Seasonal infectivity of aster leafhoppers in carrot

Ken Frost and Russ Groves
Dept. of Entomology
University of Wisconsin-Madison
Carrot in Wisconsin

~ 4300 acres produced each year

~ 6 million in revenues

• 3rd in nation for processing

• Good control with timely insecticide applications (aster yellows index)

• Typical losses of 5 – 20% each year
Aster Yellows Index

- Allowable numbers of leafhoppers on susceptible crops at a particular infectivity rate.

\[ \text{AYI} = \% \text{ leafhopper infectivity} \times \text{number} / 100 \text{ sweeps} \]

\[ \text{AYI} = 2.5\%(20) = 50 \]

- Treatment thresholds for carrots, celery and lettuce with respect to AYI:

<table>
<thead>
<tr>
<th>Crop</th>
<th>AYI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot</td>
<td></td>
</tr>
<tr>
<td>Resistant</td>
<td>100</td>
</tr>
<tr>
<td>Intermediate</td>
<td>75</td>
</tr>
<tr>
<td>Susceptible</td>
<td>50</td>
</tr>
<tr>
<td>Celery</td>
<td>35</td>
</tr>
<tr>
<td>Lettuce</td>
<td>25</td>
</tr>
</tbody>
</table>
Aster yellows

• Caused by the AY phytoplasma

• Symptoms include: Stunting, yellowing and reddening, twisting, distortion of flowers, bushy or broom-like growth, stunted and malformed roots
Aster Yellows phytoplasma (AYp)

- Small bacterium found in the phloem
- Can not survive without its plant or insect host
- Wide host range
- Transmitted in a persistent propagative manner by the aster leafhopper
Aster Yellows Host Range

Affected Crops:
lettuce, potato, onion, celery, carrot and others

Other susceptible plants:
> 300 plant species
- 38 plant families
- Predominately broad-leaf herbaceous plants
- Small Grains an emerging problem
(Hollingsworth 2008)
Persistent-propagative transmission

Acquisition time (max dose): Hours, days
Latent period: Weeks
AYp in vector hemolymph: Yes
AYp multiplies in vector: Yes
Transovarial transmission: No

Phloem cells
Aster Yellows Transmission
Persistent Propagative

Acquis. → Incubation (latency) → Inoculative or Infective → Retention

8 – 24 Hours → 7 – 15 Days → 8 – 24 Hours → For life
Leafhopper infectivity by year

- Aster yellows year
- Average Infectivity at 8 WI locations
- 14 years (1994 – 2007)
- Significant annual variation

Where does this variation arise?
Early Season AY phytoplasma sources

Significant annual variation lead to the description of annual migration

- Some early season migrants are infected with AYp

- Development Aster Yellows Index for growers

Chiykowski, L.N. and R.K. Chapman. 1965
Seasonal infectivity at 8 WI locations (14 years)

-Migrating ALH infectivity is low (0-3%)

- Local leafhoppers enter carrot fields in mid-June infected at 2-10%

- ALH numbers are weather dependent and fluctuate depending upon control activities

Is there more to the story than annual migration?
Are there other sources?

Are there local plants that serve as AYp inoculum sources for native ALHs?

What are the relative contributions of AYp from migrating ALH and local plant sources?
What is the source of leafhopper infectivity?

Research Objective I:

To determine the identity and importance of local, primary inoculum sources and their role in the spread of disease throughout carrot fields.

Outcomes and Project Goals:

- Can we assess AY risk for selected fields based on off-crop habitat?

- Is source reduction feasible? In other words, can off-crop habitat be managed to decrease the accumulation of AYp inoculum in the local environment and reduce disease pressure?
Weed species implicated as AYP\textsubscript{p}-reservoirs

Common Name:
Ragweed, chicory, marestail
Daisy fleabane, prickly lettuce,
pineapple weed,
Dandelion, yellows goatsbeard,
common plantain, wild carrot

To date, we have positive detections in ragweed and in marestail

Do not have large replicated surveys
Research Objective II:
Characterize AYp genetic variability in carrot to determine the genetic relationships associated with ability to cause disease (by symptoms and by transmission efficiency): ‘local pathotype’

Outcomes:
- Results will indicate if AYp genotypes present in carrot fields correspond with the predominant genotypes present in off-crop habitats.
- In particular, we will find out if the aster leafhopper is selectively transmitting AYp genotypes, or predominant strains.

What is the source of leafhopper infectivity?
<table>
<thead>
<tr>
<th>Strain Type</th>
<th>Symptoms on Lettuce</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY-BW</td>
<td>Bolting, abnormal leaf elongation, chlorosis, ooze</td>
</tr>
<tr>
<td>AY-BD2</td>
<td>Bolting, light green coloration, distortion of stem and leaves, ooze</td>
</tr>
<tr>
<td>AY-BD3</td>
<td>Bolting, light green coloration, distortion of stem and leaves, ooze</td>
</tr>
<tr>
<td>AY-S</td>
<td>Yellowing, stunting, loss of leaf blades, ooze</td>
</tr>
<tr>
<td>AY-SG</td>
<td>Vein clearing, yellowing, stem bending (semi-geotropism), ooze</td>
</tr>
<tr>
<td>AY-WB</td>
<td>Vein clearing, yellowing, stunting, wilting and necrosis in plants infected at the early growth stage, bolting in plants infected at the late growth stage, ooze</td>
</tr>
<tr>
<td>AY-SS</td>
<td>Yellowing, stunting, loss of leaf blades, ooze</td>
</tr>
<tr>
<td>AY-UC</td>
<td>Could not be classified according to Zhang et al. 2004</td>
</tr>
</tbody>
</table>
- 6 Field Sites Sampled
- 6 aster leafhoppers infected with AY phytoplasma / site
- 36 total insect examined
- 3 predominant strain types

Relative Abundance (% total strains)

<table>
<thead>
<tr>
<th>Strain Type</th>
<th>Relative Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY-BW</td>
<td>50</td>
</tr>
<tr>
<td>AY-BD2</td>
<td>20</td>
</tr>
<tr>
<td>AY-BD3</td>
<td>15</td>
</tr>
<tr>
<td>AY-SS</td>
<td>10</td>
</tr>
<tr>
<td>AY-SG</td>
<td>5</td>
</tr>
<tr>
<td>AY-WB</td>
<td>0</td>
</tr>
<tr>
<td>AY-S</td>
<td>0</td>
</tr>
<tr>
<td>AY-UC</td>
<td>0</td>
</tr>
</tbody>
</table>
Strain types in different carrot fields 2007

Relative Abundance (% total strains)

AY-BW  AY-BD2  AY-BD3  AY-SS  AY-SG  AY-WB  AY-S  AY-UC
How can we use this data?

Visual comparison of strain types found in leafhopper and in carrot:
How do the strain types associated with migratory leafhoppers compare to the strain types we find in carrot fields?
Results Summary To Date

- The proportion of strain types in carrot was correlated to the proportion of strain types found in Aster leafhopper (Spearman’s $\rho = 0.976$, $p < 0.05$, $n = 8$).

- There were 3 predominant strains present in all fields. In half of the fields an uncharacterized AYP strain represented 40% or more of the strain types present.

- The proportion of strain types found in one carrot field did not always correspond to strain types found at the other locations.

*Can strain variability be related to specific, non-crop sources of inoculum?*
Summary

What are the relative contributions of AYp from migrating ALH and local plant sources?

Can we use pathogen variability as a tool to better understand the epidemiology of Aster yellows?

Interested in how we can apply this knowledge to better manage aster yellows.

Future Direction:
• Document strain composition in non-crop inoculum sources
• Classify the strain composition in migrating leafhoppers
• Relate the inoculum potential in outside sources to current season disease pressure
Acknowledgements

Gumz Muck Farms
Shiprock Farms
Miller Farms
Patrykus Farms
Guth Farms
Groves Lab

QUESTIONS?

Midwest Food Processors Association