Sweet Corn IPM Workshop

Thursday morning 9:00 am

Where: Grand Gallery (lower level) Room A-B

Recertification credits: 1 (1B, PRIV CORE)
CCA Credits: PM(2.0)

Moderator: Hannah Stevens, Vegetable Educator, Macomb Co. MSU Extension

9:00 a.m. Sweet Corn Insect Management and Guidelines
  • Richard A. Weinzierl, Crop Sciences Dept., Univ. of Illinois

9:30 a.m. CEW Monitoring Network: Migration and Resistance Updates
  • William Hutchison, Entomology Dept., Univ. of Minnesota

10:00 a.m. Management of Ear Invading Insects with Bt Sweet Corn
  • Galen Dively, Integrated Pest Management Specialist, Univ. of Maryland

10:30 a.m. Stewart's Wilt, Resistant Hybrids, and Other Control Methods
  • Mike Meyer, Crop Sciences Dept., Univ. of Illinois
Sweet corn insect pests

- Corn rootworms
- Corn flea beetles
- Cutworms
- European corn borer
- Western bean cutworm
- Corn earworm
- Fall armyworm

Preseason and planting-time decisions

- Crop rotation
  - no longer effective against western corn rootworm in all areas
- Hybrids resistant to Stewart’s wilt?
- Bt hybrids?
- Soil insecticides for rootworms?
  - usually not cutworms
- Earlier versus later planting?
  - Early: more susceptible to cutworms, flea beetles, first-generation corn borer
  - Late: more susceptible to second-generation corn borer, corn earworm, rootworm adults (beetles)

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
  - 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 Capture
- Organophosphates
  - Counter, Lorsban, Fortress
- Combination
  - Aztec
- Do not rely only on seed treatments

Western corn rootworm beetles

- Populations in much of the region are near all-time highs
- Injury primarily to cucurbits and sweet corn
- Insecticides to prevent silk-clipping: pyrethroids or Sevin are most effective
  - Attractant with Sevin = Adios

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”X6” yellow sticky trap per day
**Cutworms**

- 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, Capture, Mustang Max, permethrin, and Warrior) or Lorsban are effective

**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 to 3 generations per year.
- Bt corn (dent corn) has reduced overall population densities in some 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, Beh, and Radiant also are effective
  - BT sprays 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
- 1970’s – occasional pest in Iowa
- 2000 – 1st economic damage in Iowa
- 2004 – 1st documentation in Illinois & Missouri
- Detected in Indiana in 2006
- Michigan in 2007

Corn earworm

Corn earworm distribution
- Usually doesn’t overwinter north of 40°N
- Migrates up to 59 °N

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 larvae and adults of Midwest populations
  - Larvae in multiple-dose assays to generate LDP lines
  - Adult vials tests 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

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 Bt corn

<table>
<thead>
<tr>
<th>Accumulated Degree-days</th>
<th>% Moth Emergence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1319</td>
<td>25%</td>
</tr>
<tr>
<td>1422</td>
<td>50%</td>
</tr>
<tr>
<td>1536</td>
<td>75%</td>
</tr>
</tbody>
</table>
North Central Region IPM Project

- Participants from IL, IN, MI, MN, OH, WI, and Ontario
- Primary objectives
  - Assessments of insecticide (pyrethroid) resistance
  - Improved monitoring and prediction of migrations
  - Evaluations of insecticide efficacy

Insecticide evaluations

- Regional efforts, especially IL, IN, and MN
- Late plantings provide silking corn when corn earworm moths are present and laying eggs
  - Corn borer and fall armyworm pressure may be high at the same time
- Often 4-row plots, 30 to 50 feet long, with 4 replications per treatment.
- Treatment intervals range from 2 to 5 days (often 3 days)
- Control is assessed by harvesting 15 to 25 ears per plot at maturity and recording the number (and size) of all insects in the ears and the number of kernels damaged.
- Location of damage also is recorded: tip versus side versus shank

Additional resources:

- [Adult Vial Test](http://www.pestwatch.psu.edu/sweetcorn/tool/tool.html)
- [IMRF Forecast](http://www.agweather.niu.edu/IMRF_Forecast.html)
Insecticide evaluations, 2008

- Lighter than normal pressure in IL, IN, 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

How meaningful are small-plot trials?

- Pyrethroids give significant adult control
  - When applied to large areas, re-invasion of fields by egg-laying females is not immediate
    - Re-invasion rates are likely to differ, depending on whether or not migration from the south or local emergence is ongoing or at a lull
- Small plots are likely to underestimate control provided by pyrethroids in large plantings grown for processing but may be very appropriate for estimating results in smaller sequential fresh-market plantings

Summary and Recommendations for 2009

- Buy a wire Hartstack pheromone trap and CEW lures; monitor CEW flight
- 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 corn borer) control include Belt, Coragen, Radiant, and Entrust
  - Tank-mixing Lannate, Larvin, or Sevin with pyrethroids or the alternatives just listed may improve control
  - If traps are catching CEW moths, getting a first pyrethroid application 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-days are especially important right after silking has begun
  - Bt sweet corn greatly reduces CEW numbers but does not give complete control
The corn earworm, *Helicoverpa zea*, continues to be a significant, economic pest of sweet corn, snap beans, tomatoes, and seed corn in the Midwestern U.S (Hutchison et al. 2007). Corn earworm (CEW) is not able to overwinter in Minnesota (north of the 40th latitude). Despite the inability to overwinter in Minnesota, CEW moths are able to consistently migrate from the southern U.S. each year, and cause considerable damage to late-season crops, such as sweet corn and seed corn, that are silking during these flight periods (Flood et al. 2005). During the past few years, here, we review what we observed at selected locations in Minnesota and the Midwest during 2008.

As in previous years, migrating CEW moths did not arrive in significant numbers this year, until late July to early August (Fig. 1). Unlike previous years, however, 2008 was the first “low-level moth flight” we have observed in the past 5 years. In contrast, 2007 was the highest moth flight we have documented in the past 3 years, and possibly for the past 10 years. As shown, Blue Earth, MN, has been a fairly consistent “hot spot” for CEW flights, and was again our high-catch location in 2008, with the peak flight at about 350 moths/trap/night. These results continue to support the need of monitoring CEW flights (and other pests) at multiple locations, and the timely reporting of data, for the benefit of all growers in the “network.” The flights at Blue Earth usually begin to pick up a bit sooner than our more northern MN locations, and thus serves as an early warning indicator for growers further north. Because CEW moth arrivals vary by location, we have developed a web-based moth flight monitoring tool for the U.S., known as *PestWatch*, with access from the ZEA-MAP web site: http://www.vegedge.umn.edu/ZeaMap/zeamap.htm. This is the primary “home page” for all research and outreach updates for the CEW Flight and Resistance Monitoring Network.
Despite the reduced number of CEW flight this year in Minnesota, as well as Wisconsin and Indiana, the high fecundity of CEW females (ca. 1500 to 2000 eggs/female) can still pose a significant risk of ear infestations by larvae, and larval feeding damage (8-12 kernels damaged/larva). In brief, several midwest locations still required 3-5 sprays to maintain quality ear production. The “action threshold” for CEW moth flights (via wire-mesh pheromone traps) is only 5 Moths/Night/Trap for two or more consecutive nights, during the corn silking phase. This threshold has held up well in Minnesota during the past 5 years.

In addition to the moth flight pressure we observed in 2008, we also provide a summary of CEW infestations in untreated sweet corn plots, for a historical comparison of the final larval pressure observed at the Rosemount (Dakota Co.) location (Table 1). Despite some variation in the intensity of CEW moth flights, it is useful to review the consistency of the timing and magnitude of larval infestations, at harvest in sweet corn ears.

As indicated by the lower moth flights this year at Rosemount, the subsequent larval infestations were much lower, compared to previous years, even for the late planting dates. In addition to the presence of larval infestations (fresh-market sweet corn), there is also the concern of lost kernels, which average from 8-12/ear for each large larva that survives to the last instar, and should still be a concern for processors.

Table 1. Risk of Corn Earworm (CEW) infestations in sweet corn in relationship to harvest dates (untreated plots); Rosemount, MN

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th></th>
<th>2006</th>
<th></th>
<th>2007</th>
<th></th>
<th>2008</th>
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<tbody>
<tr>
<td>Harvest date</td>
<td>%Ears-CEW</td>
<td>Harvest date</td>
<td>%Ears-CEW</td>
<td>Harvest date</td>
<td>%Ears-CEW</td>
<td>Harvest date</td>
<td>%Ears-CEW</td>
<td></td>
</tr>
<tr>
<td>8/5</td>
<td>0</td>
<td>7/31</td>
<td>0.9</td>
<td>7/30</td>
<td>0</td>
<td>8/11</td>
<td>40</td>
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</tr>
<tr>
<td>8/8</td>
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<td>0</td>
<td>8/6</td>
<td>4</td>
<td>8/14</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>8/15</td>
<td>2</td>
<td>8/14</td>
<td>6</td>
<td>8/16</td>
<td>20</td>
<td>8/20</td>
<td>17</td>
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<td>8/30</td>
<td>18</td>
<td>8/28</td>
<td>34</td>
<td>8/28</td>
<td>16</td>
<td>8/28</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>9/15</td>
<td>60</td>
<td>9/15</td>
<td>90</td>
<td>9/12</td>
<td>96</td>
<td>9/12</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>

*All data for GG63, Supersweet Jubilee Plus, and Providence for 2005, 2006, and 2007-2008, respectively; Rosemount, MN is approx. 44.7 lat., 93.1 long, an area where CEW is not able to successfully overwinter; annual late-season infestations result from long-distance migratory flights from the Southern U.S.

This past year was interesting in that we had the lowest CEW pressure in the past 5 years, as indicated by the untreated check plots for 2008 (Table 1). Conversations with extension entomologists in other Midwest states, have indicated similar light pressure this year (ca. 20-30% of ears infested with larvae, for late planting dates). At these infestations levels, the pyrethroids, as well as two new products (Coragen® with a Section 18; Belt® with new registration) also performed well in our trials (Tables 2-3). For ECB, infestations remained low at Rosemount, and in Le Sueur Minnesota, where Dr. Tom Rabaey (General Mills), found very few ECB in his annual sweet corn trial (these data not presented). This trend is not surprising given the continued use of Bt field corn in southern Minnesota (ca. 59% Bt in 2008, USDA-NASS).
Corn Earworm Efficacy, Bt Sweet Corn and Resistance Management, 2008

The 2008 efficacy results for CEW, for multiple Midwest locations (MN, WI, IN, IL) are sorted for total larvae per ear (all larval instars, Table 2) and large larvae only (instars 3-6th, Table 3). The data are summarized this way to provide efficacy results that are usually most relevant to fresh-market growers, and processors, respectively. Although all cooperators used the same varieties, and methods, including late-season planting dates for their respective regions, the results in each table also illustrate the variability in CEW control among locations. For fresh-market evaluation, the results in Table 2, overall, show relatively high levels of control (>85%) for the standard pyrethroid spray treatments (Warrior, Capture), as well as the new chemistries in development, Belt and Coragen. Bt sweet corn, like field corn, was developed by inserting genes from the soil bacterium, Bacillus thuringiensis (Bt), into the corn genome. Bt sweet corn (Attribute; BC 0805, bi-color) provides similar efficacy to what we have observed in recent years (avg., 73%), where the majority of surviving larvae are the small instars (1st and 2nd), and most of the feeding damage is limited to silk tissue, with minimal kernel damage. Adding 2 sprays of Warrior to the Bt sweet corn greatly improved overall efficacy of CEW, and in most locations is often necessary to control other silk and kernel feeding insects (e.g., rootworm beetles), that are not affected by the Bt protein in sweet corn. This added level of control was also most notable for the Bt sweet corn treatments. For all other treatments, we did not see an appreciable increase in control, when comparing the efficacy for large larvae only (Table 3) vs. all instars (Table 2).

Given the results from the small-plot efficacy trials (2003-2008), as well as multiple methods of monitoring for pyrethroid resistance, we have concluded that a low to moderate level of resistance in migrating CEW populations is evident at most northern U.S. locations each year. With these levels of resistance, there are essentially four alternatives for managing CEW in sweet corn: a) plant the majority of the sweet corn early, where most plantings (in most midwest states) harvested before August 1st, should have much less CEW pressure; b) plant Bt sweet corn (fresh-market only), for the late-season plantings, and use 1-2 pyrethroid sprays to provide additional CEW control, as well as other silk feeding insects that are not affected by Bt proteins; c) increase the rates of pyrethroid use (e.g., Warrior to 0.03 lb ai/ac; or Capture to 0.10 lb ai/ac, this has also worked well in several Minnesota trials); and d) where possible evaluate Belt or Coragen (when registered); these materials have unique modes of action, compared to the pyrethroids, and also show promise as alternatives. To date, however, only Belt is registered for sweet corn in the U.S. For updates on the status of Coragen and other control options, growers should refer to their state IPM Newsletters, and the ZEA-MAP web site for updates.

Acknowledgements: In addition to many volunteer cooperators who maintained pheromone and light traps, we thank Clarissa Hanneman and Krista Hamilton (WI –DATCP), and Clint Pilcher (Monsanto) for establishing several new Hartstack traps for CEW monitoring in WI and IA, respectively; we also thank Len Dobbins (FMC), for coordinating over 30 AVT monitoring sites in multiple states (2006-2007). Finally, we appreciate the funding from the Raw Products Comm., MWFPA, as well as support from the NC Region IPM Center, IPM Enhancement Grant; the Rapid Agricultural Response Fund-University of Minnesota; Insecticide Resistance Action Comm. (IRAC, U.S.); and the Minn. Dept. of Agriculture IPM Program.
Selected References:


  
  http://www.plantmanagementnetwork.org/sub/php/symposium/hzea/decrease/

  
  http://www.vegedge.umn.edu/MNFruit&VegNews/vol5/926veg.htm

  ZEA-MAP. On-line source of IPM and Resistance Management Information for Corn Earworm. University of Minnesota, St. Paul, MN.
  
Table 2: Summary of 2008 Midwest Efficacy Trials; Fresh-market impact (all CEW larval instars included; MN, WI, IN, IL)¹

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate</th>
<th>Percent Control</th>
<th>Overall efficacy</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P/ac</td>
<td>Al/ac</td>
<td>MN / U of MN²</td>
<td>WI / U of WI³</td>
</tr>
<tr>
<td>BC 0805 Bt (no sprays)</td>
<td>--</td>
<td>--</td>
<td>83</td>
<td>100</td>
</tr>
<tr>
<td>BC 0805 Bt + Warrior</td>
<td>1.92 oz</td>
<td>0.03</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>1CS/Warrior II (spray 1, 2)</td>
<td>6.4 / 3.84 oz</td>
<td>0.10 / 0.03</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>Capture (spray 1, 2) / Warrior (spray 3, 4)</td>
<td>3.84/1.92 oz</td>
<td>0.03 / 0.03</td>
<td>100</td>
<td>82</td>
</tr>
<tr>
<td>Coragen SC + MSO*</td>
<td>5 oz + 0.5%v/v</td>
<td>0.066</td>
<td>96</td>
<td>100</td>
</tr>
<tr>
<td>Belt + MSO</td>
<td>3 oz + 0.5%v/v</td>
<td>0.09</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Untreated check - CEW/ear</td>
<td>--</td>
<td>--</td>
<td>0.24</td>
<td>0.28</td>
</tr>
</tbody>
</table>

¹ All small-plot trials (2-6 rows each), using ground application equipment; arranged in a Randomized Complete Block Design (RCBD), with 4 replications/treatment. Percent control includes all larval sizes (1st-6th instars).

² Univ. of MN - Bill Hutchison; ³ General Mills/ Green Giant - Tom Rabaey; ⁴ Univ. of WI - Bryan Jensen; ⁵ Purdue Univ. - Rick Foster; ⁶ Univ. of IL - Rick Weinzierl.  *MSO = Methylated seed oil

Table 3: Summary of 2008 Midwest Efficacy Trials; Processing Sweet corn (3rd – 6th CEW larval instars only; MN, IN, IL)¹

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate</th>
<th>Percent Control</th>
<th>Overall efficacy</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P/ac</td>
<td>Al/ac</td>
<td>MN / U of MN²</td>
<td>IN / Purdue⁴</td>
</tr>
<tr>
<td>BC 0805 Bt (no sprays)</td>
<td>--</td>
<td>--</td>
<td>100</td>
<td>98</td>
</tr>
<tr>
<td>BC 0805 Bt + Warrior</td>
<td>1.92 oz</td>
<td>0.03</td>
<td>100</td>
<td>--</td>
</tr>
<tr>
<td>1CS/Warrior II (spray 1, 2)</td>
<td>6.4 / 3.84 oz</td>
<td>0.10 / 0.03</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Capture (spray 1, 2) / Warrior (spray 3, 4)</td>
<td>3.84/1.92 oz</td>
<td>0.03 / 0.03</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>Coragen SC + MSO*</td>
<td>5 oz + 0.5%v/v</td>
<td>0.066</td>
<td>100</td>
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<tr>
<td>Belt + MSO</td>
<td>3 oz + 0.5%v/v</td>
<td>0.09</td>
<td>94</td>
<td>96</td>
</tr>
<tr>
<td>Untreated check - CEW/ear</td>
<td>--</td>
<td>--</td>
<td>0.18</td>
<td>0.24</td>
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</table>

¹ All small-plot trials (2-6 rows each), using ground application equipment; arranged in a Randomized Complete Block Design (RCBD), with 4 replications/treatment. Percent control for large larvae only (3-6th instars). *MSO = Methylated seed oil.

² Univ. of MN - Bill Hutchison; ³ General Mills/ Green Giant - Tom Rabaey; ⁴ Purdue Univ. - Rick Foster; ⁵ Univ. of IL - Rick Weinzierl.
Corn Earworm Monitoring Network: Migration & Resistance Updates - 2008


- University, Industry, Agency Partnerships
- N. American Zea-Map Working Group

Corn Earworm Identification: (Helicoverpa zea)

Cannot Overwinter >40 Lat. (approx.)
Migrates Consistently South to North
Late June to Sept.
About 2000 Eggs/Female

14-20 Females/ac, = 100% ears infestation

CEW Moth Flights Increasing – ‘05-'07
Blue Earth, Minn. (Timing + Numbers!)

E-85 Drives Southern Corn;
Total Increase in 2007 - 93 million ac.

New Tools for CEW IPM:
Forecasting Incoming Moths

Near, Real-time
Insect Migration RISK Forecasts
Northern Illinois University
Mike Sandstrom,
Dave Changnon
Increasing # “Low-level Jet” Events (1500 ft), but Less in '08

PestWatch Expansion to Midwest and South for Corn Earworm – 2007 -
New Tools for CEW IPM: PestWatch - Rapid Tracking of Flights

Near, Real-time
Shelby Fleischer,
Doug Miller, et al.
Penn State Univ.
Official Release: July 2007
Expanded from NE to Midwest, Southern US

Pyrethroid Efficacy for Corn Earworm in Sweet Corn – 2003 Example
Rosemount, MN and Arlington, WI

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate lb AI/ac (Prod./ac)</th>
<th>MN CEW/ear (% control)</th>
<th>WI CEW/ear (% control)</th>
<th>Mean % control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capture 3C 0.04 (2.6 oz) 0.52 (18) 0.51 (23) 45.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warrior 1CS 0.025 (2.33 oz) 0.72 (32) 0.36 (45) 33.5</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Untreated Check -- 0.92 (--) 0.66 (--) --</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

PYRETHROID RESISTANCE? TRENDS IN MN-WI PYRETHROID EFFICACY AGAINST CEW, MN-WI, CAPTURE & WARRIOR

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean</th>
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</thead>
<tbody>
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<td>61</td>
</tr>
<tr>
<td>2007</td>
<td>35</td>
</tr>
<tr>
<td>2008</td>
<td>94</td>
</tr>
</tbody>
</table>

Aver. Kernel loss to CEW via Warrior timing trial 2007: Cost to Processors -- $75-100/ac

Multi-state Insecticide Trial Results - 2007

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate (%)</th>
<th>Overall efficacy x ±SD; range</th>
<th>Overall efficacy x ±SD; range</th>
<th>Overall efficacy x ±SD; range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bt 0805</td>
<td>0.088</td>
<td>82.0±12.6 (69-96)</td>
<td>82.0±12.6 (69-96)</td>
<td>82.0±12.6 (69-96)</td>
</tr>
<tr>
<td>Warrior 1CS</td>
<td>0.14</td>
<td>98.8±15.6 (49-100)</td>
<td>98.8±15.6 (49-100)</td>
<td>98.8±15.6 (49-100)</td>
</tr>
<tr>
<td>Capture (app. 1, 2) War. (app. 3, 4)</td>
<td>0.044</td>
<td>100.0±0.0 (100-100)</td>
<td>100.0±0.0 (100-100)</td>
<td>100.0±0.0 (100-100)</td>
</tr>
<tr>
<td>Coragen + MSO**</td>
<td>0.066</td>
<td>100.0±0.0 (100-100)</td>
<td>100.0±0.0 (100-100)</td>
<td>100.0±0.0 (100-100)</td>
</tr>
</tbody>
</table>

MN CEW Insecticide - Bt Efficacy, 2008 (“Low to Moderate” Pressure)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate lb (AI/ac)</th>
<th>Total CEW/ear (% control)</th>
<th>Fresh market</th>
<th>Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brigade 0.08</td>
<td>0.00 (0%)</td>
<td>0.00 (0%)</td>
<td>100.0 a 100.0 a 0.00 (0%)</td>
<td></td>
</tr>
<tr>
<td>Warrior 0.02</td>
<td>0.00 (0%)</td>
<td>0.00 (0%)</td>
<td>100.0 a 100.0 a 0.00 (0%)</td>
<td></td>
</tr>
<tr>
<td>Coragen + MSO</td>
<td>0.085</td>
<td>97.5±2.5 (92-100)</td>
<td>97.5±2.5 (92-100)</td>
<td>0.00 ref</td>
</tr>
<tr>
<td>Belt + MSO</td>
<td>0.09</td>
<td>98.8 ±0.2 (98-100)</td>
<td>98.8 ±0.2 (98-100)</td>
<td>0.00 ref</td>
</tr>
<tr>
<td>BC 0805 Br</td>
<td>0.08</td>
<td>93.0±0.5 (90-95)</td>
<td>93.0±0.5 (90-95)</td>
<td>0.54 ref</td>
</tr>
<tr>
<td>BC 0805 Br</td>
<td>0.08 (app. 1, 2)</td>
<td>93.0±0.5 (90-95)</td>
<td>93.0±0.5 (90-95)</td>
<td>0.54 ref</td>
</tr>
<tr>
<td>BC 0805 Br</td>
<td>0.08 (app. 3, 4)</td>
<td>93.0±0.5 (90-95)</td>
<td>93.0±0.5 (90-95)</td>
<td>0.54 ref</td>
</tr>
</tbody>
</table>

**MSO = Methylated seed oil

### Notes
- **a** Includes all CEW instars in the tip, side, or butt of the ear.
- **b** Percentage of ears with no kernel damage or larvae present.
- **c** Percentage of ears with only small larvae (1-2 instar ECB and/or 1-2 instar CEW) and/or damage limited to the tip; no damage or larvae on the side or butt of the ear.
- **d** Total kernels damaged in the tip, side, or butt by ECB and/or CEW.
CEW Efficacy: Timing of 1st spray

- **Total CEW (% control)**
- **Silk emergence (%)**

***OK to wait until 90-100% SILK***

All treatments = Warrior at 0.03lbs AI (3.84 oz)

DAS = days after 1st silk.

Sprays applied on 3-day interval.

Mean total CEW density, untreated check = 1.51 / ear

Resistance Monitoring Results, 2006-2007 ‘Standard AVT’ Method (moths from traps)

<table>
<thead>
<tr>
<th>State</th>
<th>Mean % survival (μg cypermethrin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN</td>
<td>2006: 11 (170) 5 (100) 2007: 14 (100) 5 (100)</td>
</tr>
<tr>
<td>IN</td>
<td>2006: 14 (151) 2 (151) 2007: 14 (100) 5 (100)</td>
</tr>
<tr>
<td>WI</td>
<td>2006: 15 (100) 3 (100) 2007: 21 (99) 2 (92)</td>
</tr>
<tr>
<td>IL</td>
<td>2006: -- 20 (100) 2007: 12 (100)</td>
</tr>
</tbody>
</table>

FMC: SD**

**Multi-dose AVT (0-30ug)**

**Single dose AVT (IA, IL, IN, MI, MN, NE, WI); Len Dobbins, FMC**

Response of Field-collected Larval Colonies to a Diagnostic Dose of Cypermethrin (5 μg/vial) -stable-

<table>
<thead>
<tr>
<th>Year</th>
<th>Survivors in IL</th>
<th>Survivors in MN</th>
<th>Survivors in WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>62</td>
<td>48</td>
<td>57</td>
</tr>
<tr>
<td>2004</td>
<td>62</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>2005</td>
<td>66</td>
<td>66</td>
<td>70</td>
</tr>
<tr>
<td>2006</td>
<td>43</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>2007</td>
<td>26</td>
<td>33</td>
<td>56</td>
</tr>
</tbody>
</table>

Response of Field-collected Larval Colonies to a Diagnostic Dose of Cypermethrin (10 μg/vial)

<table>
<thead>
<tr>
<th>Year</th>
<th>Survivors in IL</th>
<th>Survivors in MN</th>
<th>Survivors in WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>2005</td>
<td>4</td>
<td>34</td>
<td>9</td>
</tr>
<tr>
<td>2006</td>
<td>14</td>
<td>56</td>
<td>40</td>
</tr>
</tbody>
</table>

LD₅₀ Response of CEW Larvae to Cypermethrin – 2006 & 2007 – (J. Temple, R. Leonard; LSU)

<table>
<thead>
<tr>
<th>Location</th>
<th>N</th>
<th>LD₅₀</th>
<th>95% CL</th>
<th>Slope</th>
<th>X2</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wisconsin – 06</td>
<td>271</td>
<td>0.104</td>
<td>0.081-0.140</td>
<td>2.20±0.24</td>
<td>5.60</td>
<td>1-8</td>
</tr>
<tr>
<td>Minnesota – 06</td>
<td>220</td>
<td>0.088</td>
<td>0.071-0.108</td>
<td>2.24±0.27</td>
<td>2.37</td>
<td>1-6</td>
</tr>
<tr>
<td>Illinois – 06</td>
<td>221</td>
<td>0.043</td>
<td>0.029-0.057</td>
<td>1.50±0.22</td>
<td>0.82</td>
<td>0-3</td>
</tr>
<tr>
<td>Wisconsin – 07</td>
<td>175</td>
<td>0.099</td>
<td>0.073-0.138</td>
<td>1.65±0.29</td>
<td>2.00</td>
<td>1-8</td>
</tr>
<tr>
<td>Minnesota – 07</td>
<td>240</td>
<td>0.075</td>
<td>0.056-0.100</td>
<td>2.41±0.29</td>
<td>5.33</td>
<td>1-6</td>
</tr>
<tr>
<td>Illinois – 07</td>
<td>120</td>
<td>0.042</td>
<td>0.016-0.072</td>
<td>1.66±0.44</td>
<td>1.15</td>
<td>0-3</td>
</tr>
</tbody>
</table>

Resistance Ratio (RR) calculated from LD₅₀ data (0.013 – 0.065 μg) derived from MO and LA 1988; Cooperators: Jensen; T. Rabaey; Weinzierl; Foster. Conclusions to date: Response of field-collected larvae for MN, WI locations show significant but Moderate level of resistance. RRs > 5 generally reflect a significant genetic shift in resistance to an insecticide.

New Tools: (Belt ’08, Coragen- Sec 18)

- New Modes of Action
  - Coragen (Rynaxypyr, DuPont)
  - Belt (Bayer)
  - Control of a wide spectrum of Lepidopteran pests
  - Excellent GSW Control (MN, WI); 3-4 sprays, small plots
  - IR-4, Residue testing completed for Coragen
  - Foliar application as well as chemigation; soil delivery methods
  - Primary activity through insect ingestion

Key attributes of Coragen, Belt:
- Medium rates best in trials for CEW
- Short pre-harvest intervals and short reentry interval
- MOA: Rapid feeding inhibition; activation of insect ryanodine receptors; stimulates release of calcium from the internal stores of smooth and striated muscle, causing impaired muscle regulation, paralysis and death
- Low toxicity to bees, birds, fish and mammals
- Minimal impact on beneficial insects
Conclusions (to date)

- PestWatch: North-South Monitoring Network should continue – small local investment, benefits entire industry; ONLY way to verify Timing & Pressure!
- Pyrethroid resistance is highly variable, in part due to changing crop and pesticide use patterns in Southern U.S. Exacerbated by local overwintering (IL, MD) and Sheer Number of Weather Events.
- Pyrethroid resistance levels vary by method (Adult AVT, Lab assays, Field), however,
- Lab-Larval Assays consistent; show 10-20 fold increase in resistance in Midwest (past 4 yrs)
- Increased Use of Bt Stacks (cotton, corn) in South might help reduce primary source of moths in future!

CEW Recommendations for 2009

- Plant Early! (where possible)
- Only corn silking in late July to Sept, affected
- A history of poor control with pyrethroids?
  - Use High rates of SPs (first two sprays),
  - Wait until Peak Silk for first spray
  - Consider Bt sweet corn (+ 1-2 SP sprays)
  - Consider Belt (Bayer) on Some Acres
- New options = More $. Keep Bottom Line in Mind: Fresh-Market Value, approx. $4,500/ac
- Watch Monitoring Network, IPM Newsletters Closely!
- Timing is Not Everything: Also a Numbers Game!
- VegEdge: www.vegedge.umn.edu

Thanks to NC-IPM, IRAC, MWFPA for funding: Many Industry Cooperators - 2008!

Questions?

Email: hutch002@umn.edu
STEWART’S WILT, RESISTANT HYBRIDS, and OTHER METHODS of CONTROL

Michael D. Meyer
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Department Of Crop Sciences
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INTRODUCTION. Stewart’s wilt is disease of sweet corn caused by the bacterium *Pantoea stewartii*. Infection by *P. stewartii* results in chlorotic streaks that follow the veins of the plant. These streaks will eventually become necrotic. Early infection can lead to plant death. There are two phases of Stewart’s wilt: a leaf blight phase and a seedling blight phase. The seedling blight phase of Stewart’s wilt can significantly reduce the yield of fresh market sweet corn. The corn flea beetle (*Chaetocnema pulicaria*) is the vector and overwintering site of Stewart’s wilt. Corn flea beetle overwintering is most prevalent in the Midwest and Mid-Atlantic regions of the United States. If the corn flea beetle cannot overwinter in an area, then Stewart’s wilt is not usually present. Sequential warm winters allow the corn flea beetle to overwinter northern regions. The occurrence of Stewart’s wilt on early-planted corn usually corresponds with the ability of flea beetles to overwinter.

PREDICTION. Winter survival of corn flea beetles can be forecast from average daily temperatures in December, January, and February. Most flea beetles do not survive when the average temperature is below 27º F. Without flea beetles to vector the bacterium, Stewart’s wilt does not occur. If the average temperature is above 33º F, many flea beetles overwinter and Stewart’s wilt may be severe on moderately susceptible and susceptible hybrids. Flea beetle populations are also effected by the weather conditions at or around the time of planting. Cold temperatures or rainstorms can reduce the overwintering population of flea beetles. The occurrence of Stewart’s wilt on subsequent plantings depends on the abundance of flea beetles later in the season. Second and third summer generations of flea beetles acquire the bacterium from infected plants and become the overwintering population that infects the next year’s crop.

CONTROL. Stewart’s wilt can be controlled using insecticide treatments and hybrid resistance. In order to prevent yield reductions due to Stewart’s wilt, infection must be prevented until resistant or moderate reactions inhibit *P. stewartii* from systemically infecting plants or causing main stalk death. The only way to prevent plants from becoming infected is to control flea beetles. Insecticides applied foliarly and in-furrow are inconsistent at controlling flea beetles. Seed treatment insecticides have been shown to provide 70-80% control of Stewart’s wilt. Insecticide seed treatments registered for use in sweet corn include imidacloprid (Gaucho®) and chlothianidin (Poncho®). The economic value of seed treatments can be calculated using the following equation:

\[
\text{value} = \text{crop value ($/A)} \times \% \text{ incidence of Stew wilt} \times 0.7 \times \text{(% control)} \times 0.8 \times \text{yield loss coefficient}
\]

This equation accounts for crop value per acre, incidence of Stewart’s wilt in the absence of control, 70% control with seed treatment, and 0.8 yield loss coefficient. When the value of the seed treatment exceeds the cost of treating the seed it is economical to treat. The decision to treat sweet corn seed depends upon the level of hybrid resistance.
Resistance to Stewart’s wilt restricts the movement of *P. stewartii* in vascular tissues of plants. Infection is systemic in susceptible hybrids, whereas infection is confined to within a few centimeters of flea beetle feeding wounds in highly resistant hybrids. An entire range of reactions from highly resistant to highly susceptible occurs among the 500-600 sweet corn hybrids that are sold commercially. Reactions of hybrids can be classified as resistant (R), moderately resistant (MR), moderately susceptible (MS), and susceptible (S) based on results from multiple trials.

Probability distributions have been created to predict the occurrence of >2% incidence of Stewart’s wilt on hybrids with varied levels of resistance. In years when the mean winter temperature exceeds 33º F, there is at least a 0.3 probability (30% chance) of seeing >2% Stewart’s wilt on all hybrids, including those that are highly resistant. In this case, it may be economical to use a seed treatment insecticide on all hybrids. When mean winter temperature is between 27-33º F, there is less than 0.3 probability (30% chance) of seeing >2% incidence of Stewart’s wilt on moderate to resistant hybrids and a >0.7 probability (70% chance) on hybrids moderately susceptible to susceptible. Therefore, it may be advised to treat the seed of those hybrids moderately susceptible to susceptible, but not that of hybrids that are moderately resistant or better. When mean winter temperature is below 27º F, there is a <0.3 probability (30% chance) of seeing Stewart’s wilt on the most susceptible hybrids. It is not advisable to treat even the most susceptible hybrids when mean winter temperature is below 27º F.

**SUMMARY.** Stewart’s wilt can significantly reduce the yield of sweet corn. The severity of the seedling blight phase of Stewart’s wilt can be forecast using mean winter temperatures. When winter temperatures are greater than 33º F. The incidence of Stewart’s wilt is expected to be high. It is important to combine good levels of hybrid resistance with seed treatment insecticides, when Stewart’s wilt is expected to be a concern.