What’s Bugging You??
Detection and characterization of CMV in snap beans, peppers, and aphids

Processed Vegetable Grower’s Clinic
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Relative Importance of the Snap Bean Crop; Great Lakes Region

<table>
<thead>
<tr>
<th>Processing snap bean:</th>
<th>Acreage</th>
<th>Value (million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wisconsin</td>
<td>73,500</td>
<td>36.6</td>
</tr>
<tr>
<td>New York</td>
<td>22,200</td>
<td>15.1</td>
</tr>
<tr>
<td>Ontario, Canada</td>
<td>20,000</td>
<td>N/A</td>
</tr>
<tr>
<td>Michigan</td>
<td>19,000</td>
<td>9.8</td>
</tr>
<tr>
<td>Illinois</td>
<td>15,800</td>
<td>6.8</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>10,900</td>
<td>6.7</td>
</tr>
<tr>
<td>Total (U.S.)</td>
<td>169,200</td>
<td>97.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fresh-market snap bean:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>10,700</td>
<td>48.1</td>
</tr>
<tr>
<td>Total (U.S.)</td>
<td>104,700</td>
<td>324.1</td>
</tr>
</tbody>
</table>

NASS (2007)
Processing Snap Bean Production Intervals in Wisconsin

Planting

Harvesting


Date
Virus Infections
Intervals of Risk in Wisconsin

Date

Early Planted

Late Planted

Middle Planted

Symptom Development

Early Planted

Late Planted

Middle Planted
cv. ‘Goldmine’

Yield Reduction Attributed to Viruses

Nault 2006
New Insect Vector, Soybean aphid

*Aphis glycines*, soybean aphid

2005 Distribution

Lee 2002
Emerging Bean Viruses: The problem (2007)

Wisconsin Snap Bean Survey, 2007

- **Central Sands**: 93.2% CMV, 1.3% AMV
- **New Richmond**: 80.5% CMV, 0.5% AMV
- **Spring Green**: 90.2% CMV, 11.1% AMV
- **Door Co.**: 78.3% CMV, 2.7% AMV

CMV – Bell pepper

CMV – Jalapeno fruit

CMV – Jalapeno, mature leaf
Hypothesis I. Long Distance Transport
Viruliferous Soybean Aphids

Colder, Dry Air

Warm, Moist Air
Long Distance Transport
Viruliferous Soybean Aphids

CMV-infected aphid
Non-infected aphid
Hypothesis II. Long Distance Aphid Dispersal: Local Inoculum

CMV-infected aphid
Non-infected aphid
Compare the genetic structure of CMV isolates collected from (1) infected crops (beans and peppers), (2) dispersing aphids, and (3) potential reservoir hosts.

Goal: Identify the primary reservoir hosts of CMV in and around selected snap bean fields and to determine those species, or set of species, which have the greatest epidemiological importance.

Goal: Accurately determine periods of elevated risk for CMV transmission and develop disease management strategies to limit spread of the viral pathogen.
I. Genetic Structure of CMV

- CMV is tripartite, + sense RNA, with 5 ORF’s
  
  - RNA1 (3.4 Kb)
  - RNA2 (3.1 Kb)
  - RNA3 (2.2 Kb)

- ORF 2b involved in grouping by host association
I. Characterizing CMV host association

- Determine similarity / dissimilarity of CMV isolates 1) within a field (snap beans) and 2) among affected fields (regional).

- Central Sands, Ripon Plain, Lakeshore, Spring Green
I. CMV host association: Virus types

- 4 primary inoculum sources (host types)

Seneca Foods, Buttercup Ave., Adams County:
I. CMV host association: Virus types

- Hartung Bros, Hwy 14., Dane County:

  - 3 primary inoculum sources (host types)

```
Type A
Type B
Type C
```
I. CMV host association: Virus types

- Del Monte Foods, Hwy 73, Green Lake County:
  - 2 primary inoculum sources (host types)
I. CMV host association: Virus types

- Lakeside Foods, Hwy. 42, Manitowoc County:
  - 3 primary inoculum sources (host types)
II. Characterizing CMV host – vector(s) associations

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

**Acyrthosiphon pisum**
- "Pea aphid"

**Aphis craccivora**
- "Black legume aphid"
- "Soybean aphid"

**Aphis glycines**
- "Cotton-melon aphid"
- "Soybean aphid"

**Aphis gossypii**
- "Cotton-melon aphid"

**Aphis helianthi**
- "Sunflower or dogwood aphid"

**Aphis nasturtii**

**Aphis spiraecola**
- "Buckthorn-potato aphid"
- "Spiraea aphid"

**Brachycaudus helichrysi**
- "Leaf curling plum aphid"
- "Turnip aphid"

**Lipaphis pseudobrassicae**
- "Potato aphid"
- "Turnip aphid"

**Macrosiphum euphorbiae**
- "Corn leaf aphid"
- "Potato aphid"

**Myzus persicae**
- "Peach potato aphid"
- "Turnip aphid"

**Rhopalosiphum insertum**
- "Apple grass aphid"
- "Bird cherry-oat aphid"

**Rhopalosiphum maidis**

**Rhopalosiphum padi**
- "Apple grass aphid"
- "Bird cherry-oat aphid"

**Schizaphis graminum**
- "Greenbug"
- "English grain aphid"

**Sitobion avenae**
- "English grain aphid"

**Therioaphis trifolii**
- "Spotted Alfalfa aphid"
II. Characterizing CMV host – vector(s) associations

➤ Seasonal detection / transmission efficiencies (2008):

<table>
<thead>
<tr>
<th>Aphid Species</th>
<th>Estimated Transmission (Gildow et al. 2008)</th>
<th>Seasonal Detection</th>
<th>Host Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean aphid (A. glycines)</td>
<td>60%</td>
<td>11.3%</td>
<td></td>
</tr>
<tr>
<td>Spotted alfalfa aphid (T. trifolii)</td>
<td>58%</td>
<td>6.2%</td>
<td></td>
</tr>
<tr>
<td>Pea aphid (A. pisum)</td>
<td>42%</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Corn leaf aphid (R. maidis)</td>
<td>30%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>Green peach aphid (M. persicae)</td>
<td>6%</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

CMV detections in individual *A. glycines*

370 bp →
Project Goals / Expected Outcome

- Improve our understanding of the epidemiology of CMV

- Determine which vector, or set of vectors, contribute to disease cycles.

- To accurately identify the primary reservoir hosts of CMV in and around affected snap bean fields and determine those species, or set of species, which have the greatest epidemiological importance.
Managing Aphid Transmitted Viruses

Solutions for some vegetable crops

• Prevent aphids from landing on crop
  - reflective mulches (e.g., pepper)
  - row covers

• Manipulate immigrating aphid populations
  - border crop or barrier crop

• Separate crop from virus source
  - distance
  - time

• Resistant varieties

• Interfere with aphid’s ability to transmit virus
  - mineral and stylet oils (e.g., pepper and snap beans)
Minimizing Current Season Infection: Timely and Improved Oil Applications

- Selection of light, ‘white’ mineral oils
  - quality and concentration
  - (e.g. Aphoil or JMS Stylet Oil)
  - plant development
  - 20-25 day risk periods

- Selective feeding blockers:

- Systemic Acquired Resistance (SAR’s):
  - plant activators
  - defensive proteins
  - modified fertilizers
Managing Aphid Transmitted Viruses: Elevated Risk of Spread

- Crop protection during periods of greatest risk

2007 *A. glycines* flights
New Insecticide Registrations, 2009-10

- **Assail (UPI) revisions - 2008**
  Aphids, Potato leafhopper, Bean leaf beetle, Mexican bean beetle

- **Coragen* (DuPont) Target late 2009-10**
  IR-4 PCR’s completed and submitted to EPA (rynaxypyr)

- **Radiant (Dow AgroSciences)**

- **Lorsban Advanced (Dow AgroSciences)**
  Armyworm, Cutworm and Seed corn maggot

- **Brigade (FMC)**
  bifenthrin

- **Hero (FMC)**
  Pre-mix of zeta-cypermethrin and bifenthrin

- **Brigadier (FMC)**
  Pre-mix of bifenthrin and imidacloprid
ECB Control on Snap Beans:
Foliar Insecticides – Arlington, WI 2008

- University of Wisconsin, Arlington Res Station
- Planting date of May 30, 2008
- Artificial infestations; July 20, July 26
  Five consecutive plants per plot
  Each plant infested with 10 egg masses
- Single foliar application on July 23
- Backpack sprayer delivering 26.5 gpa
- Plot size 4 rows by 25 feet

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/A</th>
<th>Damaged stems</th>
<th>Larvae in stems</th>
<th>% Pod damage</th>
<th>Larvae in pods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>---</td>
<td>5.3 ab</td>
<td>2.3 a</td>
<td>22.0 b-g</td>
<td>4.0 abc</td>
</tr>
<tr>
<td>Orthene</td>
<td>1.0 lb.</td>
<td>1.3 ef</td>
<td>0.0 e</td>
<td>10.5 fgh</td>
<td>0.5 ef</td>
</tr>
<tr>
<td>Lannate</td>
<td>3 pt.</td>
<td>3.3 b-f</td>
<td>1.3 a-d</td>
<td>26.9 abc</td>
<td>4.8 ab</td>
</tr>
<tr>
<td>Brigade</td>
<td>4.5 oz.</td>
<td>2.0 def</td>
<td>0.0 e</td>
<td>10.0 fgh</td>
<td>2.0 b-f</td>
</tr>
<tr>
<td>Warrior</td>
<td>3.84 oz.</td>
<td>2.0 def</td>
<td>0.5 cde</td>
<td>10.3 fgh</td>
<td>2.3 b-f</td>
</tr>
<tr>
<td>Mustang Max</td>
<td>4 oz.</td>
<td>4.3 a-d</td>
<td>1.5 abc</td>
<td>15.0 c-h</td>
<td>3.0 b-f</td>
</tr>
<tr>
<td>Spintor</td>
<td>6 oz.</td>
<td>1.5 ef</td>
<td>0.0 e</td>
<td>8.1 h</td>
<td>0.3 f</td>
</tr>
<tr>
<td>Radiant</td>
<td>6 oz.</td>
<td>1.3 ef</td>
<td>0.3 de</td>
<td>11.0 e-h</td>
<td>2.8 b-f</td>
</tr>
<tr>
<td></td>
<td>8 oz.</td>
<td>1.3 ef</td>
<td>0.5 cde</td>
<td>6.7 h</td>
<td>0.8 def</td>
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<td>5.3 ab</td>
<td>2.3 a</td>
<td>22.0 b-g</td>
<td>4.0 abc</td>
</tr>
<tr>
<td>cyazapyr¹</td>
<td>1.72 oz.</td>
<td>5.3 ab</td>
<td>1.8 ab</td>
<td>36.0 a</td>
<td>4.3 abc</td>
</tr>
<tr>
<td>Coragen¹</td>
<td>3.5 oz.</td>
<td>2.0 def</td>
<td>0.0 e</td>
<td>8.4 h</td>
<td>0.5 ef</td>
</tr>
<tr>
<td></td>
<td>5 oz.</td>
<td>3.5 b-f</td>
<td>1.0 b-e</td>
<td>9.3 gh</td>
<td>0.3 f</td>
</tr>
<tr>
<td>Avaunt²</td>
<td>6 oz.</td>
<td>2.3 c-f</td>
<td>0.5 cde</td>
<td>13.7 c-h</td>
<td>2.8 b-f</td>
</tr>
<tr>
<td>Rimon</td>
<td>12 oz.</td>
<td>2.5 c-f</td>
<td>0.5 cde</td>
<td>17.1 c-h</td>
<td>2.3 b-f</td>
</tr>
</tbody>
</table>

¹MSO added at 0.5% v/v.

²Note: Not registered for use on legume – succulent bean
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<tr>
<th>Treatment</th>
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<tbody>
<tr>
<td>Untreated</td>
<td>---</td>
<td>5.3 ab</td>
<td>1.8 a</td>
<td>11.8 b-f</td>
<td>3.0 abc</td>
</tr>
<tr>
<td>Orthene</td>
<td>1.0 lb.</td>
<td>0.3 g</td>
<td>0.0 d</td>
<td>0.0 k</td>
<td>0.0 g</td>
</tr>
<tr>
<td>Lannate</td>
<td>3 pt.</td>
<td>5.0 a</td>
<td>2.0 ab</td>
<td>18.0 ab</td>
<td>2.8 ab</td>
</tr>
<tr>
<td>Brigade</td>
<td>4.5 oz.</td>
<td>1.8 c-g</td>
<td>0.3 d</td>
<td>0.4 k</td>
<td>0.3 fg</td>
</tr>
<tr>
<td>Warrior</td>
<td>3.84 oz.</td>
<td>1.5 d-g</td>
<td>0.3 d</td>
<td>0.0 k</td>
<td>0.0 g</td>
</tr>
<tr>
<td>Mustang Max</td>
<td>4 oz.</td>
<td>0.8 g</td>
<td>0.5 cd</td>
<td>1.0 jk</td>
<td>0.3 fg</td>
</tr>
<tr>
<td>Spintor</td>
<td>6 oz.</td>
<td>2.0 c-g</td>
<td>0.3 d</td>
<td>4.0 g-k</td>
<td>0.3 fg</td>
</tr>
<tr>
<td>Radiant</td>
<td>6 oz.</td>
<td>2.0 c-g</td>
<td>1.0 a-d</td>
<td>2.6 ijk</td>
<td>0.5 fg</td>
</tr>
<tr>
<td></td>
<td>8 oz.</td>
<td>1.3 efg</td>
<td>0.3 d</td>
<td>3.1 h-k</td>
<td>0.0 g</td>
</tr>
</tbody>
</table>
# ECB Control: Registered Foliar Sprays

3 Days Post Application (=Residual).


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/A</th>
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<td>---</td>
<td>5.3 ab</td>
<td>1.8 a</td>
<td>11.8 b-f</td>
<td>3.0 abc</td>
</tr>
<tr>
<td>cyazapyr(^1)</td>
<td>1.72 oz.</td>
<td>5.5 a</td>
<td>0.3 d</td>
<td>13.9 a-e</td>
<td>1.3 c-f</td>
</tr>
<tr>
<td>Coragen(^1)</td>
<td>3.5 oz.</td>
<td>1.0 fg</td>
<td>0.0 d</td>
<td>1.1 jk</td>
<td>0.0 g</td>
</tr>
<tr>
<td></td>
<td>5 oz.</td>
<td>1.5 d-g</td>
<td>0.3 d</td>
<td>0.8 k</td>
<td>0.0 g</td>
</tr>
<tr>
<td>Avaunt(^2)</td>
<td>6 oz.</td>
<td>1.5 d-g</td>
<td>0.5 cd</td>
<td>2.8 h-k</td>
<td>0.5 fg</td>
</tr>
<tr>
<td>Rimon</td>
<td>12 oz.</td>
<td>2.5 b-g</td>
<td>0.3 d</td>
<td>7.4 e-j</td>
<td>1.3 c-f</td>
</tr>
</tbody>
</table>

\(^1\)MSO added at 0.5% v/v.

\(^2\)Note: Not registered for use on legume – succulent bean
ECB Control on Snap Beans:
Systemic Insecticides – Arlington, WI 2008

- University of Wisconsin, Arlington Res Station
- Planting date of May 30, 2008
- Artificial infestations; July 20
  Five consecutive plants per plot
  Each plant infested with 10 egg masses
- In-furrow application (at-plant)
  Backpack sprayer delivering 4.5 gpa
- Plot size 4 rows by 25 feet

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate/A</th>
<th>Placement</th>
<th>% Damaged stems</th>
<th>% Damaged pods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>---</td>
<td>---</td>
<td>84.0 a</td>
<td>12.9 a</td>
</tr>
<tr>
<td>cyazapyr(^1)</td>
<td>3.5 oz.</td>
<td>In furrow</td>
<td>80.0 a</td>
<td>7.5 ab</td>
</tr>
<tr>
<td></td>
<td>5.0 oz.</td>
<td>In furrow</td>
<td>46.0 ab</td>
<td>3.5 b</td>
</tr>
<tr>
<td></td>
<td>9.5 oz.</td>
<td>In furrow</td>
<td>24.0 b</td>
<td>2.7 b</td>
</tr>
<tr>
<td>Coragen(^1)</td>
<td>3.5 oz.</td>
<td>In furrow</td>
<td>52.0 ab</td>
<td>7.2 ab</td>
</tr>
<tr>
<td></td>
<td>6.0 oz.</td>
<td>In furrow</td>
<td>48.0 b</td>
<td>4.4 b</td>
</tr>
</tbody>
</table>

\(^1\)Note: Not registered for use on legume – succulent bean
Acknowledgements

Hartung Brothers
Seneca Foods
Lakeside Foods
Del Monte Foods

Midwest Food Processors Association

QUESTIONS?