Corn rootworm management update

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University of Nebraska-Lincoln
Rootworms
Damage
Management options for high rootworm density fields

- Crop rotation; best option for reducing rootworm densities
- Planting time insecticides can help protect roots, reduce lodging
  - Liquid formulations
  - Granular formulations
- Do you have equipment to apply liquids or granules?
Management options for high rootworm density fields

- Planting time insecticides can help protect roots, reduce lodging
  - Liquid formulations
  - Granular formulations
- Factors influencing efficacy
  - Planting date
  - Weather
  - Rootworm density
  - Product rate/placement
Management options for high rootworm density fields

- Post emergence control of larvae
- Granular insecticides (Counter, Force)
  - Must be cultivated in
- Liquid insecticides applied by chemigation
- Scout to determine timing and need for control
Management options for high rootworm density fields

- Adult control
  - Pollination time
  - Reducing egg-laying to reduce problems next year

- Requires regular monitoring and understanding of rootworm behavior to be effective
  - Timing of sprays critical
  - Possible movement of rootworms back into field

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Western corn rootworm adult emergence, 1994, Saunders County, % cumulative emergence

<table>
<thead>
<tr>
<th>Date</th>
<th>Males</th>
<th>Females</th>
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<tbody>
<tr>
<td>July 5</td>
<td>17.9</td>
<td>6.3</td>
</tr>
<tr>
<td>July 8</td>
<td>39.3</td>
<td>12.5</td>
</tr>
<tr>
<td>July 12</td>
<td>71.4</td>
<td>31.3</td>
</tr>
<tr>
<td>July 18</td>
<td>85.7</td>
<td>59.4</td>
</tr>
<tr>
<td>July 26</td>
<td>89.3</td>
<td>15.0</td>
</tr>
<tr>
<td>August 2</td>
<td>100</td>
<td>84.4</td>
</tr>
<tr>
<td>August 11</td>
<td>100</td>
<td>96.9</td>
</tr>
<tr>
<td>August 18</td>
<td>100</td>
<td>100</td>
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</tbody>
</table>

Initial egg laying observed July 20
Management options for high rootworm density fields

- Bt corns; single or pyramided Bt proteins for rootworms
  - Consider rotating to different proteins over time
  - Always follow refuge requirements
- Two proteins in pyramided Bt hybrids have advantages for resistance management, and efficacy, and allow smaller refuge size
Monitor product performance

- Dig roots in July; look for rootworm injury
- Yield
- Less reliable measures
  - Lodging; may occur without rootworms
  - Adult emergence
Iowa Node injury rating scale

0.00  No feeding damage
1.00  One node of roots, or equivalent of a node, eaten back to within 2” of stalk
2.00  Two nodes eaten
3.00  Three or more nodes eaten

Damage between complete nodes is scored as percent:
0.25 = ¼ node eaten
1.50 = 1½ nodes eaten
### Bt proteins active against rootworms

<table>
<thead>
<tr>
<th>Protein</th>
<th>Initially developed by</th>
<th>Trade names</th>
</tr>
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<tbody>
<tr>
<td>Cry3Bb1</td>
<td>Monsanto</td>
<td>YieldGard RW, Plus, VTRW, VT Triple, Genuity VT Triple Pro, Genuity Smart Stax, SmartStax, Refuge Advanced</td>
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<tr>
<td>mCry3A</td>
<td>Syngenta</td>
<td>Agrisure RW, 3000 GT, Viptera 3111, 3122 Refuge Renew,</td>
</tr>
<tr>
<td>Cry34/35Ab1</td>
<td>Dow/Pioneer</td>
<td>Herculex RW, XTRA, Optimum AcreMax 1, RW, XTRA, Genuity Smart Stax, SmartStax,</td>
</tr>
<tr>
<td>eCry3.1Ab</td>
<td>Syngenta</td>
<td>Agrisure Duracade (registration pending)</td>
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</table>
Pyramided rootworm hybrids

<table>
<thead>
<tr>
<th>Proteins</th>
<th>Company</th>
<th>Trade names</th>
</tr>
</thead>
<tbody>
<tr>
<td>mCry3A; Cry34/35Ab1</td>
<td>Syngenta</td>
<td>Agrisure 3122 Refuge Renew</td>
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<tr>
<td>Cry3Bb1; Cry34/35Ab1</td>
<td>Dow; Monsanto</td>
<td>Smartstax, Refuge Advanced Powered by Smartstax (Dow); Genuity SmartStax, Genuity SmartStax RIB Complete (Monsanto)</td>
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</table>
## Handy Bt Trait Table

<table>
<thead>
<tr>
<th>YieldGard products</th>
<th>Cry1Ab</th>
<th>ECB</th>
<th>CEW</th>
<th>FAW</th>
<th>SB</th>
<th>RR2 (some)</th>
<th>20% within ½ mile</th>
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<tbody>
<tr>
<td>YGRW</td>
<td>Cry1Ab</td>
<td>CRW</td>
<td>---</td>
<td>CRW</td>
<td>RR2 (some)</td>
<td>20% in field/adjacent</td>
<td></td>
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<tr>
<td>YieldGard Plus</td>
<td>Cry1Ab</td>
<td>Cry3Bb1</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>SB</td>
<td>CRW</td>
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<tr>
<td>YieldGard VTRW</td>
<td>Cry3Bb1</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>SB</td>
<td>CRW</td>
<td>RR2</td>
</tr>
<tr>
<td>YieldGard VT Triple</td>
<td>Cry1Ab</td>
<td>Cry3Bb1</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>SB</td>
<td>CRW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Genuity / SmartStax products</th>
<th>Cry1A.105</th>
<th>Cry2Ab2</th>
<th>CEW</th>
<th>ECB</th>
<th>FAW</th>
<th>---</th>
<th>RR2</th>
<th>5% within ½ mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genuity VT Double Pro (VT2P)</td>
<td>Cry1A.105</td>
<td>Cry2Ab2</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>---</td>
<td>RR2</td>
<td>5% in the bag</td>
</tr>
<tr>
<td>Genuity VT Double PRO Complete</td>
<td>Cry1A.105</td>
<td>Cry2Ab2</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>CRW</td>
<td>RR2</td>
<td>20% in field/adjacent</td>
</tr>
<tr>
<td>Genuity VT Triple PRO (VT3P)</td>
<td>Cry1A.105</td>
<td>Cry2Ab2</td>
<td>Cry3Bb1</td>
<td>ECB</td>
<td>CEW</td>
<td>FAW</td>
<td>CRW</td>
<td>LL</td>
</tr>
<tr>
<td>SmartStax (Dow) or Genuity SmartStax (Monsanto)</td>
<td>Cry1A.105</td>
<td>Cry2Ab2</td>
<td>Cry1F</td>
<td>Cry3Bb1</td>
<td>Cry34/35Ab1</td>
<td>BCW</td>
<td>CEW</td>
<td>ECB</td>
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<tr>
<td>Genuity SmartStax RIB Complete</td>
<td>Same as Genuity SmartStax</td>
<td>BCW</td>
<td>CEW</td>
<td>ECB</td>
<td>FAW</td>
<td>WBC</td>
<td>SB</td>
<td>CRW</td>
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<tr>
<td>REFUGE ADVANCED Powered by SmartStax</td>
<td>Same as SmartStax</td>
<td>BCW</td>
<td>CEW</td>
<td>ECB</td>
<td>FAW</td>
<td>WBC</td>
<td>SB</td>
<td>CRW</td>
</tr>
</tbody>
</table>
Rootworm resistance history

- 1950s-WCR and NCR resistance to cyclodiene soil insecticides; aldrin, dieldrin, heptachlor
- 1980s- NCR extended egg diapause; rotation resistance
- 1990s-WCR resistance to OP and carbamate insecticides used for adult control in NE
- 1990s-WCR ‘soybean variant’ rotation resistance in eastern corn belt
- 2011-WCR reduced susceptibility to Cry3Bb1 Bt toxin in northeastern IA

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What is resistance?

- Pesticide resistance may be defined as a decreased response of a population of animals or plants to a pesticide or control agent as a result of previous exposure to the pesticide.

- Resistance may be defined as ‘a heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species’

  - http://www.irac-online.org/about/resistance/
Insecticide resistance

- Resistance is different from “tolerance” which is the innate ability to survive a given toxicant dose without prior exposure and evolutionary change.
- Resistance ≠ Immunity
Field-Evolved Resistance to Bt Maize by Western Corn Rootworm
Aaron J. Gassmann, Jennifer L. Petzold-Maxwell, Ryan S. Keweshan, Mike W. Dunbar. Department of Entomology, Iowa State University, Ames, Iowa

Principal Findings:
1. We report that fields identified by farmers as having severe rootworm feeding injury to Bt maize contained populations of western corn rootworm that displayed significantly higher survival on Cry3Bb1 maize in laboratory bioassays than did western corn rootworm from fields not associated with such feeding injury.
2. In all cases, fields experiencing severe rootworm feeding contained Cry3Bb1 maize. Interviews with farmers indicated that Cry3Bb1 maize had been grown in those fields for at least three consecutive years.
3. There was a significant positive correlation between the number of years Cry3Bb1 maize had been grown in a field and the survival of rootworm populations on Cry3Bb1 maize in bioassays.
4. However, there was no significant correlation among populations for survival on Cry34/35Ab1 maize and Cry3Bb1 maize, suggesting a lack of cross resistance between these Bt toxins.
Figure 1. Distribution of sites sampled within Iowa during 2009
Survival of western corn rootworm on Bt and non-Bt maize

Figure 2. Data are shown for A) Cry3Bb1 maize and B) Cry34/35Ab1 maize. In both cases, survival also is shown for a non-Bt near isogenic hybrid. Bar heights are means and error bars are the standard error of the mean.
Correlation analysis for corrected survival of western corn rootworm

Figure 3. For (A), no significant correlation was present between survival on Cry3Bb1 maize and Cry34/35Ab1 maize ($r = 0.068; \text{df} = 6; P = 0.87$). For (B), a significant positive correlation was present between corrected survival on Cry3Bb1 maize and the number of years Cry3Bb1 maize had been grown in a field ($r = 0.832; \text{df} = 7; P = 0.005$).
Take home messages

- Resistance to Bt proteins not documented in Nebraska rootworms; studies are underway to assess this
- High rootworm densities challenges all rootworm control options (insecticides, Bt corn)
- Need to use multiple control measures over time for sustainable rootworm management
"When you're up to your neck in alligators, it's easy to forget you came to drain the swamp."
Additional sources of information

- http://scal.unl.edu
- http://entomology.unl.edu
- http://cropwatch.unl.edu
Additional sources of information

- Handy Bt Trait Table
  - http://labs.russell.wisc.edu/cullenlab/files/2012/04/Handy_Bt_Trait_Table.pdf

- National Corn Growers Association Online IRM Refuge Calculator
  - http://ncga.com/irm-calculator
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