Managing Potato virus Y – Predicting Aphid Flights

Wisconsin Potato and Vegetable Growers Association
Grower Education Conference
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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


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

- **Asymptomatic varieties** (certification problems):
  - cv. ‘Silverton Russet’
  - cv. ‘Russet Norkotah’
  - cv. ‘Shepody’
Recombinant strains of PVY appear to be displacing the ordinary strain.
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)
- Androparae - MALE
- Gynoparae - FEMALE

Spring Migrants
- apterae
- alatae

Summer Morphs

Fall Migrants (Sexuals)

Colonies on soybean

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

Aphis glycines, soybean aphid

Annu. Rev. Entomol. 56:375–399
Research Objectives

- Determine (1) the temporal patterns of PVY disease progress, (2) seasonal phenology of dispersing aphid vectors, and (3) combination of reduced-risk, 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.
Non-Persistent Transmission

Acquisition | Transmission | Retention

seconds | seconds | hours
Aphid Alert 2003, No. 14, September 19

Aphid Alert: a research/outreach program providing region-wide virus vector surveillance to the Northern Great Plains potato industry

![Graph showing green peach aphid captures from 1992 to 2003.](chart.png)
Weekly captures of dispersing aphid species.

Dr. David Voegtlin, Illinois Natural History Survey

- **Acyrthosiphon 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"
- **Brachycerousa 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"
- **Thorioaphis trifolii** "Spotted Alfalfa aphid"
Seasonal Dispersal – 2007 Suction Trap Data

Week 19
(12-19 May)

Week 23
(9-16 June)
Seasonal Dispersal – 2007 Suction Trap Data

Week 27
(7-14 July)

Week 31
(4-11 August)
Seasonal Dispersal – 2007 Suction Trap Data

Week 35
(1-8 Sept)

Week 39
(29 Sept-6 Oct)
Detection of seasonal trends in aphid movement

Methods modified from Frost et. al. (2012).

Our methods:

- Suction trap data were averaged for each year, location, and week combination
- Data were standardized using both a random effects models together with regression splines
- Cubic polynomials were fit to the resulting “conditional” or “deseasonalized” data (linear model) with generalized additive mixed models (GAMM’s)
Modeling Aphid Phenology: GAMM’s (2005-11)
Modeling Aphid Phenology: GAMM’s (2005-11)

- **Aphis glycines**
  - Model: \( Y \sim f_{\text{aphid}}(\text{Week}) \)
  - \( P = 0.0079 \)
  - Significant peaks: Jul. 8, Oct. 27

- **Rhopalosiphum maidis**
  - \( P < 0.0001 \)
  - Significant peak: Jul. 19

- **Rhopalosiphum padi**
  - \( P = 0.0205 \)
  - Significant peaks: Aug. 9, Oct. 13

- **Theroaphis trifolii**
  - \( P = 0.0003 \)
  - Significant peaks: May 11, Sept. 19
Modeling Aphid Phenology: Wisconsin GAMM’s (2005-11)
Modeling Aphid Phenology: Minnesota GAMM’s (2005-11)

**Minnesota subset**

- **Aphis glycines**
  - Model: \( Y \sim f_{\text{aphid}}(\text{Week}) \)
  - Peak: July 11
  - Valley: Oct. 18

- **Rhopalosiphum maidis**
  - Peak: July 18
  - Valley: Oct. 12

- **Rhopalosiphum padi**
  - Peak: June 26
  - Valley: Oct. 25

- **Thrips trifolii**
  - Peak: June 4
  - Valley: Sept. 12

Week of Year
Modeling Aphid Phenology: Michigan GAMM’s (2005-11)
Seasonal Dispersal of PVY Aphid-Vectors: ‘Risk Windows’ for Wisconsin Seed Potato

**Soybean aphid**

**Corn leaf aphid**

**Spotted alfalfa aphid**

**Bird-cherry oat aphid**

<table>
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<tr>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>Sept</th>
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<td></td>
<td></td>
<td>9 July</td>
<td></td>
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<td>23 July</td>
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<td></td>
<td></td>
<td>12 June</td>
<td>17 Sep</td>
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</table>

**aphids of greatest concern in Wisconsin**
### Insecticides for Managing Aphids / PVY

In the Pipeline or under review:
- **NNI - 0101** (pyrfluquinizon) – foliar (2009-10) (Nichino America)
- **Aza-Direct** (azadirachtin) – foliar (registered) (Gowan et al)
- **Benevia** (cyantraniliprole) – foliar (2011-12) (DuPont)
- **Sulfoxaflor** – foliar (2011) (Dow AgroSciences)
- **Oils** – various formulations

<table>
<thead>
<tr>
<th>Mode of Action Class</th>
<th>Group</th>
<th>Active Ingredient</th>
<th>Trade Names</th>
<th>Application Technology</th>
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<tbody>
<tr>
<td>Nicotinic acetylcholine receptor (nAChR) agonists</td>
<td>4A</td>
<td>Imidacloprid</td>
<td>Admire Pro*, Gaucho*, Provado*</td>
<td>In-furrow, seed treatment, Foliar</td>
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<td></td>
<td></td>
<td>Thiamethoxam</td>
<td>Platinum*, Cruiser*, Actara*</td>
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<td>Clothianadin</td>
<td>Belay*</td>
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<td>Dinotefuran</td>
<td>Scorpian™</td>
<td>Foliar</td>
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<tr>
<td></td>
<td></td>
<td>Acetamiprid</td>
<td>Assail*</td>
<td>Foliar</td>
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<tr>
<td>Selective Homopteran Feeding Blockers</td>
<td>9B</td>
<td>Pymetrozine</td>
<td>Fulfill*</td>
<td>Foliar</td>
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<tr>
<td></td>
<td>9C</td>
<td>Flonicamid</td>
<td>Beleaf™</td>
<td>Foliar</td>
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<tr>
<td>Narrow-range mineral oil</td>
<td>NA</td>
<td>Petroleum oil</td>
<td>Aphoil*, Stylet Oil*</td>
<td>Foliar</td>
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<tr>
<td>Plant extract (C. ambrosoides)</td>
<td>NA</td>
<td>Plant oil</td>
<td>Requiem*</td>
<td>Foliar</td>
</tr>
</tbody>
</table>
PVY Foliar Oil Protectant Trial, 2009-10 Winter Grow-Out Results

Goldrush

Mean Proportion of PVY-Infected Plants

Initial Inoculum = 1.25%
P = 0.0113
PVY Foliar Oil Protectant Trial, 2009-10 Winter Grow-Out Results

Snowden

Mean Proportion of PVY-Infected Plants

Initial Inoculum = 1.25%
P = 0.0391

- 5% mosaic

- Foliar Protectant

- a

- b

- P = 0.0391
## Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2010-11

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Frequency</th>
<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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<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>
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<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>
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<tr>
<td>8) Aphoil</td>
<td>mineral oil</td>
<td>2.0 % V/V</td>
<td>2X weekly</td>
<td>4 (July 2)</td>
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<tr>
<td>Aza-Direct</td>
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<td>2X weekly</td>
<td>4 (July 2)</td>
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<tr>
<td>9) Requiem</td>
<td>plant oil</td>
<td>1.0 % 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>
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<tr>
<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>pyrfluquinizone</td>
<td>3.2 fl oz / ac</td>
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<td>7 (July 20)</td>
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<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>
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<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

Applied 1X/week (June 5)
Applied 2X/week (July 15)

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%)  Aza-Direct (2)  Requiem (1.0%)  Aza-Direct (2)  Aphoil (4.0%)  +NN-0101 (3.2 oz/ac)  Aphoil (4.0%)  +Beleaf (2.8 oz/ac)  Aphoil (4.0%)  +Fulfill (3.67 oz/ac)  Aphoil (4.0%)  +Fulfill (3.67 oz/ac)

5% mosaic ‘Certified’
## Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2010-11

<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>
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<td>UTC</td>
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<td>-</td>
<td>0.96</td>
<td>0.04</td>
<td>302.8</td>
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<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>
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<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>
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<td>22-Jul</td>
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<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>
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<tr>
<td>Aphoil + Benevia 10 OD</td>
<td>2 %</td>
<td>6-Jun</td>
<td>1x weekly</td>
<td>0.97</td>
<td>0.03</td>
<td>333.9</td>
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<td>3x appl</td>
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<td>0.04</td>
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<td>Aphoil + Sulfoxaflor 50 WG</td>
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<td>Aphoil + Beleaf 50 SG</td>
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<td>Aphoil + Fulfill 50 WDG</td>
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<td>20-Jul</td>
<td>2x appl</td>
<td>0.97</td>
<td>0.03</td>
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<td>0.03</td>
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<tr>
<td>LSD</td>
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P LSD 0.02 0.02 82.9
## Products Evaluated for Managing Aphid Transmission of PVY in Wisconsin, 2012-13

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<th>Treatment Number</th>
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<td>1x weekly</td>
<td>338.8 ab</td>
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<td>1x weekly</td>
<td>305.9 a-c</td>
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<tr>
<td>4</td>
<td>¹Benevia 10 OD</td>
<td>20.5 fl oz/a</td>
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<td>3x weekly</td>
<td>315.4 a-c</td>
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<td>5</td>
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<td>13-Jul</td>
<td>1x weekly</td>
<td>311.6 a-c</td>
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<td>6</td>
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<td>7</td>
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<td>3x weekly</td>
<td>291.0 a-c</td>
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<td>11</td>
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<td>17</td>
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<td>2x weekly</td>
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<td>5.5 oz/a</td>
<td>13-Jul</td>
<td>2x weekly</td>
<td>280.13 a-c</td>
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P LSD 0.1671
LSD 78.385
PVY Foliar Protectant Trial, 2012-13
Winter Grow-Out Results

Mean Proportion of PVY-Infected Plants

Oil Compound (Concentration)

UTC
Stylet Oil (0.75%)
Stylet Oil (1.5%)
Benevia (20.5)
Stylet Oil (0.75%)
Stylet Oil (2.0%)
Requiem (1.7)
Stylet Oil (0.75%)
+ Benevia (10.1)
+ Benevia (13.5)
Stylet Oil (0.75%)
+ Benevia (17.0)
Stylet Oil (0.75%)
+ Benevia (20.5)
Stylet Oil (0.75%)
+ Movento (3.3)
Stylet Oil (0.75%)
+ Fulfill (3.7)
Aphoil (2%)
Aphoil (4%)
Stylet Oil (0.75%)
+ Fulfill (5.5)
Stylet Oil (0.75%)
+ Fulfill (6.0)
Stylet Oil (0.75%)
+ Fulfill (6.3)
Stylet Oil (0.75%)
+ Fulfill (6.6)
Stylet Oil (0.75%)
+ Fulfill (7.0)
Stylet Oil (0.75%)
+ Fulfill (7.5)
Stylet Oil (0.75%)
+ Fulfill (8.0)
Stylet Oil (0.75%)
+ Fulfill (8.3)
Stylet Oil (0.75%)
+ Fulfill (8.6)
Stylet Oil (0.75%)
+ Fulfill (9.0)
Stylet Oil (0.75%)
+ Fulfill (9.3)
Stylet Oil (0.75%)
+ Fulfill (9.6)
Stylet Oil (0.75%)
+ Fulfill (10.0)

P = 0.0145

5% mosaic ‘Certified’
Minimizing Current Season PVY Infection: Foliar Protectants

- Temporal patterns of PVY movement of PVY in Wisconsin was most consistently associated with flights of *A. glycines* and *R. padi*.

- GAMM’s predict periods of elevated flight activity (e.g. risk window) within season and across different potato growing areas.

- Weekly oil applications in early season (June), combined with 2X weekly applications in mid-July, resulted in lowest overall PVY in winter test.
  - Suggests that the bulk of infection / transmission occurs in late season

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

- Fitting aphid emergence to growing degree day models –
  - *(A. glycines, R. padi, , A. pisum, R. maidis, T. trifollii)*
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

- 8,400 ac Seed
- 5,100 ac Soybean
- 5,050 ac Wheat
- 2,200 ac Commercial

2009
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- Syngenta
- FMC