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Field Test for Effects of Cross-Resistance on Root Injury to Bt Corn by Western Corn Rootworm

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Introduction

Cross-resistance occurs when resistance to one insecticide confers resistance to additional insecticides. Past research has found that western corn rootworm populations in Iowa are resistant to three of the four rootworm Bt traits (Cry3Bb1, mCry3A, and eCry3.1Ab) because of cross-resistance among these traits. The purpose of this study was to better understand the effects of cross-resistance in the field. The Northeast Research and Demonstration Farm represents an area in Iowa in which Cry3Bb1 resistance by western corn rootworm has been present since 2009. To further characterize the effect of Bt-resistance on corn rootworm management, we measured root injury to Agrisure Duracade (mCry3A + eCry3.1Ab), DeKalb YieldGard VT Triple (Cry3Bb1), and Pioneer HXX (Cry34/35Ab1).

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.

Planting. This study used both Bt hybrids and non-rootworm Bt hybrids. The Bt hybrids were Agrisure Duracade N75A-5122A, Pioneer P0448 Herculex XTRA, and DeKalb DKC 58-83 YieldGard VT Triple. The non-rootworm Bt hybrids were Agrisure N75H-GTA, DeKalb DKC 58-89 RIB VT2P, and Pioneer P0488HR. These non-rootworm Bt hybrids were combined in equal proportions to produce the non-rootworm Bt control. All corn was planted with a four-row John Deere Max Emerge™ 7100 Integral Rigid Frame Planter that had 30-in. row spacing. Planting was done at a depth of 2 in., with a spacing of 0.6 in. between seeds (35,600 seeds/acre).

Field plot design. The study was a randomized complete block design with four replications. Treatments were four rows wide and 20 ft in length. These plots were cut down to 10 ft in length to accommodate collection of corn rootworm adult beetles from tents that covered most of these plots. When corn plants reached the height of 5 ft (V10-12), all plants were cut to a height of 1.5 ft above the soil surface, with any remaining leaves left intact. Plants were trimmed to prevent anthesis (pollen production) and to facilitate collection of corn rootworm beetles from within tents. Plots were checked two times per week and any regrowth was removed.

Root injury. After the majority of corn rootworm larvae had finished feeding on corn roots, roots were dug to assess feeding injury. Root digs occurred on August 1, 2016. All remaining plants, located outside of tents being used for collection of adult rootworm, were destroyed at that time. Prior to leaving the field, all roots were labeled with study name and plot number using a permanent marker. Roots were cleaned at the ISU Johnson Farm's root washing station. Roots were first soaked in water for two hours and then washed with a hose to remove any remaining soil. Roots were evaluated

August 2, 2016 for rootworm feeding injury following the Iowa State Node Injury Scale (0-3) (Table 1).

Node injury scale (0-3).

0.0 No feeding injury (lowest rating that can be given).
1.0 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 in between complete nodes pruned was noted as the percentage of the node missing (e.g., 1.50 = one and a half nodes pruned and 0.25 = one quarter of one node pruned).

Data on node injury and product consistency were analyzed with analysis of variance (ANOVA) in SAS 9.4. When a significant treatment effect was present, pairwise comparisons were made among means with an experiment wise error rate of $P < 0.05$.

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 can result in economic yield loss, especially when plants are moisture stressed) (Table 1).

Results and Discussion

Past work has found the presence of resistance to Cry3Bb1 corn by western corn rootworm in Iowa. Additionally, resistance to Cry3Bb1 extends to mCry3A and eCry3.1Ab through cross-resistance, but not to Cry34/35Ab1. The results of this field study were consistent with this past research. Root injury to Duracade corn and VT Triple was significantly higher, and product consistency significantly lower, than HXX corn. These results demonstrate the value of the Cry34/35Ab1 trait for management of rootworm resistant to Cry3Bb1. However, recent work also has found isolated pockets of incomplete resistance to Cry34/35Ab1 in Iowa. Consequently, use of the Cry34/35Ab1 trait will need to incorporate sound insect resistant management and integrated pest management to preserve the efficacy of this trait.

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 Bt corn traits study: Northeast Research and Demonstration Farm, Nashua, IA.[1]

Treatment[2]	Node-injury[3,4,5]	Product consistency[6,7]
Pioneer HXX	0.05a	100a
Agrisure Duracade	0.36 b	50a
DeKalb VT3	0.55 b	40ab
Agrisure, DeKalb, Pioneer non-RW Bt	1.64 c	0 b

[1]Planted April 25, 2016; evaluated August 2, 2016.

[2]Non-RW Bt = an absence of any Bt trait targeting corn rootworm, with the following three non-RW Bt seeds combined in equal proportions: Agrisure non-RW Bt (Agrisure N75H-GTA), DeKalb non-RW Bt (DKC 58-89 VT2P RIB), and Pioneer non-RW Bt (P0488HR). Pioneer HXX = Pioneer Herculex XTRA (P0448HXX); DeKalb VT3 = DeKalb brand YieldGard VT Triple (DKC 58-83); Agrisure Duracade = Agrisure Duracade Artesian (Agrisure N75A-5122A).

[3]Means based on 20 observations (5 roots/4 rows x 4 replications).

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

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

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

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