Institute of Ag Professionals

Proceedings of the
2008 Crop Pest Management Shortcourse &
Minnesota Crop Production Retailers Association Trade Show

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Corn Rootworm Transgenics for 2009: A Moving Target

Ken Ostlie
University of Minnesota – Entomology
612-750-0993  ostli001@umn.edu
Development of Bt- Rootworm Transgenics

Agrisure (Syngenta)
- Moderate dose event (MIR604)
- Expresses the Bt protein modified Cry3Aa
- EPA registration fall 2006; USDA approval spring 2007

Herculex RW & Herculex Xtra (Dow - Mycogen / Pioneer)
- Moderate dose event (DAS 59122-7)
- Expresses the Bt proteins Cry 34/35, a binary toxin
- Approved for sale in 2005
- Registration of Optimum AcreMax I anticipated in 2009; Science Advisory Panel in early 2009

YieldGard VT (Monsanto)
- Moderate dose event (MON ) stacked with Bt-ECB and RR2 genes, replaced YieldGard RW and YieldGard Plus
- Expresses the Bt protein Cry3Bb
- Approved for sale in 2007
- SmartStax – A stack of 8 transgenic genes including YieldGard VT and Herculex RW; Registration anticipated in 2010

New! Announced
Projected Use of Bt-RW Corn in MN - 2008

What percentage of corn acres in 2008 will be _____?

- **Triple Stack**: 62.1%
- **Double w/ Bt-RW**: 22.1%
- **Non Bt-RW**: 15.8%

*N = 199*

Based on survey of attendees of 2008 Ag Professional Updates – MN Ext. Serv.
Optimum® AcreMax™ 1
Insect Protection for Every Acre

- Single bag solution to IRM implementation for corn rootworm
- High percentage (95-98%) HXX combined with a low percentage (2-5%) HX1
- All component products have similar herbicide tolerance
- Simplifies planting by eliminating need for separate refuge
- Eliminates need for separate CRW management in refuge

Optimum® AcreMax™ 1 insect protection is not yet available for sale or use. Products, benefits and concepts described above are subject to full regulatory approval. Herculex® Insect Protection technology by Dow AgroSciences and Pioneer Hi-Bred. ® Herculex and the HX logo are registered trademarks of Dow AgroSciences LLC.
Optimum® AcreMax™ 1 maintains flexibility for corn borer refuge, either in field or nearby. Optimum® AcreMax™ 1 insect protection is not yet available for sale or use. Products, benefits and concepts described above are subject to full regulatory approval. Herculex® Insect Protection technology by Dow AgroSciences and Pioneer Hi-Bred. ® Herculex and the HX logo are registered trademarks of Dow AgroSciences LLC.
Optimum Acre Max 1: Why Pursue an “In the Bag” Refuge?

- Successful IRM requires successful mating between corn rootworm beetles exposed as larvae to nonBt-RW and Bt-RW corn
- Feasibility of “In the Bag” refuge a balance between two factors:
  1. Refuge proximity for adults (necessitated by rapid mating and limited dispersal of females before mating) and
  2. Limited larval movement between Bt-RW and non Bt-RW plants (believed to foster more rapid development of resistance)
- Strong antifeedant mechanism, rare incidence of resistance genes, mean a low risk of resistance with seed mix ...Pioneer argues that there’s no need to stack traits.
- Pioneer sponsored research verifies product performance in terms of plantability studies (drop rate, settling, plant spacing, field distribution), agronomic performance (yield, lodging, stand), and efficacy against corn rootworm.
- Compliance issues resolved... 100% compliance.
YieldGard IRM Considerations:
Northern Corn Rootworm Emergence
Refuge in a Bag

Yieldgard RW - Minnesota 2005

Total Rootworm Emergence

WCR

NCR

100 20 10 0 Force

1626 687 423 316 162 108 108 313

1626 417 114 313
Refuge in a Bag
Agrisure - Minnesota 2007

Beetles per Tent

WCR

2806
848
592
646
418
1017

NCR

605
255
275
224
162
638

100 20 10 5 0 Force
What’s in Monsanto’s SmartStax™?

Graphic from Monsanto
Bt Corn Plus Soil Insecticides May Prove Profitable

by John Pocock, Corn and Soybean Digest, Sept. 24, 2007

“Prior to last year's rise in corn prices, most entomologists discouraged using both a soil insecticide at planting and a Bt corn rootworm hybrid in the same field for corn rootworm control. However, with corn prices hovering in the $3-4/bu. range, this two-pronged control strategy may prove profitable in the short-term for some farmers, says Kevin Steffey, University of Illinois (U of I) Extension entomologist. "Right now, with the high corn prices, I would have a hard time arguing against using both the Bt corn rootworm hybrids and a soil insecticide at planting, except obviously in Bt corn-rootworm refuge areas…”
Performance issues have been reported from Bt-RW corn in Illinois, Iowa, Nebraska…and Minnesota.
Root Injury for Corn Rootworm Products
Kevin Steffey and Mike Gray, Urbana, IL – 2007
http://www.ipm.uiuc.edu/bulletin/article.php?id=838

<table>
<thead>
<tr>
<th>Product</th>
<th>Rate</th>
<th>Placement</th>
<th>Nodal Injury Rating*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter 15G: YieldGard VT3</td>
<td>6 oz</td>
<td>T-band, SB</td>
<td>0.07 h</td>
</tr>
<tr>
<td>Counter 15G: Isoline</td>
<td>8 oz</td>
<td>T-band, SB</td>
<td>0.13 gh</td>
</tr>
<tr>
<td>Fortress 2.5G: Isoline</td>
<td>8 oz</td>
<td>IF, SB</td>
<td>0.15 gh</td>
</tr>
<tr>
<td>Force 3G: Isoline</td>
<td>4 oz</td>
<td>T-band, SB</td>
<td>0.41 g</td>
</tr>
<tr>
<td>Lorsban 15G: Isoline</td>
<td>8 oz</td>
<td>T-band, SB</td>
<td>0.40 g</td>
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<tr>
<td>HxXtra</td>
<td></td>
<td></td>
<td>0.49 g</td>
</tr>
<tr>
<td>YieldGard VT3</td>
<td></td>
<td></td>
<td>0.84 f</td>
</tr>
<tr>
<td>Poncho</td>
<td>1250 mg</td>
<td>Seed trt</td>
<td>1.49 cde</td>
</tr>
<tr>
<td>Pioneer Isoline Check</td>
<td></td>
<td></td>
<td>2.36 ab</td>
</tr>
<tr>
<td>DeKalb Isoline Check</td>
<td></td>
<td></td>
<td>2.74 a</td>
</tr>
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</table>

*Means followed by the same letter do not differ significantly*
Double-Barreled Rootworm Control Won't Pay In Most Cases

by John Pocock, Corn and Soybean Digest, Oct. 1, 2007

"For farmers in Minnesota, layering another level of protection on top of what is generally excellent control from Bt corn rootworm hybrids would be redundant and probably uneconomical," says Ken Ostlie, University of Minnesota Extension entomologist. He says that in Minnesota, this layering approach to corn rootworm control amounts to taking out an expensive insurance policy to protect against lodging.

Redundant and unnecessary is also the way Marlin Rice, Iowa State University Extension entomologist characterizes this two-pronged corn rootworm control approach. "Occasionally a Bt corn rootworm hybrid will stumble and we will be at a loss as to why that happens, but it is an extremely unlikely event," says Rice. "I would question spending an additional $12-15/acre on a soil insecticide…”
Comparative Performance of Bt CRW Events against Corn Rootworms: 2008

**Design:** Factorial combinations of 4 CRW management options (None, Force 3G, Bt RW, Bt RW + Force3G) with two genetic platforms: YieldGard VT3, Herculex RW. Note: Permission was denied to use Agrisure hybrids in this study.

**Soil insecticide:** Applied either IF or as T-band depending on weather conditions at 4oz/1000 row-t.

**Seed treatment:** Poncho 250 on all seed.

**Locations:** Fields chosen with various corn rootworm histories:
- Continuous corn – Rosemount, Waseca
- 2nd year corn – Cleveland
- Rotated corn
  - No Bt-RW history - Glencoe, Heron Lake
  - Bt-RW history – Granite Falls

**Data collected:** root protection, lodging, yield, and corn rootworm emergence

**Funding:** Rapid Agricultural Response Fund, MN Corn Research & Promotion Council
Yield Response to Corn Rootworm Management: YieldGard VT3 and Force

**MINNEAPOLIS - 2008**

*Strong thunderstorms on Aug. 7 led to green snap and/or root lodging.*
Relative Performance of Bt-RW Corn and Soil Insecticides  
*U of MN Studies, 2006-8*

<table>
<thead>
<tr>
<th>Event (Trials)</th>
<th>CRW Mgmt. Tactic</th>
<th>Yield Benefit (bu/A)</th>
<th>Confidence Limit (bu/A)</th>
<th>t-Value</th>
<th>Prob. &gt; t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>YieldGard Plus &amp; VT3 (N=21)</td>
<td>Force 3G</td>
<td>5.22</td>
<td>-0.22, 10.66</td>
<td>2.00</td>
<td>0.0590</td>
</tr>
<tr>
<td></td>
<td>Bt-RW</td>
<td>9.01</td>
<td>2.30, 15.73</td>
<td>2.80</td>
<td>0.0110</td>
</tr>
</tbody>
</table>

- **Application of Force to non-Bt RW hybrids significantly increased yield.**
- **Yield response to protection by the YieldGard RW trait was also significant across these 21 sites.**
- **Force 3G provided 85% of yield protection provided by the Bt-RW trait.**
Yield Response to Corn Rootworm Management: Herculex Xtra and Force

*Strong thunderstorms on Aug. 7 led to green snap or root lodging.*
Relative Performance of Bt-RW Corn and Soil Insecticides  
*U of MN Studies, 2006-8*

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<tr>
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<th>CRW Mgmt. Tactic</th>
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<th>Confidence Limit (bu/A)</th>
<th>t-Value</th>
<th>Prob. &gt; t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herculex Xtra (N=16)</td>
<td>Force 3G</td>
<td>5.58</td>
<td>-0.05, 11.21</td>
<td>2.11</td>
<td>0.0517</td>
</tr>
<tr>
<td></td>
<td>Bt-RW</td>
<td>8.66</td>
<td>1.01, 16.30</td>
<td>2.41</td>
<td>0.0290</td>
</tr>
</tbody>
</table>

- Application of Force to non-Bt RW hybrids significantly increased yield.
- Yield response to protection by the Herculex Xtra was also significant across these 16 sites.
- Force 3G provided 64% of yield protection provided by the Bt-RW trait.
Factors Confounding Yield Response to Bt-RW Corn and Soil Insecticides

- Drought conditions: Affects germination, reduces stalk/root growth, enhances rootworm survival, accelerates corn and rootworm development, accentuates impacts of silk clipping
- Excessive spring moisture: Reduces stand, decreases larval survival (direct = drowning, indirect = delayed planting), delays corn rootworm development
- Strong summer thunderstorms: Causes root lodging and green snap
- Soil fertility: Deficiencies amplify growth and yield impacts, higher early-season N may reduce intensity of root injury
- Planting date: Reduced root injury vs reduced yield potential with delayed planting
- Weeds and volunteer corn: Affects rootworm survival & corn yield
Insecticide Options for Managing Corn Rootworm Injury

**Granules**
- Aztec 2.1G, 4.67G*
- Counter 15G
- Empower² 1.15G
- Force 3G*
- Fortress 2.5G, 5G*
- Lorsban 15G***
- Thimet 15G & 20G

* Available in SmartBox
*** EPA Reviewing Petition To Cancel all Uses

**Liquids**
- Capture 2E / LFR**
- Force CS**
- Furadan 4F
- Regent 4SC**
  ** Mix w/ starter fertilizer

**Seed Treatments**
- Cruiser
- Poncho
Insecticides provided partial yield protection, ca. 7 bu/A, while Bt-RW trait provided 13.5 bu/A. No differences between insecticides.
Corn Root Protection: Insecticides vs Bt-RW Corn

Zone of Root Protection For T-band Insecticide

Zone of Root Protection For Bt-RW Protein
What’s the Prognosis of Extended Diapause Problems for 2009?

Remember: We’ll be dealing with eggs laid by 2007 corn rootworm beetles in rotated corn and by 2006-8 beetles in continuous corn!
Corn Rootworm Risk in MN Rotated Corn

B. Potter from MDA Survey Data

MDA Plant Pest Survey Program has changed its survey procedures. Relevance of 2006, 2007 and 2008 data for maps is questionable. If you would like to express your opinion on this survey, contact: Robert Koch (651-201-6505) Robert.Koch@state.mn.us
A New Complication?
Corn Rootworm Egglaying
Near RoundUp Ready® Volunteer Corn
Seasonal Corn Rootworm Captures on Pherocon AM Sticky Traps
Rosemount, MN (July 12 – Sept. 12, 2007)

Seasonal Captures per Trap

Western Corn Rootworms

Captures/Trap/Day

Volunteer Corn Density (1000s/A)

Yield (bu/A)
Comparative Efficacy of Bt - RW Events Against WCR and NCR - Rosemount 2007

◆ **Design:** Factorial combinations of 3 Bt-RW events (YieldGard VT3 – DK 5259, Herculex Xtra – P37Y14, Agrisure – N45A5) and their isolines (DK5263, P37Y13, N45A6) from the same genetic family.

◆ **Soil insecticide:** 2007 - Force 3G only on non-Bt N45A6.

◆ **Seed treatment:** Poncho 250 on all seed.

◆ **Tents:** Erected July 2-3, re-setup on July 5-6 after significant lodging. Covered ca. 80 plants, replicated 3 times.

◆ **Data collected:** Beetles collected ca. 3X per week.

◆ **Funding:** Rapid Agricultural Response Fund, MN Corn Research & Promotion Council, & Syngenta
# Comparative Efficacy of Bt-RW Events

**Minnesota - 2007**

<table>
<thead>
<tr>
<th>Hybrid Family / Event</th>
<th>Western Corn Rootworm</th>
<th>Northern Corn Rootworm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Refuge Hybrid</td>
<td>Bt-RW Hybrid</td>
</tr>
<tr>
<td>DK 5263/5259 VT3</td>
<td>3017a</td>
<td>129d</td>
</tr>
<tr>
<td>P37Y13/14 Herculex Xtra</td>
<td>2672a</td>
<td>100d</td>
</tr>
<tr>
<td>NK45A6/5 Agrisure</td>
<td>2806a</td>
<td>416c</td>
</tr>
<tr>
<td>NK45A6 + Force 3G</td>
<td>1017b</td>
<td>63.8</td>
</tr>
</tbody>
</table>

Means followed by the same letter do not differ statistically (p<0.05).
Comparative Efficacy of Bt-RW Events Against NCR

**Design:** Factorial combinations of 3 Bt-RW events (YieldGard VT3, Herculex Xtra, Agrisure) and their isolines from the same genetic family.

**Soil insecticide:** Force 3G only on both Bt-RW and non Bt-RW hybrids.

**Seed treatment:** Poncho 250 on all seed.

**Traps:** Placed in field July 2-3 with each covering two plants, 4 cages per plot, replicated 4 times.

**Data collected:** Beetles collected three times per week. Identified by species and sex.

**Funding:** Rapid Agricultural Response Fund, MN Corn Research & Promotion Council
# How Well do Bt-RW Events Perform Against Northern Corn Rootworms?

<table>
<thead>
<tr>
<th>Hybrid Family / Event</th>
<th>Northern Corn Rootworm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Refuge Hybrid</td>
</tr>
<tr>
<td>DK 5263/5259 VT3</td>
<td>545</td>
</tr>
<tr>
<td>P37Y13/14 Herculex Xtra</td>
<td>418</td>
</tr>
<tr>
<td>N40T Agrisure</td>
<td>297</td>
</tr>
</tbody>
</table>

Data represents sum of seasonal emergence from 16 traps covering 32 plants.

*Sponsored by MN Corn Research & Promotion Council

MN Legislative Rapid Agricultural Response Fund
How Well do Bt-RW Events Perform Against Northern Corn Rootworms?

*Efficacy expressed as % of emergence in refuge hybrid.
Will You Help Us Get a Handle on CRW Risk and Bt-RW Benefits?

1. Scout a Bt-RW and refuge corn to generate a MN map of corn rootworm pressure.
2. Compare Bt-RW and refuge with on-farm strip trials (pressure, lodging, yield, and harvest times.)
Your Challenge: Getting a Handle on Risk!

Count Beetles!  
Dig Roots!  
Test Strips!
Your Challenge:
Watch Out for Resistance

Dig Roots!
Any Questions?