Soybean Aphid Biotypes: Understanding Geographic Distribution 2008-2010

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Monsanto Company
Soybean Aphid
*Aphis glycines* Matsumura

- Soybean aphids confirmed in Wisconsin in 2000 and quickly spread to the North Central region
- Much of N America suitable climate for soybean aphid
- Expansion limited by availability overwintering host, buckthorn
- Viviparous and Oviparous
  - Population can build-up rapidly
- Migrate large distances

Soybean Aphid Distribution

Average Number of Aphids per Plant

<table>
<thead>
<tr>
<th>Range</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Black</td>
</tr>
<tr>
<td>0-5</td>
<td>Green</td>
</tr>
<tr>
<td>6-39</td>
<td>Cyan</td>
</tr>
<tr>
<td>40-149</td>
<td>Yellow</td>
</tr>
<tr>
<td>150-249</td>
<td>Orange</td>
</tr>
<tr>
<td>250-499</td>
<td>Orange</td>
</tr>
<tr>
<td>&gt;500</td>
<td>Purple</td>
</tr>
</tbody>
</table>

Management Techniques

• Biological Control
  – Lady beetles
  – Parasitic wasps (*Binodoxys communis*)

• Scouting

• Insecticide Treatments

• Aphid associated loci
  – *Rag1, Rag2, rag3, rag4*
  – Insect Biotypes
Insect Biotypes

• The performance of a genotype or group of genotypes of unknown relation on particular host (host differentials) Downie. 2010. J. Insect Science 10:176(1-18)

• Not: A population or group of individuals having the same genotypes
Understanding More about Soybean Aphid Biotypes

- Initiated in 2008
- Collaborated with public entomologists/breeders to design and conduct evaluations
Identification of ‘Biotypes’ in Soybean Aphid


<table>
<thead>
<tr>
<th>Soybean genotype</th>
<th>No. of aphids plant(^{-1}) 10 d after infestation</th>
<th>Average PDI 15 d after infestation(^{†})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dowling</td>
<td>157(^{a#})</td>
<td>4.2(^{a#})</td>
</tr>
<tr>
<td>Dwight</td>
<td>180(^{a#})</td>
<td>4.0(^{a#})</td>
</tr>
<tr>
<td>Jackson</td>
<td>110(^{b#})</td>
<td>4.3(^{a#})</td>
</tr>
<tr>
<td>PI 200538</td>
<td>24(^{c#})</td>
<td>1.2(^{d#})</td>
</tr>
<tr>
<td>Williams 82</td>
<td>166(^{a#})</td>
<td>4.5(^{a#})</td>
</tr>
<tr>
<td>PI 567541B</td>
<td>38(^{c#})</td>
<td>2.2(^{c#})</td>
</tr>
<tr>
<td>PI 567597C</td>
<td>32(^{c#})</td>
<td>2.2(^{c#})</td>
</tr>
<tr>
<td>LD05-16611</td>
<td>172(^{a#})</td>
<td>3.0(^{b#})</td>
</tr>
</tbody>
</table>

\(^{†}\)The plant damage index (PDI) ranges from 1 (no stunting and leaf distortion) to 5 (severe plant damage).

\(^{\#}\)Means followed by the same letters in a column are not significantly different by the least significant different test ($P = 0.05$).
Collaborators

• Vaino Poysna and David Hunt
  – Ag Canada: Harrow, ON
• Mike Gray and Ron Estes
  – University of Illinois
• Matt O’Neal
  – Iowa State University
• Brian McCornack
  – Kansas State University
• Christian Krupke
  – Purdue
• Dechun Wang
  – Michigan State University
• David Ragsdale
  – University of Minnesota
  (currently at Texas A &M)
• Deirdre Prischmann-Voldseth
  – N. Dakota State University
• Guo-Liang Jiang and Marci Green
  – S. Dakota State University
• Rouf Mian
  – USDA –Wooster, OH
• Eileen Cullen (2008)/ Ag Stat (2009-10)
  – University of Wisconsin
Objectives

• Understand the distribution of aphid biotypes

• Develop a panel of host differentials to characterize aphid biotypes
# Host Differentials

<table>
<thead>
<tr>
<th>Line</th>
<th>Institution</th>
<th>Gene</th>
<th>LG</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1621</td>
<td>KSU</td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>PI567598B</td>
<td>MSU</td>
<td>rag1_b, rag3</td>
<td>M, J</td>
</tr>
<tr>
<td>PI567541B</td>
<td>MSU</td>
<td>rag1_c, rag4</td>
<td>M, F</td>
</tr>
<tr>
<td>Dowling</td>
<td>Univ IL</td>
<td>Rag1</td>
<td>M</td>
</tr>
<tr>
<td>Jackson</td>
<td>Univ IL</td>
<td>Rag</td>
<td>M</td>
</tr>
<tr>
<td>PI243540</td>
<td>USDA-OH</td>
<td>Rag2</td>
<td>F</td>
</tr>
<tr>
<td>PI200538</td>
<td>Univ IL</td>
<td>Rag2</td>
<td>F</td>
</tr>
<tr>
<td>UGA-MON PI</td>
<td>UGA-MON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNS</td>
<td>Public</td>
<td>Variable Rxn</td>
<td></td>
</tr>
<tr>
<td>Wyandot</td>
<td>USDA-Ohio</td>
<td>Susceptible Check</td>
<td></td>
</tr>
</tbody>
</table>
Design

- Protocol based on Mensah et al. 2005
- No-choice evaluation in small field cages
- 15 seed/ cage
- 3 replications/ entry
- 10 entries

- Field collected aphids reared on Wyandot or susceptible variety
- Plant inoculated at V1 and monitored weekly
  - 5 wingless aphids/ plant
- Rating (0-4):
  - Evaluate entire panel when Wyandot reaches 3.5-4
- 8-11 locations
Rating Scale
Mensah et al. 2005

0 = no aphids, plant is normal and healthy

1 = 151 – 300 aphids per plant, mostly on the young leaves and the tender stem

2 = More than 800 aphids per plant, plants stunted, leaves severely curled, yellow, covered with sooty mold and cast skins
* Only 2 years of testing
Snapshot of Data

2008

2009

2010
Data Transformation

• Rating Scale Converted to Damage Index (DI)

\[ DI = \frac{\text{Average Scale Value of Entry}}{\text{Average Scale Value of Susceptible Check}} \times 100 \]

• DI Scores ranged from 0-115%

• Cluster Analysis:
  – Gene Cluster© and TreeView© used to visualize trends
  – Transformed ratings by (50-DI)%
DI = \sum \left( \text{Scale value} \times \text{No. of plants in the category} \right) / \left( 4 \times \text{Total no. of plants evaluated} \right) \times 100.

- Ohio Biotype (Rag1 Virulence) have high frequency in eastern aphid isolates
- Dowling and Jackson perform similarly across aphid isolates
- PI567541B and PI567598B perform similarly across aphid isolates
2009

• *Rag1* virulent isolates were less frequent compared to 2009.
• *Dowling* and *Jackson* perform similarly across aphid isolates.
• *Rag2* (*PI243540* and *PI200538*) sources performed differently across aphid isolates.
• Virulence to *PI567598B* appears to be rare.

**Damage Index Scale**

\[ DI = \Sigma (\text{Scale value} \times \text{No. of plants in the category})/ (4 \times \text{Total no. of plants evaluated}) \times 100. \]
Damage Index (DI) = \( \sum (\text{Scale value} \times \text{No. of plants in the category}) / (4 \times \text{Total no. of plants evaluated}) \times 100. \)

- Dowling and Jackson perform differently across aphid isolates.
- \textit{Rag1} virulent isolates were common and not limited to eastern sites.
- \textit{Rag2} (PI243540 and PI200538) sources performed differently across aphid isolates.
- Virulence to PI567598 B appears to be rare.
<table>
<thead>
<tr>
<th>Line</th>
<th>Gene</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1621</td>
<td></td>
<td>Clustered together in 2008-2010</td>
</tr>
<tr>
<td>PI243540</td>
<td>Rag2</td>
<td>Performed differently than PI243540</td>
</tr>
<tr>
<td>PI200538</td>
<td>Rag2</td>
<td>Clustered together in 2008-2010</td>
</tr>
<tr>
<td>PI567598B</td>
<td>rag1_b, rag3</td>
<td>Clustered together in 2008 and 2010; In general lowest aphid ratings; both 2 recessive genes</td>
</tr>
<tr>
<td>PI567541B</td>
<td>rag1_c, rag4</td>
<td>Clustered together in 2008-2009; single genes</td>
</tr>
<tr>
<td>Dowling</td>
<td>Rag1</td>
<td>Clustered together in 2008-2009; single genes</td>
</tr>
<tr>
<td>Jackson</td>
<td>Rag</td>
<td>Did not consistently cluster with other entries</td>
</tr>
<tr>
<td>UGA-MON PI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNS</td>
<td>Variable Rxn</td>
<td>Often Susceptible</td>
</tr>
</tbody>
</table>
Learnings

• Prevalence of Ohio-biotype (*Rag1* tolerance) populations varies year-to-year and geography-to-geography
• Aphid isolates often perform similarly on Dowling and Jackson across geographies
• Aphid isolates performed differently PI243540 and PI200538 across geographies
• Aphid isolates tolerant on PI567598B are also tolerant on PI567541B
• Isolates from different geographies did not consistently cluster together across years
Acknowledgements

Researchers
• Ag Stat (2009-10)
• Eileen Cullen (2008)
• Ron Estes
• Mike Gray
• Marcy Green
• David Hunt
• Guo-Liang Jiang
• Christian Krupke
• Brian McCormack
• Rouf Mian
• Matt O’Neal
• Vaino Poysna
• Deirdre Prischmann-Voldseth
• David Ragsdale
• Dechun Wang

Seed
• Rouf Mian
• Dechun Wang
• John Reese
• Monsanto MSP and Purity for increasing seed

Monsanto
• Vergel Concibido
• Erika Goecki
• Katy Hillard
• David Hoffman
• Ivan Husic
• Brad Lavallee
• Rick Leitz
• Charles Rexer
• Calvin Treat
• Jennifer Yates
Questions?