Control of Corn Rootworms and Spider Mites in Field Corn

Advanced Crop Advisors Workshop
February 10-11, 2015
Janet Knodel, Extension Entomologist
Species of Corn Rootworm

Western Corn Rootworm
*Diabrotica virgifera virgifera*

- Male
  - Males - more solid black marking on wing covers
  - Patrick Beauzay

- Female
  - Females - light yellow to green with 3 black stripes on wing covers
  - Janet Knodel

Northern Corn Rootworm
*Diabrotica barberi*

- ¼ inch long, pale to dark green
  - Patrick Beauzay
Corn Rootworm Life Cycle

- Eggs overwinter in soil
- Eggs hatch in June
- Larvae Feed for 30 d
- Pupae - earthen cells in soil
- Adults lay 300-400 eggs and feed on silks, pollen from late summer to early fall
- Adults require 5-10 days to transform from pupae and begin to emerge in mid-July to late September
- One generation per year
Corn Rootworm - Damage

Larvae - $\frac{1}{8}$-½ inch long

Corn rootworm larval feeding on roots

Patrick Beauzay

Goose-necked Corn

Janet Knodel
Corn Rootworm Root Injury

Healthy Root (Rating = 0)

Damaged Root (Rating = 2.75)
Corn Rootworm Economics $$$

• Cause over $1 billion in annual losses in U.S.
  – Caused by larval feeding on roots
    • Injured plant roots are attacked by disease organisms.
    • Reduces ability of plant to transport water and nutrients into plant
    • Reduces plant growth
    • Lodging of corn plant making harvest difficult
  – Yield reduction
  – Cost of control practices
    • Single largest user of conventional insecticides, many are restricted
‘Best’ Pest Management for CRW

• Crop rotation (avoid continuous corn)

• Increase corn yield by 10% and help reduce weed problems
Problems with Crop Rotation

• Variant Strains
  – Extended or prolonged diapause
    • Northern corn rootworm
    • Selecting for rootworms that were able to remain dormant as viable eggs for more than one winter season
  – Adapted behaviors – ‘soybean’ variant
    • Western corn rootworm
    • Lay eggs in soybean fields resulting in risk of economic injury to corn planted in the same field the next year
Corn after soybeans
Rootworm larval damage
DeKalb County
September 8, 2004

Treated refuge
‘Best’ Pest Management for CRW

- Bt corn
  - Plant your refuge of non-Bt corn
  - Use a different Bt corn hybrid that expresses a different Cry protein or multiple Cry proteins form the one that may be performing poorly
  - Avoid using the same Cry protein for >3 years in a row

- More acres of Bt corn will place more selection pressure on corn rootworm populations, which over time, have adapted to . . .
  - Chlorinated hydrocarbon insecticides (resistance)
  - Methyl parathion and carbaryl in NE (resistance)
  - Crop rotation
Western Corn Rootworm

Resistance to Bt Corn

- Gassmann et al. 2011 Field-Evolved Resistance to Bt Maize by Western Corn Rootworm
  - PloS ONE 6(7): e22629
  - Cry3Bb1 protein
  - 2011 confirmed in Iowa
  - 2012 – confirmed in Illinois, Minnesota, Nebraska
  - Continuous corn > 3 years
  - Relied on a single Bt trait for control CRW
  - Increased lodging and root feeding on Bt hybrids with CRW-resistant trait
‘Best’ Pest Management for CRW

– Control any Volunteer Corn
  • Volunteer corn is a host where rootworms develop (maybe resistant CRW)
  • Alternate hosts - giant ragweed, other weeds

Fig. 5: Crop rotation can eliminate western corn rootworm populations but manage volunteer corn!
North Dakota in 2012

- Increasing numbers of adult WCRWs in SE ND
  - Not document increased lodging or root feeding
- Continuous corn for last 10 years
- Same Bt trait (YieldGard VT Triple (VT3) - Cry1Ab & Cry3Bb1) for about 5 years
- Lots of volunteer corn in field (good food source for resistant CRW)
- Adult Western CRW were very common and outnumbered northern CRW 10 to 1
Trap Survey Methods

- Monitoring adult beetle activity
  - Sticky traps: 6 yellow (Pherocon AM)
  - Visual inspections (20 plants per 5 sites per field)
  - Mid-July through mid-September
- Record numbers and sex from traps
Corn for Grain Production
North Dakota: 2013

1 Dot = 10,000 Bushels
Dots randomly placed within county.
Blank counties represent none harvested or undisclosed data.

Corn Rootworm Distribution by Species

Field Survey, 2013

29 fields in 18 counties

- ● No Corn Rootworm Detected
- ▲ Northern Corn Rootworm
- ■ Western Corn Rootworm
- ○ Western & Northern Corn Rootworm
Northern Corn Rootworm

*Diabrotica barberi*

Field Survey, 2013

2304 NCRs captured on traps
Western Corn Rootworm

*Diabrotica virgifera virgifera*

Field Survey, 2013

3545 WCRs captured on traps

Total number of CRWs per 10 traps per week:

- **•** 0
- **△** < 1
- **▲** 1 - 20
- **▼** 20 - 50
- **▲** 51 - 100
- **△** > 100
Bt corn Efficacy Study

• Field near Arthur, ND, with a history of CRW and continuous corn for more than three years

• Treatments using an adapted corn hybrid:
  1. Non-Bt check
  2. Yieldgard VT Triple (Cry3Bb1)
  3. Herculex RW (Cry34/35Ab1)
  4. SmartStax (Cry34/35Ab1 + Cry3Bb1)
  5. Non-Bt check with Poncho 1250 seed treatment

• Trt #1-5 with and without soil insecticide
  Force 3 G @ 5 oz. per 1,000 row-feet
Power Washing Corn Roots
Root Injury Rating Scale (0-3)
(developed by Iowa State University)

0  No feeding damage

1  One node (circle of roots), or the equivalent of an entire node, pruned back to within 1.5 inch of the stalk.

2  Two complete nodes pruned

3  Three complete nodes pruned
Corn Rootworm Injury and Yield Treatment Means Regardless of Soil Insecticide at Arthur, 2013

CRW Injury Score (0-3)

Yield (bu/acre)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CRW Injury Score</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pioneer P9675-R + Cruiser 250</td>
<td>0.95a</td>
<td></td>
</tr>
<tr>
<td>Pioneer P9675-R + Poncho 1250 + Votivo</td>
<td>0.76a</td>
<td></td>
</tr>
<tr>
<td>Pioneer P9675 AMRW-R (Cry34/35Ab1)</td>
<td>0.34b</td>
<td></td>
</tr>
<tr>
<td>Dekalb DKC43-27 VT3 (Cry3Bb1)</td>
<td>0.32b</td>
<td></td>
</tr>
<tr>
<td>Dekalb DKC44-13 Genuity SS (Cry3Bb1 + Cry34/35Ab1)</td>
<td>0.09b</td>
<td></td>
</tr>
</tbody>
</table>
Comparison of CRW Injury and Yield for Hybrids With and Without Soil Insecticide at Arthur, 2013

CRW Injury Score (0-3)

Yield (bu/acre)

No soil insecticide

*Force 3G at 5 oz per 1,000 row-feet

Pioneer P9675 R + Cruiser 250
Pioneer P9675 R + Poncho 250 + Votivo
Pioneer P9675 AMRW-R (Cry34/35Ab1)
Dekalb DKC43-27 VT3 (Cry3Bb1)
Dekalb DKC44-13 Generity SS (Cry3Bb1 + Cry34/35Ab1)
Results 2013

- **2013 Heavy CRW pressure:**
  - Rootworm Bt-corn hybrids had less root injury than the non-Bt corn hybrids.
  - There were no differences for root injury among the rootworm Bt-corn hybrids.
  - Rootworm Bt-corn hybrids had higher yields than the non-Bt corn hybrids.
  - The use of *Poncho 1250* seed treatment on the non-Bt corn hybrids reduced feeding injury, but did not significantly increase yield.
  - The use of *Force 3G* resulted in a yield increase for the non-Bt corn hybrid, but **not for the rootworm Bt-corn hybrids.**
CRW Injury and Yield for Hybrids With and Without Soil Insecticide at Arthur, 2014

CRW Injury Score (ISU 0-3 Scale)

Yield (bu/acre)

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>CRW Injury Score</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>P8640</td>
<td>0.15a</td>
<td>163.6ab</td>
</tr>
<tr>
<td>P8640*</td>
<td>0.16a</td>
<td>165.9a</td>
</tr>
<tr>
<td>P9526 AM-R 1250</td>
<td>0.16a</td>
<td>151.1ab</td>
</tr>
<tr>
<td>P9526 AM-R 1250*</td>
<td>0.12b</td>
<td>150.2ab</td>
</tr>
<tr>
<td>P9526 AMX-R 1250 (Cry3Bb1)</td>
<td>0.05bc</td>
<td>154.1ab</td>
</tr>
<tr>
<td>P9526 AMX-R 1250 (Cry3AAb1)</td>
<td>0.05bc</td>
<td>163.8ab</td>
</tr>
<tr>
<td>DKC43-48 500 (Cry3Bb1)</td>
<td>0.06bc</td>
<td>174.7a</td>
</tr>
<tr>
<td>DKC43-48 500 (Cry3Bb1)*</td>
<td>0.07bc</td>
<td>174.9a</td>
</tr>
<tr>
<td>DKC44-13 500 (Cry3Bb1 + Cry3AAb1)</td>
<td>0.04c</td>
<td>161.1ab</td>
</tr>
<tr>
<td>DKC44-13 500 (Cry3Bb1 + Cry3AAb1)*</td>
<td>0.02c</td>
<td>137.0b</td>
</tr>
</tbody>
</table>

Note: CRW Injury Score and Yield values with different letters indicate significant differences.

*Force 3G at 5 oz per 1,000 row-feet

Legend:
- Blue: No soil insecticide
- Red: *Force 3G at 5 oz per 1,000 row-feet
• 2014 Light CRW feeding pressure:
  – Rootworm Bt-corn hybrids had less root injury than the non-Bt corn hybrids.
  – There were no differences for root injury among the rootworm Bt-corn hybrids.
  – There were no differences for root injury in the non-Bt corn hybrids regardless of whether Poncho 1250 seed treatment was used.
  – Force soil insecticide did not significantly impact root injury.
Methods – Bt-resistant CRWs

• Hand-collect beetles using aspirator from any corn fields with high CRW populations

• Arthur - Monitoring for beetle emergence through October
  – Emergence traps – 1 trap per plot
  • Record species and sex
Average Adult CRW Emergence Trap Counts by Species, Arthur 2013

**Force 3G at 5 oz/acre**
Results 2013-2014

• 2013 Emergence Trapping:
  – Disproportionally high number of WCR adults that emerged from the VT Triple Pro (Cry3Bb1) hybrid plots at one field in northern Cass County
  – Root feeding injury was not significantly different compared to the other rootworm Bt-corn hybrids
  – But, the fact that WCR were surviving indicates potential resistance to Cry3Bb1 hybrids in a localized WCR population. This field had at least a five year history of continuous Cry3Bb1 corn.
Future Work 2015-2016

• **Collected 1000s** of CRW adults in summer of 2014!!
• Eggs are in diapause now at NDSU Research Greenhouse
• Need to complete screening of ND-collected CRWs for Bt-resistance bioassay (from 2014 research)
• Use laboratory of Dr. Wade French of USDA ARS in Brookings, SD
• Use single plant assay method developed by Gassmann (2011)
Two-spotted Spider Mite (*Tetranychus urticae*) in Field Corn

Tiny, yellow mites with two dark spots on sides of abdomen
Life Cycle of Two-Spotted Spider Mites

- Attack a wide variety of crops, ornamentals and trees
- Overwinter as eggs in permanent vegetation
- Egg to adult development takes 5-19 days, faster at hotter temps
- Wind-blown dispersal via a silk thread

Life stages of the two-spotted spider mite:
Egg-larva-protonymph-deutonymph-adult

Photo credit Tom Klubertanz
Field Corn - Spider Mite Damage Symptoms

- Leaf Stippling
- Leaf Yellowing
- Mite Webbing (gray area near midrib)

Spider mites in corn – YouTube Video
http://www.ag.ndsu.nodak.edu/aginfo/entomology/entupdates/entvideos.htm#Corn
Scouting for Spider Mites

• Determine how far mites have moved into the field (leading edge of spider mite infestation)
• Continue to scout rest of field if mites are found
  – Walking a ‘U’ pattern into field, start 100 feet into field
  – Check 2 plants per sites and 20 sites per field
When to Spray for Spider Mites in Field Corn

• Susceptible stages:
  – Tasseling through hard dough

• Action (Spray) Threshold
  – Treat when lower ¼ to ⅓ of canopy is injured and mites or mite damage symptoms are present. Do not let mite injury reach the ear leaves.

(Source: University of Minnesota, Ostlie & Potter)
Corn Silage Trial 2009

6 tons/ac yield loss = 17% reduction

Source: E. Bynum, P. Porter and M. Vandiver
Spider Mite – Grain Loss

25 year average grain yield loss at Rocky Ford – 22%

TREATED

UNTREATED

Colorado State University
Source: E. Bynum, P. Porter and M. Vandiver
# Corn Miticide & Insecticide Products

<table>
<thead>
<tr>
<th>Company</th>
<th>Trade Name</th>
<th>Chemical Name</th>
<th>Beneficial Impact</th>
<th>IRAC Class</th>
<th>Days PHI Silage</th>
<th>Days PHI Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemtura AgroSolutions</td>
<td>Comite II</td>
<td>Propargite</td>
<td>soft</td>
<td>12C</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Bayer CropScience</td>
<td>Oberon 4SC</td>
<td>Spiromesifen</td>
<td>soft</td>
<td>23</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Gowan</td>
<td>Onager 1E</td>
<td>Hexythiazox</td>
<td>soft</td>
<td>10A</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Valent U.S.A.</td>
<td>Zeal</td>
<td>Etoxazole</td>
<td>soft</td>
<td>10B</td>
<td>No restriction</td>
<td>21</td>
</tr>
<tr>
<td>FMC</td>
<td>Brigade 2EC</td>
<td>Bifenthrin</td>
<td>hard</td>
<td>3A</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>FMC</td>
<td>Hero</td>
<td>Zeta-Cypermethrin Bifenthrin</td>
<td>hard</td>
<td>3A</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Winfield Solutions</td>
<td>Dimate 4E</td>
<td>Dimethoate</td>
<td>hard</td>
<td>1B</td>
<td>14 forage</td>
<td>28</td>
</tr>
</tbody>
</table>

*Source: E. Bynum, P. Porter and M. Vandiver*
Insecticide Guidelines

• Use adequate water volume to ensure complete coverage
  – Minimum of 10 GPA by ground, 18 GPA best
  – Minimum of 5 GPA by air
• Use higher labeled rate in drought or severe mite infestations
• Avoid using pyrethroid insecticides (except bifenthrin) that may flare mite populations
• Re-scout field in 5-7 days after treatment for mite resurgence, since insecticides do not control eggs
• If a second treatment is needed, alternative between different modes of action, e.g. organophosphate and pyrethroid or miticide
Aerial Application 2.5 gal/A
Chemical Marker – Lithium sulfate monohydrate
Total concentration / plant = 1.9 µg/cm² ± 0.2 µg/cm²


Aerial Spray Coverage

Upper 1/3 – 53%
Middle 1/3 – 30%
Bottom 1/3 – 17%

Upper surface – 59%
Lower surface – 41%

Basal 25%  Center 32%  Distal 44%
Secondary Mite Outbreak

Not Sprayed for WCR adults

Sprayed for WCR adults

Photos: courtesy of Monti Vandiver
Example of pyrethroids causing an outbreak

Muleshoe Mite Trial 2009

- Oberon 4oz/a
- Oberon 6oz/a
- Oberon 8oz/a
- Hero 10.2oz/a
- Hero 5.1oz/a
- UTC

Mean No. Mites per Leaf

Sample Date:
- 3 DBT
- 4 DAT
- 18 DAT
- 24 DAT

Spray volume 19 gpa, spray mix include 32 oz COC
Dedicated Miticides for Corn

- Controls eggs and immature stages of mites
- All fairly “soft” on beneficial species (give or take)
- Usually $24 to $30 per application
- Different timing for application
  - Comite II: early pre-tassel (can be used post-tassel)
  - Onager: early and post-tassel
  - Oberon: early and post-tassel (mostly used for post-tassel control)
  - Zeal: 2013 label
- No cross-resistance potential between products
- Never use the same one twice in a season – ROTATE CHEMISTRY

Source: E. Bynum, P. Porter and M. Vandiver
Pre-tassel Miticide Control

2007 Banks Grass Mite
Montrose, CO

Data courtesy of Bob Hammon
2013 Corn Field Damaged by CRW near Page, ND
NDSU Crop & Pest Report

- Free to subscribers with email but **MUST SIGN-UP ON WEBSITE!!!**
  (Do not need to re-sign up if you subscribed in 2012)
Acknowledgements

- North Dakota Corn Council for funding
- Dr. Joel Ransom, Extension Agronomist
- Dr. Mark Boetel, Research Entomologist
- Research Specialists
  - Patrick Beauzay
  - Chad Deplazes
  - Grant Mehring
- Graduate Students
  - Veronica Calles-Torrez (PhD)
  - Kellie Podliska (M.S.)
- Growers
  - Jason Dows
  - Randy Huschka

Left to right: Dr. Ransom, Pat Beauzay, Kellie Podliska and Dr. Boetel