Season-Long Patterns of Attraction of Brown Marmorated Stink Bug to Pheromone Lure in Orchard Agroecosystems

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Brown Marmorated Stink Bug is a Devastating Pest of Tree Fruit
Feeding and Reproduction Throughout The Season
July 29, 2010

Many mid-Atlantic growers in WV, MD, PA, NJ and VA had significant losses.

Numerous growers lost over 50% of their peach crop in 2010.

Some lost their entire crop.
BMSB Feeding Injury—Rate and Severity
Regional Commercial Apple Orchards
2010 Growing Season

 Severity = 4.26

Severity = 3.11

Economic Injury

Perimeter

Interior

Orchard Sample Location

% Fruit Injury

2010 economic loss in mid-Atlantic apples due to BMSB feeding estimated at 37 million dollars (US Apple Association)
Development of Effective Detection and Monitoring Tools

- Tools that provide accurate measurements of presence, abundance, and seasonal activity of BMSB.

- Growers can make informed management decisions.
Key Components: 2009-2010 Studies

• Visual Stimulus
  – Large black pyramid

• Olfactory Stimulus
  – methyl (2E,4E,6Z)-decatrienoate

• Capture Mechanism
  – Tapered pyramid to inverted funnel jar with DDVP toxicant strip

• Deployment Strategy
  – Traps placed in peripheral row of orchard
Pheromone of *Plautia stali*

- Methyl (2E, 4E, 6Z)-decatrieonate.

- Cross attractive to brown marmorated stink bug and other pentatomids.

- Reports from Asia and U.S.
Will BMSB Respond to Methyl \((2E, 4E, 6Z)\)-Decatrienoate in the early-season?

- Reports of early-season attraction in Asia.
- Previous trials had relied on low doses (<5 mg).
- Evaluated 66 mg lures.
Despite Reports in the Asian Literature, Our Only Attractant Fails During the Early- and Mid-Season

Methyl (2E,4E,6Z)-decatrieonate (MDT) attractive to adults only during the late-season. Confirmed in MD, WV, NJ, PA, VA and other states in 2011. Not attractive to adults in early- and mid-season.
Almost No Captures in Traps Baited with MDT, Despite Very Large Immigrating Populations

Serious Early-Season Invasion Period
Identification of BMSB Aggregation Pheromone
Identification of the BMSB Aggregation Pheromone

9-30 September 2011

Traps baited with #10 captured ~15x more than control and ~3-4x more than other treatments.
Is #10 Attractive in the Early Season?
Pre-Trial (March 20-April 17, 2012)
Early Season Attraction Documented for BMSB
March 20-April 17, 2012

N = 77 BMSB

N = 8 BMSB

Mean No. Adults Per Trap

#10

Control

Treatment
Biology, Ecology, and Management of Brown Marmorated Stink Bug in Orchard Crops, Small Fruit, Grapes, Vegetables, and Ornamentals

USDA-NIFA SCRI Project

- USDA-ARS
  - Appalachian Fruit Research Station, Kearneysville, WV
  - Beneficial Insects Introduction Research Unit, Newark, DE
  - Invasive Insect Biocontrol and Behavior Laboratory, Beltsville, MD
  - Horticultural Crops Research Unit, Corvallis, OR
- The Pennsylvania State University
- Washington State University
- North Carolina State University
- Virginia Polytechnic Institute and State University
- Rutgers University
- Northeastern IPM Center
- Oregon State University
- University of Maryland
- University of Delaware
- Cornell University
Broad Validation in Multi-State Trial

• Is BMSB attracted to #10 in the early season?

• Is BMSB attracted to #10 season-long?

• How attractive is this stimulus relative to MDT and unbaited traps?

• WV, MD, VA, PA, NJ, NY, DE, NC, OR, WA, and OH
Leveraged and In-Kind Support
USDA-ARS
USDA-APHIS
AgBio
Sterling/Rescue

Total of 350 Traps Deployed Across 12 States
General Protocol

- Black pyramid traps

- Three odor treatments
  - 1) #10
  - 2) MDT
  - 3) unbaited control

- Traps are deployed between wild host habitat and agricultural production area.

- Traps were deployed in mid-April and left in place season-long.
Early Season Summary
Mid-April to Mid-June 2012

- BMSB reliably captured by traps baited with #10.
- These captures represent invading overwintering adults during early season.

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Trap Capture Ratios

- #10:Unbaited 11 : 1
- MDT:Unbaited 1 : 1
- #10:MDT 9 : 1
Mid-Season Summary
Mid-June to Mid-August

- Low numbers during much of mid-season.
- Increasing populations beginning in mid-July.
Late-Season Summary
Mid-August to Mid-October

- MDT very attractive and #10 attractive in late season.
- MDT outcompetes #10 in late season at tested release rates.
- Large numbers in the field.

Trap Capture Ratios

- #10: Unbaited 12 : 1
- MDT: Unbaited 90 : 1
- MDT:#10 7 : 1
## Season-Long Trap Captures

### Adult Captures

<table>
<thead>
<tr>
<th>Period</th>
<th>Time</th>
<th>Reps</th>
<th>#10</th>
<th>MDT</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Season</td>
<td>Mid-April to Mid-June</td>
<td>79</td>
<td>208</td>
<td>26</td>
<td>18</td>
</tr>
<tr>
<td>Mid Season</td>
<td>Mid-June to Mid-August</td>
<td>81</td>
<td>568</td>
<td>443</td>
<td>59</td>
</tr>
<tr>
<td>Late Season</td>
<td>Mid-August to Mid-October</td>
<td>81</td>
<td>3793</td>
<td>14420</td>
<td>421</td>
</tr>
</tbody>
</table>

### Nymphal Captures

<table>
<thead>
<tr>
<th>Period</th>
<th>Time</th>
<th>Reps</th>
<th>#10</th>
<th>MDT</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Season</td>
<td>Mid-April to Mid-June</td>
<td>79</td>
<td>2</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Mid Season</td>
<td>Mid-June to Mid-August</td>
<td>81</td>
<td>4845</td>
<td>11990</td>
<td>666</td>
</tr>
<tr>
<td>Late Season</td>
<td>Mid-August to Mid-October</td>
<td>81</td>
<td>2714</td>
<td>10633</td>
<td>638</td>
</tr>
</tbody>
</table>
Dose Response Trial
June 14-July 19, 2012

11:1 Ratio (Baited: Unbaited) for 10 mg lure
~25:1 Ratio (Baited: Unbaited) for 100 mg lure
Lure Affordability: Encouraging Results from Purity Trial

The diagram shows the mean number per trap for different levels of purity. The treatments are:
- Highly Purified
- Crude
- Semi-Purified
- Control

The results are indicated by the bars, with letters (a and b) above them to denote significant differences. The bars for Highly Purified, Crude, and Semi-Purified are all labeled with 'a', indicating they are not significantly different from each other. The Control group is labeled with 'b', indicating it is significantly different from the other groups.
Conclusions

• Aggregation pheromone of BMSB has been identified.

• This stimulus provides reliable, season-long detection of BMSB.

• Likely will need a higher loading of material.

• Crude material can be used to formulate lures, reducing overall costs.

• MDT is very sensitive stimulus in the late-season.
Peak Late-Season Captures using MDT in Commercial Apple Orchards Indicative of Early-Season Populations The Following Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Adults</th>
<th>Nymphs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean No. ± SE</td>
<td>Mean No. ± SE</td>
</tr>
<tr>
<td>2010</td>
<td>68.1 ± 21.0a</td>
<td>5.2 ± 1.6ab</td>
</tr>
<tr>
<td>2011</td>
<td>6.7 ± 2.7b</td>
<td>0.3 ± 0.2b</td>
</tr>
<tr>
<td>2012</td>
<td>60.6 ± 6.8a</td>
<td>7.4 ± 2.0a</td>
</tr>
</tbody>
</table>
Visual Cues

Identifying Optimal Wavelengths and Intensities of Light
Experimental Light Traps
Traps Provisioned With Blue 25W Compact Fluorescent Bulbs
Attractive and Species-Specific
## Season-Long Evaluation of Combination Stimuli

### Preliminary Results 2012

<table>
<thead>
<tr>
<th>Line of Sight To Trap</th>
<th>Light</th>
<th>#10</th>
<th>Combination</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>178 m²</td>
<td>7.5 ± 1.6b (448)</td>
<td>4.1±0.8bc (246)</td>
<td>15.0 ± 3.4a (898)</td>
<td>0.3 ± 0.1c (20)</td>
</tr>
<tr>
<td>10 m²</td>
<td>0.8 ± 0.2bc (47)</td>
<td>2.2 ± 0.5a (133)</td>
<td>1.7±0.5ab (103)</td>
<td>0.1 ± 0.1c (6)</td>
</tr>
</tbody>
</table>
Next Steps

- Establish physiological and behavioral state of responders to different stimuli.

- Combining attractive visual and olfactory stimuli.
  - Improve monitoring tools.
  - Develop attract and kill strategies.
Acknowledgements

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