Roots of Evil:
Corn Rootworms and Crop Rotation

Ken Ostlie
Dept. of Entomology - University of Minnesota
ostli001@umn.edu
(612) 624-7436 voice (612) 750-0993 cell
Farmer Perceptions and Management Contrasts in Minnesota

1995 Management Status

- **European Corn Borer**
  - Yield loss = $350 million
  - or ca. 17 bu/acre
  - Insecticide use = 320K acres or ca. 4.8%

- **Corn Rootworms**
  - Yield loss = $1 million
  - Insecticide use = 528K acres or 8% (94% corn after corn)

A Tale of Two Corn Rootworms Trying to Make it in a World of Rotated Corn
And the Struggle To Manage this Corn Rootworm Problem!
After 5 to 10 days, western (left) and northern (right) corn rootworm beetles emerge from the soil in late July and August.

Beetles feed primarily on corn pollen and silks. After two weeks, egg laying continues until frost.

Larvae feed for 3 weeks and then 3rd stage larvae build a soil cell and pupate.

Eggs hatch in early June. Newly hatched larvae tunnel within roots while older larvae attack newly initiating roots.

Eggs laid in August and September overwinter. Fall and spring tillage redistribute the eggs.
The Simple Management Solution for Corn Rootworms: Crop Rotation!


A judicious rotation of crops is so simple and complete a preventive measure, that remedies for injury to corn by the northern corn rootworm are practically unnecessary.
Should Someone Tell Northern Corn Rootworms?

Produced by Bruce Potter. Data from MDA Plant Pest Survey Program.
What’s happening With Northern Corn Rootworms?

Northern Corn Rootworms in Rotated Corn

- Sample sites
- Corn rootworm/plant
  - ≤ 0.1
  - 0.1 - 0.5
  - 0.5 - 1.0
  - 1.0 - 2.5
  - 2.5 - 5.0
  - > 5.0
  - No Data

2002

2003

Northern Corn Rootworms in Rotated Corn
What’s Changing with Northernns?
Extended Diapause

Ability of northern corn rootworm eggs to overwinter two or more years before hatching.

A Strategy to Succeed in Rotated Corn!
**Extended Diapause: Adaptation to Crop Rotation**

1965  
**BEFORE ROTATION**

- Time in diapause: 99.7%  
- 1 year: 0.3%

1985  
**AFTER 20 YEARS ROTATION**

- Time in diapause: 60 - 70%  
- 1 year: 30 - 40%

2000  Fuller (SD): All 12 samples from Brookings Co. >40%
What about Northern Corn Rootworms on Other Crops?

- Pigweed: 6 eggs recovered
- Lambsquarter: 3 eggs recovered
- Foxtail: 6 eggs recovered
- Oat stubble: 2 eggs recovered
- Soybean: 6 eggs recovered
- Corn: 355 eggs recovered

Boetel & Walgenbach 1992
Crop Rotation and Extended Diapause

Corn/Sugar Beet/Corn Rotation

150 bpa (Avg of 4 checks)

182 bpa (Avg of 4 checks)

Corn/Sugar Beet/Pea/Corn Rotation
(3 Crop)

Picture taken south of Olivia, Minnesota 2002
Western corn rootworms have lost their fidelity to corn and now lay eggs in other crops.
Distribution of WCR in First Year Corn
Damage to Rotated Corn by Western Corn Rootworms
What’s happening with Western Corn Rootworms?

Western Corn Rootworms in Rotated Corn

2002

Western Corn Rootworms in Rotated Corn

2003
Corn rootworms are now a greater threat in MN in rotated corn!
Management Options for Corn Rootworms

Crop Rotation?  
Soil Fertility?  
Tillage?  
Hybrid?  
Plant Spacing?  
Insecticide?  

What’s in the IPM toolbox?
What’s Changed with Corn Production?

- Earlier planting dates
- Higher plant populations
- Narrower row spacing
- Higher yielding hybrids
- Reduced tillage

*These Changes Increase Corn Rootworm Survival or Damage!*
Corn Rootworms and Tillage

*Eash & Potter, 2001*

**Legend:**
- FallCP/Spr.FC
- Spring FC
- Ridge Till
- Spr.Strip Till
- Strip Till
- No Till
Tillage Effects on Root Pruning

Eash & Potter, 2002

% of total roots pruned

Fall
CH/Sp FC
Sp FC
RT
NT
ST
SpST
LSD 0.05

% <3"
% <1.5"
Corn Rootworm Emergence under Different Row Spacings

- 20" row spacing:
  - 1998: 23.6 Beetles/Sq. ft.
  - 1999: 26.4 Beetles/Sq. ft.

- 30" row spacing:
  - 1998: 19.6 Beetles/Sq. ft.
  - 1999: 20.5 Beetles/Sq. ft.

- 40" row spacing:
  - 1999: 21.5 Beetles/Sq. ft.
Insecticide Options for Managing Corn Rootworms are Diversifying

**Granules**
- Aztec 2.1G, 4.67G
- Counter CR
- Empower 1.15G
- Force 3G
- Fortress 2.5G, 5G
- Lorsban 15G
- Thimet 15G & 20G

**Transgenics**
- Cry3Bb (Monsanto)
- Strain 149B1 (Dow-Mycogen, Pioneer)

**Liquids**
- Capture 2E
- Furadan 4F
- Lorsban 4E
- Regent 4SC

**Seed Treatments**
- ProShield
- Prescribe
- Cruiser
Development of Transgenic Technology for Corn Rootworm

Current status:

**Monsanto**
- Moderate dose event (MON863)
- Expresses the Bt protein Cry3Bb
- SAP for IRM completed
- Approved by EPA in 2003

**Dow - Mycogen / Pioneer**
- High dose event (Strain 149B1)
- Expresses the Bt proteins Cry 34/35, a binary toxin
- Limited field tests in 2001-2; agronomic issues with event
- Field tests with Universities in 2004 (Pioneer)
- Anticipate registration / introduction by 2005-6
Corn Root Protection: Transgenics, Seed Treatments and Soil Insecticides

Ostlie & Potter – Lamberton, 2001

Root Injury Rating (1-6 scale)

Control | MON863 | Aztec | Force | Counter | Lorsban | Prescribe | Furadan | Regent

| Transgenic | 5.23 |
| Granules    | 3.28  |
| Seed Trt. Liquids | 3.25 |
| Root Injury Rating | 3.08 |
|              | 3.33  |
|              | 4.45  |
|              | 4.88  |
|              | 4.38  |
## Corn Root Protection: Transgenics, Seed Treatments and Soil Insecticides

*Ostlie – Rosemount, 2003*

### Root Injury Rating (1 - 6 scale)

<table>
<thead>
<tr>
<th>Transgenic</th>
<th>Liquids</th>
<th>Seed Trt.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>3.75</td>
<td>4.50</td>
</tr>
<tr>
<td>MON863</td>
<td>2.20</td>
<td>3.00</td>
</tr>
<tr>
<td>Counter</td>
<td>2.40</td>
<td>3.35</td>
</tr>
<tr>
<td>Fortress</td>
<td>2.63</td>
<td>3.30</td>
</tr>
<tr>
<td>Aztec</td>
<td>2.58</td>
<td>3.20</td>
</tr>
<tr>
<td>Force</td>
<td>2.88</td>
<td>2.90</td>
</tr>
<tr>
<td>Lorsban</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Empower</td>
<td>3.35</td>
<td>3.00</td>
</tr>
<tr>
<td>Furadan</td>
<td>3.30</td>
<td>3.00</td>
</tr>
<tr>
<td>Regent</td>
<td>3.20</td>
<td>3.00</td>
</tr>
<tr>
<td>Capture</td>
<td>2.90</td>
<td>3.00</td>
</tr>
<tr>
<td>Poncho</td>
<td>3.20</td>
<td>3.00</td>
</tr>
<tr>
<td>ForceST</td>
<td>2.95</td>
<td>3.00</td>
</tr>
<tr>
<td>Cruiser</td>
<td></td>
<td>3.00</td>
</tr>
</tbody>
</table>

### Notes

- Transgenics: MON863
- Seed Treatments: Control, MON863, Counter, Fortress, Aztec, Force, Lorsban, Empower, Furadan, Regent, Capture, Poncho, ForceST, Cruiser
- Root Injury Rating Scale: 1 - 6
### Corn Root Protection: Transgenics, Seed Treatments and Soil Insecticides

*Ostlie & Potter – Lamberton, 2003*

<table>
<thead>
<tr>
<th>Transgenic</th>
<th>Liquids</th>
<th>Root Injury Rating (1 - 6 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td><strong>MON863</strong></td>
<td><strong>Counter</strong></td>
</tr>
<tr>
<td>2.23</td>
<td>2.35</td>
<td>2.4</td>
</tr>
</tbody>
</table>

**Note:** The chart shows the root injury ratings for different treatments. Higher numbers indicate greater root injury.
Yield Protection: Transgenics, Seed Treatments and Soil Insecticides

Ostlie & Potter – Lamberton, 2003

Root Injury Rating (1 - 6 scale)

<table>
<thead>
<tr>
<th>Transgenic</th>
<th>Granules</th>
<th>Liquids</th>
<th>Seed Trt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>97.3</td>
<td>101.7</td>
<td>107</td>
</tr>
<tr>
<td>MON863</td>
<td>111.8</td>
<td>104.4</td>
<td>108.3</td>
</tr>
<tr>
<td>Counter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fortress</td>
<td></td>
<td>103.9</td>
<td></td>
</tr>
<tr>
<td>Aztec</td>
<td></td>
<td>104.8</td>
<td></td>
</tr>
<tr>
<td>Force</td>
<td></td>
<td>105.5</td>
<td></td>
</tr>
<tr>
<td>Lorsban</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furadan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poncho</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ForceST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cruiser</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Diagram showing root injury ratings for different treatments]
Management Considerations for Rootworm Problems in Rotated Corn

- Lengthen crop rotation
- Ensure agronomic practices favor optimal root health
- Choose a conventional hybrid with better root system or use a transgenic hybrid
- Consider using insecticides
  - Granular insecticides offer most consistent performance and reduced rates.
  - Plumb for liquids and apply at full label. Dry weather?
  - Seed treatments convenient but do not protect roots under heavy pressure.
- Scout to target resources
Do you have any questions?