Evaluation of Soil-Applied Insecticide and Bt Corn for Management of Larval Corn Rootworm in Central Iowa

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Introduction

The purpose of this study was to evaluate the effectiveness of Bt corn targeting corn rootworm and soil insecticide, either alone or in combination, for management of larval corn rootworm injury. The Bt trait packages evaluated in this study were DeKalb Smartstax RIB, Pioneer AcreMax Xtreme (AMXT), and Pioneer AcreMax Xtra (AMX). Two soil-applied insecticides Aztec HC and Index CS also were evaluated.

Materials and Methods

Study location. The study was conducted at the Iowa State University (ISU) Bruner Farm. The field site 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.

Field plot design. This study was a randomized complete block design with four replications. Treatments were four rows wide, and 35 ft long. Plots were cut to 30 ft long after planting.

Planting. This study was planted May 31, 2019, using a four-row John Deere Max Emerge™ 7100 Integral Rigid Frame Planter with 30-in. row spacing. The study was planted at a depth of 2 in. with a spacing of 6 in. between seeds (35,600 seed/acre).

SmartBox soil-applied insecticide. Aztec-HC 9.34G insecticide was applied in-furrow 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. An inverted 1 liter plastic bottle attached to the top provided a secure and sealed container for insecticide used by the SmartBox units. Clear plastic tubes directed the granular insecticides to the in-furrow placement.

Liquid soil-applied insecticide. The liquid product, Index 2.80 CS, was applied in-furrow at planting with a compressed-air system built directly into the planter by Almaco manufacturing (Nevada, IA). Index 2.80CS was applied using Teejet XR80015EVS spray nozzles at 21 psi to deliver 5 GPA of finished spray at a tractor speed of 4 mph. The Index 2.80 CS product used water as the carrier.

Before the season, two new spray nozzles were installed per row (T-Band & In-Furrow) and calibrated with water to ensure proper application of product. For the liquid application, each row was checked for correct spray pattern prior to application.

Rows were monitored during application to ensure all insecticides were applied correctly. Final incorporation was accomplished with drag chains mounted behind the closing wheels.

Stand counts. On July 2, 2019, early-season stand counts were measured in all treatments. These were measured by using a 2-in. PVC pipe cut to a length of 17.4 ft (1/1,000 of an acre for 30-in. row spacing) placed between

two rows of corn and the number of plants in both rows counted. Late-season stand counts were measured October 9, 2019, 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).

Root injury. After the majority of corn rootworm larvae had finished feeding, roots were dug August 15, 2019, to assess feeding injury. Prior to leaving the field, all roots were labeled with study name and plot number. Roots were cleaned at the ISU Johnson Farm's root washing station. Roots first were soaked in water for two hours, then washed with a hose to remove any remaining soil. Roots were evaluated August 20, 2019, for rootworm feeding injury following the Iowa State Node Injury Scale (0-3) (Table 1).

Node injury scale (0-3).
0.00 - No feeding injury (lowest rating that can be given).
1.00 - One node (circle of roots), or the equivalent of an entire node, pruned to within 1.5 in. of the stalk or soil line
2.00 - Two nodes pruned
3.00 - Three or more nodes pruned (highest rating that can be given).

Injury between complete nodes pruned was noted as the proportion of the node missing (e.g., 1.50 = one and a half nodes pruned and 0.25 = one quarter of one node pruned).

Yields. This study was machine harvested November 13, 2019, with a modified John Deere 9450 plot combine owned by ISU. Weight (lb) and percent moisture were recorded with a high capacity grain gauge, using 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 (Table 3).

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

Data. Data were analyzed with analysis of variance (ANOVA) in SAS Enterprise Guide 7.1. The treatment means were compared using LSMEAN procedure with an experimentwise error rate of $P < 0.05$.

Results and Discussion

Rootworm feeding injury at this location was moderate, with the untreated check suffering 0.74 nodes of injury on average (Table 1). Although the study was planted later (May 31) than corn is typically planted, the cool spring conditions in 2019 substantially delayed rootworm egg hatch and may have consequently contributed to the presence of reasonable feeding injury to the untreated check.

All treatments had lower root injury than the untreated check. With the exception of AMX, without insecticide, all rootworm treatments reduced injury below 0.50 nodes, which is often used as an economic injury level for corn rootworm, meaning reducing injury below 0.50 will save enough yield to pay for the cost of insecticide or Bt traits.

The reason AMX achieved the smallest reduction in injury was likely due in part to the presence of only one active rootworm trait in this hybrid (Cry34/35Ab1). By contrast, the other Bt hybrids studied had two rootworm active Bt traits (Cry34/35Ab1 and Cry3Bb1).

The rootworm treatments SSX, AMXT, Index, and Aztec all achieved satisfactory reductions in root injury, with average injury of less than 0.5 nodes in these treatments (Table 1). Adding soil-applied insecticide to Bt corn did lead to some statistically significant reductions

in injury. However, the reduction achieved by adding insecticide to Bt corn was between 0.1 and 0.25 nodes (Table 1), which means the amount of yield saved would not compensate for the additional cost of purchasing insecticide, and consequently, is not recommended.

Patterns of product consistency among treatments were similar to root injury (Table 1). Some differences in stand counts were observed with the SSX treatments having significantly fewer plants than the other treatments in some cases (Table 2).

Some differences in yield also were observed (Table 3). The untreated check (AM) had the lowest yield, and this was likely due to that treatment suffering the highest level of root injury.

The lower levels of yield observed for some of the SSX treatments were likely the result of the lower stand counts for those treatments (Tables 2 and 3). The application of insecticide to Bt corn did not lead to an increase in yield for any of the treatment combinations (Table 3).

Acknowledgements

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Additional Information

Annual reports for the Iowa Evaluation of Insecticides and Plant-Incorporated Protectants are available online through the ISU Department of Entomology:
http://www.ent.iastate.edu/dept/faculty/gassmann/rootworm

Table. Average root injury and product consistence for insecticide on RW-Bt corn, ISU Bruner Farm, Boone, IA.[1]

Treatment[2]	Formulation	Rate[3]	Placement[4]	Node-injury[5,6,7]	Product consistency[8]
Dekalb SSTX RIB + Aztec HC	9.34G	0.15	Furrow-SB	0.06a	95a
Dekalb SSTX RIB + Index	2.80CS	0.27	Furrow	0.11ab	85ab
Pioneer AMXT + Index	2.80CS	0.27	Furrow	0.22abc	65abc
Dekalb SSTX RIB	-----	-----	----------	0.25bc	55bcd
Pioneer AMX + Aztec HC	9.34G	0.15	Furrow-SB	0.28c	45cde
Pioneer AM + Aztec HC	9.34G	0.15	Furrow-SB	0.30c	55bcd
Pioneer AMX + Index	2.80CS	0.27	Furrow	0.30c	55bcd
Pioneer AMXT + Aztec HC	9.34G	0.15	Furrow-SB	0.30c	40cde
Pioneer AM + Index	2.80CS	0.27	Furrow	0.36cd	30cde
Pioneer AMXT	-----	-----	----------	0.48de	20de
Pioneer AMX	-----	-----	----------	0.55e	15e
Pioneer AM	-----	-----	----------	0.74f	10e

[1]Planted May 31, 2019; evaluated August 20, 2019.
[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; Pioneer non-RW Bt= Pioneer AcreMax (P1151 AM); DeKalb SSTX RIB = Dekalb brand Smartstax RIB (DKC 60-52); Pioneer AMX = Pioneer AcreMax Xtra (P1151 AMX); Pioneer AMXT = Pioneer AcreMax Xtreme (P1197 AMXT).
[3]All insecticides listed as lb of a.i./acre.
[4]Furrow-SB = insecticide applied in furrow with SmartBox system at planting time; Furrow = insecticide applied in furrow at planting time.
[5]Means based on 20 observations (5 roots/2 rows x 4 replications).
[6]Iowa State Node-Injury scale (0-3). Number of full or partial nodes completely eaten.
[7]Product consistency = percentage of times nodal injury was 0.25 (¼ node eaten) or less.
[8]Significant difference between the treatment means for both node-injury and product consistency (ANOVA, $P < 0.05$).

Table 2. Average stand count for insecticide on RW-Bt corn, ISU Bruner Farm, Boone, IA.[1]

Treatment[2]	Formulation	Rate[3]	Placement[4]	Stand counts[5,6]
Pioneer AM + Aztec HC	9.34GR	1.50	Furrow-SB	25.4a
Pioneer AMX + Index	2.80CS	0.72	Furrow	25.3a
Pioneer AMX + Aztec HC	9.34GR	1.50	Furrow-SB	25.2a
Pioneer AMXT	-----	-----	----------	25.1a
Pioneer AMX	-----	-----	----------	24.9a
Dekalb SSTX RIB + Index	2.80CS	0.72	Furrow	24.2ab
Pioneer AMXT + Index	2.80CS	0.72	Furrow	23.8ab
Pioneer AM	-----	-----	----------	22.6ab
Pioneer AM + Index	2.80CS	0.72	Furrow	22.4ab
Pioneer AMXT + Aztec HC	9.34GR	1.50	Furrow-SB	22.3abc
Dekalb SSTX RIB + Aztec HC	9.34GR	1.50	Furrow-SB	21.4bc
Dekalb SSTX RIB	-----	-----	----------	19.3c

[1]Planted May 31, 2019; evaluated July 2 and October 9, 2019.
[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; Pioneer non-RW Bt= Pioneer AcreMax (P1151 AM); DeKalb SSTX RIB = Dekalb brand Smartstax RIB (DKC 60-52); Pioneer AMX = Pioneer AcreMax Xtra (P1151 AMX); Pioneer AMXT = Pioneer AcreMax Xtreme (P1197 AMXT).
[3]All insecticides listed as lb of a.i./acre.
[4]Furrow-SB = insecticide applied in furrow with SmartBox system at planting time; Furrow = insecticide applied in furrow at planting time.
[5]Data presented as plants per 1/1,000 of an acre.
[6]Significant differences between means (ANOVA, $P < 0.05$).

Table 3. Average yield for insecticide on RW-Bt corn, ISU Bruner Farm, Boone, IA.[1]

Treatment[2]	Formulation	Rate[3]	Placement[4]	Bushels/acre[5,6,7]
Pioneer AMXT	-----	-----	----------	167.4a
Dekalb SSTX RIB + Index	2.80CS	0.72	Furrow	161.3ab
Pioneer AMX + Index	2.80CS	0.72	Furrow	158.4ab
Pioneer AMXT + Index	2.80CS	0.72	Furrow	154.8ab
Pioneer AM + Index	2.80CS	0.72	Furrow	152.5abc
Pioneer AMX + Aztec HC	9.34GR	1.50	Furrow-SB	150.9abc
Pioneer AMX	-----	-----	----------	150.6abc
Pioneer AMXT + Aztec HC	9.34GR	1.50	Furrow-SB	150.3abc
Pioneer AM + Aztec HC	9.34GR	1.50	Furrow-SB	146.9abc
Dekalb SSTX RIB + Aztec HC	9.34GR	1.50	Furrow-SB	146.4abc
Dekalb SSTX RIB	-----	-----	----------	133.3bc
Pioneer AM	-----	-----	----------	123.0c

[1]Planted May 31, 2019; harvested November 13, 2019.
[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm; Pioneer non-RW Bt= Pioneer AcreMax (P1151 AM); DeKalb SSTX RIB = Dekalb brand Smartstax RIB (DKC 60-52); Pioneer AMX = Pioneer AcreMax Xtra (P1151 AMX); Pioneer AMXT = Pioneer AcreMax Xtreme (P1197 AMXT).
[3]All insecticides listed as lb of a.i./acre.
[4]Furrow-SB = insecticide applied in furrow with SmartBox system at planting time; Furrow = insecticide applied in furrow at planting time.
[5]Means based on four observations (4-row treatment x 30 row-ft/treatment x 4 replications).
[6]Significant differences between means (ANOVA, $P < 0.05$)
[7]Yields converted to 15.5% moisture.