Disease Management in Cucurbits

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Powdery Mildew of Cucurbits

Occurrence:
Very common

Impact:
Reduced yield +/- or fruit quality

Biology - Key Facts:
Long-distance, wind-dispersed spores
Infection occurs when dry
Sexual stage survives over winter
Other hosts: verbena
Tools for Managing Cucurbit Powdery Mildew

Resistant varieties
Fungicides

Recommendation: Integrated program to delay pathogen adaptation.
Mobile fungicides:
- Needed for control on lower leaf surfaces.
- Prone to resistance.

Start early:
Threshold = 1 of 50 older leaves affected.
Mobile Fungicides labeled for Powdery Mildew in Cucurbits

- MBC (FRAC Code 1) - Topsin M
- DMI (FRAC Code 3) - Procure
- QoI (FRAC Code 11) - Quadris
- SDHI (FRAC Code 7) - Pristine
- Aza-naphthalene (FRAC Code 13) - Quintec
- Phenyl-acetamide (FRAC Code U6) - Torino
- Aryl-phenyl-ketone (FRAC Code U8) - Vivando
MBC (FRAC Code 1)
  thiophante-methyl (Topsin M)
DMI (FRAC Code 3)
  myclobutanil, triflumizole, tebuconazole
    (Rally, Procure, Tebuzol, Folicur, etc.)
QoI (FRAC Code 11)
  trifloxystrobin, azoxystrobin, pyraclostrobin, etc.
    (Flint, Amistar, Quadris, Cabrio, Sovran)
SDHI (FRAC Code 7)
  boscalid (+ pyraclostrobin in Pristine)
    penthiopyrad (Fontelis), fluopyram (Luna fungicides)
Aza-naphthalene (FRAC Code 13)
  quinoxyfen (Quintec)
Phenyl-acetamide (FRAC Code U6)
  cyflufenamid (Torino)
Aryl-phenyl-ketone (FRAC Code U8)
  metrafenone (Vivando)
<table>
<thead>
<tr>
<th>Fungicide Group</th>
<th>FRAC Code</th>
<th>Registered</th>
<th>Resistance (USA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBC</td>
<td>1</td>
<td>1972</td>
<td>1967</td>
</tr>
<tr>
<td>DMI</td>
<td>3</td>
<td>1984</td>
<td>1990s</td>
</tr>
<tr>
<td>QoI</td>
<td>11</td>
<td>1999</td>
<td>2002</td>
</tr>
<tr>
<td>SDHI</td>
<td>7</td>
<td>2003</td>
<td>2008</td>
</tr>
<tr>
<td>Aza-naphthalene</td>
<td>13</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>Phenyl-acetamide</td>
<td>U6</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Aryl-phenyl-ketone</td>
<td>U8</td>
<td>2014</td>
<td></td>
</tr>
</tbody>
</table>
Types of Fungicide Resistance

**Qualitative Resistance**
One gene involved.
Pathogen sensitive or completely resistant.
Complete loss of control.
Ex. QoI (Code 11) fungicides.

**Quantitative Resistance**
Several genes involved.
Pathogen exhibits range in sensitivity.
Gradual loss of control; can be regained with higher rate or more active fungicide.
Ex. DMI (Code 3) fungicides.

Cross resistance common in fungicide (FRAC) groups.
MBC (FRAC Code 1) — thiophanate-methyl (Topsin-M)

DMI (FRAC Code 3) — myclobutanil, triflumizole, tebuconazole (Rally, Procure, TebuZol, Folicur, etc.)

QoI (FRAC Code 11) — trifloxystrobin, azoxystrobin, pyraclostrobin, etc. (Flint, Amistar, Quadris, Cabrio, Sovran)

SDHI (FRAC Code 7) — boscalid (+ pyraclostrobin in Pristine)

Phenyl-acetamide (FRAC Code U6) — cyflufenamid (Torino)

Aryl-phenyl-ketone (FRAC Code U8) — metrafenone (Vivando)

Aza-naphthalene (FRAC Code 13) — quinoxyfen (Quintec)
Mobile Fungicides - Powdery Mildew

FRAC Code 7 (SDHI)

Pristine (boscalid + QoI - pyraclostrobin) 2003.

Luna fungicides (fluopyram; alone + mixtures)
  federal registration watermelon February 2012.

Fontelis (penthiopyrad)
  federal registration cucurbit March 2012.

Merivon (fluxapyroxad + QoI - pyraclostrobin)
  registration pome + stone fruit in 2012; cucurbit?

Cross resistance among all except Luna fungicides.

Labeled also for Alternaria blight, anthracnose, gray mold, gummy stem blight, and Sclerotinia stem rot.
New Mobile Fungicides for Cucurbit Powdery Mildew

FRAC Code U6
Torino (cyflufenamid)

Registered for use on all cucurbits.
Translaminar activity with some vapor action.
Targeted activity for powdery mildews.
Highly effective.
4 hr REI*. 0 day PHI. 2 application maximum.
* other products are 12 hr REI.

Resistance developed quickly in Japan and Italy.
Fungicide Program for Managing Powdery Mildew & Fungicide Resistance

Alternate among mobile fungicides (different FRAC code; highest label rate):

- Vivando (2 consecutive, 3 total applications)
- Quintec (2 consecutive, 4 total applications)
- Torino (2 applications)
- Procure (1 application recommended)
- Fontelis (1 application recommended)

Tank-mix with contact fungicide.
Supplemental Label

Vivando®
Fungicide

For use on apricot; cherry subgroup 12-12A; cucurbit vegetables, group 9; hops; and peach subgroup 12-12B to control powdery mildew

This supplemental label expires December 31, 2017 and must not be used or distributed after this date.

Active Ingredient*:
metrafenone: (3-bromo-6-methoxy-2-methylphenyl)(2,3,4-trimethoxy-6-methylphenyl)methanone ........................................ 25.20%
Other Ingredients: ........................................................................................................ 74.80%
Total: ............................................................................................................................ 100.00%

*This product contains 2.5 lbs active ingredient per gallon.

EPA Reg. No. 7969-284

Directions For Use
• It is a violation of federal law to use this product in a manner inconsistent with its labeling.
• The supplemental labeling and the entire Vivando® fungicide container label, EPA Reg. No. 7969-284, must be in possession of the user at the time of application.

Resistance Management
Vivando contains metrafenone, a fungicide with a mode of action different from that of other fungicides currently registered for use against powdery mildew. Refer to the Vivando container label for additional fungicide resistance recommendations.

Application Instructions
Example Fungicide Program

Quintec, Vivando, Q, V, Q, V, Q (7 weeks)

Tank-mix with contact (protectant) fungicide (sulfur, chlorothalonil, copper, biopesticide)

Start early. 1 of 50 older leaves affected.

Add to program:
- Torino (FRAC U6)
- Fontelis or Pristine (FRAC 7)
- Procure or other DMI fungicide (FRAC 3)
Plant diseases cannot be cured!!

Fungicides act on pathogens before infection.

Critical to success to begin applications

VERY early in disease development.

Curative use can select for resistance.
There is a lag time between infection and symptom appearance (latent period).

Critical to success to begin applying fungicides very early in disease development.
Determine efficacy of fungicides replicated experiment conducted with field-grown, naturally-infected pumpkin.

Examine fungicide sensitivity in pathogen isolates collected at season end and tested with leaf-disk bioassay.
<table>
<thead>
<tr>
<th>Treatment (7-day)</th>
<th>Lower Leaf Surface (AUDPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
</tr>
<tr>
<td>Procure 6 oz/A (3)</td>
<td>40</td>
</tr>
<tr>
<td>Procure 8 oz/A (3)</td>
<td>72</td>
</tr>
<tr>
<td>Pristine 12.5 oz/A (7 + 11)</td>
<td></td>
</tr>
<tr>
<td>Pristine 18.5 oz/A (7 + 11)</td>
<td>80</td>
</tr>
<tr>
<td>Fontelis 1 pt/A (7)</td>
<td></td>
</tr>
<tr>
<td>Quintec 4-6 oz/A (13)</td>
<td>86</td>
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<tr>
<td>Q, Procure, Q, Pristine, Q</td>
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White values – severity not significantly less than nontreated.
### Control of Pumpkin Powdery Mildew (%)

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<tbody>
<tr>
<td></td>
<td>Control of Pumpkin</td>
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<tr>
<td>procured 6 oz/A (3)</td>
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<tr>
<td>procured 8 oz/A (3)</td>
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<td>69 22 57 95 70</td>
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<tr>
<td>pristine 12.5 oz/A (7 + 11)</td>
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<tr>
<td>pristine 18.5 oz/A (7 + 11)</td>
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<td>50 28 40 93 54</td>
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<td>fontelis 1 pt/A (7)</td>
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<td>33</td>
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<tr>
<td>quintec 4-6 oz/A (13)</td>
<td></td>
<td>95 41 96 99 96</td>
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<tr>
<td>Q, procured, Q, pristine, Q</td>
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<td>89 98 95</td>
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White values – severity not significantly less than nontreated.
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<tr>
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<td>95</td>
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<tr>
<td>Q, Procure, Q, Pristine, Q</td>
<td>89</td>
</tr>
<tr>
<td>Vivando 10 fl oz/A (U8)</td>
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<tr>
<td>Vivando 15 fl oz/A (U8)</td>
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White values – severity not significantly less than nontreated.
Determine efficacy of fungicides 
replicated experiment conducted with 
field-grown, naturally-infected pumpkin.

Examine fungicide sensitivity in pathogen 
isolates collected at season end and tested 
with leaf-disk bioassay.
Bioassay - PA - 10 July 2008

Non-treated

Flint (11)

Procure 80 ppm (3)

Topsin M (FRAC code 1)

Rally 80 ppm (3)

Quintec 1 ppm (13)

doscalid 100 ppm (7)
Laboratory Leaf Disk Assay
Fungicide Sensitivity Testing of Individual Isolates

Boscalid
50 ppm

Control

Myclobutanil (Rally)
100 ppm
50 ppm
Fungicide Sensitivity in Powdery Mildew Fungus in 2013

FRAC Code 1 (MBC fungicides) (Topsin)  
100% resistant

FRAC Code 11 (QoI fungicides) (Quadris)  
100% resistant

FRAC Code 7 (SDHI fungicides) (Pristine)  
23% resistant (500 ppm boscalid)
Fungicide Sensitivity in Powdery Mildew Fungus in 2013

FRAC Code 7 (SDHI fungicides)

0% resistant in untreated plots
0% resistant in Procure (FRAC 3) plots
0% resistant in Quintec (FRAC 13) plots
Fungicide Sensitivity in Powdery Mildew Fungus in 2013

FRAC Code 7 (SDHI fungicides)
0% resistant in untreated plots
0% resistant in Procure (FRAC 3) plots
0% resistant in Quintec (FRAC 13) plots
100% resistant in Pristine (FRAC 7) plots
33% resistant with alternation program
(Quintec, Procure, Quintec, Pristine, Quintec)
34% resistant in commercial fields
Sexual Stage of Cucurbit Powdery Mildew Fungus can Overwinter in Northern US
Organic Fungicides – Cucurbit Powdery Mildew

Actinovate
Companion
Double Nickel
Serenade
Sonata
BacStop
EF400
Kaligreen
MilStop
Organocide
OxiDate
Regalia
Sporatec
Trilogy
Sulfur  Copper
JMS Stylet-oil
Downy Mildew

Occurrence:
Sporadic, more common since 2004.

Impact: Reduced yield +/or fruit quality

Biology - Key Facts:
Long-distance, wind-dispersed spores
No survival over winter in north
No other crop hosts
Plants susceptible at all growth stages
Pathotypes affect cucumber, different cucurbits
Resistant cucumber varieties now susceptible
Downy Mildew on Acorn Squash
Managing Downy Mildew

Select resistant cucumber varieties.

Grow most cucurbit crops early in the season.

Use cultural practices that minimize leaf wetness.

Monitor disease occurrence and forecasts.

Check cdm.ipmpipe.org for occurrence reports and forecasts.

Sign up to receive alerts.

Apply fungicides. Start when downy mildew forecast or occurring in area. Apply regularly.

Scout for symptoms.

Report promptly when downy mildew occurs.
Downy Mildew on Cucumber
Downy Mildew on Cucumber
Downy Mildew on Cucumber
Downy Mildew On Cucumber
Downy Mildew on Cucumber

Water-soaked symptoms seen after rain. Flatbed scanner used to reveal.

cf. Gerald Holmes, Valent USA Corporation, Bugwood.org
Downy Mildew on Cucumber

Water-soaked symptoms seen after rain. Flatbed scanner used to reveal.

cf. Gerald Holmes, Valent USA Corporation, Bugwood.org
Giant Pumpkin
(*Cucurbita maxima*)
Downy Mildew on Giant Pumpkin (Cucurbita maxima)
Downy Mildew on Giant Pumpkin
Downy Mildew - Pumpkin
Downy Mildew - Pumpkin
Downy Mildew
Pumpkin
Downy Mildew Pumpkin
Downy Mildew on Cantaloupe
Downy Mildew on Cantaloupe
Downy Mildew on Cantaloupe
Downy Mildew on Cantaloupe
Downy Mildew – Watermelon

cf. Gerald Holmes,
Valent USA Corporation,
Bugwood.org
Downy Mildew – Watermelon

cf. Gerald Holmes,
Valent USA Corporation,
Bugwood.org
Downy Mildew – Watermelon
Downy Mildew Watermelon
Cucurbit Downy Mildew: Initial Symptoms

Click on images for a larger view.

Return to disease photo index.

Being able to recognize initial symptoms of a disease is important for ensuring application of fungicides is started before the disease becomes too well established to be managed effectively. Fungicides have limited to no activity following infection. Infection begins about one week before symptoms appear. Additionally, when using targeted fungicides with single-site mode of action, potential to select pathogen strains with resistance increases with the size of the pathogen population (amount of diseased tissue) being treated.

Below: The following three images show symptoms of downy mildew on cucumber begin as light yellow spots with a water-soaked appearance on the leaf underside. At this early stage some spots already have the characteristic angular shape for this disease as symptoms do not expand past major veins. The white spot is physical injury.
Cucurbit Downy Mildew

Knowing early symptoms important:
- for timing fungicide applications.
- selecting appropriate targeted fungicides.

HOWEVER:
This disease can start to develop at any time.
Infection occurred about one week before symptoms visible.
Fungicides have no to limited curative activity.
Cucurbit Downy Mildew Forecasts - July 18, 2011

*** Epidemic Update - 18 July: First report from WI. New report from NC. CDM has been confirmed in Columbia County, WI and Randolph County, NC. Please see the Epidemic History for details. ***

*** Epidemic Update - 15 July: First reports from AL. New Report from MD. CDM has been confirmed in Baldwin and Escambia Counties, AL and Caroline County, MD. Please see the Epidemic History for details. ***

Regional Weather: Eastern & Central U.S. / southern Canada

Hot and dry under a dominating upper-level High in the central U.S.; scattered showers possible parts of the North, East, and Gulf Coast. A strong dome of high pressure is situated over the U.S. midsection. Dry and dangerously hot weather is expected over most of the central U.S. Showers may occur as system of various kinds move around the periphery of the High. These will mainly be associated with a cold front pressing south from the Great Lakes / southern Canada into the Northeast / Ohio Valley / mid-Atlantic. Showers are also possible in the central to western Gulf Coast. Tropical Storm Bret in the northern Bahamas does not appear to be a factor. Highs in 90s to 100s most areas, cooler 80s in the Northeast. Lows mostly 70s and 80s, with some 50s and 60s Northeast and some 60s East tonight. The upper-level ridge is forecast to spread its influence toward the East Coast by midweek.
Cucurbit Downy Mildew

Ideal Disease to Forecast Occurrence:
- No survival over winter (no sexual reproduction).
- No other crop hosts. Not seed-borne.
- Only sources of pathogen in most of USA:
  - Long-distance, wind-dispersed spores (asexual).
  - Infected transplants (rare source).

CDM Forecast is Unique:
- Predicting pathogen movement. AND
- Conditions favorable for infection.
cf. Gerald Holmes,
Valent USA Corporation,
Bugwood.org
Monitoring Cucurbit Downy Mildew

Sentinel Plots:

- ≤ 85 locations
- 6 cucurbit types:
  - cucumber
  - cantaloupe
  - watermelon
  - acorn squash
  - butternut squash
  - giant pumpkin

Commercial Crops
Research Plots
Gardens
# Cucurbit Downy Mildew Pathogen

<table>
<thead>
<tr>
<th>Host</th>
<th>Pathotype</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Netted melon</td>
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<tr>
<td>Watermelon</td>
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</tr>
<tr>
<td>Squash</td>
<td></td>
<td></td>
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<td></td>
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<td>X</td>
</tr>
</tbody>
</table>
Downy Mildew First Occurrences on Long Island in 2013

22 July  cucumber
6 Aug  cantaloupe
16 Aug  butternut squash
19 Aug  giant pumpkin
26 Aug*  acorn squash
26 Aug*  watermelon

*estimated, 10 Sep seen
## Downy Mildew First Occurrence on Long Island (Riverhead area)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cucumber Date</th>
<th>Basil Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>27 Aug</td>
<td>early Sept</td>
</tr>
<tr>
<td>2009</td>
<td>27 July</td>
<td>5 Aug</td>
</tr>
<tr>
<td>2010</td>
<td>7 Sept</td>
<td>10 Aug</td>
</tr>
<tr>
<td>2011</td>
<td>1 Aug</td>
<td>19 Aug</td>
</tr>
<tr>
<td>2012</td>
<td>17 July</td>
<td>16 Aug</td>
</tr>
<tr>
<td>2013</td>
<td>22 July</td>
<td>6 Aug</td>
</tr>
<tr>
<td>2014</td>
<td>2 Sept</td>
<td>18 Aug</td>
</tr>
</tbody>
</table>
Customized alerts via text or e-mail.

http://cdm.ipmpipe.org
User-defined email alerts

My farm is located in state county

☐ Alert me when…

1. Downy mildew has been detected within (100|200|300|400|500) miles of my farm
2. There is a new (location|host|report) reported
3. My farm is at (low|medium|high) risk

☐ Send alert as an Email to johndoe@def.com
☐ Send alert as a text message to my cell phone
Example of a user-defined text alert

- Downy mildew was reported from Erie, PA on July 15, 2014
- This disease source is $X$ miles from your farm
- The current risk to your farm is (low | med | high)

Current disease map  Current trajectories
Control recommendations  etc
CUCURBIT DOWNY MILDEW ipmPIPE

Cucurbit Downy Mildew Forecasts - July 18, 2011

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July 18

**First report from WI. New report from NC.** CDM has been confirmed on cucumber in a research plot in Columbia County, WI. Incidence is 5%; severity is 10%. Estimated date of first symptoms is July 14. CDM has been confirmed on cucumber in a home garden in Randolph County, NC. Incidence is 100%; severity is very high. Estimated date of first symptoms is July 7.

July 15

**First reports from AL. New report from MD.** CDM has been confirmed on acorn squash, butternut squash, and cucumber in the sentinel plot in Baldwin County, AL. Incidence is 100%; severity is 10% (1% acorn). Estimated date of first symptoms is July 7. CDM has been confirmed on butternut squash and jack-o-lantern pumpkin in the sentinel plot in Escambia County, AL. Incidence is 100%, severity is 20%. Estimated date of first symptoms is July 1. CDM has been confirmed on cucumber in a commercial field in Caroline County, MD. Estimated date of first symptoms is July 4.

July 13

**New reports from OH and NC.** CDM has been confirmed on cucumber in a 9 acre commercial field in Huron County, OH. Incidence is 1%; severity is 1%. Estimated date of first symptoms is July 12. CDM has been confirmed on cucumber in the sentinel plot in Johnston County, NC. Incidence is 1%, severity is 0.01%. Estimated date of first symptoms is July 12.

July 11

**First report from VA. New report from MI.** CDM has been confirmed on cucumber in a 1 acre commercial field in Prince George County, VA. Incidence is 100%; severity is 10%. Estimated date of first symptoms is July 5. CDM has been confirmed on cucumber in a home garden in Dinwiddie County, VA. Incidence is 100%, severity is 50%. Estimated date of first symptoms is July 5. CDM has been reported on cucumber in a commercial field in Bay County, MI. Severity is 5%. First-symptom date is July 11.

July 8

**First reports from GA, OH, and MI. New report from DE. Update from NC.** CDM has been confirmed on cucumber in a small research plot in Tift County, GA. Incidence is 10%; severity is 5%. Estimated date of first symptoms is July 3. CDM has been reported on cucumber in commercial fields in Wayne and Ashland Counties, OH. Wayne County outbreak is in a 1 acre field, 30% incidence, 10% severity. Estimated date of first symptoms is July 6. The Ashland County report is from a 2 acre field, incidence is 20%, severity is 10%, estimated first-symptom date is July 6. CDM has been confirmed on cucumber in a commercial field in Monroe County, MI. Estimated date of first symptoms is July 7. CDM has been confirmed on cucumber in the sentinel plot in New Castle County, DE. Incidence and severity are 1%. Estimated date of first symptoms is July 7. CDM has moved to cantaloupe in the sentinel plot in Sampson County, NC. First symptoms estimated at July 3.
July 18

First report from WI. New report from NC. CDM has been confirmed on cucumber. Incidence is 5%; severity is 10%. Estimated date of first symptoms is July 14. CDM has been confirmed in Randolph County, NC. Incidence is 100%; severity is very high. Estimated date of first symptoms is July 14.

July 15

First reports from AL. New report from MD. CDM has been confirmed on acorn. Sentinel plot in Baldwin County, AL. Incidence is 100%; severity is 10% (1% acorn). CDM has been confirmed on butternut squash and jack-o-lantern pumpkin in the sentinel plot. Incidence is 10%; severity is 20%. Estimated date of first symptoms is July 1. CDM has been confirmed in Montgomery County, MD. Estimated date of first symptoms is July 4.

July 13

New reports from OH and NC. CDM has been confirmed on cucumber in a 9 acre field. Incidence is 1%; severity is 1%. Estimated date of first symptoms is July 12. CDM has been confirmed in Cleveland County, NC. Incidence is 1%, severity is 0.01%. Estimated date of first symptoms is July 12.
CUCURBIT DOWNY MILDEW ipmPIPE

Cucurbit Downy Mildew Forecasts - July 18, 2011

*** Epidemic Update - 18 July: First report from WI. New report from NC. CDM has been confirmed in Columbia County, WI and Randolph County, NC. Please see the Epidemic History for details. ***

*** Epidemic Update - 15 July: First reports from AL. New Report from MD. CDM has been confirmed in Baldwin and Escambia Counties, AL and Caroline County, MD. Please see the Epidemic History for details. ***

Regional Weather: Eastern & Central U.S. / southern Canada

Hot and dry under a dominating upper-level High in the central U.S.; scattered showers possible parts of the North, East, and Gulf Coast. A strong dome of high pressure is situated over the U.S. midsection. Dry and dangerously hot weather is expected over most of the central U.S. Showers may occur as system of various kinds move around the periphery of the High. These will mainly be associated with a cold front pressing south from the Great Lakes / southern Canada into the Northeast / Ohio Valley / mid-Atlantic. Showers are also possible in the central to western Gulf Coast. Tropical Storm Bret in the northern Bahamas does not appear to be a factor. Highs in 90s to 100s most areas, cooler 80s in the Northeast. Lows mostly 70s and 80s, with some 50s and 60s Northeast and some 60s East tonight. The upper-level ridge is forecast to spread its influence toward the East Coast by midweek.
OUTLOOK:

Overview: Mixed conditions for epidemic spread follow the cold front. Future disease development possible in portions of the Great Lakes, Northeast, and mid-Atlantic. Some short-range spread is possible also near the AL and FL sources.

Risk prediction map for Day 1: Monday, July 18

Transport events from the Great Lakes are moving east; those from the East Coast are moving generally northeast. Epidemic spread is more likely across the northern areas today. Events in the mid-Atlantic will encounter too much sunshine and little chance of rain. High Risk near the northeast PA source. Moderate Risk for cucurbits in parts of WI, eastern MI, northern OH, western NY, western PA, southern FL, near the southern border of AL and MS, and southeast NY. Areas of Low Risk are present in central PA / central NY and in southern New England. Minimal Risk most other areas.
18 Aug 2005

First symptoms of downy mildew on cucumber.

About 6 days after spore dispersal to area.
North Carolina State University
Cucurbit Downy Mildew Forecast

Forecast Summary: Thursday, July 7

Due to the approach of Hurricane Dennis and its potential impact on the southern US, a Saturday downy mildew forecast will be issued.

Weather - Eastern U.S.: The remnants of Cindy are still swirling across the Mid-Atlantic region, bringing rain and triggering severe weather. High pressure will control the weather over the Mid-Atlantic after Cindy leaves. However, the south isn't as lucky. Currently, Hurricane Dennis is forecast to make landfall somewhere on the central Gulf Coast Sunday. Florida will begin to see the effects of Dennis as early as Friday evening. The approach of Dennis will, of course, bring heavy rain and wind to the Gulf Coast area late in the forecast period.
The Forecast:

For more specific forecast details, please follow the links for the individual forecast locations.

**Thursday:** High Risk to cucurbitis in Southern NJ, PA, DE, MD, eastern WV, and northern VA for the Thursday transport event. Weakly Moderate Risk to cucurbitis in southern Florida and Georgia for the Thursday transport event. Low Risk otherwise.

**Friday:** High Risk to cucurbitis in NJ, southeastern PA, eastern MD, and DE for the Friday transport event. High Risk to cucurbitis in southern Florida for the Friday transport event. Weakly Moderate Risk to cucurbitis in Georgia for the Friday transport event. Low Risk otherwise.

-MM

Current Sources:

- Cumberland County, NJ
- Duplin County, NC
- Mershon, GA
- Seaford, DE
- South Florida
Thursday and Friday: The forecast trajectories for Thursday and Friday get caught up in the low pressure system that was Cindy. **High Risk to cucurbits in Southern NJ, PA, DE, and MD for the Thursday transport event. High Risk to cucurbits in NJ, southeastern PA, and DE for the Friday transport event. Low Risk otherwise.**

NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 07 Jul 05
18 UTC 07 Jul NAM Forecast Initialization
Saturday through Monday: Higher moisture and a slightly more favorable upper air environment will increase the risk for disease development. **Weakly Moderate Risk** to cucurbits in CT, NJ, eastern PA, and southeastern NY Saturday through Monday. **Low Risk** otherwise.

NOAA HYSPLIT MODEL
Forward trajectory starting at 14 UTC 11 Aug 05
06 UTC 11 Aug  GFSG Forecast Initialization

Source ★ at 39.45N 75.25W
Conventional Fungicides - Downy Mildew

**Protectant Fungicides**
- Mancozeb and chlorothalonil
  - Apply before downy mildew reported in region.
  - Apply when forecast risk is low to moderate.
  - Apply when conditions favorable.
  - Apply with targeted fungicides.

**Targeted Fungicides**
- Curzate, Presidio, Previcur Flex, Ranman, Revus, Tanos, Zampro, Zing!
  - Apply when downy mildew reported near by.
  - Apply when forecast risk is moderate to high.
  - Apply in alternation.
  - Apply with protectant fungicides.
  - Apply fungicides every 5 - 7 days when downy mildew present.
<table>
<thead>
<tr>
<th>Fungicide</th>
<th>FRAC Group</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranman</td>
<td>Group 21</td>
<td>Use surfactant.</td>
</tr>
<tr>
<td>Zing!</td>
<td>Group 22 + M5</td>
<td>Replaces Gavel.</td>
</tr>
<tr>
<td>Curzate</td>
<td>Group 27</td>
<td>or Tanos.</td>
</tr>
<tr>
<td>Previcur Flex</td>
<td>Group 28</td>
<td></td>
</tr>
<tr>
<td>Zampro</td>
<td>Group 40 + 45</td>
<td>Use surfactant.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replaces Forum.</td>
</tr>
<tr>
<td>Revus</td>
<td>Group 40</td>
<td>Must use surfactant.</td>
</tr>
<tr>
<td>Presidio</td>
<td>Group 43</td>
<td>Resistance??</td>
</tr>
</tbody>
</table>
**Targeted Fungicides – Downy Mildew**

- **Tanos or Curzate.** Must tank-mix with contact fungicide.
  - Cymoxanil. ≤ 2 day kickback. Only ~ 3 day residual.
  - Tanos. 5 - 7 day interval. 4X max. No seq’l.
  - Curzate. 5 - 7 day interval. 9X max.

- **Ranman.** 7 - 10 day. 6X max. 3 sequential. Preventive.
- **Zampro.** 5 - 7 day. 3X max. 2 sequential. Preventive.
- **Zing!** 7 - 10 day. 8X max. 2 seq’l. Has chlorothalonil.
- **Revus.** 7 - 10 day. 4X max. No seq’l. Must tank-mix. Pre.+
- **Previcur Flex.** 7 - 14 d. 5X. Must apply before infection. *
- **Presidio.** 7 - 10 day. 4X max. Must tank-mix. Pre.**

QoIs + Ridomil not recommended due to resistance.

* Not effective for Phytophthora blight. ** Resistance??
+ variable efficacy; good on pumpkin not cucumber.
Organic Fungicides – Cucurbit Downy Mildew

Actinovate
Double Nickel
Serenade
Sonata
MilStop
Organocide
Regalia
Sporatec
Trilogy
Zonix

Copper
Biopesticides

As defined by US EPA (1994):
Pesticides derived from natural materials.

3 Major classes:
   - Microbial pesticides
   - Biochemical pesticides (naturally occurring substances).
   - Plant Incorporated Protectants (GMO)

Most suitable for organic production.
Most have contact activity. Some also induce SAR (systemic acquired resistance).
Biopesticides - Microbial
(active ingredient is microbe)

**Cease.** 1.34% *Bacillus subtilis* QST 713 strain. Greenhouse and high tunnel use.

**Companion.** 0.03% *Bacillus subtilis* GB03.

**DoubleNickel 55 LC and WDG.** *Bacillus amyloliquefaciens* strain D747.

**Serenade Opti.** 26.2% *Bacillus subtilis* strain QST 713.

**Serenade ASO.** 1.34% *Bacillus subtilis* strain QST 713.

**Sonata.** 1.38% *Bacillus pumilus* strain QST 2808.

**Taegro.** 13% *Bacillus subtilis* var. *amyloliquefaciens* strain FZB24.
Biopesticides – Microbial

**Actinovate AG.** 0.0371% *Streptomyces lydicus*.

**Contans WG.** 5.3% Coniothyrium mimitans strain CON/M/91-08.

**MeloCon WG.** 6% Paecilomyces lilacinus strain PL251.

**Bio-Tam or Tenet.** 2% *Trichoderma asperellum* strain ICC 012 and 2% *Trichoderma gamsii* strain ICC 080.

**RootShield Plus WP.** 1.15% *Trichoderma harzianum* Rifal strain T-22 and *Trichoderma virens* strain G-41.

**Mycostop.** 30% *Streptomyces griseoviridis* strain K61.

**Prestop.** 32% *Gliocladium catenulatum* strain J1446.

**SoilGard 12G.** 12% *Gliocladium virens* strain GL-21.
Biopesticides – Biochemical
(naturally occurring substances)

BacStop. 2% thyme, 2% clove & clove oil, 1.5% cinnamon, 1% peppermint & peppermint oil, and 1% garlic oil.

Mildew Cure (formerly GC-3 Organic fungicide). 30% cottonseed oil, 30% corn oil, 23% garlic extract.

Organocide. 5% sesame oil. (no ag label)

Promax. 3.5% thyme oil.

Sporatec AG. 18% rosemary oil, 10% clove oil, and 10% thyme oil. Not readily available any more.

Trilogy. 70% extract of neem oil.

Most of these are exempt from EPA registration.
Biopesticides – Biochemical

Regalia. 5% Extract of *Reynoutria sachalinensis*. Kaligreen, MilStop. EcoMate Armicarb O. 82 - 85% Potassium bicarbonate. M-Pede. 49% Potassium salts of fatty acids. OxiDate, Zerotol. 27% hydrogen dioxide. KeyPlex 350 OR. defensive proteins (alpha-keto acids) and secondary and micronutrients. SafeStrike. Blend of natural oils and surfactants, containing vitamens, minerals, enzymes, antioxidants, and plant hormones.
Biopesticides NOT Acceptable for Organic Production
(synthetic substances)

Oso. 5% Polyoxin D zinc salt.

Phosphorous acid fungicides.

Most effective against Oomycetes (downy mildew).
K-Phite. Mono- and di-potassium salts of phosphorous acid.
Fosphite. Mono- and di-potassium salts of phosphorous acid.
Fungi-Phite. Mono- and di-potassium salts of phosphorous acid.
Rampart. Mono- and di-potassium salts of phosphorous acid.
pHorsepHite. Mono potassium phosphate and mono potassium phosphite.
ProPhyt. Potassium phosphite.
Phostrol. Mono- and dibasic sodium, potassium, and ammonium phosphites.
Other Organic Fungicides

Copper. Several products
Sulfur. Several products
  Microthiol Disperss. 80% sulfur.
JMS Stylet-Oil. 97.1% paraffinic (mineral) oil.
Tritek (Saf-T-Side). 80% petroleum oil.
SuffOil-X. 80% mineral oil.
Managing Diseases with Biopesticides

Most have contact activity (phosphorous acid fungicides are mobile; others induce SAR).

Plant diseases can be difficult to manage. Best to use preventive spray program. Maximize coverage on leaf underside. Use tight spray interval. Integrated program often better. Most effective for powdery mildews. Effective for bacterial diseases. Soil-borne pathogens?
Biopesticides – Root Rots
(Phytophthora, Pythium, Fusarium, Rhizoctonia)

Actinovate AG. 0.0371% Streptomyces lydicus.
Mycostop. 30% Streptomyces griseoviridis.
Serenade ASO. 1.34% Bacillus subtilis. Old = SerenadeSoil.
DoubleNickel 55 LC and WDG. Bacillus amyloliquefaciens.
Taegro. 13% Bacillus subtilis var. amyloliquefaciens.
Bio-Tam. 2% Trichoderma asperellum and 2% T. gamsii.
RootShield Plus WP. 1.15% Trichoderma harzianum and Trichoderma virens.
Prestop. 32% Gliocladium catenulatum.
SoilGard 12G. 12% Gliocladium virens.
Bacterial Leaf Spot - Pumpkin
Bacterial Leaf Spot
Pumpkin
Bacterial Leaf Spot (all cucurbits)

Inoculum sources:
- Contaminated seed
- Splashing water

Management:
- Quality seed
- Rotate crops
- Scout
- Drip irrigation
- Fungicides*
- Incorporate debris

* copper + mancozeb (ManKocide)
use Quintec for powdery mildew
Biopesticides – Bacterial Diseases

**BacStop.** 2% thyme, 2% clove & clove oil, 1.5% cinnamon, 1% peppermint & peppermint oil, and 1% garlic oil.

**Companion.** 0.03% *Bacillus subtilis* GB03.

**DoubleNickel 55 LC and WDG.** *Bacillus amyloliquefaciens*.

**OxiDate.** 27% hydrogen dioxide.

**Regalia.** 5% Extract of *Reynoutria sachalinensis*.

**Serenade Opti.** 14.6% *Bacillus subtilis*. 
Control of Bacterial Spot in Pumpkin (%)

<table>
<thead>
<tr>
<th>Treatment (7-day)</th>
<th>Fruit affected (%)</th>
<th>Fruit severity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
<td>2013</td>
</tr>
<tr>
<td>Nodox 75WG 1.25 lb/A (7-8X)</td>
<td>--</td>
<td>55 d-g</td>
</tr>
<tr>
<td>Serenade 6 qt/A (7-8X)</td>
<td>81 bc</td>
<td>39 b-f</td>
</tr>
<tr>
<td>Regalia 1 qt/A (7-8X)</td>
<td>100 c</td>
<td>50 c-g</td>
</tr>
<tr>
<td>Sonata 4 qt/A (7-8X)</td>
<td>50 a-c</td>
<td>38 b-f</td>
</tr>
<tr>
<td>Actinovate 12 oz/A (7-8X)</td>
<td>33 ab</td>
<td>44 c-g</td>
</tr>
</tbody>
</table>

‘a’ = ineffective

Treatments started 3 or 4 days before inoculation.
Seed-Borne Pathogens - Cucurbits

Alternaria leaf blight
Angular leaf spot
Anthracnose
Bacterial leaf spot
Gummy stem blight
Phytophthora blight
Scab
Soil-Borne Pathogens - Cucurbits

Alternaria leaf blight (infested debris)
Angular leaf spot (infested debris)
Anthracnose (infested debris)
Bacterial leaf spot (infested debris)
Gummy stem blight (infested debris)
Phytophthora blight
Plectosporium blight (infested debris)
Scab (infested debris)
Root rots
Disease Identification Tips

Determine what can occur (good winter task!). State guidelines.

Vine crops – lots of diseases.

Learn symptoms and signs.

Scout routinely. Early in day. Look at all plant parts. Use hand lens.

Take pictures.

Get help when needed. Extension.
Gummy Stem Blight - Melon
Photo gallery: Vegetable diseases observed on Long Island

Plus herb diseases, strawberry diseases and vegetable disorders

New! Late blight 'imitators' - How to distinguish late blight from other diseases and disorders with similar symptoms.

Basil

- Downy mildew

Beans

- Ozone injury
- Phytophthora blight

Beet and Swiss Chard

- Cercospora leaf spot

Carrot

- Powdery mildew
Plectosporium Blight

Pumpkin and summer squashes most susceptible
Plectosporium Blight

Inoculum sources:
Wind or rain dispersed spores from debris or other crops

Management:
Rotate crops
Scout
Drip irrigation
Fungicides*
Incorporate debris

* Bravo
FRAC 11: Quadris, Cabrio, Flint, Pristine (best, not specifically labeled)
Pumpkin - Virus
Pumpkin - Virus
Squash Silver Leaf
Phytophthora Blight
Biofumigant Mustard Cover Crop

Select variety high in glucosinolates.
Plant in early spring or fall. 10 lb/A.
50-100 lb/A N.
Drill (best) or broadcast.
Incorporate after 5-6 weeks flowering:
- Flail chop well early in day when coolest.
- Incorporate asap.
- Seal surface.
- Plant ≥ 7 days later.

Caliente 199
Integrated Management Program in Field with Severe Phytophthora Blight in 2011

Caliente 199  10 lb/A

4-3-12 seeded mustard
7-3-12 seeded pumpkin

6-12-12
Mustard decomposes: Glucosinolates break down into allyl-isothiocyanate (methyl isothiocyanate is in Metam Sodium)
Fungicide Program Implemented

Jul 18    ProPhyt
Jul 31    Curzate, Presidio, Ranman
Aug 8     Revus
Aug 17    Presidio    Sep 7    Forum
Aug 24    Ranman    Sep 14    Presidio
Sep 1     Revus    Sep 21    Presidio
Bravo +/or copper included except Jul 18

Oct 17    91% fruit without rot.
Purslane Roots Susceptible to *Phytophthora capsici*
Previous Sod Fields - Unsuccessful Attempts to Escape Phytophthora Blight

3 Farms on Long Island.
5 Fields.

8-22-12
Fungicide Program for Blight

Targeted fungicides key.
Preventive schedule.
Manage resistance.
Do not rely on one fungicide.
Plus broad-spectrum, contact fungicides.
Plus cultural practices:
   Manage soil moisture.
Targeted Fungicides for *P. capsici*

- **Presidio**  FRAC Group 43
- **Ranman**  FRAC Group 21. Use surfactant
- **Zampro***  FRAC Group 40 + 45.
- **Revus**  FRAC Group 40. Use surfactant
- **Tanos**  FRAC Group 27
- **Zing!***  FRAC Group 22

Phosphorous acid fungicides  (Group 33)
- **Ridomil**  FRAC Group 4. Resistance common

*new products; use in place of Forum + Gavel.*
Limitations - Targeted Fungicides

Presidio  3 - 4 sprays, 2 consecutive
         18-mo rotational restriction
Ranman*  6 sprays, ≥ 2 consecutive
Zampro   5 sprays, 2 consecutive
Revus     4 - 6 sprays, 2 consecutive
Tanos     4 sprays, no consecutive
Zing!     8 sprays
Phosphorous acid fungicides
*Resistance has developed in SE USA.
Targeted Fungicides Can Be Very Specific

Previcur Flex:
Good for downy mildew
Good for late blight
\((\text{Phytophthora infestans})\)

Poor for Phytophthora blight
\((\text{Phytophthora capsici})\)
Biofungicides – Phytophthora Blight

Apply at planting

Actinovate. Apply to seed as a spray or dry coating, or applied in-furrow.

Double Nickel. Apply to transplants before or at transplanting, or in-furrow at seeding.

RootShield. Granular is labeled for use on pepper but not cucurbits. WP can be applied as a drench to potting soil or field soil, or in furrow or broadcast.

Serenade ASO. Apply as a directed spray in the furrow just before the seeds are covered for cucurbits. Replacing SerenadeSoil.
Scout for Early Symptoms

Phytophthora Blight
Phytophthora Blight
Early Symptoms of Blight
Fusarium Crown Rot
Fusarium Crown Rot
Fusarium Fruit Rot