farmdoc DAILY

Department of Agricultural and Consumer Economics, University of Illinois Urbana-Champaign

Managing Corn Rootworm in Illinois: Outlook for 2020

Nick Seiter

Department of Crop Sciences
University of Illinois

Kelly Estes and Joe Spencer

Illinois Natural History Survey
University of Illinois

March 13, 2020

***farmdoc daily* (10): 47**

Recommended citation format: Seiter, N., K. Estes, and J. Spencer. "Managing Corn Rootworm in Illinois: Outlook for 2020." *farmdoc daily* (10): 47, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 13, 2020.

Permalink: https://farmdocdaily.illinois.edu/2020/03/managing-corn-rootworm-in-illinois-outlook-for-2020.html

Corn rootworm remains the greatest insect pest threat to corn in Illinois, despite low populations in recent years compared with historical averages. Resistance to Bt traits and crop rotation throughout much of Illinois complicates the management decisions faced by corn growers. Corn rootworms overwinter as eggs in the soil that generally hatch in late May to early June, well after corn has been planted in most years (2019 notwithstanding). Upon hatching, the larvae begin feeding on and ultimately pruning corn roots, causing reduced uptake of water and nutrients and increasing the potential for plant lodging (Fig. 1). Due to the timing and nature of rootworm damage, any controls (whether a Bt corn hybrid, soil insecticide, or crop rotation) must be chosen prior to planting. Adult population monitoring from the previous season and field history are the primary sources of information available to estimate corn rootworm damage potential and determine whether a control is justified.

Populations of western and northern corn rootworm adults were low across most of Illinois in 2019. This continues a recent trend of relatively low population densities throughout Illinois and much of the Corn Belt over the past several years. Annual statewide field surveys were conducted for western corn rootworms in Illinois back to 2011. The mean number of corn rootworm beetles per plant ranged from a low of 0.01 in 2015, 2016 and 2019 to a high of 0.51 in 2017 (Table 1). A mild winter followed by favorable conditions at egg hatch and adult emergence helped the western corn rootworm population to gain some traction from 2016 to 2017; however, compared to historical averages even these recent "peaks" were low. Despite low averages, the variability observed between fields within counties and even counties within crop reporting districts indicates there are locations with higher populations of western corn rootworm. While western corn rootworm is the most important species throughout most of Illinois, northern corn rootworm has gained some attention in northern portions of the state in recent years. Our colleagues recently confirmed the development of resistance in the northern corn rootworm to Cry3Bb1 and Cry34/35Ab1 in some localized areas of North Dakota – the first instance of field-evolved resistance to Bt traits in this species (Calles-Torrez et al. 2019). Northern corn rootworm numbers jumped

dramatically in Illinois in 2018 based on the statewide survey for that insect, though they dropped considerably in 2019 (Table 2).

Figure 1. Western Corn Rootworm Adult (A), Larva (B, Image John Obermeyer, Purdue University), Damage (C), and Lodging Due to Larval Feeding (D)

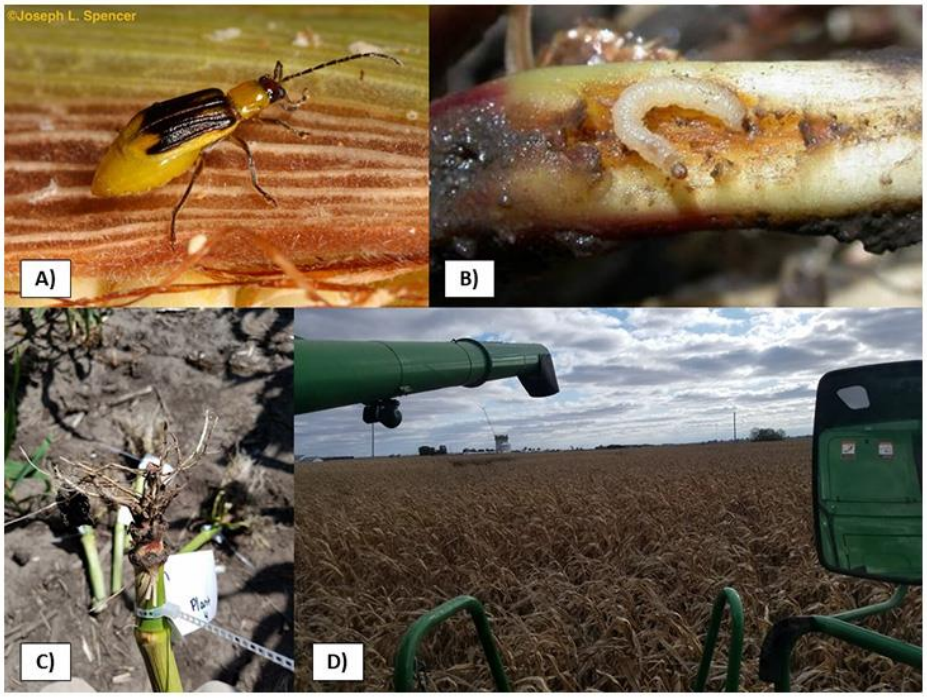

Table 1. Mean Number of Western Corn Rootworm Beetles Per Plant in Corn by Crop Reporting District of Illinois and Year

District	2011	2013	2014	2015	2016	2017	2018	2019
Northwest	0.26	0.33	0.05	0.02	0.02	0.1	0.04	0.08
Northeast	0.15	0.2	0.02	0	0.02	1.95	0.35	0
West	0.01	0.1	0.01	0.01	0	0.75	0	0
Central	0.35	0.37	0.74	0.02	0.05	0.3	0.12	0.12
East	0.31	0.81	0.51	0.01	0.01	0.4	0.02	0.12
West-southwest	0.01	0.2	0.06	0	0.01	0.7	0.35	0.52
East-southeast	0.02	0.01	0	0	0	0	0.03	0.05
Southwest	0	0	0	0.01	0.01	0.15	0	0
Southeast	0	0.03	0.01	0	0.02	0.2	0.03	0
State Average	**0.12**	**0.23**	**0.18**	**0.01**	**0.01**	**0.51**	**0.1**	**0.01**

Means were determined by counting the number of beetles on 20 consecutive plants for between 15 and 50 fields per district.

Table 2. Mean Number of Northern Corn Rootworm Beetles Per 100 Sweeps in Soybeans By Crop Reporting District of Illinois and Year

District	2016	2017	2018	2019
Northwest	3.8	0	7.5	0.24
Northeast	0	2.6	26.56	0.32
West	0.8	0.2	4.2	0
Central	0.8	0	1.9	0
East	0	0	0.08	3.6
West-southwest	0	0	1.04	0
East-southeast	0	0	0.65	0
Southwest	0	0	1.6	0.5
Southeast	0	0	0.8	0.16
State Average	**0.27**	**0.31**	**4.6**	**0.57**

Means were determined by counting the number of beetles in 100 sweeps for between 15 and 50 fields per district.

The development of resistance to Bt traits in the western corn rootworm is an ongoing problem, with critical implications for management. During 2019, offspring from seven Urbana, IL western corn rootworm populations (collected in east-central Illinois in 2018) were evaluated for resistance to the Cry3Bb1, mCry3A and Cry34/35Ab1 Bt toxins expressed in commercial corn hybrids. Single-plant Bt resistance bioassays (Gassmann et al. 2011) compared the survival of larvae from potentially-Bt resistant local populations to USDA Bt-susceptible laboratory populations. Because of cross-resistance between the structurally similar Cry3Bb1 and mCry3A toxins, results for those toxins were combined and analyzed as the “Cry3” trait. These bioassays indicated that all Urbana western corn rootworm populations were resistant to the Cry3 toxins, regardless of their collection circumstance. These larvae survived as well on Cry3 Bt corn hybrids as they did on non-Bt isoline hybrids (Table 3). As expected, USDA susceptible population larvae had significantly reduced survival on both Bt hybrids compared to non-Bt isoline hybrids. Bioassay results indicated no evidence of resistance to the Cry34/35Ab1 toxin among the offspring of Urbana, IL western corn rootworm beetles collected from open fields and from within tents over non-Bt hybrids. However, among the offspring of parental western corn rootworm that developed on Bt corn hybrids and inter-mated with other Bt survivors within tented plots of Bt corn, there was significantly reduced susceptibility, but not resistance to the Cry34/35Ab1 toxin. The larvae from this population survived on Cry34/35Ab1 at a higher rate than those from the USDA susceptible colony, but at a reduced rate compared to their survival on non-Bt corn (Table 3). These results suggest that Cry34/35Ab1 resistance genes are detectable in local western corn rootworm populations. Fortunately, East-central Illinois western corn rootworm populations still retain some susceptibility to the Cry34/35Ab1 toxin. Given resistance to Cry3 toxins, it is sobering to realize that the efficacy of most pyramided Bt hybrids may be largely dependent on continued rootworm susceptibility to the Cry34/35Ab1 toxin.

Table 3. Results of Bioassays on Urbana, IL Populations of Western Corn Rootworm

Collection circumstance	Bt trait family	Bt expressed in corn hybrid	Western corn rootworm Bt resistance status	n	Proportion larval survival (mean ± SEM) [a]
Bt corn tents	Cry3 [b]	Non-Bt isoline	Suspected resistant	72	0.611 ± 0.027 a
			USDA susceptible	24	0.608 ± 0.056 a
		Cry3	Suspected resistant	72	0.615 ± 0.025 a
			USDA susceptible	24	0.063 ± 0.021 **b**
	Cry34/35Ab1	Non-Bt isoline	Suspected resistant	36	0.761 ± 0.027 a
			USDA susceptible	12	0.717 ± 0.058 a
		Cry34/35Ab1	Suspected resistant	36	0.264 ± 0.033 **b**
			USDA susceptible	12	0.075 ± 0.035 **c**
Open Fields + Non-Bt tents	Cry3	Non-Bt isoline	Suspected resistant	96	0.484 ± 0.022 a
			USDA susceptible	48	0.577 ± 0.034 a
		Cry3	Suspected resistant	96	0.548 ± 0.022 a
			USDA susceptible	48	0.110 ± 0.020 **b**
	Cry34/35Ab1	Non-Bt isoline	Suspected resistant	48	0.554 ± 0.033 a
			USDA susceptible	24	0.608 ± 0.043 a
		Cry34/35Ab1	Suspected resistant	48	0.169 ± 0.025 **b**
			USDA susceptible	24	0.079 ± 0.020 **b**

[a] ANOVA was performed on Log10(proportion survival + 0.5) transformed data. Untransformed data are depicted; JMP Pro 14 (2014 SAS Institute) was used to perform analyses. Means sharing the same letter within a trait family and collection circumstance do not differ significantly (P<0.05) based on least-squares means (Tukey HSD).

[b] Data pooled for cross-reactive Bt Cry toxins Cry3Bb1 and mCry3A as "Cry3".

Despite ongoing resistance development to these individual Bt proteins, pyramided trait packages have generally performed well in Illinois over the last several years. Where unexpected damage has occurred in these pyramided hybrids, it has primarily been in northern Illinois and associated with continuous corn. In east-central Illinois, these pyramided trait packages and a variety of soil insecticides continue to provide effective control, especially under the low to moderate pressure situations that have been typical in recent years (Table 4). However, the use of rootworm control in Illinois generally exceeds what is needed based on rootworm pressure due to difficulties in monitoring this insect and the potential for yield losses if a needed control is not applied. This is especially true given recent low population densities, which provide an opportunity for producers to cut back on control costs when monitoring indicates a low risk of rootworm damage in their local area.

Table 4. Mean (± standard error) node-injury ratings for experimental plots where corn rootworm larval injury was controlled with various soil insecticides and/or Bt traits. Node-injury ratings follow a scale of 0-3, where "0" = no damage, "1.00" = 1 full node of corn roots pruned to within 0.5 inches of the soil line, "2.00" = 2 full root nodes pruned, etc. Excerpt from 2019 Applied Research Results: Field Crop Disease and Insect Management; the full report is available to download at: https://uofi.box.com/v/2019PestPathogenARB.

Treatments	Node-injury ratings 24 July (R1)
1) No Bt, no insecticide	0.78 ± 0.19 a[a]
2) No Bt, Capture LFR (17 fl. oz/a)	0.24 ± 0.06 b
3) No Bt, Aztec 4.67G (3.27 lb/a)	0.36 ± 0.13 b
4) No Bt, Ampex EZ (12 fl. oz/a)	0.04 ± 0.02 c
5) No Bt, Ampex EZ (8 fl. oz/a)	0.05 ± 0.01 bc
6) No Bt, Force 3G (4.4 lb/a)	0.11 ± 0.04 bc
7) SmartStax RIB, no insecticide	0.03 ± 0.02 c
8) SmartStax RIB, Force Evo (8 fl. oz/a)	0.03 ± 0.01 c
9) Agrisure 3111A, no insecticide	0.09 ± 0.03 bc
10) Agrisure 3122 EZ Refuge, no insecticide	0.18 ± 0.07 bc
11) No Bt, no insecticide	0.89 ± 0.18 a

[a] Means followed by the same letter are not different based on the Fisher method of least significant difference (α = 0.05)

Ideally, rootworm control decisions should be based on the results of in-field monitoring of adults conducted the previous year when adult emergence is mostly complete (typically late July-mid August). When monitoring corn rootworms with a standard yellow sticky card trap, use an economic threshold of 1.5 beetles per trap per day (10 beetles per trap per week) in first-year corn, and a threshold of 2 beetles per trap per day (14 beetles per trap per week) in continuous corn (Dunbar and Gassmann 2013). Extended diapause allows some northern corn rootworm to overcome crop rotation as a management tactic – a proportion of their eggs deposited in a cornfield remain in the soil for 2, 3, or even 4 years before hatching, allowing them to hatch into rotated corn. Fields with high populations of northern corn rootworm adults are at risk of rootworm damage for 2-3 additional seasons, complicating management decisions when this species is present in rotated corn. (Note, however, that extended diapause also reduces the intensity of the damage by reducing the proportion of eggs that hatch in a given year). Where control decisions are made without access to monitoring data, consider including some untreated strips within the field to determine whether control was in fact justified. Where a control is necessary, use either a pyramided Bt hybrid targeting corn rootworm or a labeled rate of a soil insecticide.

Whatever control you choose to implement, you should monitor its effectiveness by examining some roots for pruning sometime after pollination but before black layer. When using a pyramided Bt hybrid for rootworm control, greater than ½ of a root node pruned to within 1½-inches is considered greater-than-expected damage, and should be reported. When resistance is suspected, the best mitigation strategy is to rotate the field(s) to soybean. Though crop rotation in Illinois does not necessarily protect first-year corn as it once did, planting soybean after corn does reduce the local population – any eggs that hatch in a soybean field will die. Populations with resistance to both crop rotation and a Bt trait have been observed in Illinois. However, it should come as no surprise that new instances of resistance to a Bt protein have always been observed first in areas with continuous corn production. Corn rootworm remains our most serious insect pest of corn in Illinois, but low western corn rootworm populations mean that the current risk in rotated corn is lower than it has been since rotation resistance was first observed in the early 1990s.

References

Calles-Torrez, V., J. J. Knodel, M. A. Boetel, B. W. French, B. W. Fuller, and J. K. Ransom. 2019. Field-evolved resistance of northern and western corn rootworm (Coleoptera: Chrysomelidae) populations to corn hybrids expressing single and pyramided Cry3Bb1 and Cry34/35Ab1 Bt proteins in North Dakota. *Journal of Economic Entomology* 112: 1875-1886.

Dunbar, M. W., and A. J. Gassmann. 2013. Abundance and distribution of western and northern corn rootworm (*Diabrotica* spp.) and prevalence of rotation resistance in eastern Iowa. *Journal of Economic Entomology* 106: 168-180.

Estes, K., N. Kleczewski, K. Ames, N. Seiter, and A. Decker. "2019 Applied Research Results: Field Crop Disease and Insect Management." Full report is available to download at: https://uofi.box.com/v/2019PestPathogenARB.

Gassmann, A. J., J. L. Petzold-Maxwell, R. S. Keweshan, and M. W. Dunbar. 2011. Field-evolved resistance to Bt maize by western corn rootworm. *PLOS One* 6: e22629