Modeling Aphid Flights for Accurate Timing of PVY Management

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Development of comprehensive strategies to manage *Potato virus Y* in potato and eradication of the tuber necrotic variants recently introduced into the United States

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www.potatovirus.com

“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”
Increase proportion of down-grades and rejections resulting from PVY

Percent of lots without mosaic symptoms

Year

Trajectory

20%
Potato virus Y (PVY) re-emergence in the United States

- **Asymptomatic varieties** (certification problems):
  - 'Silverton Russet'
  - 'Russet Norkotah'

- **Recombinant Strains:**
  - $PVY^O$
  - $PVYN:O$
New Insect Vector, Soybean aphid in the Eastern US

*Aphis glycines*, soybean aphid

2005 Distribution

Lee 2002
Research Objectives

- **Determine:** (1) seasonal phenology of dispersing aphid vectors and (2) crop protection options to limit spread of PVY.

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

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

Acquisition | Transmission | Retention

seconds | seconds | hours
Seasonal Aphid Dispersal

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

- **Acrithosiphon pisum** "Pea aphid"
- **Aphis craccivora** "Black legume aphid"
- **Aphis glycines** "Soybean aphid"
- **Aphis gossypii** "Cotton-melon aphid"
- **Aphis helianthi** "Sunflower or dogwood aphid"
- **Aphis nasturtii** "Buckthorn-potato aphid"
- **Aphis spiraecola** "Spiraea aphid"
- **Brachycaudus helichrysi** "Leaf curling plum aphid"
- **Lipaphis pseudobrassicae** "Turnip aphid"
- **Macrosiphum euphorbiae** "Potato aphid"
- **Myzus persicae** "Peach potato aphid"
- **Rhopalosiphum insertum** "Apple grass aphid"
- **Rhopalosiphum maidis** "Corn leaf aphid"
- **Rhopalosiphum padi** "Bird cherry-oat aphid"
- **Schizaphis graminum** "Greenbug"
- **Sitobion avenae** "English grain aphid"
- **Therioaphis trifolii** "Spotted Alfalfa aphid"
Annual Variation in Aphid Dispersal (Wisconsin 2005-2011)
Modeling Aphid Phenology
Soybean aphid Captures, Wisconsin 2005-2011

N = 680
Generalized Additive Model
Wisconsin 2005-2011

Mean soybean aphids / trap

95% CI (Year)

Mean capture

Julian Date
Generalized Additive Model
Aphid Thresholds

Mean soybean aphids / trap

Julian Date
Cumulative Soybean Aphid Counts

P = 0.0228

Cumulative soybean aphids / trap

Julian Date
Proportion Soybean Aphid Counts

Proportion soybean aphids / trap

Relative A. glycines Risk

Calendar Day

Julian Date

P = 0.3916

39 days
Seasonal Dispersal of PVY Aphid-Vectors: 2005 - 2011

<table>
<thead>
<tr>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept</th>
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<tbody>
<tr>
<td>136</td>
<td>178</td>
<td>198</td>
<td>234</td>
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<td>152</td>
<td>195</td>
<td>214</td>
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<td>182</td>
<td>201</td>
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<tr>
<td>162</td>
<td>200</td>
<td>229</td>
<td></td>
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</tr>
</tbody>
</table>

Pea aphid
Soybean aphid
Cotton - melon aphid
Potato aphid
Peach potato aphid
Corn leaf aphid
Bird cherry-oat aphid
English grain aphid
Spotted Alfalfa aphid
Insecticides for Managing Aphids / PVY

<table>
<thead>
<tr>
<th>Mode of Action Class</th>
<th>Group</th>
<th>Active Ingredient</th>
<th>Trade Names</th>
<th>Application Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicotinic acetylcholine receptor (nAChR) agonists</td>
<td>4A</td>
<td>Imidacloprid</td>
<td>Admire Pro®, Gaucho®, Provo®</td>
<td>In-furrow, seed treatment, Foliar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiamethoxam</td>
<td>Platinum®, Cruiser®, Actara®</td>
<td>In-furrow, seed treatment, Foliar</td>
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<tr>
<td></td>
<td></td>
<td>Clothianadin</td>
<td>Belay®</td>
<td>In furrow, seed treatment, Foliar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dinotefuran</td>
<td>Scorpian™</td>
<td>Foliar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acetamiprid</td>
<td>Assail®</td>
<td>Foliar</td>
</tr>
<tr>
<td>Selective Homopteran Feeding Blockers</td>
<td>9B</td>
<td>Pymetrozine</td>
<td>Fulfill®</td>
<td>Foliar</td>
</tr>
<tr>
<td></td>
<td>9C</td>
<td>Flonicamid</td>
<td>Beleaf™</td>
<td>Foliar</td>
</tr>
<tr>
<td>Narrow-range mineral oil</td>
<td>NA</td>
<td>Petroleum oil</td>
<td>Aphiol®, Stylet Oil®</td>
<td>Foliar</td>
</tr>
<tr>
<td>Plant extract (C. ambrosoides)</td>
<td>NA</td>
<td>Plant oil</td>
<td>Requiem®</td>
<td>Foliar</td>
</tr>
</tbody>
</table>

In the Pipeline or under review:

- NNI - 0101 (pyrfluquinizon) – foliar (2009-10) (Nichino America)
- Aza-Direct (azadirachtin) – foliar (2010-11) (Gowan Co)
- Benevia (cyantraniliprole) – foliar (2011) (DuPont)
- Sulfoxaflor – foliar (2011) (Dow AgroSciences)
- Oils – foliar
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%)
QRD 416 (1.0%)

P = 0.0213

5% mosaic ‘Certified’

Greatest Protection Level with cv. Silverton Russet Achieved with:

(1) 2X weekly applications, and
(2) highest product concentrations
# Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2009-10

<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) UTC</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td>3) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (July 15)</td>
</tr>
<tr>
<td>4) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
<td>4 (July 15)</td>
</tr>
<tr>
<td>5) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
<td>4 (July 15)</td>
</tr>
<tr>
<td>Fulfill</td>
<td>pymetrozine</td>
<td>5.5 fl oz / ac</td>
<td>2X</td>
<td>2 (July 20)</td>
</tr>
<tr>
<td>6) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
<td>4 (July 15)</td>
</tr>
<tr>
<td>Beleaf</td>
<td>flonicamid</td>
<td>2.8 fl oz / ac</td>
<td>3X</td>
<td>3 (July 20)</td>
</tr>
<tr>
<td>7) Aphoil</td>
<td>mineral oil</td>
<td>4.0 % V/V</td>
<td>weekly</td>
<td>7 (June 5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.0 % V/V</td>
<td>weekly</td>
<td>4 (July 15)</td>
</tr>
<tr>
<td>NNI-0101</td>
<td>pyrfluquinizon</td>
<td>3.2 fl oz / ac</td>
<td>3X</td>
<td>3 (July 20)</td>
</tr>
</tbody>
</table>

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**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, 2009-10 Winter Grow-Out Results

**Goldrush**

Initial Inoculum = 1.25%
P = 0.0113

Mean Proportion of PVY-Infected Plants

Untreated Control | Aphoil 1X / week June 15 | Aphoil 1X / week July 15 | Aphoil 1X / 2X June 15 - July 15 | Aphoil 1X / 2X June 15 - July 15 | Aphoil 1X / 2X June 15 - July 15 | Aphoil 1X / 2X June 15 - July 15 | Foliar Protectant

5% mosaic

**Legend:**
- a
- ab
- bc
- c

**Note:**
- Initial Inoculum = 1.25%
- P = 0.0113
- Mean Proportion of PVY-Infected Plants
- Foliar Protectant
PVY Foliar Oil Protectant Trial, 2009-10 Winter Grow-Out Results

Mean Proportion of PVY-Infected Plants

Initial Inoculum = 1.25%
P = 0.0391

Snowden

5% mosaic

Foliar Protectant

Un-treated Control
Aphoil IX/week June 15
Aphoil IX/week July 15
Aphoil IX/2X June 15-July 15
Aphoil IX/2X June 15-July 15 Fulfill (2X)
Aphoil IX/2X June 15-July 15 Beleaf (3X)
Aphoil IX/2X NNI-0101 (3X)
PVY Foliar Oil Protectant Trial, 2010-11
Winter Grow-Out Results

Mean Proportion of PVY-Infected Plants

P = 0.0061

5% mosaic ‘Certified’

Oil Compound (Concentration)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Start Date</th>
<th>Application Frequency</th>
<th>Proportion US #1-A</th>
<th>Proportion US #1-B</th>
<th>CWT/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.96</td>
<td>0.04</td>
<td>302.8</td>
</tr>
<tr>
<td>Aphoil</td>
<td>2 %</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.97</td>
<td>0.03</td>
<td>389.7</td>
</tr>
<tr>
<td>Stylet Oil</td>
<td>0.75 %</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.95</td>
<td>0.05</td>
<td>319.2</td>
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<tr>
<td>Aphoil</td>
<td>4 %</td>
<td>22-Jul</td>
<td>2x weekly</td>
<td>0.97</td>
<td>0.03</td>
<td>359.5</td>
</tr>
<tr>
<td>Stylet Oil</td>
<td>1.5 %</td>
<td>22-Jul</td>
<td>2x weekly</td>
<td>0.94</td>
<td>0.06</td>
<td>339.2</td>
</tr>
<tr>
<td>Requiem 25 EC</td>
<td>1.7 fl oz/a</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.96</td>
<td>0.04</td>
<td>350.8</td>
</tr>
<tr>
<td>Aphoil + Benevia 10 OD</td>
<td>10.1 fl oz/a</td>
<td>15-Jul</td>
<td>3x appl</td>
<td>0.97</td>
<td>0.03</td>
<td>333.9</td>
</tr>
<tr>
<td>Aphoil + Benevia 10 OD</td>
<td>2 %</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.96</td>
<td>0.04</td>
<td>384.5</td>
</tr>
<tr>
<td>Aphoil + Sulfoxaflor 50 WG</td>
<td>13.5 fl oz/a</td>
<td>22-Jul</td>
<td>3x appl</td>
<td>0.96</td>
<td>0.04</td>
<td>415.1</td>
</tr>
<tr>
<td>Aphoil + Beleaf 50 SG</td>
<td>2 %</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.96</td>
<td>0.04</td>
<td>314.8</td>
</tr>
<tr>
<td>Aphoil + Fulfill 50 WDG</td>
<td>3.67 fl oz/a</td>
<td>20-Jul</td>
<td>3x appl</td>
<td>0.96</td>
<td>0.04</td>
<td>348.6</td>
</tr>
</tbody>
</table>

P LSD: 0.42, 0.02; LSD: 0.22, 82.9
Minimizing Current Season Infection: Foliar Protectant Summary

- In all experiments, 2X weekly oil applications of Aphoil and Stylet Oil significantly reduced PVY in daughter tubers.

- 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 (1) selective feeding blockers (2) insecticides as behavioral modifiers warrants further investigation

- Level (degree) of foliar protection required varied by cultivar
  
  - Mature plant resistance (e.g. Snowden vs. Goldrush)

- Improved understanding of disease dynamics and relationship to primary insect vectors – A. glycines