Evaluation of Experimental and Registered Soil-Applied Insecticides for Management of Larval Corn Rootworm

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Introduction

The purpose of this study was to evaluate the effectiveness of soil-applied insecticides for management of corn rootworm (*Diabrotica* spp.) larvae. The insecticides evaluated in this study were: Nurizma at two rates, BAS 450UMI, Capture LFR, Force EVO, Aztec 2.1G and Nurizma paired with TWO.O. The corn used for this study was a hybrid that contained no Bt traits targeting larval rootworm. Nurizma, Capture LFR, Force Evo and Aztec 2.1G are all registered by the EPA and available for management of corn rootworm larvae. TWO.O (*Bacillus thuringiensis* strain EX297512) is registered by the EPA for enhancing microbial activity in the soil.

Materials and Methods

Study location. The study was conducted at the Iowa State University (ISU) Northeast Research and Demonstration Farm (NERF). 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 typically 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 feet long. Plots were trimmed to 30 feet in length after planting.

Planting. This study was planted on May 12, 2023 using a four-row John Deere Max Emerge™ 7100 Integral Rigid Frame Planter with 30-inch row spacing. The study planted at a depth of 2 inches, with a spacing of approximately 6 inches between seeds (35,600 seeds per acre).

Liquid soil-applied insecticides. Insecticides were applied in-furrow at planting with a compressed-air system built directly into the planter by Almaco manufacturing (Nevada, IA). All liquid products were applied as ounces per 1000 row feet. Liquid insecticides were applied with a Teejet XR80015EVS spray nozzles at 21 psi to deliver 5 GPA of finished spray at a tractor speed of 4 mph. Before the field season, new spray nozzles were installed and calibrated with water to ensure proper application of product. For these liquid applications, each row was checked for correct spray pattern prior to plot application and monitored during application to ensure that insecticides were applied correctly.

Stand counts. On June 7, 2023, the first set of stand counts were recorded in all treatments. These were measured by using a 2 inch PVC pipe cut to the length of 17.4 feet (1/1,000 of an acre for 30 inch row spacing) that was placed between two rows of corn, with the number of plants in both rows then counted. Late season stand counts were measured on September 26, 2023 following the same procedure as the earlier stand counts. Measurements were averaged to provide a single value for stand counts (Table 2).

Root injury. After the majority of corn rootworm larvae had finished feeding on corn roots, roots were dug to assess feeding injury. Roots were dug on July 27, 2023. Prior to leaving the field, all roots were labeled with

study name and plot number using a permanent marker. On August 2, 2023 roots were cleaned at the ISU Johnson Farm's root washing station. Roots were first soaked in water for 2 to 8 hours and then washed with a hose to remove any remaining soil. After being washed, roots were evaluated 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 inches 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 in between complete nodes pruned was noted as the proportion of the node injured (e.g., 1.50 = one and a half nodes pruned and 0.25 = one quarter of one node pruned).

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).

Lodging counts. Lodging counts were collected on September 26, 2023. A plant was considered lodged if it was leaning greater than 30 degrees from vertical. Lodging counts were taken alongside the stand counts that were collected on the same date. The percent lodging was calculated by dividing the number of lodged plants by the total stand in each plot then multiplied by 100 (Table 3).

Yields. This study was machine harvested on October 11, 2023 with a modified John Deere 9450 plot combine owned by Iowa State University. Weight (pounds) and percent moisture were recorded using a Shivvers brand 5010 moisture meter and Avery-WeighTronix weigh system. These measurements were converted to bushels per acre of No. 2 shelled corn (56 pounds per bushel at 15.5% moisture) in Microsoft Excel. (Table 4)

Data analysis. 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

The 2023 field season at the NERF included drought, with May through August rainfall totals 12 inches below average, and substantial rootworm feeding injury, with the untreated check in this study suffering almost two nodes of root injury (Table 1). The low moisture availability in the soil likely reduced the efficacy of soil-applied insecticide and reduced yields. All treatments experienced significantly lower injury than the untreated experimental control (check), although Aztec had higher root injury than the other insecticidal treatments, with the exception of BAS 450UMI. Only product consistency for Capture was significantly higher than the other treatments, with product consistency not differing among the other treatments or the untreated control (Table 1). Stand counts did not differ among treatments, and there was almost no lodging in this study (Tables 2 and 3). The lack of lodging, despite high levels of rootworm feeding, likely arose from the lack of rainfall events and the dry, hard soils. Yields were significantly higher for Nurizma, Force EVO and Capture LFR compared to the untreated check, but no difference in yield was observed among Aztec 2.1G, BAS 450UMI and the untreated check (Table 4).

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 Plant Pathology, Entomology and Microbiology at Iowa State University:
http://www.ent.iastate.edu/dept/faculty/gassmann/rootworm

Table 1. Average Node Injury and Product Consistency for Insecticide on Non-RW Bt Corn: NERF, Floyd Co.[1]

Treatment[2,3]	Rate[4]	Placement[5]	Node-Injury[6,7,9]	Product Consistency[8,9]
Capture LFR	0.490	In-Furrow	0.48[a]	45.0[a]
Nurizma*	0.075	In-Furrow	0.58[a]	15.0[ab]
Force EVO	0.460	In-Furrow	0.70[a]	20.0[ab]
Nurizma + TWO.O	0.070 + 0.075	In-Furrow	0.76[a]	30.0[sb]
Nurizma	0.070	In-Furrow	0.92[a]	15.0[ab]
BAS 450UMI[10]	0.070	In-Furrow	0.95[ab]	20.0[ab]
Aztec 2.1G	6.700	In-Furrow	1.43[b]	5.0[b]
Check	-----	--------	1.92[c]	0.0[b]

[1] Planted May 12, 2023 evaluated August 2, 2023
[2] Non-RW Bt = an absence of any Bt trait targeting corn rootworm
[3] All treatments used water as a carrier
[4] Liquid insecticides listed as fluid ounces per 1000 row feet; Aztec 2.1G listed as ounces per 1000 row feet
[5] In-Furrow = Insecticides were applied as liquids in furrow at planting time
[6] Means based on 20 observations (5 roots/treatment x 4 replications)
[7] Iowa State Node-Injury scale (0-3). Number of full or partial nodes completely eaten
[8] Product consistency = Percentage of times nodal injury was 0.25 (¼ node eaten) or less
[9] Significant difference between the treatment means for both Node-Injury and Product Consistency (ANOVA, P < 0.05)
[10] BAS 450UMI is an experimental formulation of Nurizma that is compatible with liquid fertilizer
*** Nurizma(0.075) had only 3 replications due to an application issue**

Table 2. Average Stand Count for Insecticide on Non-RW Bt Corn: NERF, Floyd Co.[1]

Treatment[2,3]	Rate[4]	Placement[5]	Stand Counts[6,7]
Nurizma	0.070	In-Furrow	33.9
BAS 450UMI[8]	0.070	In-Furrow	33.7
Force EVO	0.460	In-Furrow	33.6
Aztec 2.1G	6.700	In-Furrow	33.5
Check	-----	--------	33.4
Nurizma + TWO.O	0.070 + 0.075	In-Furrow	33.3
Capture LFR	0.490	In-Furrow	32.9
Nurizma*	0.075	In-Furrow	32.3

[1] Planted May 12, 2023; evaluated June 7 and September 26, 2023
[2] Non-RW Bt = an absence of any Bt trait targeting corn rootworm
[3] All treatments used water as a carrier
[4] Liquid insecticides listed as fluid ounces per 1000 row feet; Aztec 2.1G listed as ounces per 1000 row feet
[5] In-Furrow = Insecticides were applied as liquids in furrow at planting time
[6] Data presented as plants per 1/1000 of an acre
[7] No significant difference between the treatment means (ANOVA, P ≥ 0.05)
[8] BAS 450UMI is an experimental formulation of Nurizma that is compatible with liquid fertilizer
*** Nurizma(0.075) had only 3 replications due to an application issue**

Table 3. Average Percent Lodging for Insecticide on Non-RW Bt Corn: NERF, Floyd Co.[1]

Treatment[2,3]	Rate[4]	Placement[5]	Lodging Counts[6,7]
Aztec 2.1G	6.700	In-Furrow	1.2
Nurizma	0.070	In-Furrow	0.0
Nurizma*	0.075	In-Furrow	0.0
Capture LFR	0.490	In-Furrow	0.0
Check	-----	--------	0.0
Nurizma + TWO.O	0.070 + 0.075	In-Furrow	0.0
BAS 450UMI[8]	0.070	In-Furrow	0.0
Force EVO	0.460	In-Furrow	0.0

[1] Planted May 12, 2023; evaluated September 26, 2023
[2] Non-RW Bt = an absence of any Bt trait targeting corn rootworm
[3] All treatments used water as a carrier
[4] Liquid insecticides listed as fluid ounces per 1000 row feet; Aztec 2.1G listed as ounces per 1000 row feet
[5] In-Furrow = Insecticides were applied as liquids in furrow at planting time
[6] Data presented as percentage of plants from the September 26, 2023 stand count that were lodged
[7] No significant difference between the treatment means (ANOVA, P ≥ 0.05)
[8] BAS 450UMI is an experimental formulation of Nurizma that is compatible with liquid fertilizer
*** Nurizma(0.075) had only 3 replications due to an application issue**

Table 4. Average Yield for Insecticide on Non-RW Bt Corn: NERF, Floyd County[1]

Treatment[2,3]	Rate[4]	Placement[5]	Bushels/Acre[6,7,8]
Nurizma*	0.075	In-Furrow	151.5[a]
Force EVO	0.460	In-Furrow	150.3[a]
Nurizma + TWO.O	0.070 + 0.075	In-Furrow	145.9[ab]
Nurizma	0.070	In-Furrow	142.6[ab]
Capture LFR	0.490	In-Furrow	140.0[ab]
BAS 450UMI[9]	0.070	In-Furrow	134.8[bc]
Aztec 2.1G	6.700	In-Furrow	124.8[c]
Check	-----	--------	121.8[c]

[1] Planted May 12, 2023; machine harvested October 11, 2023 for crop destruct
[2] Non-RW Bt = an absence of any Bt trait targeting corn rootworm
[3] All treatments used water as a carrier
[4] Liquid insecticides listed as fluid ounces per 1000 row feet; Aztec 2.1G listed as ounces per 1000 row feet
[5] In-Furrow = Insecticides were applied as liquids in furrow at planting time
[6] Means based on 4 observations (4-row treatment x 30 row-feet/treatment x 4 replications)
[7] Significant differences between the treatment means (ANOVA, P < 0.05)
[8] Yields converted to 15.5% Moisture
[9] BAS 450UMI is an experimental formulation of Nurizma that is compatible with liquid fertilizer
*** Nurizma(0.075) had only 3 replications due to an application issue**