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Abstract

The purpose of this study was to evaluate the effectiveness of Bt corn, with and without soil insecticides, for management of corn rootworm. Evaluation of Bt hybrids included Agrisure 3000GT, Agrisure 3122 RIB, DeKalb YieldGard VT3, and Pioneer Optimum AcreMax1. Soil insecticides evaluated were Aztec 2.1G, Aztec-SB 4.67G, Capture LFR 1.5SC, Counter-SB 20G, Force 250CS, and SmartChoice-SB 5G.

Keywords

Entomology

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences | Entomology | Natural Resources and Conservation

Evaluation of Bt Corn and Soil-applied Insecticides for Management of Corn Rootworm Larvae

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Introduction

The purpose of this study was to evaluate the effectiveness of Bt corn, with and without soil insecticides, for management of corn rootworm. Evaluation of Bt hybrids included Agrisure 3000GT, Agrisure 3122 RIB, DeKalb YieldGard VT3, and Pioneer Optimum AcreMax1. Soil insecticides evaluated were Aztec 2.1G, Aztec-SB 4.67G, Capture LFR 1.5SC, Counter-SB 20G, Force 250CS, and SmartChoice-SB 5G.

Materials and Methods

The study was conducted in a field 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 study was a randomized complete block design with four replications. Treatments were two rows wide and 75 ft in length. This study was planted on May 7 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 insecticide Aztec 2.1G was 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 insecticide was applied with

in-furrow 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. These 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. An inverted 1-liter bottle provided a sealed container for insecticide for the SmartBox™ units. Plastic tubes directed the granular insecticides to the in-furrow placement. The liquid product Capture LFR 1.5FL was applied in-furrow and Force 250CS insecticide was applied T-Band at planting with a compressed-air system built directly into the planter by Almaco manufacturing (Nevada, IA). Capture LFR and Force CS were applied as ounces per 1,000 row feet using Teejet XR80015EVS spray nozzles at 21 psi to deliver 5 GPA of finished spray at a tractor speed of 4 mph. The liquid product Capture LFR 1.5SC was mixed with starter fertilizer (10-34-0 NPK) while Force CS used water as the carrier.

Eleven-inch poly-bristle skirts were 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 6, early-season stand counts were measured in all treatments. These were measured by laying a stand count chain length 17.5 ft long (1/1,000 of an acre for 30-in. row spacing) between the two corn rows and counting the number of plants in both rows. Late-season stand counts were measured October 9 by laying a one-inch PVC pipe cut to a length of 17.5 ft between the two corn

rows and counting the plants in both rows. Measurements for both dates were averaged to provide a single value for stand counts (Table 2).

On July 28, five root systems were dug per replication from all treatments for a total of 20 roots/treatment. Prior to leaving the field, excess soil was removed and all roots were labeled. 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).

On October 9, lodging counts were taken (Table 3). A plant was considered lodged if it was leaning at least 30 degrees from vertical.

This study was machine harvested October 21 with a modified John Deere 9450 plot combine. Weights (pounds) and percent moisture were recorded from Avery-Weigh Tronix load cell bars with an XL900 weigh scale indicator and a Shivvers 5010 Moisture meter data collector. These measurements were converted to bushels/acre of No. 2 shelled corn (56 lb/bushel) at 15.5 percent moisture in Excel (Table 4).

Percent product consistency (Table 1) 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 this location was moderate to heavy, with the untreated checks displaying between 1.6 to 1.9 nodes of root injury. Past research at Nashua has found resistance by Western corn rootworm to Bt toxin Cry3Bb1, which is the rootworm active Bt toxin in YieldGard VT3. Past research also has found cross-resistance between Cry3Bb1 and mCry3A, which is the rootworm active Bt toxin in Agrisure 3000GT. The presence of resistance to Cry3Bb1 and mCry3A is reflected in the root injury observed in this study. Injury to 3000GT was 1.6 nodes and did not differ from the untreated checks (Table 1). Similarly, injury to VT3 was significantly greater than all other rootworm treatments (Table 1). To date, no resistance to Cry34/35Ab1 has been found at Nashua and this Bt toxin is present in Pioneer OAM1 and Agrisure 3122. In general, similar performance was observed among non-rootworm Bt corn with Aztec, OAM1, and 3122. In some cases, combining soil-applied insecticide with Bt corn reduced injury, but in other instances, this was not observed. Among rootworm treatments, yields were lowest for YieldGard VT3 and Agrisure 3000GT, and these did not differ from the untreated checks (Table 4). These reductions in yield were likely the result of high levels of root injury caused by the presence of resistance to mCry3A and Cry3Bb1.

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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. Root injury and product consistency for comparison among multiple products.¹

Treatment ²	Form.	Rate ³	Placement ⁴	Node-injury ^{5,6,7}	Product consistency ^{8,9}
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/Furrow	0.05a	95a
Agrisure 3122 RIB + Force	250CS	0.57	T-Band	0.06a	100a
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/Furrow	0.07ab	95a
DeKalb VT3 + Aztec-SB	4.67G	0.14	SB/Furrow	0.21ab	80ab
Agrisure 3000GT + Force	250CS	0.57	T-Band	0.32 bc	75ab
Agrisure 3000GT + Capture LFR	1.5SC	0.10	Furrow	0.33 c	55ab
DeKalb non-RW Bt + Aztec	2.1G	0.14	Furrow	0.38 c	50ab
Agrisure 3122 RIB	-----	-----	-----	0.40 c	73ab
Pioneer OAM1	-----	-----	-----	0.48 c	45ab
DeKalb VT3	-----	-----	-----	0.77 d	30 bc
Pioneer non-RW Bt	-----	-----	-----	1.66 e	0 c
Agrisure 3000GT	-----	-----	-----	1.67 e	0 c
DeKalb non-RW Bt	-----	-----	-----	1.77 e	0 c
Agrisure non-RW Bt	-----	-----	-----	1.90 e	0 c

¹Planted May 7, 2014; evaluated July 29, 2014

²Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 = YieldGard VT Triple (DKC58-83); DeKalb-non-RW Bt = DeKalb brand VT2PRO Isoline (DKC 59-89); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N53-W3, Glyphosate Tolerant); Agrisure 3122 RIB = Syngenta Agrisure RIB (Agrisure N52W-3122 RIB); Agrisure 3000GT = Syngenta Agrisure Viptera (Agrisure N53W-3000GT).

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

⁴Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Chemical and check means based on 20 observations (5 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 ($\frac{1}{4}$ node eaten) or less.

⁹Means sharing a common letter do not differ significantly according to Ryan's Q Test ($P \leq 0.05$).

Table 2. Stand counts for comparison among multiple products.¹

Treatment ²	Form.	Rate ³	Placement ⁴	Stand count ^{5,6}
Agrisure 3122 RIB + Force	250CS	0.57	T-Band	34.00a
Agrisure 3122 RIB	-----	-----	-----	33.00ab
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/Furrow	32.50ab
Agrisure 3000GT	-----	-----	-----	32.50ab
Agrisure 3000GT + Force	250CS	0.57	T-Band	32.00ab
DeKalb non-RW Bt	-----	-----	-----	31.75qb
DeKalb non-RW Bt + Aztec	2.1G	0.14	Furrow	31.75ab
DeKalb VT3	-----	-----	-----	31.50ab
Pioneer OAM1	-----	-----	-----	31.25ab
Agrisure 3000GT + Capture LFR	1.5SC	0.10	Furrow	31.25ab
DeKalb VT3 + Aztec-SB	4.67G	0.14	SB/Furrow	30.75ab
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/Furrow	30.50ab
Agrisure non-RW Bt	-----	-----	-----	29.75ab
Pioneer non-RW Bt	-----	-----	-----	29.50ab

¹Planted May 7, 2014; evaluated June 6 and October 9, 2014.

²Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 = YieldGard VT Triple (DKC58-83); DeKalb-non-RW Bt = DeKalb brand VT2PRO Isoline (DKC 59-89); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N53-W3, Glyphosate Tolerant); Agrisure 3122 RIB = Syngenta Agrisure RIB (Agrisure N52W-3122 RIB); Agrisure 3000GT = Syngenta Agrisure Viptera (Agrisure N53W-3000GT).

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

⁴Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Chemical and check means 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 ($P \leq 0.05$).

Table 3. Lodging for comparison among multiple products.¹

Treatment ²	Form.	Rate ³	Placement ⁴	Lodging ^{5,6}
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/Furrow	1a
Agrisure 3122 RIB + Force	250CS	0.57	T-Band	3a
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/Furrow	3a
DeKalb VT3 + Aztec-SB	4.67G	0.14	SB/Furrow	4a
DeKalb non-RW Bt + Aztec	2.1G	0.14	Furrow	7a
Agrisure 3122 RIB	-----	-----	-----	9ab
Pioneer OAM1	-----	-----	-----	9ab
Agrisure 3000GT + Force	250CS	0.57	T-Band	13abc
Agrisure 3000GT + Capture LFR	1.5SC	0.10	Furrow	17abcd
DeKalb VT3	-----	-----	-----	30abcd
Agrisure non-RW Bt	-----	-----	-----	44 bcd
Pioneer non-RW Bt	-----	-----	-----	51 cd
Agrisure 3000GT	-----	-----	-----	52 cd
DeKalb non-RW Bt	-----	-----	-----	58 d

¹Planted May 7, 2014; evaluated October 9, 2014.

²Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 = YieldGard VT Triple (DKC58-83); DeKalb-non-RW Bt = DeKalb brand VT2PRO Isoline (DKC 59-89); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N53-W3, Glyphosate Tolerant); Agrisure 3122 RIB = Syngenta Agrisure RIB (Agrisure N52W-3122 RIB); Agrisure 3000GT = Syngenta Agrisure Viptera (Agrisure N53W-3000GT).

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

⁴Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Chemical and check means based on 8 observations (2-row treatment × 17.5 row-feet/treatment × 4 replications).

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

Table 4. Yield for comparison among multiple products.¹

Treatment²	Form.	Rate³	Placement⁴	Bushels/acre^{5,6,7}
DeKalb non-RW Bt + Aztec	2.1G	0.14	Furrow	193a
Agrisure 3000GT + Force	250CS	0.57	T-Band	191a
Pioneer OAM1 + SmartChoice-SB	5G	0.25	SB/Furrow	188ab
Agrisure 3000GT + Capture LFR	1.5SC	0.10	Furrow	180abc
Agrisure 3122 RIB	-----	-----	-----	176abc
Agrisure 3122 RIB + Counter-SB	20G	0.90	SB/Furrow	176abc
Agrisure 3122 RIB + Force	250CS	0.57	T-Band	176abc
DeKalb VT3 + Aztec-SB	4.67G	0.14	SB/Furrow	173abc
Pioneer OAM1	-----	-----	-----	172abcd
DeKalb non-RW Bt	-----	-----	-----	153 bcde
DeKalb VT3	-----	-----	-----	153 bcde
Agrisure 3000GT	-----	-----	-----	147 cde
Pioneer non-RW Bt	-----	-----	-----	140 de
Agrisure non-RW Bt	-----	-----	-----	139 e

¹Planted May 7, 2014; machine harvested October 21, 2014.

²Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 = YieldGard VT Triple (DKC58-83); DeKalb-non-RW Bt = DeKalb brand VT2PRO Isoline (DKC 59-89); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N53-W3, Glyphosate Tolerant); Agrisure 3122 RIB = Syngenta Agrisure RIB (Agrisure N52W-3122 RIB); Agrisure 3000GT = Syngenta Agrisure Viptera (Agrisure N53W-3000GT).

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

⁴Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.

⁵Chemical and check means 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 15.5% moisture.