

# Evaluation of Various Technologies for Management of Larval Corn Rootworm

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### Introduction

The purpose of this study was to evaluate the effectiveness of Bt corn and soil insecticides, either alone or in combination, for management of corn rootworm. Evaluation of Bt hybrids included Agrisure 3000GT, Agrisure 3111, Agrisure 3122 and Herculex XTRA, Pioneer Optimum AcreMax1, Smartstax, and YieldGard VT3. Soil insecticides evaluated were Aztec 2.1G, Aztec-SB 4.67G, Capture LFR 1.5FL, Counter-SB 20G, Force 3G, and SmartChoice-SB 5G.

### Materials and Methods

The corn was planted in an area that had been planted the previous year with a trap crop, which is a mixed-maturity blend with a greater proportion of late-maturing varieties. This trap crop constitutes a favorable environment for adult female rootworm late in the season when other fields are maturing, and results in a high abundance of rootworm larvae the following year. The experimental design for this study was a randomized complete block design with four replications. Treatments were two rows wide × 75 ft long. This study was planted on May 15 at a population of 35,600 seeds/acre. Seeds were pre-bagged and planted with a four-row John Deere Max Emerge™ 7100 integral planter that had 30-in. row spacing.

The granular insecticides Aztec 2.1G and Force 3.0G were applied with modified Noble® metering units mounted on the planter. The Noble units were calibrated in the

laboratory to accurately deliver material at a tractor speed of 4 mph. The Aztec 2.1G was applied with in-furrow placement and the Force 3.0G insecticide was applied with T-band placement. The SmartChoice-SB 5G, Counter-SB 20G, and Aztec-SB 4.67G insecticide treatments were applied with modified SmartBox™ metering units mounted on the planter. The commercial SmartBox™ were removed from their large-base containers and sandwiched between a flat metal plate on the bottom and a custom-made, threaded plastic cap on the top. The bottom plate had been fabricated so that it could slide in and out of the same planter mounting brackets used for the noble units. An inverted 1-liter Nalgene bottle attached to the top provided a secure and sealed container for insecticide for the SmartBox™ units. Clear plastic tubes directed the granular insecticides to both the in-furrow (Furrow) and T-band placement.

The liquid product Capture LFR 1.5FL insecticide was applied at planting with a compressed-air system built directly into the planter by Almaco manufacturing (Nevada, IA). Capture LFR 1.5FL was applied in-furrow and was mixed with starter fertilizer (10-34-0 NPK) as a carrier. This liquid product was applied as ounces/1,000 row feet using Teejet XR80015 spray nozzles at 21 psi to deliver 5 GPA of finished spray at a tractor speed of 4 mph.

Eleven-inch poly-bristle skirts were attached to the frame and positioned so the bristle tips touched the ground. Each row was constantly monitored to ensure that insecticides were applied correctly. Final incorporation was accomplished with drag chains mounted behind the closing wheels.

On June 11, early-season stand counts were measured in all treatments. These were measured by laying a one-inch PVC pipe cut to a length of 17.5 ft (1/1,000 of an acre for 30-in. row spacing) between the two rows and counting the number of plants. Stand counts were taken again on October 10. Measurements for both dates were averaged to provide a single value for stand counts (Table 2).

On July 25, five corn root systems were dug/replication from all treatments for a total of twenty roots/treatment. Prior to leaving the field, excess soil was removed and all roots were labeled with study name, plot number, and row. Roots were transported to the Insectary Building at Iowa State University where they were soaked in water and then washed with a pressurized hose to remove any remaining soil. Roots then were evaluated for rootworm feeding injury following the Iowa State Node-Injury Scale (0-3) (Table 1).

This study was machine harvested on October 10 with a modified John Deere 9410 plot combine. Weights (pounds) and percent moisture were recorded from a HarvestMaster brand plot harvest data collection system. These measurements were converted to bushels/acre of No. 2 shelled corn (56 lb/bushel at 15% moisture) (Table 3).

Percent product consistency (Table 1) was calculated as the percentage of times a treatment limited feeding injury to 0.25 nodes or less (greater injury can result in economic yield loss, especially when plants are moisture stressed).

All data were analyzed with standard ANOVA procedures using SAS 9.3. When a significant

treatment effect was present, pairwise comparisons were made among means with an experiment wise error rate of  $P < 0.05$ .

### **Results and Discussion**

Rootworm pressure at the site was moderate with the untreated checks displaying between 1.0 to 1.35 nodes of root injury on average (Table 1). Significant differences were present among treatments for both root injury and product consistency (Table 1). Both Bt traits and soil-applied insecticides led to a significant reduction in injury. No lodging was observed in any of these treatments.

The dry conditions during the second half of the 2013 growing season likely enhanced some effects of rootworm injury on yield (Table 3). Differences in yield also may have resulted in part from significant differences in stand count among treatments (Table 2). Statistical differences tended to be minimal among corn protected by either a Bt trait, a soil applied insecticide, or both, but yields were significantly lower for the untreated checks compared with the other treatments.

### **Acknowledgements**

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### **Additional Information**

Annual reports for the Iowa Evaluation of Insecticides and Plant-Incorporated Protectants are available online through the Department of Entomology at Iowa State University:

<http://www.ent.iastate.edu/dept/faculty/gassmann/rootworm>.

**Table 1. Comparison of corn rootworm management for noted injury and product consistency, Crawfordsville, Iowa.<sup>1</sup>**

Treatment <sup>2</sup>	Form.	Rate <sup>3</sup>	Placement <sup>4</sup>	Node-injury <sup>5,6,7</sup>	Product consistency <sup>8,9</sup>
Agrisure 3111 + Force	3G	0.15	T-Band	0.01 a	100 a
Agrisure 3122	-----	-----	-----	0.02 ab	100 a
Pioneer OAM1 + Capture LFR + SF	1.5SC	0.10	In-Furrow	0.02 ab	100 a
Pioneer OAM1 + Aztec	2.1G	0.14	In-Furrow	0.02 ab	100 a
Agrisure 3122 + Force	3G	0.15	T-Band	0.03 ab	100 a
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/In-Furrow	0.03 ab	100 a
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/In-Furrow	0.03 ab	100 a
DeKalb Smartstax	-----	-----	-----	0.05 ab	100 a
DeKalb VT3 + Aztec	2.1G	0.14	In-Furrow	0.05 ab	100 a
DeKalb VT3 + Capture LFR + SF	1.5SC	0.10	In-Furrow	0.06 ab	95 a
Pioneer HXX	-----	-----	-----	0.06 ab	100 a
DeKalb VT3 + Starter Fertilizer	-----	-----	In-Furrow	0.07 ab	100 a
Agrisure 3111 + Capture LFR + SF	1.5SC	0.10	T-Band	0.07 ab	100 a
Agrisure 3122 RIB	-----	-----	-----	0.07 ab	90 a
DeKalb VT3	-----	-----	-----	0.08 ab	95 a
DeKalb VT3 PRO RIB + Aztec-SB	4.67G	0.14	SB/In-Furrow	0.08 ab	90 a
Agrisure 3111	-----	-----	-----	0.10 ab	95 a
Pioneer OAM1 + Starter Fertilizer	-----	-----	In-Furrow	0.11 ab	90 a
Pioneer OAM1	-----	-----	-----	0.13 bc	90 a
DeKalb VT3 PRO RIB	-----	-----	-----	0.20 bc	85 a
DeKalb non-RW Bt + Aztec	2.1G	0.14	In-Furrow	0.42 c	70 a
DeKalb non-RW Bt	-----	-----	-----	0.92 d	15 b
Agrisure non-RW Bt	-----	-----	-----	0.94 de	15 b
Pioneer non-RW Bt	-----	-----	-----	1.35 e	5 b

<sup>1</sup>Planted May 15, 2013; evaluated July 30, 2013.

<sup>2</sup>Non-RW Bt=an absence of any Bt trait targeting corn rootworm; SF=Starter Fertilizer (10-34-0) used as carrier with insecticide; DeKalb Smartstax=DeKalb Smartstax (DKC 59-90); DeKalb VT3=YieldGard VT Triple (DKC59-88); DeKalb VT3 PRO RIB=DeKalb brand VT3 PRO RIB (DKC 61-86); DeKalb-non-RW Bt=DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1=Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt=Pioneer Herculex 1 (P0533HR); Pioneer HXX=Pioneer Herculex XTRA (P0533HXX); Agrisure non-RW Bt=Syngenta Agrisure (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111=Syngenta Agrisure (Agrisure N68-3111); Agrisure 3122=Syngenta Agrisure (Agrisure N68-3122); Agrisure 3122 RIB=Syngenta Agrisure RIB (Agrisure N68-3122 RIB).

<sup>3</sup>Insecticide listed as ounces a.i./1,000 row-ft.

<sup>4</sup>In-Furrow and T-Band=insecticide applied at planting time; SB=SmartBox application at planting time.

<sup>5</sup>Chemical and check means based on 20 observations (5 roots/2 rows × 4 replications).

<sup>6</sup>Iowa State Node-Injury scale (0-3). Number of full or partial nodes completely eaten.

<sup>7</sup>Means sharing a common letter do not differ significantly according to Ryan's Q Test ( $P \leq 0.05$ ).

<sup>8</sup>Product consistency=percentage of times nodal injury was 0.25 (1/4 node eaten) or less.

<sup>9</sup>No significant differences between means (ANOVA,  $P \leq 0.05$ ).

**Table 2. Comparison of rootworm management for stand count, Crawfordsville, IA.<sup>1</sup>**

<b>Treatment<sup>2</sup></b>	<b>Form.</b>	<b>Rate<sup>3</sup></b>	<b>Placement<sup>4</sup></b>	<b>Stand count<sup>5,6</sup></b>
DeKalb Smartstax	-----	-----	-----	34.25 a
Agrisure 3111 + Force	3G	0.15	T-Band	33.75 ab
Agrisure 3111 + Capture LFR + SF	1.5SC	0.10	T-Band	33.75 ab
Agrisure 3122	-----	-----	-----	33.75 ab
DeKalb VT3 + Capture LFR + SF	1.5SC	0.10	In-Furrow	33.50 abc
Agrisure 3122 + Force	3G	0.15	T-Band	33.25 abc
DeKalb VT3	-----	-----	-----	33.25 abc
DeKalb VT3 PRO RIB	-----	-----	-----	33.00 abcd
Agrisure 3111	-----	-----	-----	33.00 abcd
DeKalb VT3 + Aztec	2.1G	0.14	In-Furrow	32.75 abcde
Agrisure 3122 RIB	-----	-----	-----	32.00 abcde
Agrisure non-RW Bt	-----	-----	-----	32.00 abcde
DeKalb non-RW Bt	-----	-----	-----	31.75 abcde
DeKalb non-RW Bt + Aztec	2.1G	0.14	In-Furrow	31.75 abcde
Pioneer OAM1	-----	-----	-----	31.50 abcde
Pioneer HXX	-----	-----	-----	31.50 abcde
DeKalb VT3 PRO RIB + Aztec-SB	4.67G	0.14	SB/In-Furrow	31.50 abcde
DeKalb VT3 + Starter Fertilizer	-----	-----	In-Furrow	31.25 abcde
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/In-Furrow	31.00 abcdef
Pioneer OAM1 + Aztec	2.1G	0.14	In-Furrow	30.25 bcdef
Pioneer OAM1 + Capture LFR + SF	1.5SC	0.10	In-Furrow	30.00 cdef
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/In-Furrow	29.75 def
Pioneer non-RW Bt	-----	-----	-----	29.50 ef
Pioneer OAM1 + Starter Fertilizer	-----	-----	In-Furrow	28.00 f

<sup>1</sup>Planted May 15, 2013; evaluated June 11 and October 10, 2013.

<sup>2</sup>Non-RW Bt=an absence of any Bt trait targeting corn rootworm; SF=Starter Fertilizer (10-34-0) used as carrier with insecticide; DeKalb Smartstax=DeKalb Smartstax (DKC 59-90); DeKalb VT3=YieldGard VT Triple (DKC59-88); DeKalb VT3 PRO RIB=DeKalb brand VT3 PRO RIB (DKC 61-86); DeKalb-non-RW Bt=DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1=Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt=Pioneer Herculex 1 (P0533HR); Pioneer HXX=Pioneer Herculex XTRA (P0533HXX); Agrisure non-RW Bt=Syngenta Agrisure (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111=Syngenta Agrisure (Agrisure N68-3111); Agrisure 3122=Syngenta Agrisure (Agrisure N68-3122); Agrisure 3122 RIB=Syngenta Agrisure RIB (Agrisure N68-3122 RIB).

<sup>3</sup>Insecticide listed as ounces a.i./1,000 row-ft.

<sup>4</sup>In-Furrow and T-Band=insecticide applied at planting time; SB=SmartBox application at planting time.

<sup>5</sup>Means based on 16 observations (2-row treatment × 17.5 row-ft/treatment × 4 replications × 2 evaluation dates).

<sup>6</sup>Means sharing a common letter do not differ significantly according to Ryan's Q Test ( $P \leq 0.05$ ).

**Table 3. Comparison of rootworm management for yield, Crawfordsville, IA.<sup>1</sup>**

<b>Treatment<sup>2</sup></b>	<b>Form.</b>	<b>Rate<sup>3</sup></b>	<b>Placement<sup>4</sup></b>	<b>Bushels/ acre<sup>5,6,7</sup></b>
DeKalb VT3 PRO RIB + Aztec-SB	4.67G	0.14	SB/In-Furrow	223 a
Agrisure 3111	-----	-----	-----	222 a
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/In-Furrow	220 ab
DeKalb VT3 PRO RIB	-----	-----	-----	219 abc
DeKalb Smartstax	-----	-----	-----	217 abc
DeKalb VT3 + Aztec	2.1G	0.14	In-Furrow	212 abcd
DeKalb VT3 + Capture LFR + SF	1.5SC	0.10	In-Furrow	209 abcde
Agrisure 3111 + Capture LFR + SF	1.5SC	0.10	T-Band	208 abcde
DeKalb VT3	-----	-----	-----	207 abcde
Agrisure 3111 + Force	3G	0.15	T-Band	206 abcde
Agrisure 3122	-----	-----	-----	204 abcde
DeKalb VT3 + Starter Fertilizer	-----	-----	In-Furrow	198 abcde
Agrisure 3122 + Force	3G	0.15	T-Band	197 abcde
Agrisure 3122 RIB	-----	-----	-----	196 abcde
Pioneer HXX	-----	-----	-----	177 abcde
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/In-Furrow	174 abcde
Pioneer OAM1 + Capture LFR + SF	1.5SC	0.10	In-Furrow	166 bcde <sup>8</sup>
Pioneer OAM1 + Aztec	2.1G	0.14	In-Furrow	165 bcde
Pioneer OAM1	-----	-----	-----	165 bcde
Pioneer OAM1 + Starter Fertilizer	-----	-----	In-Furrow	164 cde
DeKalb non-RW Bt + Aztec	2.1G	0.14	In-Furrow	163 cde
DeKalb non-RW Bt	-----	-----	-----	160 def
Agrisure non-RW Bt	-----	-----	-----	155 ef
Pioneer non-RW Bt	-----	-----	-----	122 f

<sup>1</sup>Planted May 15, 2013; machine harvested October 10, 2013.

<sup>2</sup>Non-RW Bt=an absence of any Bt trait targeting corn rootworm; SF=Starter Fertilizer (10-34-0) used as carrier with insecticide; DeKalb Smartstax=DeKalb Smartstax (DKC 59-90); DeKalb VT3=YieldGard VT Triple (DKC59-88); DeKalb VT3 PRO RIB=DeKalb brand VT3 PRO RIB (DKC 61-86); DeKalb-non-RW Bt=DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1=Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt=Pioneer Herculex 1 (P0533HR); Pioneer HXX=Pioneer Herculex XTRA (P0533HXX); Agrisure non-RW Bt=Syngenta Agrisure (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111=Syngenta Agrisure (Agrisure N68-3111); Agrisure 3122=Syngenta Agrisure (Agrisure N68-3122); Agrisure 3122 RIB=Syngenta Agrisure RIB (Agrisure N68-3122 RIB).

<sup>3</sup>Insecticide listed as ounces a.i./1,000 row-ft.

<sup>4</sup>In-Furrow and T-Band=insecticide applied at planting time; SB=SmartBox application at planting time.

<sup>5</sup>Means based on 4 observations (2-row treatment × 68 row-ft/treatment × 4 replications).

<sup>6</sup>Means sharing a common letter do not differ significantly according to Ryan's Q Test ( $P \leq 0.05$ ).

<sup>7</sup>Yields converted to 15% moisture.

<sup>8</sup>Mean based on 3 observations (2-row treatment × 68 row-ft/treatment × 3 replications).