Comparisons Among Various Tactics for Management of Corn Rootworm Larvae

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Introduction

The purpose of this study was to evaluate the effectiveness of Bt corn and soil insecticide, either alone or in combination, for management of larval corn rootworm. Evaluation of Bt hybrids included Agrisure 3111, DeKalb YieldGard VT3 RIB, and Pioneer Optimum AcreMax1. Evaluation of at-planting, soil-applied insecticides included Aztec-SB 4.67G and Precept 3G.

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 May 4 at a population of 35,600 seed/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 Precept 3G 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 Precept 3G insecticide was applied with in-furrow and T-Band placement. Aztec-SB 4.67G was applied with modified SmartBox™ metering units mounted on the planter. The commercial SmartBox™ units were removed from the 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 it could be used interchangeably with 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 insecticide container for the SmartBox™ units. Clear plastic tubes directed the granular insecticides to the in-furrow placement.

Eleven inch poly-bristle skirts were attached to the frame of the planter 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 29, 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 rows of corn and counting the number of plants in both rows. Late season stand counts were measured September 22 following the same procedure as early season stand counts. Measurements for both dates were averaged to provide a single value for stand counts (Table 2).

On August 11, 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 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 evaluated for rootworm feeding injury following the Iowa State University Node Injury Scale (0–3) (Table 1). Percent product consistency (Table 1) was calculated as the percentage of times a treatment limited feeding injury to 0.25 node or less.

On September 22, lodging was scored for the same plants evaluated during stand counts (Table 3). A plant was considered lodged if it was leaning at least 30 degrees from vertical.

This study was machine harvested October 14 with a modified John Deere 9450 plot combine. Weight (lb) and percent moisture were recorded from a HarvestMaster brand harvest data collection system. These measurements were converted to bushels/acre of No. 2 shelled corn (56 lb/bushel) at 15.5 percent moisture in Excel (Table 4).

All data were analyzed with standard ANOVA procedures using SAS 9.4. 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 Johnson Farm was moderate in 2015. For this study, we observed slightly over 1.5 nodes of root injury to the untreated check, on the 0–3 node injury scale. On average, yield is reduced by 17 percent for each node of roots lost to feeding by rootworm larvae, although this will depend on environmental factors such as water availability.

Unlike many areas in Iowa, the western corn rootworm population at the Johnson Farm has remained susceptible to Cry3Bb1 corn, and we observed good performance among all Bt traits and soil-applied insecticides tested in this study. In general, the goal of larval management is to reduce root injury to below 0.5 to 0.25 nodes. Further reductions below this level typically will cost more for inputs (insecticide or traits) than will be saved in yield.

While single trait Bt corn, including Cry3Bb1 corn (VT3) and mCry3A corn (Agrisure 3111) worked well in this study, many areas in Iowa contain populations of western corn rootworm resistant to these Bt traits. In general, management of corn rootworm larvae in Iowa should include a rotation among several management tactics over time. These include corn pyramided with Cry34/35Ab1 and a second Bt toxin (e.g., Cry3Bb1) targeting rootworm larvae, use of soil-applied insecticides on non-rootworm Bt corn, and rotation of fields out of corn production at least once every five years. By adopting a diversified management approach that includes crop rotation, it is possible to reduce the size of rootworm populations in cornfields and delay the onset of resistance to currently available management tactics.

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. Node injury and product consistency for comparison among multiple products: ISU Johnson Farm, Ames.[1]

Treatment[2]	Form.	Rate[3]	Placement[4]	Node-injury[5,6,7]	Product consistency[8,9]
Pioneer OAM1 + Aztec-SB	4.67G	0.14	SB/Furrow	0.22a	80a
DeKalb VT3 RIB + Aztec-SB	4.67G	0.14	SB/Furrow	0.26ab	70a
DeKalb VT3 RIB	-------	-------	-------	0.27ab	60a
Agrisure 3111 + Aztec-SB	4.67G	0.14	SB/Furrow	0.38ab	70a
Pioneer OAM1	-------	-------	-------	0.39ab	70a
Pioneer non-RW Bt + Aztec-SB	4.67G	0.14	SB/Furrow	0.42ab	60a
Pioneer non-RW Bt + Precept	3G	0.13	T-Band	0.46ab	40ab
Agrisure 3111	-------	-------	-------	0.49 b	45ab
Pioneer non-RW Bt + Precept	3G	0.13	Furrow	0.50ab	40ab
Pioneer non-RW Bt	-------	-------	-------	1.56 c[10]	3 c
Agrisure non-RW Bt	-------	-------	-------	1.73 c	15 bc

[1]Planted May 4, 2015; evaluated August 12 and 13, 2015

[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 RIB = YieldGard VT Triple RIB (DKC 58-83 RIB); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111 = Syngenta Agrisure (Agrisure N68B-3111).

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

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

[5]Chemical and check means based on 20 observations (5 roots/2 rows × 4 replications).

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

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

[8]Product consistency = percentage of times nodal injury was 0.25 (¼ node eaten) or less.

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

[10]This check mean based on 40 observations.

Table 2. Stand counts for comparison among multiple products: ISU Johnson Farm, Ames.[1]

Treatment[2]	Form.	Rate[3]	Placement[4]	Stand counts[5,6]
DeKalb VT3 RIB + Aztec-SB	4.67G	0.14	SB/Furrow	37.75a
Pioneer OAM1 + Aztec-SB	4.67G	0.14	SB/Furrow	37.50ab
Pioneer non-RW Bt + Precept	3G	0.13	T-Band	37.00ab
Pioneer non-RW Bt + Precept	3G	0.13	Furrow	37.00ab
Pioneer non-RW Bt + Aztec-SB	4.67G	0.14	SB/Furrow	37.00ab
Pioneer OAM1	-------	-------	-------	36.25ab
DeKalb VT3 RIB	-------	-------	-------	36.00ab
Pioneer non-RW Bt	-------	-------	-------	36.00ab[7]
Agrisure non-RW Bt	-------	-------	-------	35.75ab
Agrisure 3111 + Aztec-SB	4.67G	0.14	SB/Furrow	35.00ab
Agrisure 3111	-------	-------	-------	34.50 b

[1]Planted May 4, 2015; evaluated May 29 and September 22, 2015.

[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 RIB = YieldGard VT Triple RIB (DKC 58-83 RIB); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111 = Syngenta Agrisure (Agrisure N68B-3111).

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

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

[5]Chemical and check means based on 16 observations (2-row treatment × 17.5 row-feet/treatment × 4 replications × 2 evaluation dates).

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

[7]This check mean based on 32 observations.

Table 3. Lodging for comparison among multiple products: ISU Johnson Farm, Ames.[1]

Treatment[2]	Form.	Rate[3]	Placement[4]	Lodging[5,6]
DeKalb VT3 RIB + Aztec-SB	4.67G	0.14	SB/Furrow	0
Pioneer non-RW Bt + Precept	3G	0.13	T-Band	0
Pioneer OAM1 + Aztec-SB	4.67G	0.14	SB/Furrow	0
Pioneer OAM1	-------	-------	-------	1
DeKalb VT3 RIB	-------	-------	-------	1
Pioneer non-RW Bt + Aztec-SB	4.67G	0.14	SB/Furrow	3
Agrisure 3111 + Aztec-SB	4.67G	0.14	SB/Furrow	3
Agrisure 3111	-------	-------	-------	12
Pioneer non-RW Bt	-------	-------	-------	19[7]
Pioneer non-RW Bt + Precept	3G	0.13	Furrow	20
Agrisure non-RW Bt	-------	-------	-------	23

[1]Planted May 4, 2015; evaluated September 22, 2015.
[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 RIB = YieldGard VT Triple RIB (DKC 58-83 RIB); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111 = Syngenta Agrisure (Agrisure N68B-3111).
[3]Insecticide listed as ounces a.i. per 1,000 row-feet.
[4]Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.
[5]Chemical and check means based on 8 observations (2-row treatment × 17.5 row-feet/treatment × 4 replications).
[6]No significant differences between means (ANOVA, $P \leq 0.05$).
[7]This check mean based on 16 observations.

Table 4. Yield for comparison among multiple products: ISU Johnson Farm, Ames.[1]

Treatment[2]	Form.	Rate[3]	Placement[4]	Bushels/acre[5,6,7]
DeKalb VT3 RIB	-------	-------	-------	226
Agrisure 3111 + Aztec-SB	4.67G	0.14	SB/Furrow	221
Pioneer non-RW Bt + Aztec-SB	4.67G	0.14	SB/Furrow	219
Agrisure 3111	-------	-------	-------	213
Pioneer OAM1	-------	-------	-------	212
Agrisure non-RW Bt	-------	-------	-------	211
Pioneer non-RW Bt + Precept	3G	0.13	Furrow	192
DeKalb VT3 RIB + Aztec-SB	4.67G	0.14	SB/Furrow	191
Pioneer OAM1 + Aztec-SB	4.67G	0.14	SB/Furrow	191
Pioneer non-RW Bt + Precept	3G	0.13	T-Band	187
Pioneer non-RW Bt	-------	-------	-------	180[8]

[1]Planted May 4, 2015; machine harvested October 14, 2015.
[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; DeKalb VT3 RIB = YieldGard VT Triple RIB (DKC 58-83 RIB); Pioneer OAM1 = Pioneer Optimum AcreMax1 (P0533AM1); Pioneer non-RW Bt = Pioneer Herculex 1 (P0533HR); Agrisure non-RW Bt = Syngenta Agrisure GT (Agrisure N68B-GT, Glyphosate Tolerant); Agrisure 3111 = Syngenta Agrisure (Agrisure N68B-3111).
[3]Insecticide listed as ounces a.i. per 1,000 row-feet.
[4]Furrow & T-Band = insecticide applied at planting time; SB = SmartBox application at planting time.
[5]Chemical and check means based on 4 observations (2-row treatment × 68 row-feet/treatment × 4 replications).
[6]No significant differences between means (ANOVA, $P \leq 0.05$).
[7]Yields converted to 15.5% moisture.
[8]This check mean based on 8 observations.