Integrated pest management for corn rootworm in Iowa

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Introduction

The western corn rootworm (WCR) ***Diabrotica virgifera virgifera*** LeConte and the northern corn rootworm (NCR) ***Diabrotica barberi*** Smith & Lawrence are two significant insect pests of corn in North America. Various pest management options are available to farmers to control rootworm including crop rotation, soil insecticides, and transgenic Bt corn. Crop rotation is effective because rootworm typically lay eggs in corn fields during the fall, which then hatch the next spring and injure corn. If fields are rotated from corn to soybeans, larvae will hatch and starve in the soybean field. Rotation back to corn from soybeans provides a corn field that is free from rootworm eggs. Transgenic rootworm corn produces a Bt toxin that kills rootworm. The Environmental Protection Agency requires that a non-Bt refuge is planted in conjunction with the Bt corn. When possible, crop rotation is the recommended method for managing rootworm. For continuous corn, planting of transgenic corn or use of a soil insecticides is recommended after the first year of corn production. Current questions about these management options include: 1) does the presence of rotation-resistant western corn rootworm threaten the efficacy of crop rotation in Iowa? 2) Will application of a soil insecticide on Bt corn increase yield?

Both rootworm species have recently developed ways to circumvent crop rotation, and rotation-resistant variants of WCR and NCR are present in Iowa. Rotation-resistant NCR oviposits in corn fields and the eggs undergo prolonged diapause for two or more seasons (Steffey et al. 1992). Rotation-resistant WCR oviposit in soybean fields and the eggs hatch the following season (Grey et al. 2009). WCR expressing the rotation-resistant behavior were first observed in east-central Illinois in the late 1980's (O'Neal et al. 1999). The rotation-resistant WCR has expanded its range westward and now occurs in the eastern half of Iowa. In 2008 we conducted a five week survey and collected data on the distribution and abundance of rotation-resistant WCR in Iowa.

Both soil insecticides and transgenic corn protect roots from rootworm injury, and injury to roots protected with either strategy is typically minimal. However, questions arise about the potential benefit of using both a soil insecticide and a transgenic rootworm hybrid in combination. We conducted a field evaluation to test potential benefits using both rootworm transgenic corn and a soil insecticide.

Methods

Rotation-resistance survey

To systematically survey the eastern half of Iowa for rotation-resistant WCR, three transects were created in the northern, central, and southern parts of Iowa. Transects ran from west to east between I-35 and the Mississippi River, following highways 3, 30, and 92 (the northern, central, and southern parts of Iowa, respectively). Two sites were monitored per county along transects, with sites being identified by regional agronomists and cooperators, for a total of 38 sites. At each site Pherocon AM sticky traps were placed in soybean and adjacent corn fields following the University of Illinois protocol (Cook et al. 2005). Twelve sticky traps were placed in corn and soybean fields starting in the last week of July and traps were changed weekly. During the last week of August, sticky traps in corn fields were discontinued and traps in soybean fields were reduced from twelve traps per field to six traps per field. A total of three weekly samples were collected from corn fields and five weekly samples from soybean fields. WCR per trap were counted to calculate the average number of WCR per trap per day at each site.

Field evaluation

The study was conducted in an area that had been planted the previous year with trap crop. The seed planted for the trap crop was a mixed maturity blend with a greater proportion of late-maturing varieties. This trap crop constitutes a favorable environment for adult females late in the season when other fields are maturing and results in a high abundance of rootworm larvae the following year. The experimental design for this study was a split-plot design with four replications. Treatments were eight rows wide, to minimize boarder effects, and 75 feet in length. This study was planted on May 9,2008 by Ryan Rusk from the Sutherland Research and Demonstration Farm at a population of 32,000 seeds per acre. The hybrids studied were VT Triple (DKC 61-69) and a non- Bt near isoline (DKC 61-72). The Poncho 1250 seed treatment was applied commercially on both hybrids tested. The insecticide, Aztec, was applied in furrow at an application rate of 6.7 ounces per 1000 row-ft. Stand counts were taken by counting the number of plants in 17.5 row feet. These stand counts were taken both early and late in the growing season and averaged. After the majority of corn rootworms had finished feeding, five roots were dug per treatment from rows two and five. Roots were evaluated for rootworm feeding injury following the Iowa State Node-Injury Scale (0-3). The percent product consistency was calculated for each treatment as the percentage of times a treatment limited feeding injury to 0.25 nodes or less. Lodging counts were taken at harvest time along with final stand count. A plant was considered lodged if it was leaning at least 30 degrees from vertical. Yields were taken by machine harvesting rows three and four from the plots. Weights were converted to bushels per acre of No. 2 shelled corn at 15.5% moisture.

Results

Rotation-resistance survey

Rotation-resistant WCR, as evidenced by the presence of beetles in soybean fields, were most prevalent along the eastern half of the northern and central transects (Fig. 2A, 2C), but rarely observed along the southern transect (Fig. 2E). WCR were found in cornfields throughout the study area (Fig. 2B, 2D, 2F). The highest recorded WCR per trap per day was recorded at the eastern end of the northern transect during the third week of monitoring (Fig. 2A), averaging 1.0 ±0.15 beetles per day. Occurrence of rotation-resistant WCR at a site was determined based on a consistent presence (at least three of the five weeks monitored) of WCR beetles in soybean fields. The majority of counties monitored on the northern transect met this criterion, as did the eastern counties along the central transect. On the southern transect, only the eastern most site monitored had a consistent presence of WCR in soybean fields (Fig 2).

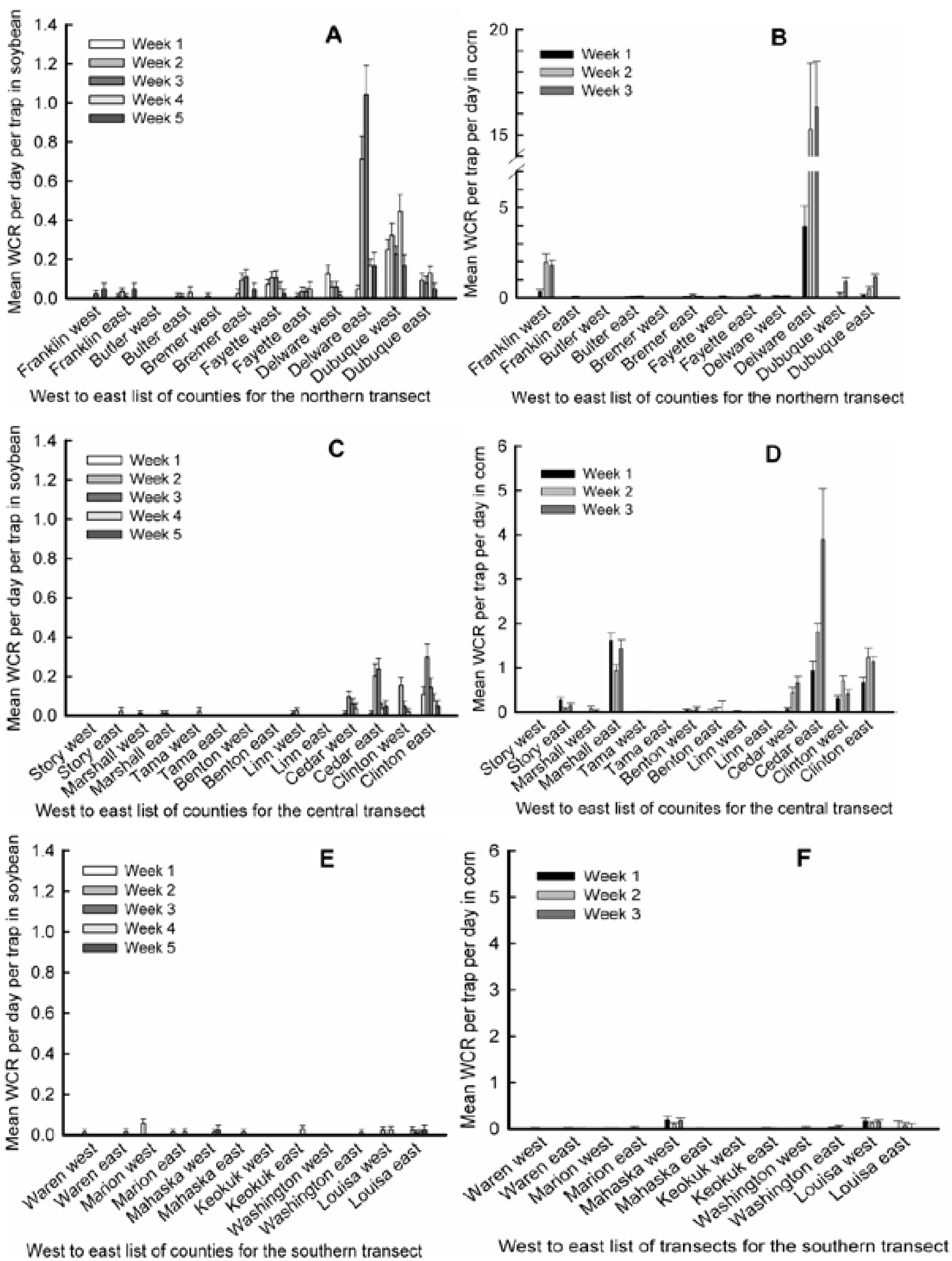

Figure 1. Average western corn rootworm per trap per day along the northern (A and B), central (D and C), and southern (E and F) transects in soybean fields (A, C, and E) and corn fields (B, D, and F). Bar heights are sample means and error bars are the standard error of the mean.

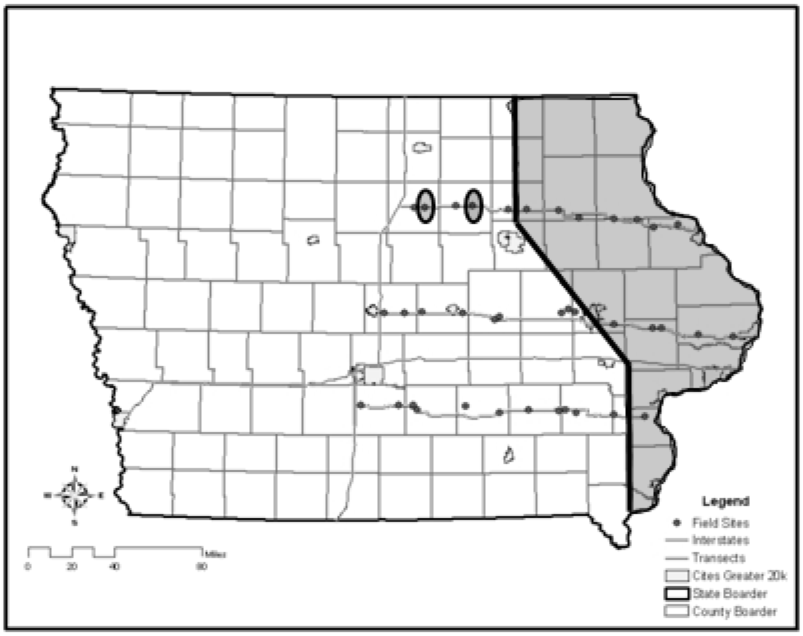

Figure 2. Northern, central, and southern transects surveyed in Iowa during 2008 and occurrence of rotation-resistant western corn rootworm. East-west lines are transects and points are sampling sites. The shaded regions indicate the presence of the rotation-resistant western corn rootworm.

Field evaluation

Tables 1 and 2 summarize the means for nodal injury, stand counts, percent lodging and yield. The percent lodging was significantly higher for DKC 61-72 alone than for DKC 61-72 treated with Poncho 1250. DCK 61-72 treated with Aztec and VT Triple (DKC 61-69) with or without additional insecticide had the least lodging and did not differ (Table 1). Yield was significantly higher for DKC 61-69 than DKC 61-72 regardless of soil insecticide treatment (Table 1). The Bt rootworm corn (DKC 61-69) had lower nodal injury and higher product consistency than the untreated check (DKC 61-72), and this effect was not influence by the presence or absence of insecticide. For the non-Bt corn (DKC 61-72), Aztec showed significantly higher product consistency than untreated corn or corn treated with Poncho 1250. Both Aztec and Poncho 1250 significantly decreased injury compared with the untreated check.

Discussion

All soybean fields monitored in 2008 were below the economic threshold for rotation-resistant WCR. This means that economic damage from rotation-resistant WCR is not expected if these fields were rotated to corn in the following season. The rotation-resistant variant was detected predominantly in the north-eastern quarter of the state and to a lesser degree in south eastern quarter. Famers in these areas should monitor their soybean fields for the presence of western corn rootworm. Protection of first-year corn against corn rootworm is recommended if capture of WCR with Pherocon AM sticky traps exceeds 9.2 insects per trap per day in soybeans (O'Neal et al. 2001).

Yield for Bt rootworm transgenic corn did not increase significantly when a soil insecticide was applied. These results suggest that the benefit to farmers of applying an insecticide to transgenic rootworm corn would be absent or minimal, perhaps increasing yield by four to five bushels. Any financial gain from this strategy will depend on commodity prices, insecticide and seed costs, and potential yield gain.

Table 1. Average stand counts, percent lodging, and yield

Treatment	Hybrid[2]	Form.	Rate[3]	Placement4	Stand Counts[5,6]	% Lodging[6,7]	Bushels/ Acre [8,9,10]
Poncho 1250	DKC 61-69	600FS	1.25	ST	29.40	0a	213a
Aztec	DKC 61-69	2.1G	6.7	Furrow	29.60	0a	212a
CHECK	DKC 61-69	------	------	------	29.50	0a	208a
Aztec	DKC 61-72	2.1G	6.7	Furrow	30.75	1a	202 b
Poncho 1250	DKC 61-72	600FS	1.25	ST	30.75	12 b	202 b
CHECK	DKC 61-72	------	------	------	29.60	35 c	195 b

[1] Planted May 9, 2008; evaluation dates: stand counts October 2; lodging October 2; yield October 30, 2008
[2] Hybrids were YieldGard VTTriple (DKC 61-69) and the associated non-Bt near isoline (DKC 61-72)
[3] Insecticide listed as ounces per 1,000 row-ft; seed treatment (ST) listed as mg a.i/seed
[4] T-band & Furrow = Insecticide applied at planting time; ST = seed treatment
[5] No significant differences between means (ANOVA, $P \leq 0.05$)
[6] Means based on 8 observations (2-row trt x 17.5 row-ft/treatment x 4 reps)
[7] Means sharing a common letter do not differ significantly according to Ryan's Q Test ($P \leq 0.05$)
[8] Means sharing a common letter do not differ significantly based on ANOVA ($P \leq 0.05$)
[9] Means based on 4 observations (2-row trt x 70 row-ft/treatment x 4 reps)
[10] Yields converted to 15.5% Moisture

Table 2. Average root injury and product consistency

Treatment	Hybrid[2]	Form.	Rate[3]	Placement[4]	Node-Injury[5,6,7]	Product Consistency[7,8]
Poncho 1250	DKC 61-69	600FS	1.25	ST	0.01a	100a
Aztec	DKC 61-69	2.1G	6.7	Furrow	0.02a	100a
CHECK	DKC 61-69	------	------	------	0.03a	100a
Aztec	DKC 61-72	2.1G	6.7	Furrow	0.63ab	50 b
Poncho 1250	DKC 61-72	600FS	1.25	ST	1.05 b	0 c
CHECK	DKC 61-72	------	------	------	1.56 c	0 c

[1] Planted May 9, 2008; evaluated August 15, 2008
[2] Hybrids were YieldGard VTTriple (DKC 61-69) and the associated non-Bt near isoline (DKC 61-72)
[3] Insecticide listed as ounces per 1,000 row-ft; seed treatment (ST) listed as mg a.i/seed
[4] T-band & Furrow = Insecticide applied at planting time; ST = seed treatment
[5] Chemical and check means based on 20 observations (5 roots/2 row treatment x 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

References

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