective of the targeted fungicides evaluated in 2014 (96 and 98%); Pristine was moderately effective (54%); Procure was slightly but not significantly better (70%). In 2013 Quintec, Pristine, and Procure provided excellent control (93-99%). 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%). These experiments have documented year-to-year variation in the pathogen population.

Fungicides Labeled for Other Diseases in Addition to Powdery Mildew.

Proline (FRAC 3). Fusarium blight and gummy stem blight.

Rhyme (FRAC 3). Gummy stem blight.

Luna Experience (FRAC 3 and 7). Alternaria leaf spot, anthracnose, gummy stem blight, and belly rot.

Aprovia Top (FRAC 3 and 7). Anthracnose, Alternaria leaf blight, gummy stem blight, and Plectosporium blight.

Inspire Super (FRAC 3 and 9). Alternaria leaf blight, anthracnose, gummy stem blight, Plectosporium blight, and Septoria leaf spot

Miravis Prime (FRAC 3 and 12). Alternaria leaf blight and spot, gummy stem blight, and scab.

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.

AVIV. 0.08% *Bacillus subtilis* strain IAB/BS03. Replaces Prevont. OMRI-listed. EPA Reg. No. 91473-1-86182.

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.

Cinnerate. 60% cinnamon oil. OMRI-listed. Exempt from EPA registration.

Companion. 0.03% *Bacillus subtilis* strain GB03. EPA Reg. No. 71065-3.

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.

EcoSwing Botanical Fungicide. 82% extract of *Swinglea glutinosa*. OMRI-listed. EPA Reg. No. 10163-357.

ECOWORKS EC. 70% cold pressed neem oil. OMRI-listed. EPA Reg. No. 89152-4.

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

JMS Stylet-oil. 97.1% paraffinic oil. OMRI-listed. EPA Reg. No. 65564-1.

Kaligreen . 82% potassium bicarbonate. OMRI-listed. EPA Reg. No. 11581-2.

KeyPlex 350 OR. 0.063% yeast extract hydrolysate from *Saccharomyces cerevisiae*. Combination of defensive proteins (alpha-keto acids) and secondary and micronutrients. EPA Reg. No. 73512-4.

LifeGard WG. 40% *Bacillus mycoides* isolate J. Biological Plant Activator. OMRI-listed. EPA Reg No. 70051-119.

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

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

M-Pede. 49% Potassium salts of fatty acids. OMRI-listed. EPA Reg. No. 10163-324.

Organocide. 5% sesame oil. OMRI-listed. Exempt from EPA registration.

OSQ. 5% polyoxin D zinc salt. OMRI-listed. EPA Reg No. 68173-4-70051.

OxiDate 2. 27% hydrogen dioxide. OMRI-listed. EPA Reg. No. 70299-2.

Prevont. Renamed AVIV.

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

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

Regalia. 5% Extract of *Reynoutria sachalinensis*. OMRI-listed. EPA Reg. No. 84059-2.

Serenade Opti. 26.2% *Bacillus subtilis* strain QST 713. OMRI-listed. EPA Reg. No. 264-1160.

Serifel. 9.9% *Bacillus amyloliquefacinens* strain MBI 600. OMRI-listed. EPA Reg No. 71840-18.

Sil-Matrix. 29% potassium silicate. OMRI-listed. EPA Reg. No. 82100-1.

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

Sporan EC². 16% rosemary oil, 10% clove oil, 10% thyme oil, 2% peppermint oil. OMRI-listed. Exempt from EPA registration.

Taegro 2. 13% *Bacillus subtilis* var. *amyloliquefaciens* strain FZB24. OMRI-listed. EPA Reg. No. 70127-12.

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

Timorex Act. 12.5% tea tree oil. OMRI-listed. EPA Reg. No. 86182-3-88783.

Timorex Gold. 23.8% tea tree oil. OMRI-listed. EPA Reg. No. 70051-2.

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

TriTek. 80% mineral oil. OMRI-listed. EPA Reg. No. 48813-1.

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. Check labels for use restrictions. Confirm approval with certifier for organic products. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.