Revising the Aster Yellows Index and Management in Wisconsin

Central Wisconsin Processing Crops Conference
March 9, 2011  Plover, WI

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(http://www.pestprosinc.com/)³
Factors Influencing Insect Pest Management

‘Food Safety’

– Major food retailers are setting acceptable residue levels below those set by government regulatory agencies.

“No detectable residues” will be a competitive advantage for food retailers.

– Older insecticides that do not meet these requirements are not being re-registered, resulting in increased use of novel insecticides

“Reduced-risk or Bio-pesticides”
Factors Influencing Insect Pest Management

‘Environmental Concerns’

– With increasing affluence domestically and globally, there are increasing concerns about pesticide usage and perceived environmental effects.

– This has rapidly accelerated the shift to “softer” products and technologies – ‘sustainability’.
Aster Yellows Management - Synthetic Pyrethroid Insecticides

The Challenge!

*Increasing the efficiency and profitability of carrot production…*

- Synthetic pyrethroids represent the “*current*” backbone of low-cost, ALH and AY management

- Re-registration eligibility decisions (RED’s) for pyrethroids under scrutiny: conditionally registered for use on vegetables, as they are highly lipophilic strongly adsorb to sediments in aquatic environments.

- New registrations and delivery systems offer promising alternatives
Presentation Outline

Goal - Sustainable Carrot IPM

- Define Aster Yellows disease and the insect vector
- Identify periods of ‘elevated risk’ for disease transmission.
- New approaches to achieve sustainable, reduced-risk, IPM in carrot.

Seed Treatments
Aster yellows: in carrot

Disease incidence:
1%-15% in intensively managed carrot fields
Likely 80-100% if not managed

Variable symptoms: Above ground – leaf yellowing and reddening, twisting, witches' brooming; Below ground – stunted and malformed roots, adventitious root growth

Other crops affected: Lettuce, celery, cilantro, canola, parsnip, potato
Aster yellows phytoplasma (AYp), *Ca. phytoplasma asteris*

Small (0.4 μm diameter), wall-less prokaryotic organism of the provisional genus *Candidatus*

Infects > 350 species in 38 plant families

Phloem limited

Has not been cultured

Obligately associated with host (insect and plant) and not mechanically transmissible

Small genome (~ 700 kb) possibly as a result of reductive evolution

Division: Firmicutes  
Class: Mollicutes  
Order: Acholeplamatales  
Family: Acholeplasmataceae  
Genus: *Candidatus*  
'phytoplasma asteris'
Vector: Aster leafhopper (ALH)

**Adult**

- *Macrosteles quadrilineatus* Forbes (Hemiptera: Cicadellidae)
- Approximately 4 mm long and weigh 1 mg (0.8 mg M; 1.2 mg F)
- Light greenish-yellow in color (seasonally variable)
- Widely distributed in the U.S.
Aster leafhopper migratory behavior

Early season migration of the ALH from the Gulf-states to the Upper Midwest

Migratory behavior together with the mode of transmission makes possible the movement of AYp over great distances...

Probable Aster Leafhopper Spring Migration Routes

Chiykowski, L.N. and R.K. Chapman. 1965
Aster yellows management

WI AY management heavily influenced by R. K. Chapman

Characterized ALH migratory behavior and recognized its importance for producing year-to-year variation in AY pressure

Developed a strategy to account for that variation and manage AY

Chapman & Wyman and Longridge sweeping in Arkansas (circa 1985)
Aster yellows management: controlling the ALH

- AYI calculated as:
  \[ \% \text{ leafhopper infectivity} \times \text{ number} / 100 \text{ sweeps} \]

- AY control is achieved through repetitive applications of insecticide
  - Synthetic pyrethroids - currently the backbone of AY control programs ($7-9/ac)

*Do we have all the tools that we need to manage this disease?*

*Can we modernize and improve our current management strategies?*
Aster Leafhopper Management

AYI Thresholds

- Estimated AYI values exceed established crop resistance levels:
  - Carrots (resistant = 100, intermediate = 75, susceptible = 50)
  - Celery = 35
  - Lettuce = 25

Need to protect carrot crop from ALH for 8-10 weeks??

Foliar Pyrethroids ($36-40 / A)

Carrot Crop

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Seed Treatments
A.) **Identify trends in Aster Yellows (AY) risk:**

- Use historical data collections (Pest Pros Inc.)
- Target control to high AY risk periods, offset higher costs of novel “softer” chemistries

*Can we better understand the factors that are important for the variability in insect abundance and infectivity in carrot fields?*

*Can we discover and exploit an understanding of ‘risk intervals’*
Evaluating variability associated with ALH abundance and infectivity

Part I – Collect relevant historical pest scouting data
- Pest scouting records (Pest Pros, Inc.)
- Additional AY reports (UW-Entomology)

Part II – Data exploration and analysis
- Variance component analysis
- Standardization and detection of seasonal trends
Variance Component Analysis

The objective of this analysis is to *estimate variances* not to detect differences

<table>
<thead>
<tr>
<th>Factor</th>
<th>LRT</th>
<th>% of total variance</th>
</tr>
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<tbody>
<tr>
<td>Location</td>
<td>P&lt;0.0001</td>
<td>2.7</td>
</tr>
<tr>
<td>Year</td>
<td>P&lt;0.0001</td>
<td>5.0</td>
</tr>
<tr>
<td>Day</td>
<td>P&lt;0.0001</td>
<td>25.2</td>
</tr>
<tr>
<td>Time</td>
<td>P&lt;0.0001</td>
<td>18.1</td>
</tr>
<tr>
<td>Residual</td>
<td></td>
<td>48.9</td>
</tr>
</tbody>
</table>

Chapman was right!!! - Year describes 29% of variability of ALH infectivity- but there is room for improvement...

ALH Abundance (25%) - Day within year
ALH infectivity (26%) - Week within year

Can we explain the variability within years?
Detection of seasonal trends in AY ‘Risk Windows’


Our methods:
Sweep data were averaged for each year, field, and date combination

Data were standardized using either random effects models or regression splines

Cubic polynomials were fit to the resulting “conditional” or “deseasonalized” data (linear model)

Does seasonality describe any more of this variability?
Seasonal trends: ALH abundance

Fit random effects model to data
Extract the conditional expectation of the values for Julian Date (i.e. BLUPs for Julian Date)
Plot BLUPs vs. Julian date and fit cubic polynomial

Solve for $S = 0$

$X_1$: 155 (June 3)
$X_2$: 216 (August 3)
$X_3$: 265

Above average ALH catches between $X_1$ and $X_2$

Risk “window” ??
Seasonal trends: ALH infectivity

Using similar methodology to examine ALH infectivity

Above average ALH infectivity

$X_1$: 139 (May 18)
$X_2$: 197 (July 15)
$X_3$: 259

Risk “window” ??
Seasonal trends: AY Index

Calculate historical average AY risk that accounted for annual variation and seasonal variation

Calculate AYI:
Average daily ALH abundance

Average weekly ALH infectivity for low, average and high years

Add smoothing function (Regression spline or moving average)

AYI treatment thresholds used to estimate crop risk
## Concurrence of AY “risk windows”

<table>
<thead>
<tr>
<th></th>
<th>Open</th>
<th>Close</th>
<th># Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Susceptible carrot</td>
<td>May 25</td>
<td>Sept. 1</td>
<td>100</td>
</tr>
<tr>
<td>Aster Leafhopper</td>
<td>June 7</td>
<td>August 1</td>
<td>55</td>
</tr>
<tr>
<td>ALH infectivity</td>
<td>May 18</td>
<td>July 15</td>
<td>58</td>
</tr>
<tr>
<td>Overlap</td>
<td>June 7</td>
<td>July 15</td>
<td>40</td>
</tr>
<tr>
<td>Aster yellows index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistant Carrot (High infectivity)</td>
<td>June 18</td>
<td>July 8</td>
<td>20</td>
</tr>
<tr>
<td>Susceptible Carrot (High infectivity)</td>
<td>June 7</td>
<td>August 7</td>
<td>61</td>
</tr>
</tbody>
</table>

**Can we reduce the number of applications by targeting times of higher AY risk?**

**Can the higher cost of novel, reduced risk, and less broad spectrum insecticides be offset by using fewer applications?**
Presentation Outline

Goal - Sustainable Carrot IPM

- Define Aster Yellows disease and the insect vector

- Identify periods of ‘elevated risk’ for disease transmission.

- New approaches to achieve sustainable, reduced-risk, IPM in carrot.
What tactics or combinations of tactics, can effectively provide plant protection during high AY risk period (i.e. planting later, insecticide treated seed, and/or fewer applications of reduced risk insecticides)?

- Compare reduced risk and less broad spectrum insecticides (neonicotinoid) to current AY management (seed treatments and foliar applications)

- Timing of foliar applications based on ALH infectivity, AY risk phenology and degree day model forecasting the emergence of local ALH
Neonicotinoids & Anthranilic Diamides

Beneficial Attributes

- **Broad spectrum**
  - PLH & aphids
- **Flexible**
  - In-furrow, seed treatments
- **Long residual**
  - Rate dependant
- **Low toxicity**
  - “Healthy Grown”

- DPX-HGW86 (cyazypyr)**
  - Anthranillic diamide (MoA group 28)
    - Use rate 6.5-13.5 fl oz / ac (OD foliar)
    - Control of leafhoppers, aphids, and Leps
## Reduced Risk In-Furrow and Seed Treatment Options – 2011 HARS Trials

<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Product</th>
<th>Active Ingredient</th>
<th>Rate</th>
<th>Application Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UTC</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Admire Pro</td>
<td>imidacloprid</td>
<td>10.5 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>9.0 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Gaucho</td>
<td>imidacloprid</td>
<td>6.4 fl oz / cwt</td>
<td>Seed</td>
</tr>
<tr>
<td>5</td>
<td>Platinum 75SG</td>
<td>thiamethoxam</td>
<td>4.0 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>3.5 fl oz / A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Cruiser**</td>
<td>thiamethoxam</td>
<td>0.1 mg a.i./seed</td>
<td>Seed</td>
</tr>
<tr>
<td>8</td>
<td>HGW86 20SC**</td>
<td>cyazypyr</td>
<td>13.5 fl oz / A</td>
<td>In-furrow</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>10.0 fl oz / A</td>
<td></td>
</tr>
</tbody>
</table>

Water soluble, systemically mobile insecticides

** Not currently registered
Estimated AYI values exceed established crop resistance levels:

- Carrots (resistant = 100, intermediate = 75, susceptible = 50)
- Celery = 35
- Lettuce = 25

Need to protect carrot crop from ALH for 8-10 weeks??

- At-plant ($12-18/A)
- Seed / In-furrow
- Foliar ($12-14/A)
- Pyrethroids

Aster leafhopper

Carrot Crop

Northern root-knot nematode (NRKN); *Meloidogyne hapla*

http://vegetablemdonline.ppath.cornell.edu/factsheets/RootKnotNematode.htm
# Miller Farms – 2011
Reduced Risk Carrot IPM

- **Avicta (abamectin + thiamethoxam):**
  - (MoA Group 6 + 4A)
  - Use rate 8 – 16 fl oz / ac (foliar)
  - Control of NRKN and PLH

<table>
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<tr>
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<th>Application Method</th>
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<tr>
<td>1</td>
<td>UTC</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Cruiser**</td>
<td>thiamethoxam</td>
<td>0.1 mg a.i./seed</td>
<td>Seed</td>
</tr>
<tr>
<td>3</td>
<td>Avicta**</td>
<td>abamectin + thiamethoxam + 0.1 mg a.i./seed</td>
<td>0.014 mg a.i./seed + 0.1 mg a.i./seed</td>
<td>Seed</td>
</tr>
</tbody>
</table>
Overall summary: refining the AYI

Advance our basic understanding of the epidemiology of aster yellows in Wisconsin towards the development and implementation of a comprehensive management plan

Incorporate biological information about the AY disease system from multiple scales to improve on-farm AY management decisions

Utilize available and emerging technologies in the context of management to:

I) Ensure AYP detection is accurate and reflects biology – *Reduce unwarranted sprays*

II) Identify trends in AY risk – *Target control to high AY risk periods, offset high costs of new “softer” chemistries*
Acknowledgements

Groves Lab: Carol Groves, Emily Mueller, Scott Chapman, Shahideh Nouri, Anders Huseth, David Lowenstein, Natalie Hernandez, Sarah Schramm, Matt Mockenhaupt

Pest Pros, Inc.: Randy Van Haren, Linda Kotolski

Others: Tom German, Jeff Wyman, Brian Flood, D. Kyle Willis, Amy Charkowski, Paul Esker, Jed Colquhoun,

Dept. of Plant Pathology
Dept. of Entomology

Walnut Street Greenhouses

Carrot growers:
Gumz Muck Farms
Shiprock Farms
Miller Farms
Patrykus Farms
Guth Farms
Kincaid Farms

Funding Sources:
NCR-SARE
Wisconsin Specialty Crops Block
QUESTIONS?