STUDY: 2017 Rootworm Insecticide on Refuge Hybrid

INVESTIGATOR:
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Travis Vollmer – University of Minnesota Southwest Research and Outreach Center

OBJECTIVE:
Efficacy evaluation of liquid and granular soil insecticide products for corn rootworm as in-furrow treatments in refuge corn.

CROP INFORMATION
Crop: Corn (zea mays)  Cultivar: Dekalb DKC 53-58 GENVT2PRIB
History:
2013: Corn  2014: Corn  2015: Corn  2016: Corn

PEST INFORMATION
This site had a history of Cry 3Bb1 failure in 2015. Western corn rootworm dominated the populations with very few northern corn rootworm adults observed on the studies’ corn plants or Trece Pherocon® AM traps in 2016 and 2017.

SITE INFORMATION
Location: University of Minnesota Southwest Research and Outreach Center
Lamberton, Redwood County, Minnesota

Soil fertility (2016 sample):
Name: Normania loam
% OM: 4.7  pH: 6.0
P (bray): 21 ppm  K: 104 ppm  Zn: 1.0 ppm

PLANTING INFORMATION
Planting Date: 5/11/2017  Emergence Date: 5/23/2017
Planting Equipment: John Deere (Moline, IL) Max Emerge 4-row narrow planter modified for plot planting with a Precision Planting LLC (Tremont, IL) vacuum system and vSet meters.
Row Spacing: 30-inch  Seeding Rate: 34,000 seeds/acre  Seeding Depth: 2 inch
Soil Temperature: 64°F  Soil Moisture: Dry
Precipitation: Above-average growing season precipitation after planting

PLOT MAINTENANCE
Tillage Fall 2016: Disc Ripper  Tillage Spring 2017: Field cultivator
Fertilizer: 5/10/17
PRE Herbicide: 5/10/17  Harness – 2.6 pts/A
POST Herbicide: 6/19/17  Cornerstone Plus–36 fl. oz./A
Insecticide: 5/11/17  Part of study. See Treatment List
HARVEST INFORMATION
Harvest equipment: Plot combine (ALMACO, Nevada, IA).
The center two rows of each four-row plot were combined. Grain yields were adjusted to 15.5% moisture and 56 pounds/bushel.

EXPERIMENTAL DESIGN
Study Design: Randomized Complete Block Treatments: 14 Replications: 4
Treated Plot Width: 10 foot (four 30-inch rows) Treated Plot Length: 30 foot

TREATMENTS EVALUATED
The insecticides and other products and application rates tested are listed in Table 1 below.

<table>
<thead>
<tr>
<th>Trt. No.</th>
<th>Type</th>
<th>Trade Name</th>
<th>Compound(s)</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Untreated control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Insecticide</td>
<td>Index™</td>
<td>chlorethoxyfos+bifenthrin</td>
<td>12.6 fl. oz./acre</td>
</tr>
<tr>
<td>3</td>
<td>Insecticide</td>
<td>Force® CS</td>
<td>tefluthrin</td>
<td>8.7 fl. oz./acre</td>
</tr>
<tr>
<td>4</td>
<td>Insecticide</td>
<td>Capture®LFR®</td>
<td>bifenthrin</td>
<td>17.1 fl. oz./acre</td>
</tr>
<tr>
<td>5</td>
<td>Insecticide</td>
<td>Aztec® HC</td>
<td>tebuvinphos+cyfluthrin</td>
<td>1.5 oz./1000 row-ft</td>
</tr>
<tr>
<td>6</td>
<td>Insecticide</td>
<td>Smartchoice® HC</td>
<td>chlorethoxyfos+bifenthrin</td>
<td>1.7 oz./1000 row-ft</td>
</tr>
<tr>
<td>7</td>
<td>Insecticide*</td>
<td>Force® 10G HL **</td>
<td>tefluthrin</td>
<td>1.3 oz./1000 row-ft</td>
</tr>
<tr>
<td>8</td>
<td>Insecticide</td>
<td>Ethos® XB</td>
<td>bifenthrin+Bacillus amyloliquefaciens</td>
<td>8.5 fl. oz./acre</td>
</tr>
<tr>
<td>9</td>
<td>Insecticide/Fungicide</td>
<td>Temitry™ LFR®</td>
<td>bifenthrin+pyraclostrobin</td>
<td>9.5 fl. oz./acre</td>
</tr>
<tr>
<td>10</td>
<td>Insecticide + soil amendment</td>
<td>F4022-1(Capture® LFR® + VGR®)</td>
<td>bifenthrin + Bacillus licheniformis</td>
<td>8.5 fl. oz./acre</td>
</tr>
<tr>
<td>11</td>
<td>Insecticide + soil amendment</td>
<td>Puma</td>
<td>bifenthrin</td>
<td>4.0 fl. oz./acre</td>
</tr>
<tr>
<td>12</td>
<td>Insecticide</td>
<td>Capture® LFR®</td>
<td>bifenthrin</td>
<td>5.0 gal/acre</td>
</tr>
<tr>
<td>13</td>
<td>Insecticide</td>
<td>Capture® 3RIVE 3D®</td>
<td>bifenthrin</td>
<td>8.0 fl. oz./a</td>
</tr>
<tr>
<td>14</td>
<td>Insecticide</td>
<td>Capture® 3RIVE 3D®</td>
<td>bifenthrin</td>
<td>16.0 fl. oz./acre</td>
</tr>
</tbody>
</table>

Table 1. Insecticides evaluated. All treatments were applied in-furrow. The liquid insecticide treatments 3 and 4 were applied with 5 GPA water; other liquid insecticides were applied with 5 GPA Nucleus HP liquid pop-up fertilizer.

ASSESSMENT METHODS
Corn rootworm injury:
On August 1, the root systems of five plants were dug in each plot. No effort was made to differentiate refuge plants in selecting or the subsequent rating root systems. After soaking overnight, root systems were power-washed and corn rootworm injury was rated. For each of nodes 5-7, the total roots and the number of roots

Trademarks
Force CS - Syngenta Crop Protection, LLC
Aztec® HC, SmartChoice® HC, Index™, Force 10G - Amvac Chemical Corporation
Capture®LFR®, Capture® 3RIVE 3D®, Ethos® XB, Temitry™ LFR®, VGR® - FMC Corporation
Puma - Elemental Enzymes
Nucleus® HP Hyperlink high performance - Helena

** The Force 10G HL (tefluthrin) formulation is not currently labeled
pruned to 1.5 inches or less were recorded. These data were used to generate 0-3 node injury scores. Additional data on the number of roots pruned less than 3 inches and any scarring caused by rootworm feeding were also recorded.

Root lodging: In this study, lodging associated with corn rootworm damage occurred early and was rated when root injury was assessed. This first rating was a subjective whole plot 0-4 score: 0) no lodging; 1) occasional plants slightly leaning; 2) slight leaning common or some plants lodged more than 45 degrees from vertical; 3) plants with severe lodging common; 4) Most plants severely lodged, some may have root broken and exposed. On August 1, lodging was rated as the percentage of the five plants rated for CRW root injury with goose-necked lower stalks. On October 19, the percentage of plants were by determining the percentage of the plants in the center two rows of each plot lodged. At this last rating, a plant was considered lodged if the ear was lodged so low as to present potential harvest issues.

Stalk lodging:
Stalk rot was a problem in many 2017 fields. This disease was assessed at the same time as root lodging on October 19. In addition to recording stalk lodged plants, stalks were grasped below the ear and given a moderate push. Stalks that collapsed were include in the percentage stalk lodged.

RESULTS
The 2017 growing season was wetter than normal with the last 1/2 of May and the first 1/2 of June averaging 2-3 inches above normal. After planting, 3.98 inches of rainfall occurred from May 16 -21. Western corn rootworm damage was severe in this study as well as the adjacent corn plantings in this field.

Means for yield, corn stand and growth, CRW root injury and root lodging are presented in Table 2.

No differences among treatments in V1 and V5 stage corn stands were observed.

No crop injury was observed for any of the treatments. At the V5 stage, the Capture LFR +VGR treatment was taller than the SmartChoice HC, the shortest treatment. All other heights were similar.

The untreated control was the lowest yielding treatment; significantly lower (p= 0.05) than Index, Force CS, Aztec HC, Force 10G, Temtrity LFR, and both F 4022 -1 treatments.

The untreated control had the most rootworm injury, averaging 1.48 of the 3 rated nodes destroyed. Index, Force CS, Aztec HC, and SmartChoice HC all averaged less than 0.25 NIS. Index and SmartChoice HC most consistently kept NIS less than 0.25, generally accepted as the CRW root injury level where yield loss can occur.

A high percentage of root lodging occurred in some of the plots; both with and without at-plant insecticides. The spatial variability of lodging severity within this study did not allow detection of statistical significance of R1 and R6 lodging among treatments.

High and variable root lodging prevented accurate stalk-lodging assessments and therefore, these data are not shown.

Correlation coefficients of yield with potential yield limiting factors are shown in Table 3. Yield was negatively correlated (p ≤ 0.05) with node injury score (-0.6017), R1 lodging (-0.484) and VT lodging (-0.532). Yield was positively correlated with stand (0.321) and percent consistency of control (0.4498). NIS appeared as a slightly better predictor of yield than control consistency of control in the study. The R6 end-of-season lodging rating was not predicative of yield and not correlated with earlier lodging ratings.
**Table 2.** Means and mean separations for corn stands, yield and for corn rootworm and disease associated injury.  
UMN Southwest Research and Outreach Center, Lamberton, MN 2017.

<table>
<thead>
<tr>
<th>Product</th>
<th>Rate</th>
<th>Yield</th>
<th>V5 Stand</th>
<th>V5 Height</th>
<th>V5 NIS (0-3)</th>
<th>Percent Consist.</th>
<th>VT Lodging</th>
<th>R6 Lodging</th>
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<tr>
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<tr>
<td>Un-treated</td>
<td></td>
<td>1</td>
<td>0.3210</td>
<td>0.1454</td>
<td>0.1739</td>
<td>0.4498</td>
<td>-0.4840</td>
<td>0.011</td>
</tr>
<tr>
<td>2 Index</td>
<td>12.6 fl oz/a</td>
<td></td>
<td></td>
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<tr>
<td>3 Force CS</td>
<td>8.7 fl oz/a</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>4 Capture LFR</td>
<td>17.1 fl oz/a</td>
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<tr>
<td>5 Aztec HC</td>
<td>1.5 oz at 1000 row/ft</td>
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<tr>
<td>6 Smartchoice HC</td>
<td>1.7 oz at 1000 row/ft</td>
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<tr>
<td>7 Force 10G HL</td>
<td>1.3 oz at 1000 row/ft</td>
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<tr>
<td>8 Ethos XB</td>
<td>8.5 fl oz/a</td>
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<tr>
<td>Nucleus HP</td>
<td>5.0 g/a</td>
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<tr>
<td>9 Temmity LFR</td>
<td>8.5 fl oz/a</td>
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<tr>
<td>10 F4022-1</td>
<td>8.5 fl oz/a</td>
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<tr>
<td>11 F4022-1</td>
<td>8.5 fl oz/a</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Puma</td>
<td>4.0 fl oz/a</td>
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<td></td>
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<tr>
<td>Nucleus HP</td>
<td>5.0 g/a</td>
<td></td>
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<td></td>
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<tr>
<td>12 Capture LFR</td>
<td>8.5 fl oz/a</td>
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<tr>
<td>Nucleus HP</td>
<td>5.0 g/a</td>
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</tbody>
</table>

Means followed by same letter or symbol do not significantly differ (P=0.05, Tukey’s HSD) 
Mean comparisons performed only when ADV Treatment P(F) is significant at mean comparison OSL.

**Table 3.** Pearson correlation coefficients and p-values for yield, stand, early season height and CRW injury. Bold probabilities are significant at 0.05 or less.  
UMN Southwest Research and Outreach Center, Lamberton, MN 2017.

**CONCLUSIONS**
2017 weather was optimum for at-plant insecticide performance during this study. Differences in root injury among treatments were observed with Index, Force CS, Aztec HC and SmartChoice HC averaging less than 0.25 NIS. Two of these treatments were liquid. Yield was negatively correlated with root injury from CRW and early season lodging. There was not a rate response between the two rates of Capture LFR. Variable recovery from root lodging (goose-necking) and other early vs. late season impacts of lodging, late season lodging may not always be a good indicator of CRW impacts on yield.
Figure 1. Yield and root nodal injury scores (red dots) for 13 in-furrow insecticides compared to the same hybrid without a Bt-RW trait without insecticide. Yield means with the same letter are not different (p = 0.05 Tuckey's HSD). * = 5 GPA Nucleus HP 8-24-4 liquid fertilizer, in-furrow. Other than capture 3RIVE 3D, all other liquid insecticides were applied with 5 GPA water.

ACKNOWLEDGEMENTS
Matthew Wordes and Adam Hass provided valuable help in plot maintenance and root digs and the root rating process.

We would like to thank Amvac Chemical Corporation and FMC Corporation for supporting this study.

Always read and follow label directions

Aztec® HC, Capture® LFR®, Capture® 3RIVE 3D®, Ethos® XB, Force® CS, SmartChoice® HC and Temitry™ LFR® are Restricted Use insecticides.

Products are mentioned for illustrative purposes only. Their inclusion does not mean endorsement and their absence does not imply disapproval.

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