Managing Corn Earworm, Cutworms, and Armyworms in Vegetable Crops

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Lots of corn earworm problems in 2012

• Some overwintering in 2011-2012?
• Drought-stressed field corn was unattractive
• Early and heavy flights in some locations
• Pyrethroid resistance in some populations
• Too much reliance on BT sweet corn’s imperfect effectiveness

Corn earworm distribution

• Usually doesn’t overwinter north of 40° N
• May have been more successful in the winter of 2011-12
• Migrates up to 59° N
Concerns for corn earworm management

- Pyrethroids not as effective in small plot trials since late 1990s
  - Previously >95 percent reductions in damage and contamination; now often 40 to 70 percent control
  - Increasing survival in bioassays of larvae 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.

Insecticide Evaluation, Urbana, IL 2006

- 1.26 M-L larvae per ear in the check
- Pyrethroids: 67-77% control (Warrior, Capture / Brigade, Mustang Max, etc.)
- Larvin: 84% control; Warrior + Larvin: 87%
- Sevin: 72% control; Warrior + Sevin: 83%
- Rynaxypyr (E2Y45 / Coragen) at 0.088 lb a.i./A: 99% control
- Bt sweet corn, with or without Warrior: 92-94% control of M-L larvae; small larvae were present

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</td>
<td>0.13 (99)</td>
<td>0 (100)</td>
<td>1 (98)</td>
</tr>
<tr>
<td>Ryn .044</td>
<td>0.39 (97)</td>
<td>0 (100)</td>
<td>1 (98)</td>
</tr>
<tr>
<td>BT+War</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).

Insecticide evaluations, 2008-09

- Lighter than normal pressure in IL, IN, WI, MN.
  - Percent damaged ears in the untreated checks ranged from ~25-75 percent
  - Control provided by pyrethroids was better than usual in comparison with recent years
  - Effective products included
    - Baythroid, Bifenture / Capture / Brigade (bifenthrin), Hero, Mustang-Max, and Warrior
    - Belt, Coragen, Entrust, and Radiant
2010 … much greater pressure; CEW populations apparently characterized by greater levels of pyrethroid resistance

- Pyrethroids effectively controlled ECB, FAW, and WBC
- Belt, Coragen, and Radiant out-performed pyrethroids

Voliam Xpress outperformed other products in trials at the Dixon Springs Ag Center

- Voliam Xpress is a combination of the active ingredients in Warrior and Coragen … see limits for # of applications … the ingredients in Voliam Xpress will be sold in 2013 as Besiege.
- Pyrethroids OR alternative compounds were not as effective as this combination
- A pyrethroid (Warrior, Brigade, Mustang-Max, or generics) tank-mixed with an alternative (Coragen, Belt, or Radiant) should be as effective as a pre-mix

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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.

Status of Insecticide Efficacy and Control

- Pyrethroids have lost 1/3 of their efficacy since 2002.
- No consistent differences among pyrethroid products.
- Efficacy of pyrethroids varies from year to year.
- Mixtures of Lannate and pyrethroids – better control.
- Recommend rotations with newer products (Coragen, Belt, Radiant). (These can also be applied in mixtures with pyrethroids.)
- Silk zone spray coverage is essential.
- Tighter schedules may compensate for reduced efficacy.

Fresh Market Sweet Corn Ear Quality – Mid Atlantic States

Median and range of percent control

Mid Season Trial Results - 2011

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Application Timing</th>
<th>% Clean + Tip Damaged Ears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voliam Xpress Warrior II</td>
<td>1,3,5  2,4,6</td>
<td>96.64a</td>
</tr>
<tr>
<td>Voliam Xpress Warrior II</td>
<td>1,2,3  4,5,6</td>
<td>93.87a</td>
</tr>
<tr>
<td>Coragen Lannate + Asana</td>
<td>1,3,5  2,4,6</td>
<td>83.05abcd</td>
</tr>
<tr>
<td>Belt + Baythroid Lannate + Baythroid</td>
<td>1,2,4,5  3,6</td>
<td>88.87abc</td>
</tr>
<tr>
<td>Untreated</td>
<td>-----</td>
<td>1.27f</td>
</tr>
</tbody>
</table>

Untreated Control – CEW and SB Damaged Ears – 98%
Attribute series Bt varieties effects on corn earworm

- Reduces kernel area consumed by >90%.
- Reduces side ear damage.
- Reduces insecticide applications by 80% or more depending on population pressure.
- High Bt protein expression in green silk tissue.

After pollination, the Bt protein degrades as the silk tissue wilts and the expressed protein degrades. Larvae can bypass silk tissue and move directly to developing kernels.

- Larvae have a better chance to survive in the ear, because not all kernels express Bt protein.
- More damage is likely to occur under high insect pressure and in hybrids lacking good tip cover.
- Surviving larvae still become sick and do not develop or feed normally; but can be present in 25% or more of the ears.
- When earworm pressure is high, insecticide sprays are needed to prevent ear damage from exceeding fresh market standards.

Next Generation of Bt Sweet Corn Technology

Seminis Seeds - Cry1A.105 + Cry2Ab + Cry3Bb1 – Performance Series
Syngenta Seeds - VIF3A + Cry1Ab – Attribute II (not available until 2013)

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

Pyramided and stacked genes

Relative efficacy of single and pyramided transgenic corn with Bt events for caterpillar pests

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

Kernel Segregation Ratios

<table>
<thead>
<tr>
<th>B</th>
<th>b</th>
<th>B</th>
<th>b</th>
<th>B</th>
<th>b</th>
</tr>
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<tbody>
<tr>
<td>B</td>
<td>BB</td>
<td>BB</td>
<td>Bb</td>
<td>Bb</td>
<td>Bb</td>
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<tr>
<td>b</td>
<td>Bb</td>
<td>Bb</td>
<td>BB</td>
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</tr>
</tbody>
</table>

Attribute single gene expression (Cry1Ab)
Performance Series (Cry1A.105 + Cry2Ab vectored)

<table>
<thead>
<tr>
<th>BV</th>
<th>Bv</th>
<th>bV</th>
<th>Bv</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV</td>
<td>BBVV</td>
<td>BBVV</td>
<td>BbVV</td>
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<tr>
<td>Bv</td>
<td>BBVV</td>
<td>BBVV</td>
<td>BbVV</td>
</tr>
<tr>
<td>bV</td>
<td>BbVV</td>
<td>BbVV</td>
<td>bbVV</td>
</tr>
<tr>
<td>bv</td>
<td>BbVV</td>
<td>BbVV</td>
<td>bbVV</td>
</tr>
</tbody>
</table>

Attribute II (Vip3A + Cry1Ab separate events)

<table>
<thead>
<tr>
<th>Sweet corn hybrid</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>Obsession II Bt</td>
<td>2 sprays</td>
<td>91</td>
<td>11</td>
<td>&gt;0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Obsession nonBt</td>
<td>6 sprays</td>
<td>72</td>
<td>30</td>
<td>&gt;0.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Providence nonBt</td>
<td>unsprayed</td>
<td>4</td>
<td>96</td>
<td>0.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

2011 Experiment at Beltsville MD; sprays applied every 3 days starting at early fresh silk.
Efficacy of ‘Performance Series’ Sweet Corn to prevent whorl and tassel injury

<table>
<thead>
<tr>
<th>Obsession Non-Bt Isoline</th>
<th>Obsession Bt Cry1A.105 + Cry2Ab</th>
</tr>
</thead>
</table>

Insect management in Bt sweet corn in 2013

- 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 Bt toxins; older silks do not
  - 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 ?? … research is needed
- 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

Summary and Recommendations for 2013

- Buy a wire Hartstack pheromone trap and 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 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 2-3 days are especially important right after silking has begun
- Bt sweet corn …

Buy and use a Hartstack pheromone trap

- The wire Hartstack trap is not cheap … think in the $300 range, and think higher numbers if the traps must be shipped a long way. And you need to buy lures each year
- They last for many years (I have a couple that are >25 years old) … as long as you don’t run over them with tractors or other vehicles
- Along with a few dollars for lures every year and daily monitoring of moth counts, they provide you with guidance that can keep you from spending thousands of dollars unnecessarily or losing thousands of dollars worth of sweet corn sales
- If you spray 10 acres of sweet corn even twice a week for 3 weeks before earworms are actually present and require control, that’s 6 applications at (conservatively) $20.00 per acre for each application … multiplied by 10 acres, that’s $1200 (plus the loss of time not spent doing something more necessary). Multiply that by a 20-year life span for the trap, and the total exceeds $24,000. I think that pays for the trap and the lures
- Viewed in a different way, if high trap counts lead you to spray more often in order to get the control you really need, you market more corn. If you sell sweet corn at $3.00 per dozen, a yield of 1,800 dozen per acre is worth $5,400. Preventing a 5 percent loss by spraying extra when needed saves $270 per acre in sales. Multiply that by 10 acres and 20 years, and the total reaches $54,000 … that, plus keeping your customers from complaining about wormy corn, certainly pays for the cost of a trap and a package of lures every year.
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 25 ears for egg counts
- 25 ears evaluated at harvest for infestation and damage

In tomatoes

- Corn earworm (tomato fruitworm), beet armyworm, and tomato hornworm enter fruit (as do a few other cutworms and armyworms)

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.

In peppers

- European corn borer, corn earworm, fall armyworm, and others enter fruit

Effective insecticides against “Lep” larvae include:
- Asana … not against European corn borer
- Avaunt … only for corn borers (peppers)
- BT … not for cutworms or pinworms
- Baythroid … rates vary by pest
- Brigade
- Coragen
- Danitol
- Entrust (OMRI)
- Lannate
- Mustang Max
- Pounce
- Radiant
- Sevin
- Warrior
- generics

Resources

- Wire trap from:
  - Bob Poppe, 25738 N. 3200 East, Lexington, IL 61753. Ph 309-275-5477
- Lures – Hercon zealures lures from:
  - Great Lakes IPM, 10220 Church Road, Vestaburg, MI 48891-9746. Ph 989-268-5693. www.greatlakesipm.com
- 2013 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/

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  - Sevin
  - Warrior
  - generics