Sweet Corn Insect Management

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Sweet corn insect pests
- Corn rootworm larvae
- Corn flea beetles
- Cutworms
- European corn borer
- Corn rootworm adults
- Western bean cutworm
- Corn earworm
- Fall armyworm

Several pest species, but this discussion will focus on corn earworm.

Western corn rootworms
- Increased densities because of egg-laying in soybeans – rotations no longer effective in much of IL and eastward into IN, MI, OH ...
- but numbers were low in many areas in 2014
- Thresholds for control in dent corn after corn or soybeans: 5 beetles per Pherocon AM trap per day in soybeans the previous Aug-Sep; 0.75 beetles per plant in corn the previous Aug-Sep.
- Pyrethroids:
  - Force and Brigade
- Organophosphates
  - Counter, Lorsban, Fortress
- Combination
  - Aztec
- Rootworm Bt sweet corns – Seminis Performance Series, including Obsession II, Passion II, Temptation II ... also Roundup-Ready Rootworm resistance already documented.

Corn flea beetle management
- Adult beetles overwinter, carrying the Stewart’s wilt bacterium from season to season; survival is temperature-dependent
- Plant Stewart’s wilt-resistant hybrids
- Use seed treated with a systemic insecticide (Gaucho, Poncho, etc.)
- Use foliar sprays on seedlings (<5-leaf stage)
- Threshold = 6 beetles per 100 plants or 1.5-2 corn flea beetles per 6” X 6” yellow sticky trap per day

Winter temperatures (snow cover dependent) often prevent successful overwintering in the northern Midwest ... last year and this year? But ... widespread use of seed treatments in field corn has reduced equilibrium populations of corn flea beetles throughout the Midwest.

Cutworm management
- Black cutworm is a southern migrant each season; other species also damage corn
- BCW moths prefer weedy fields for egg-laying
- Pheromone traps detect flights; cutting begins approximately 320 F degree-days later (base 50 F)
- Threshold: ~3 percent plants cut; larvae still present and feeding
- Pyrethroids (Asana, Baythroid, Brigade, Force, Mustang Max, permethrin, and Warrior) or Lorsban are effective
- Generally controlled by the new Seminis Performance series and the Attribute II series of pyramided Bt sweet corns

European corn borer
- Mature larvae overwinter in stalks.
- Area-wide tillage practices influence survival, but there are no single-field effects.
- Female moths prefer to lay eggs on corn taller than 24 inches and before senescence begins.
- Heavy rains during egg-laying and early larval feeding reduce survival.
- 2 generations per year in most years in northern IL; sometimes 3 in southern IL
- Bt corn (dent corn) has reduced overall population densities in many areas.
European corn borer control

- Whorl-stage to "row-tassel" scouting:
  - Use light traps or pheromone traps to monitor flights; "threshold" = 10 moths per black light trap per night.
  - Examine whorl-stage corn for shot-hole injury; pull whorls to check for live larvae.
  - Threshold = 15 percent of plants infested with live larvae at late whorl, or egg hatch anticipated at "row tassel".
  - Apply insecticide before third instars (third stage larvae) tunnel into stalks or to kill larvae that would bore into the tassel.

Insecticides for corn borer control

- At whorl stage
  - Any of the insecticides listed for later application, and BT insecticides
    - *Bacillus thuringiensis kurstaki* must be eaten to kill caterpillars; sprays or granules (in the whorl) are effective (moderately)
  - After tassel emergence
    - Pyrethroids are effective and least expensive
    - Coragen, Belt, and Radiant also are effective
    - BT sprays at whorl stage can give some benefit for organic growers; Entrust is more effective
  - "Row-tassel" timing is very important if corn borer larvae are present then
    - 5- to 6-day spray intervals are adequate for ECB
    - Bt sweet corn provides total control of ECB

Western bean cutworm

- Native to North America
- Pest of the western corn belt
- 2004 – 1st documentation in Illinois, Wisconsin, & Missouri
- Detected in Indiana in 2006
- Michigan in 2007
  - Control if 4% of plants have an egg mass.
  - Sampling follows adult detection in traps.
  - Row tassel to brown silk (similar to ECB/CEW control program)

WBC scouting & monitoring

- Use black light or pheromone traps to detect moth flights
  - Flights generally begin in early to mid July
  - Begin scouting when moths are first noticed
  - Continue scouting until after moth flights peak
  - Egg laying declines after peak moth flight
  - Continue to monitor for 7 – 10 days after peak
  - Can also use degree-days to predict moth emergence
    - Begin May 1, base 50°F
    - Spray programs aimed at earworm or ECB are effective; this insect is not controlled by early Bt sweet corn varieties (Attribute series) but is controlled by new varieties that produce an additional Bt toxin (the Seminis Performance series and the Syngenta Attribute II series)

Fall Armyworm

- Does not overwinter in the Midwest
- Pheromones/traps available, but foliage feeding is obvious sign of infestation
- Treat prior to ear formation if larvae are present
- Pyrethroids, Radiant, or Coragen
- Controlled well by the new Seminis Performance series and the Attribute II series of pyramided Bt sweet corns

Western corn rootworm beetles

- Populations in IL and eastward reached all-time highs but dropped since 2011
- Insecticides prevent silk-clipping: pyrethroids or Sevin are most effective
Corn earworm distribution

- Usually doesn’t overwinter north of 40°N
- May have been more successful in the winter of 2011-12 and even 2012-13 ... less so last winter
- Migrates up to 59°N

Timing of flights differs by location and season!!!

Concerns for corn earworm management

- Pyrethroids not as effective in small plot trials since late 1990s
  - Previously >90 percent reductions in damage and contamination; now often 40 to 70 percent control
- Increasing survival in bioassays of larval and adults of Midwest populations
  - Larvae in multiple-dose assays
  - Adult vials test at discriminating doses and multiple doses
  - Leonard et al., Louisiana; Jacobsen and Foster, Purdue, and collaborators throughout Midwest
  - Follows trends from southern US source regions

The key message here is that some corn earworm populations are resistant to pyrethroids and it is not practical to determine resistance levels in individual fields before sprays are applied ... you must assume that pyrethroids will not consistently be highly effective alone.

Results differ according to resistance characteristics of specific populations ... here are results from a pyrethroid-susceptible population at the University of Illinois Dixon Springs station (southern IL) from 2007.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Kernels Damaged Per Ear, Tip</th>
<th>Kernels Damaged Per Ear, Side</th>
<th>Medium-Large CEW Per 100 Ears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated check</td>
<td>13.24</td>
<td>3.77</td>
<td>51</td>
</tr>
<tr>
<td>BC 0805 (Bt, untreated)</td>
<td>2.89 (78)</td>
<td>0.44 (89)</td>
<td>14 (77)</td>
</tr>
<tr>
<td>Rynaxypyr 0.066 (Coragen)</td>
<td>0.47 (96)</td>
<td>0 (100)</td>
<td>1 (98)</td>
</tr>
<tr>
<td>Rynaxypyr 0.077 (6-day int.)</td>
<td>0.53 (96)</td>
<td>0 (100)</td>
<td>3 (94)</td>
</tr>
<tr>
<td>Larvin (thiodicarb)</td>
<td>0.39 (97)</td>
<td>0 (100)</td>
<td>1 (98)</td>
</tr>
<tr>
<td>Warrior (L-cyhalothrin)</td>
<td>0.18 (99)</td>
<td>0 (100)</td>
<td>1 (98)</td>
</tr>
<tr>
<td>Eco-Tec AD + Entrust</td>
<td>0.62 (95)</td>
<td>0.38 (89)</td>
<td>2 (96)</td>
</tr>
</tbody>
</table>

The same year’s (2007) results from a trial at Urbana showed reduced effectiveness of Warrior (a pyrethroid) in comparison with Coragen (rynaxypyr).

<table>
<thead>
<tr>
<th>Tmt</th>
<th>Tip Damage</th>
<th>Side Damage</th>
<th>M &amp; L CEW</th>
<th>ECB</th>
<th>FAW</th>
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<tbody>
<tr>
<td>Warrior</td>
<td>67</td>
<td>87</td>
<td>49</td>
<td>96</td>
<td>78</td>
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<tr>
<td>War + Entr</td>
<td>70</td>
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<td>73</td>
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<td>100</td>
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<tr>
<td>War + Sev</td>
<td>66</td>
<td>94</td>
<td>67</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>War + Lar</td>
<td>78</td>
<td>92</td>
<td>78</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>War + Lan</td>
<td>79</td>
<td>94</td>
<td>78</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>NNI 0001</td>
<td>66</td>
<td>87</td>
<td>49</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Kyn .044</td>
<td>85</td>
<td>99</td>
<td>65</td>
<td>99</td>
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<td>Ryn .088</td>
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<td>99</td>
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<td>BG0856</td>
<td>73</td>
<td>92</td>
<td>76</td>
<td>99</td>
<td>67</td>
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<tr>
<td>BT+War</td>
<td>80</td>
<td>97</td>
<td>62</td>
<td>99</td>
<td>67</td>
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</tbody>
</table>
Effectiveness of initial Attribute Bt sweet corn varieties

- High levels of expression (toxin production) in kernels and silks, especially fresh silks
- 100 percent effective against European corn borer
- Effective against corn earworm larvae that ingest toxins – not all kernels contain toxins
- Often small larvae infest ears at harvest
- Less effective against fall armyworm and western bean cutworm
- Ineffective against rootworm beetles, sap beetles, grasshoppers, etc.

Next Generation of Bt Sweet Corn Technology

Seminis Seeds - Cry1A.105+Cry2Ab + Cry3Bb1 – Performance Series
Syngenta Seeds - VIP3A + Cry1Ab – Attribute II (limited varieties)

Advantages:
- Added herbicide tolerant genes
- Broader spectrum of insect control
- Higher efficacy
- Less prone to resistance development

Pyramided and stacked genes

Non-Bt

Cry1Ab

<table>
<thead>
<tr>
<th>Event</th>
<th>Protein</th>
<th>ECB</th>
<th>CEW</th>
<th>FAW</th>
<th>BCW</th>
<th>WBCW</th>
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<tbody>
<tr>
<td>MON810</td>
<td>Cry1Ab</td>
<td>E</td>
<td>G</td>
<td>G</td>
<td>P</td>
<td>P</td>
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<tr>
<td>BT11</td>
<td>Cry1Ab</td>
<td>E</td>
<td>G</td>
<td>G</td>
<td>P</td>
<td>P</td>
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<tr>
<td>TC16-507</td>
<td>Cry1F</td>
<td>E</td>
<td>F</td>
<td>VG</td>
<td>G</td>
<td>VG</td>
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<tr>
<td>MON89034</td>
<td>Cry1A.105</td>
<td>E</td>
<td>VG</td>
<td>E</td>
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<td>F</td>
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<tr>
<td></td>
<td>Cry2Ab</td>
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<td></td>
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<tr>
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<td>E</td>
<td>VG</td>
<td>E</td>
<td>VG</td>
<td>VG</td>
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<tr>
<td>TC16-507</td>
<td>Cry2Ab</td>
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<tr>
<td>MIR162</td>
<td>Vip3A, Cry1Ab</td>
<td>E</td>
<td>E</td>
<td>E</td>
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<td>E</td>
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</table>

ECB= European corn borer; CEW= corn earworm; FAW= fall armyworm; BCW= black cutworm; and WBCW= western bean cutworm.
Control rating: E= excellent, VG= very good, G= good, F=fair, and P= poor.

Photos by Galen Dively, University of Maryland
### Kernel Segregation Ratios

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<th></th>
<th>B</th>
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<th>Bv</th>
<th>Bv</th>
<th>Bv</th>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>b</td>
<td>Bb</td>
<td>bb</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Parents are all Bb genotype. Endosperm (= offspring): 1 kernel in 4 has no Bt toxins*

**Attribute single gene expression (Cry1Ab)**

**Performance Series** (Cry1A.105 + Cry2Ab vectored)

<table>
<thead>
<tr>
<th></th>
<th>Bv</th>
<th>Bv</th>
<th>Bv</th>
<th>Bv</th>
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<tbody>
<tr>
<td>BV</td>
<td>BBV</td>
<td>BBV</td>
<td>BbV</td>
<td>BbV</td>
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<tr>
<td>Bv</td>
<td>BBV</td>
<td>BBv</td>
<td>BbV</td>
<td>Bbv</td>
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<tr>
<td>bV</td>
<td>BbV</td>
<td>BbV</td>
<td>bbV</td>
<td>bbV</td>
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<tr>
<td>bv</td>
<td>BbV</td>
<td>BbV</td>
<td>bbv</td>
<td>bbv</td>
</tr>
</tbody>
</table>

*Parents are all BbVv genotype. Endosperm (= offspring): 1 kernel in 16 has no Bt toxins*

**Attribute II** (Vip3A + Cry1Ab separate events)

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### Sweet Corn Hybrid

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control Program</th>
<th>Percent Marketable Ears</th>
<th>Percent CEW Damage</th>
<th>CEW per Ear</th>
<th>Kernel Area Consumed (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC 0805 Bt</td>
<td>2 sprays</td>
<td>54</td>
<td>46</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>unsprayed</td>
<td>10</td>
<td>87</td>
<td>1.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Obsession II Bt</td>
<td>2 sprays</td>
<td>91</td>
<td>11</td>
<td>&gt;0.1</td>
<td>0.1</td>
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<tr>
<td></td>
<td>unsprayed</td>
<td>74</td>
<td>37</td>
<td>0.4</td>
<td>0.3</td>
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<tr>
<td>Obsession nonBt</td>
<td>6 sprays</td>
<td>72</td>
<td>30</td>
<td>&gt;0.1</td>
<td>0.8</td>
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<td>unsprayed</td>
<td>4</td>
<td>96</td>
<td>0.9</td>
<td>7.1</td>
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<tr>
<td>Providence nonBt</td>
<td>unsprayed</td>
<td>0</td>
<td>100</td>
<td>1.2</td>
<td>10.3</td>
</tr>
</tbody>
</table>

2011 Experiment at Beltsville MD; sprays applied every 3 days starting at early fresh silk. Data from Galen Dively, University of Maryland

### Attribute II series varieties are significantly "better" than the original Attribute series varieties.

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### Efficacy of Attribute II Sweet Corn MD and MN 2007-2010

**Corn earworms/ear**

- Garrison: 11a, 12.9a, 7.0a, 67.0a, 74.0a
- Attribute II: 98c, 0.1c, 1.0b, 1.0c, 2.0c

**Garrison All Sprays**

- 41b, 4.8b, 13.0a, 17.0b, 30.0b

**Attribute II Sprays 1 + 2**

- 100c, 0.0c, 0.0b, 0.0c, 0.0c

**Attribute II Sprays 1, 3, 5**

- 100c, 0.0c, 0.0b, 0.0c, 0.0c

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### Attribute II varieties: Protector (a Bt transformation of the sh2 variety ‘Garrison’, and…

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### Corn earworm damage and infestations, means of 4 replications per treatment, in sweet corn harvested on September 11, 2013, Urbana, IL. (Means in the same column followed by the same letter do not differ significantly at \( P = 0.05 \))

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Undamaged Ears / 100</th>
<th>Damaged Kernels / Ear</th>
<th>Small CEW / 100 Ears</th>
<th>Med + Large CEW / 100 Ears</th>
<th>Total CEW / 100 Ears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garrison</td>
<td>11a, 12.9a, 7.0a, 67.0a, 74.0a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attribute II</td>
<td>98c, 0.1c, 1.0b, 1.0c, 2.0c</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Garrison All Sprays</td>
<td>41b, 4.8b, 13.0a, 17.0b, 30.0b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attribute II Sprays 1 + 2</td>
<td>100c, 0.0c, 0.0b, 0.0c, 0.0c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attribute II Sprays 1, 3, 5</td>
<td>100c, 0.0c, 0.0b, 0.0c, 0.0c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Data from Galen Dively, University of Maryland

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### Attribute II series varieties are significantly "better" than the original Attribute series varieties and the Performance series varieties.

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### Corn earworm damage and infestations, means of 4 replications per treatment, in sweet corn harvested on September 11, 2013, Urbana, IL. (Means in the same column followed by the same letter do not differ significantly at \( P = 0.05 \).)

**Treatment**

- Garrison: 11a, 12.9a, 7.0a, 67.0a, 74.0a
- Attribute II: 98c, 0.1c, 1.0b, 1.0c, 2.0c
- Garrison All Sprays: 41b, 4.8b, 13.0a, 17.0b, 30.0b
- Attribute II Sprays 1 + 2: 100c, 0.0c, 0.0b, 0.0c, 0.0c
- Attribute II Sprays 1, 3, 5: 100c, 0.0c, 0.0b, 0.0c, 0.0c

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Data from Galen Dively, University of Maryland
Summary and Recommendations for 2015

- Buy a wire Harsttack pheromone trap and Zealure CEW lures; monitor CEW flight
- Monitor western bean cutworm and European corn borer flights with pheromone traps and light traps
- Read newsletters, check web sites, and scout to determine the status of the key pests covered in this summary, and make decisions accordingly
- Pyrethroids remain the mainstays for control of several sweet corn insect pests; they include the following trade names and their generics:
  - Baythroid, Brigade/Capture, Hero, Mustang-Max, and Warrior
- Alternatives for corn earworm (and ECB, WBC, and FAW) control include Belt, Coragen, Radiant, and Entrust (and Lannate) … and Voliam Xpress / Besiege or tank mixes of a pyrethroid plus one of these alternatives
- If traps are catching CEW moths, getting a first pyrethroid or pyrethroid plus Lannate application on at row tassel or by first silk MAY improve control over starting sprays within 2 days of first silk, especially where adult control over a large acreage is accomplished
- Application intervals of 2- to 3-day intervals are especially important right after silking has begun
- Bt sweet corn …

Pheromone traps and CEW egg-laying

- Foster, Krupke, and Weinzierl
- 10 plantings of 2 varieties at 4 locations (Collinsville or DSAC, Urbana, Vincennes, West Lafayette) per season, 2009-2010
- 10 flag colors; 50 plants per treatment.
- Ears bagged before silking (shoot bags or tassel bags)
- Ears exposed to egg-laying one night only. 10 nights of exposures per planting, beginning just after first silk – 50 ears per night.
- Silks clipped on 22 ears for egg counts
- 25 ears evaluated at harvest for infestation and damage

Egg-laying is markedly greater in isolated fields and when nearby corn is not in silk.
So … thresholds for spray decisions based on trap counts:
- 5-10 per trap per night when silking field corn is abundant nearby
- 1 per trap per night for isolated fields and before/after field corn silks.

Insect management in Bt sweet corn in 2015

- Insecticides for rootworms? … as needed in non-Bt, Attribute and Attribute II series Bt varieties
- Control black cutworm and fall armyworm? … as needed in non-Bt and Attribute series … not in Attribute II or Performance series Bt varieties (pyrethroids / Coragen / Radiant)
- Control rootworm beetles as silks emerge (pyrethroids or Sevin)
- Control earworms – when?
  - Fresh silks contain greater amounts of Bt toxins than older silks
  - 1 of 4 kernels does not produce Bt toxins in Attribute and Performance series varieties; 1 in 16 kernels does not produce a Bt toxin in Attribute II series hybrids
  - So, if pressure is moderate (5-30 moths per trap per night) … one application 3-4 days after first silk, one or two more beginning about 10 days after first silk. If … research is needed. If flights are heavy … spray at 3-4-day intervals
- Control sap beetles – when?
  - Usually not entering ears until at least 5 to 7 days after first silk … controlled by a minimum spray program above IF pyrethroids are used

Resources

- Wire trap from:
  - Bob Poppe, 25738 N. 3200 East, Lexington, IL 61753. Ph 309-275-5477
- Lures – Hercon zealures and WBC lures from:
  - Great Lakes IPM, 10220 Church Road, Vestaburg, MI 48891-9746. Ph 989-268-5693. www.greatlakesipm.com
- 2015 Midwest Vegetable Production Guide
  - http://www.btny.purdue.edu/pubs/id/id56/
- Illinois Fruit and Vegetable News and other regional newsletters
  - http://ipm.illinois.edu/ifvn/