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Aaron J. Gassmann

Iowa State University, aaronjg@iastate.edu

Patrick J. Weber

Iowa State University, pjweber@iastate.edu

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Abstract

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 Smartstax, YieldGard VT3, Pioneer Optimum AcreMax1, Agrisure 3000GT, and Herculex XTRA. Soil insecticides evaluated were SmartChoice-SB 5G, Counter-SB20G, Aztec-SB 4.67G, Lorsban 15G, Capture LFR1.5FL, Aztec 2.1G, and Force 3G and 250CS.

Keywords

Entomology

Disciplines

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Evaluation of Bt Corn and Soil Insecticides for Management of Corn Rootworm

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Aaron Gassmann, assistant professor
Patrick Weber, agricultural specialist
Department of Entomology

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 Smartstax, YieldGard VT3, Pioneer Optimum AcreMax1, Agrisure 3000GT, and Herculex XTRA. Soil insecticides evaluated were SmartChoice-SB 5G, Counter-SB 20G, Aztec-SB 4.67G, Lorsban 15G, Capture LFR 1.5FL, Aztec 2.1G, and Force 3G and 250CS.

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 and 75 ft long. This study was planted on April 25 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, Force 3.0G, and Lorsban 15G 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. Both the Aztec 2.1G and Lorsban 15G insecticides were applied with in-furrow (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™ units 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 products Force 250CS and Capture LFR 1.5FL insecticides were applied at planting with a compressed-air system built directly into the planter by Almaco manufacturing (Nevada, IA). The liquid product Force 250CS was applied T-band and Capture LFR 1.5FL was applied in-furrow. Both were applied as ounces per 1,000-row ft 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 May 30, early season stand counts were measured in all treatments. These were measured by laying a one-in. PVC pipe cut to a length of 17.5 ft between the two rows and counting the number of plants. Stand counts were taken again on October 3. Measurements for both dates were averaged to provide a single value for stand counts (Table 2). On October 3, plants were scored for lodging and were considered lodged if leaning at least 30 degrees from vertical (Table 3).

On September 28, two root systems were dug per replication from all treatments for a total of eight roots per treatment. Prior to leaving the field, excess soil was removed and all roots were labeled with study name, plot number, and row using a permanent marker. 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 were then evaluated for rootworm feeding injury following the Iowa State Node-Injury Scale (0–3) (Table 1).

This study was machine harvested on October 3 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 percent moisture in Microsoft Excel (Table 4).

Percent product consistency was calculated as the percentage of times a treatment limited feeding injury to 0.25 node 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 high with the untreated checks displaying between 1.5 to greater than 2.5 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. With the exception of Agrisure 3000GT, adding an insecticide on top of the Bt trait did not lead to a significant reduction in root injury. With the exception of the untreated checks, lodging was minimal to absent (Table 3).

The dry conditions in 2012 led to lower yields and contributed to some effects of rootworm injury reducing yield (Table 4). Differences in yield also may have resulted in part from significant differences in stand count among treatments (Table 3). Statistical yield differences tended to be minimal among corn protected by either a Bt trait or a soil applied insecticide but were significantly lower for the untreated checks. Furthermore, no significant differences in yield were present for Bt traits with an insecticide versus without an insecticide.

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Additional Information

Annual reports for the Iowa Evaluation of Insecticides and Plant-Incorporated Protectants are available through the Iowa State University Department of Entomology <http://www.ent.iastate.edu/>.

Table 1. Comparison of corn rootworm management for node injury and product consistency, Crawfordsville, IA.¹

Treatment ²	Form.	Rate ³	Placement ⁴	Node-injury ^{5,6,7}	Product consistency ^{7,8}
Agrisure 3000GT + Counter	20G	0.90	SB/In-furrow	0.08a	100a
DeKalb VT3 + Capture LFR	1.5FL	0.09	In-furrow	0.14ab	88ab
Pioneer OAM1 + Capture LFR	1.5FL	0.09	In-furrow	0.18ab	88ab
DeKalb VT3 + Aztec	2.1G	0.14	In-furrow	0.19ab	63abcd
Mycogen Smartstax	---	---	---	-0.29abc	63abcd
DeKalb VT3	---	---	---	-0.29abc ⁹	75abc
Pioneer HXX + SmartChoice	5G	0.25	SB/In-furrow	0.33abc	88ab
Pioneer non-RW Bt + Aztec	4.67G	0.14	SB/In-furrow	0.37abc	63abcd
Pioneer non-RW Bt + Force	250CS	0.12	T-band	0.55abcd	13 cd
Pioneer OAM1	---	---	---	0.61abcd	38abcd
Pioneer OAM1 + Force	3.0G	0.12	T-band	0.62 bcd	13 cd
Pioneer HXX	---	---	---	0.66 bcd	25 bcd
Pioneer non-RW Bt + Lorsban	15G	0.18	In-furrow	0.71abcd	50abcd
Mycogen HXX	---	---	---	0.84 cd	13 cd
Agrisure 3000GT	---	---	---	1.10 d	75abc
DeKalb non-RW Bt	---	---	---	1.59 d	25 bcd
Mycogen non-RW Bt	---	---	---	2.44 e	0 d
Pioneer non-RW Bt	---	---	---	2.52 e	0 d
Agrisure non-RW Bt	---	---	---	2.63 e	0 d

¹Planted April 25, 2012; evaluated September 28, 2012.

²Mycogen HXX = Mycogen brand Herculex XTRA (Mycogen 2K592); Mycogen non-RW Bt = Mycogen brand RR2 (Mycogen 2K591); Mycogen Smartstax = Mycogen Smartstax (Mycogen 2K594); DeKalb VT3 = YieldGard VT Triple (DKC59-88); DeKalb non-RW Bt = DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1 = Pioneer refuge in a bag (P0461 AMX-R); Pioneer non-RW Bt = Pioneer Herculex 1 (P0987HR); Pioneer HXX = Pioneer Herculex XTRA (P0987XR); Agrisure non-RW Bt = Syngenta (Golden Harvest brand) glyphosate tolerant hybrid (Agrisure H-8969 GT); Agrisure 3000GT = Syngenta (Golden Harvest brand) rootworm hybrid (Agrisure H-8969 3000GT).

³Insecticide listed as ounces a.i. per 1,000 row-ft.

⁴In-furrow and T-band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Chemical and check means based on 8 observations (2 roots/2 rows × 4 replications).

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

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

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

⁹This mean based on 16 observations (2 roots/2 rows × 8 replications).

Table 2. Comparison of rootworm management for stand count, Crawfordsville, IA.¹

Treatment²	Form.	Rate³	Placement⁴	Stand count^{5,6}
Pioneer non-RW Bt + Aztec	4.67G	0.14	SB/In-furrow	33.50a
Pioneer OAM1 + Capture LFR	1.5L	0.09	In-furrow	32.75ab
Pioneer OAM1	---	---	---	32.25abc
Pioneer HXX + SmartChoice	5G	0.25	SB/In-furrow	29.50abcd
Pioneer HXX	---	---	---	29.25abcd
Pioneer non-RW Bt + Force	250CS	0.12	T-band	28.75abcd
DeKalb VT3	---	---	---	28.25abcd ⁷
DeKalb non-RW Bt	---	---	---	28.00abcde
Pioneer OAM1 + Force	3.0G	0.12	T-band	27.25 bcde
DeKalb VT3 + Aztec	2.1G	0.14	In-furrow	27.25 bcde
Pioneer non-RW Bt	---	---	---	26.75 cdef
DeKalb VT3 + Capture LFR	1.5FL	0.09	In-furrow	26.50 cdef
Pioneer non-RW Bt + Lorsban	15G	0.18	In-furrow	26.50 cdef
Mycogen HXX	---	---	---	26.00 def
Agrisure 3000GT	---	---	---	26.00 def
Mycogen non-RW Bt	---	---	---	25.75 def
Mycogen Smartstax	---	---	---	24.75 def
Agrisure non-RW Bt	---	---	---	22.25 ef
Agrisure 3000GT + Counter	20G	0.90	SB/In-furrow	21.75 f

¹Planted April 25, 2012; evaluated May 30 and October 3, 2012.

²Mycogen HXX = Mycogen brand Herculex XTRA (Mycogen 2K592); Mycogen non-RW Bt = Mycogen brand RR2 (Mycogen 2K591); Mycogen Smartstax = Mycogen Smartstax (Mycogen 2K594); DeKalb VT3 = YieldGard VT Triple (DKC59-88); DeKalb non-RW Bt = DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1 = Pioneer refuge in a bag (P0461 AMX-R); Pioneer non-RW Bt = Pioneer Herculex 1 (P0987HR); Pioneer HXX = Pioneer Herculex XTRA (P0987XR); Agrisure non-RW Bt = Syngenta (Golden Harvest brand) glyphosate tolerant hybrid (Agrisure H-8969 GT); Agrisure 3000GT = Syngenta (Golden Harvest brand) rootworm hybrid (Agrisure H-8969 3000GT).

³Insecticide listed as ounces a.i. per 1,000 row-ft.

⁴In-furrow and T-band = insecticide applied at planting time; SB = SmartBox application at planting time.

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

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

⁷This mean based on 32 observations (2-row treatment × 17.5 row-feet/treatment × 8 replications × 2 evaluation dates).

Table 3. Comparison of rootworm management for lodging percent, Crawfordsville, IA.¹

Treatment²	Form.	Rate³	Placement⁴	% Lodging^{5,6}
Pioneer OAM1 + Capture LFR	1.5FL	0.09	In-furrow	0a
Pioneer OAM1	---	---	---	0a
Pioneer non-RW Bt + Force	250CS	0.12	T-band	0a
Pioneer OAM1 + Force	3.0G	0.12	t-band	0a
Agrisure 3000GT + Counter	20G	0.90	SB/In-furrow	0a
Mycogen HXX	---	---	---	0a
Mycogen Smartstax	---	---	---	0a
DeKalb VT3 + Capture LFR	1.5FL	0.09	In-furrow	0a
DeKalb VT3 + Aztec	2.1G	0.14	In-furrow	0a
Pioneer HXX	---	---	---	0a
Pioneer non-RW Bt + Aztec	4.67G	0.14	SB/In-furrow	0a
Agrisure 3000GT	---	---	---	0a
DeKalb VT3	---	---	---	1a ⁷
Pioneer HXX + SmartChoice	5G	0.25	SB/In-furrow	1a
DeKalb non-RW Bt	---	---	---	2ab
Pioneer non-RW Bt + Lorsban	15G	0.18	In-furrow	5ab
Agrisure non-RW Bt	---	---	---	11 ab
Pioneer non-RW Bt	---	---	---	14 bc
Mycogen non-RW Bt	---	---	---	38 c

¹Planted April 25, 2012; evaluated October 3, 2012.

²Mycogen HXX = Mycogen brand Herculex XTRA (Mycogen 2K592); Mycogen non-RW Bt = Mycogen brand RR2 (Mycogen 2K591); Mycogen Smartstax = Mycogen Smartstax (Mycogen 2K594); DeKalb VT3 = YieldGard VT Triple (DKC59-88); DeKalb non-RW Bt = DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1 = Pioneer refuge in a bag (P0461 AMX-R); Pioneer non-RW Bt = Pioneer Herculex 1 (P0987HR); Pioneer HXX = Pioneer Herculex XTRA (P0987XR); Agrisure non-RW Bt = Syngenta (Golden Harvest brand) glyphosate tolerant hybrid (Agrisure H-8969 GT); Agrisure 3000GT = Syngenta (Golden Harvest brand) rootworm hybrid (Agrisure H-8969 3000GT).

³Insecticide listed as ounces a.i. per 1,000 row-ft.

⁴In-furrow and T-band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Means based on 8 observations (2-row treatment × 17.5 row-ft/treatment × 4 replications).

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

⁷This mean based on 16 observations (2-row treatment × 17.5 row-ft/treatment × 8 replications).

Table 4. Comparison of rootworm management for yield, Crawfordsville, IA.¹

Treatment²	Form.	Rate³	Placement⁴	Bushels/ acre^{5,6,7}
Pioneer HXX + SmartChoice	5G	0.25	SB/In-furrow	159a
DeKalb VT3 + Capture LFR	1.5FL	0.09	In-furrow	142ab
Pioneer HXX	---	---	---	139ab ⁸
DeKalb VT3	---	---	---	134ab ⁹
DeKalb VT3 + Aztec	2.1G	0.14	In-furrow	129ab
Mycogen Smartstax	---	---	---	127ab
Pioneer OAM1 + Capture LFR	1.5FL	0.09	In-furrow	125ab
Pioneer non-RW Bt + Force	250CS	0.12	T-band	122ab ⁸
Agrisure 3000GT + Counter	20G	0.90	SB/In-furrow	122ab
Mycogen HXX	---	---	---	119ab
Pioneer OAM1	---	---	---	119ab
Pioneer OAM1 + Force	3.0G	0.12	T-band	118ab
Agrisure 3000GT	---	---	---	117abc
Pioneer non-RW Bt + Aztec	4.67G	0.14	SB/In-furrow	110 bc
Pioneer non-RW Bt + Lorsban	15G	0.18	In-furrow	109 bc
DeKalb non-RW Bt	---	---	---	99 bcd
Pioneer non-RW Bt	---	---	---	82 cde
Agrisure non-RW Bt	---	---	---	73 de
Mycogen non-RW Bt	---	---	---	65 e

¹Planted April 25, 2012; machine harvested October 3, 2012.

²Mycogen HXX = Mycogen brand Herculex XTRA (Mycogen 2K592); Mycogen non-RW Bt = Mycogen brand RR2 (Mycogen 2K591); Mycogen Smartstax = Mycogen Smartstax (Mycogen 2K594); DeKalb VT3 = YieldGard VT Triple (DKC59-88); DeKalb non-RW Bt = DeKalb brand RR Isoline (DKC 59-89); Pioneer OAM1 = Pioneer refuge in a bag (P0461 AMX-R); Pioneer non-RW Bt = Pioneer Herculex 1 (P0987HR); Pioneer HXX = Pioneer Herculex XTRA (P0987XR); Agrisure non-RW Bt = Syngenta (Golden Harvest brand) glyphosate tolerant hybrid (Agrisure H-8969 GT); Agrisure 3000GT = Syngenta (Golden Harvest brand) rootworm hybrid (Agrisure H-8969 3000GT).

³Insecticide listed as ounces a.i. per 1,000 row-ft.

⁴In-furrow and T-band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Means based on 4 observations (2-row treatment × 68 row-feet/treatment × 4 replications).

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

⁷Yields converted to 15 percent moisture.

⁸These means based on 3 observations (2-row treatment × 68 row-feet/treatment × 3 replications).

⁹This mean based on 8 observations (2-row treatment × 68 row-feet/treatment × 8 replications).