The economics and efficacy of Bt hybrids vs. rootworms: After 20 years, what have we learned?







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Northern







Western*



Overwinter as eggs

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<u>Very</u> cold-tolerant



Corn Rootworm - Damage





Root lodging has multiple causes

High Winds and/or Heavy Rains



Herbicide





Compaction





Rootworm Larval Thresholds (no longer used, but worth reviewing...)

2 or more rootworm/plant while hand sorting

or

8 or more rootworm/plant while floating larvae

"2 if by land and 8 if by sea"

Node Injury Rating Scale (0-3)

0 No feeding damage

- 1 One node (circle of roots), or the equivalent of an entire node, pruned back to within 1.5 inch of the stalk.
- 2 Two complete nodes pruned
- 3 Three complete nodes pruned



Rootworm Management: Bt-RW hybrids are the primary tool...

Adoption of genetically engineered corn in the United States, by trait, 2000–23



Rootworm Management: Bt-RW hybrids are expensive technology



price indexes for wheat, barley, oats, sorghum, rice, flaxseed, potatoes, and peanuts.

Source: USDA, Economic Research Service using crop and seed price indexes from USDA, National Agricultural Statistics Service (NASS).

Are Corn Rootworms still a "billion dollar pest"? It depends where you live...

JOURNAL ARTICLE

Multi-Year Surveys Reveal Significant Decline in Western Corn Rootworm Densities in Illinois Soybean Fields @

Nicholas A Tinsley, Joseph L Spencer, Ronald E Estes, Kelly A Estes, Alexandra L Kaluf, Scott A Isard, Eli Levine, Michael E Gray

American Entomologist, Volume 64, Issue 2, Summer 2018, Pages 112–119, https://doi.org

/10.1093/ae/tmy024

Published: 13 June 2018

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- 2013-15 sampling revealed 88% decline vs. 1997-2003
- Likely reasons why: Bt corn adoption and excessive rain during RW hatch period

Are Corn Rootworms still a "billion dollar pest"?

A different story in lowa...

Review > Insects. 2021 Feb 5;12(2):136. doi: 10.3390/insects12020136.

Resistance to Bt Maize by Western Corn Rootworm: Effects of Pest Biology, the Pest-Crop Interaction and the Agricultural Landscape on Resistance

Aaron J Gassmann¹

Affiliations + expand PMID: 33562469 PMCID: PMC7915852 DOI: 10.3390/insects12020136 Free PMC article

 Mostly continuous corn, many Bt plantings must be supplemented by use of soil insecticides + spraying adults

What about going <u>without</u> CRW protection in Indiana?

RESEARCH ARTICLE | BIOLOGICAL SCIENCES | 8

IPM reduces insecticide applications by 95% while maintaining or enhancing crop yields through wild pollinator conservation

Jacob R. Pecenika 🤗 🖽, Laura L. Ingwell 🤗, Bick E. Foster, Christian H. Knupke, and Ian Kaplan 😤 💽 Authors Infa & Affiliations

Edited by Hans Herner, Millennium Institute, Washington, DC, and approved September 22, 2021 (received for review Hay 5, 2021) October 25, 2021 | 118 (44) e2108429118 | https://doi.org/10.1073/pnas.2108429138



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Corn root damage was only different between +/- NST treatments after the 4th year. Each point within each cluster (n = 5) represents all observations from a single site during that season. Corn roots at each site (n = 40) were excavated, washed, and scored using the Oleson root scale (0-3). Whiskers within the plot show the mean ± SEM of average root damage within each cluster of points. Results based on generalized linear model with post hoc pairwise comparisons using P < 0.05.

- 5 years of continuous corn plots at 5 locations
- Naked, non-Bt corn seed vs. high rate NST/Bt
- No differences in root damage (i.e. almost zero) until year 5

Resistance: came quickly and all traits have succumbed...







(photos courtesy Kenny Ostlie, U of MN)

How are some areas avoiding Bt resistance? Is the refuge approach working?



https://youtu.be/A5p8EoIX7AQ?si=MVnmrs1TTgq6zv3L



Produced by

USDA-CSREES Multi-state Research Project NC246: Ecology and Management of Arthropods in Corn.



Refuge in the Bag: 5 or 10%

Optimum AcreMax Xtra, Genuity SmartStax





Do refuges actually work?

Previous research has shown: WCR from Bt and refuge plants have 1) different emergence timings, and 2) vary in size.

<u>Hypothesis</u> – There is limited mating between resistant and susceptible beetles in refuges.

<u>Research Questions</u>: Who mates with who, and when? Where did mating adult beetles feed as larvae? A permanent mark is needed to characterize beetles...

Solution: Stable isotopes!

- 1.Natural abundance -
- Example: ¹²C/¹³C ratios used to determine host plant type



2.Enrichment -

• Example: ¹⁵N spiked diet used to determine transfer of nitrogen from male to female to eggs

Isotopes of Nitrogen



Field trials: Do refuges work?







version



3. (Cry3Bb1 + Cry3¢/35Ab19 0 0

Materials and methods:

- N¹⁵ applied to refuge plants only at V2
- 0.0125g N¹⁵/plant, mixed with fertilizer and applied with backpack spray nozzle
- Plant is "charged" with N¹⁵ for life (surrounding soil is charged as well...)
- Any insect feeding on this plant with incorporate N¹⁵ into its tissues, for life



Adult insect emergence period:

2X weekly WCR Sampling and collection, late June through August



Materials and methods:

N¹⁵ quantification with mass spectrometry



Excess % N¹⁵ > 1.5%?

If Yes= refuge beetle If No= Bt beetle







Results: In-field mating Remember we want *mixed* matings (purple)...



5% blend – no mixed matings!



Sally Taylor 🔀 Christian Krupke

First published: 30 March 2018 | https://doi.org/10.1002/ps.4927 | Citations: 4

<u>Bottom line</u>: Seed blend refuges (5%) are probably not doing much to delay resistance. Resistance indicates that relying on refuges isn't the best approach

New technology: RNAi

- First offered in 2022 by Bayer (marketed as Bayer SmartStax Pro, only available with Bt)
- Initial trials show very low rootworm survival in the field when combined with existing Bt traits... but survival nevertheless!
- Not a "high dose" toxin... no reason to expect a different outcome or longevity than what we have seen with current Bt offerings...
- Is there anything we should do differently with this (and future) new technologies?

Final thoughts

- Resistance to Bt corn <u>is</u> somewhat predictable doing the same thing each year = shorter lifespan for Bt traits (lose 8-12% susceptibility/year if continuous corn)
- Solution: ROTATE crops and technologies
- Benefits: 1) Prolong use of traits, and
 2) Save \$ on tech/seed fees
- This technology can last a long time (decades) simply by using only when needed