Modeling Vector Flights and Timing Foliar Protectants

Wisconsin Potato and Vegetable Growers Association
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1) New explanations associated with re-emergence of Potato virus Y

2) Modeling vector flights for targeted use of foliar protectants

3) Strategies to minimize current season spread of Potato virus Y (A. Crockford).
Increase proportion of down-grades and rejections resulting from PVY

Percent of lots without mosaic symptoms

Year


Trajectory
Potato virus Y (PVY) re-emergence in the United States

- Asymptomatic varieties (certification problems):
  - ‘Silverton Russet’
  - ‘Russet Norkotah’
  - ‘Shepody’
  - ‘Typhoid Mary’
## Potato virus Y Recombinant Strains

<table>
<thead>
<tr>
<th>PVY strain</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>PVY(^O)</td>
<td>49</td>
<td>39</td>
<td>108</td>
<td>196</td>
</tr>
<tr>
<td>PVY(^N:O)</td>
<td>2 (3.9%)</td>
<td>26 (40.0%)</td>
<td>45 (29.4%)</td>
<td>73</td>
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<tr>
<td>PVY(^N) or NTN</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Mix of strains</td>
<td>0</td>
<td>0</td>
<td>2 (1.3%)</td>
<td>2</td>
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</tbody>
</table>

S.M. Gray (2006)
Biology and Distribution of the soybean aphid

**Morphs on Buckthorn (Winter Host)**
- Fundatrix (Stem Mother)
- Eggs laid by buds
- Oviparae

**Morphs on Soybean (Summer Host)**
- SPRING MIGRANTS
- apterae
- alatae
- SUMMER MORPHE
- Androparae - MALE
- FALL MIGRANTS (SEXUALS)
- Gynoparae - FEMALE

**Colonies on soybean**

**Aphis glycines, soybean aphid**

Map showing distribution:
- Red: 2000
- Yellow: 2001-2009

Citation:
Research Objectives

- Determine the (1) seasonal phenology of dispersing aphid vectors, (2) temporal patterns of PVY disease progress, and (3) combination of foliar protectants that limit current season spread.

**Goal:** Accurately determine periods of elevated risk for PVY transmission and develop disease management strategies to limit spread of the viral pathogen.

**Goal:** Evaluate the influence of well-timed, foliar control product (combinations) to limit the spread of PVY.
Presentation Outline

1) New explanations associated with re-emergence of Potato virus Y

2) Modeling vector flights for targeted use of foliar protectants

3) Strategies to minimize current season spread of Potato virus Y.
Seasonal Dispersal – Aphid Alerts
Seasonal Dispersal - Suction Trap Network

- Weekly captures of dispersing aphid species.
- D. Voegtlin, Illinois Natural History Survey

**Regional Soybean Aphid Suction Trap Network**

- *Acyrthosiphon pisum*
- *Aphis craccivora*
- *Aphis glycines*
- *Aphis gossypii*
- *Aphis helianthi*
- *Aphis nasturtii*
- *Aphis spiraecola*
- *Brachycaudus helichrysi*
- *Lipaphis pseudobrassicaceae*
- *Macrosiphum euphorbiae*
- *Myzus persicae*
- *Rhopalosiphum insertum*
- *Rhopalosiphum maidis*
- *Rhopalosiphum padi*
- *Schizaphis graminum*
- *Sitobion avenae*
- *Therioaphis trifolii*

- "Pea aphid"
- "Black legume aphid"
- "Soybean aphid"
- "Cotton-melon aphid"
- "Sunflower or dogwood aphid"
- "Buckthorn - potato aphid"
- "Spiraea aphid"
- "Leaf curling plum aphid"
- "Turnip aphid"
- "Potato aphid"
- "Peach potato aphid"
- "Apple grass aphid"
- "Corn leaf aphid"
- "Bird cherry-oat aphid"
- "Greenbug"
- "English grain aphid"
- "Spotted Alfalfa aphid"
Seasonal Dispersal of Soybean Aphid: Modeling Central WI Suction Traps

2007 A. *glycines* raw data

2007 A. *glycines* standardized data
Seasonal Dispersal of Soybean Aphid: Modeling Aphid Flights – 2007 All Traps
Seasonal Dispersal of Soybean Aphid: Modeling Aphid Flights – 2007 Mean

![Chart showing seasonal dispersal of soybean aphid models for 2007 mean. The chart displays the dispersion of different aphid species (e.g., Rhopalosiphum rufiabdominale, Schizaphis graminum, etc.) across various x and y coordinates, illustrating the seasonal flight patterns.]

\[ S = 1.953 \times 10^2 - (3.099 \times 10^0 \times \text{julian}) + (1.616 \times 10^{-2} \times \text{julian}^2) - (2.769 \times 10^{-5} \times \text{julian}^3) \]

195 = July 14

<table>
<thead>
<tr>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept</th>
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<td>234</td>
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<td>131</td>
<td></td>
<td>229</td>
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</tbody>
</table>

"Pea aphid"
"Soybean aphid"
"Cotton-melon aphid"
"Potato aphid"
"Peach potato aphid"
"Corn leaf aphid"
"Bird cherry-oat aphid"
"Greenbug"
"English grain aphid"
"Spotted Alfalfa aphid"
Monitoring the spread of PVY
Monitoring the spread of PVY

‘Unbiased’ Pan Traps

- Traps collected / replaced weekly (17 May – 30 Aug)
- Trap contents held in 70% EtOH
- Species designations underway

9 fields with 21 traps
Monitoring the spread of PVY

- Plants collected / replaced weekly (14 June – 30 Aug)
- Plants returned to the aphid-free greenhouse for 21 days
- Plants originated from ‘G1’ Foundation seed
Monitoring the spread of PVY – Experimental Site
Monitoring the spread of PVY – 2010 Counts / Region

- Langlade, Co
- Central Sands
- Spring Green

Weeks 1 to 15

Counts range from 0 to 2.5
Monitoring the spread of PVY – 2010 Proportion Detections

- Langlade, Co
- Central Sands
- Spring Green

Weeks 1 to 15
Seasonal Dispersal of Soybean Aphid: Relationship to PVY Spread

2009, Langlade Agricultural Research Station

Mean Proportion Capture / PVY Infection

\[ P = 0.2582 \]

\[ T_{50} = 21 \text{ July} \]

\[ T_{50} = 2 \text{ Aug} \]
1) New explanations associated with re-emergence of Potato virus Y

2) Modeling vector flights for targeted use of foliar protectants

3) Strategies to minimize current season spread of Potato virus Y.
PVY Foliar Oil Protectant Trial, 2008-10

- Selection of mineral oils
  - Aphoil
  - JMS Stylet Oil
  - QRD-416 (Requiem)
  - NNI-0101 (pyrfluquinizon)
  - Aza-Direct

- Application Frequency
  - once weekly (every 7 days)
  - twice weekly (every 4 days)

- Application rates
  - Aphoil (2 and 4%)
  - JMS Stylet Oil (0.75 and 1.5%)

- Application Technology
  - D3-DC25 (hollow-cone)
  - XR-11004 (flat fan)
  - 80 and 45 psi
  - 21.1 and 37.5 gpa
PVY Foliar Oil Protectant Trial, 2009
Winter Grow-Out Results

Greatest Protection Level with cv. Silverton Russet Achieved with:
(1) 2X weekly applications, and
(2) highest product concentrations

Mean Proportion of PVY-Infected Plants

UTC Aphoil (2%) Aphoil (4%) Aphoil (2%) Aphoil (4%) Stylet Oil (0.75%) Stylet Oil (1.5%) Stylet Oil (0.75%) Stylet Oil (1.5%) Stylet Oil (1.5%) Stylet Oil (1.5%) QRD 416 (1.0%)

P= 0.0213

Greatest Protection Level:
(1) 2X weekly applications, and
(2) highest product concentrations

5% mosaic ‘Certified’

Oil Compound (Concentration)
## Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2009

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Frequency</th>
<th>Application Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1)</td>
<td>UTC</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td>3)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td>4)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td>5)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td>Fulfill</td>
<td>pymetrozine</td>
<td>5.5 fl oz / ac</td>
<td>2X</td>
</tr>
<tr>
<td>6)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td>Beleaf</td>
<td>flonicamid</td>
<td>2.8 fl oz / ac</td>
<td>3X</td>
</tr>
<tr>
<td>7)</td>
<td>Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
</tr>
<tr>
<td></td>
<td>NNI-0101</td>
<td>pyrfluquinizon</td>
<td>3.2 fl oz / ac</td>
<td>3X</td>
</tr>
</tbody>
</table>

**Do all varieties require similar levels of protection?**

*Goldrush vs. Snowden*

**Can we define periods of greatest need for protection?**
PVY Foliar Oil Protectant Trial, 2010 Winter Grow-Out Results

Goldrush

Initial Inoculum = 1.25%
P = 0.0113
PVY Foliar Oil Protectant Trial, 2010 Winter Grow-Out Results

Snowden

Initial Inoculum = 1.25%
P = 0.0391

Mean Proportion of PVY-Infected Plants

- Untrained Control
- Aphol 1X/week June 15
- Aphol 1X/week July 15
- Aphol 1X/2X June 15 - July 15
- Aphol 1X/2X Fulfill (2X)
- Aphol 1X/2X June 15 - July 15 Belaef (3X)
- Aphol 1X/2X June 15 - July 15 NN-0101 (3X)
## Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2010

<table>
<thead>
<tr>
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<th>Application Interval (days)</th>
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<tr>
<td>1) UTC</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>2) Aphiol</td>
<td>mineral oil</td>
<td>2.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
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<tr>
<td>3) Stylet Oil</td>
<td>mineral oil</td>
<td>0.75 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td>4) Aphiol</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
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<tr>
<td>5) Stylet Oil</td>
<td>mineral oil</td>
<td>1.5 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
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<tr>
<td>6) Requiem</td>
<td>plant oil</td>
<td>1.0 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
</tr>
</tbody>
</table>
### Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2010

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Frequency</th>
<th>Application Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7) Stylet Oil</td>
<td>mineral oil</td>
<td>0.75 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
</tr>
<tr>
<td>Aza-Direct</td>
<td>azadirachtin</td>
<td>2.0 pts / ac</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
</tr>
<tr>
<td>8) Aphoil</td>
<td>mineral oil</td>
<td>2.0 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
</tr>
<tr>
<td>Aza-Direct</td>
<td>azadirachtin</td>
<td>2.0 pts / ac</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
</tr>
<tr>
<td>9) Requiem</td>
<td>plant oil</td>
<td>1.0 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
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<tr>
<td>Aza-Direct</td>
<td>azadirachtin</td>
<td>2.0 pts / ac</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
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<td>10) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>1X weekly</td>
<td>4 (June 5)</td>
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<tr>
<td>NNI-0101</td>
<td>pyrfluoquinizon</td>
<td>3.2 fl oz / ac</td>
<td>3X appl</td>
<td>7 (July 20)</td>
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<tr>
<td>11) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>1X weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td>Beleaf</td>
<td>flonicamid</td>
<td>2.8 fl oz / ac</td>
<td>3X appl</td>
<td>7 (July 20)</td>
</tr>
<tr>
<td>12) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>1X weekly</td>
<td>7 (June 5)</td>
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<tr>
<td>Fulfill</td>
<td>pymetrozine</td>
<td>3.67 fl oz / ac</td>
<td>3X appl</td>
<td>7 (July 20)</td>
</tr>
</tbody>
</table>
PVY Foliar Oil Protectant Trial, 2010-11
Winter Grow-Out Results

Mean Proportion of PVY-Infected Plants

P = 0.0061

Oil Compound
(Concentration)

UTC
Aphoil (2%) Stylet (0.75%)
Aphoil (4%) Stylet (1.5%)
Requiem (1.0%) Stylet (0.75%)
Aza-Direct (2 pts/ac) + Aphoil (2.0%)
Aza-Direct (2 pts/ac) + Requiem (1.0%) + +NN-9010 (3.2 oz/ac) + Aphoil (4.0%) + Azalube (2 oz/ac)
Aphoil (4.0%) + Azalube (2 oz/ac)
Aphoil (4.0%) + Azalube (3.67 oz/ac)

5% mosaic ‘Certified’

Applied 1X / week
(June 5)

Applied 2X / week
(July 15)

Applied 1X / week
(June 5)
## Large Block, Strip Trials, 2010

<table>
<thead>
<tr>
<th>Variety</th>
<th>Plot</th>
<th>Compound</th>
<th>Application Frequency</th>
<th>Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Norkotah Colorado 8</td>
<td>338A</td>
<td>Requiem</td>
<td>weekly</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td>338B</td>
<td>Stylet Oil</td>
<td>weekly</td>
<td>0.75%</td>
</tr>
<tr>
<td>Silverton</td>
<td>399A</td>
<td>Requiem</td>
<td>weekly</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td>399B</td>
<td>Stylet Oil</td>
<td>weekly</td>
<td>0.75%</td>
</tr>
<tr>
<td>Silverton</td>
<td>403A</td>
<td>Requiem</td>
<td>weekly</td>
<td>1.0%</td>
</tr>
<tr>
<td></td>
<td>403B</td>
<td>Stylet Oil</td>
<td>weekly</td>
<td>0.75%</td>
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</tbody>
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PVY Foliar Oil Protectants, Strip Trial Results, 2011 Winter Growout

Mean Proportion of PVY-Infected Plants

<table>
<thead>
<tr>
<th>Foliar Protectant</th>
<th>R. Norkotah Colorado 8</th>
<th>Silverton Russet</th>
<th>5% mosaic</th>
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<tbody>
<tr>
<td>Requiem</td>
<td>2</td>
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<td>P = 0.3451</td>
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<td>4</td>
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</tr>
<tr>
<td>Requiem</td>
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<td>6</td>
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</tr>
<tr>
<td>Stylet Oil</td>
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<td>4</td>
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Minimizing Current Season Infection: Foliar Protectant Summary

- In 2008, 2X weekly oil applications of Aphoil and Stylet Oil reduced PVY in daughter tubers of Silverton Russet.

- Again in 2009, Aphoil weekly (June 15) and twice weekly (July 15), resulted in lowest overall PVY in winter test.

  - Suggests that the bulk of infection / transmission occurs in late season
  - Additive effects of selective feeding blockers / behavioral modifiers warrants further investigation

- Level (degree) of foliar protection required varied by cultivar

  - Mature plant resistance in Snowden vs. Goldrush

- Improved understanding of disease progress curve and relationship to primary insect vectors – *A. glycines*
Current Season PVY Spread: Multi-tactic Approach

I. Avoidance in Time: early vine kill

II. Avoidance in Space

III. Plant Clean Potato Seed

IV. Improved Crop Protection

Table:

- 2009
- 8,400 ac Seed
- 5,100 ac Soybean
- 5,050 ac Wheat
- 2,200 ac Commercial
Potato Crop Protection
Future Directions

• Accurately predict dispersal dynamics of the soybean aphid
  - physical factors (temperature, precipitation) - abiotic

• Repeat and refine crop protection strategies
  - crop protection combinations
  - application rates, frequency, and intervals
  - cultivar responses to infection
    ‘mature plant resistance’

• New products / behavioral modifiers
  - HGW86 (cyazypyr - DuPont Crop Protection)
  - Movento (spirotetramet – Bayer Crop Sci)
  - Oils (Tobacco Bio-Oil, Superior Spra-Oil, Volck Oil, peppermint, etc..)
A. Charkowski, S. Gray, R. Groves, P. Hutchinson, A. Karasev, C. McIntosh, P. Nolte, J. Whitworth

“Refine the current PVY management strategies used by growers and seed certification agencies to reduce virus levels in seed stocks and to reduce the spread of virus within the crop”