Avoiding Train wrecks: Monitoring and Managing Corn Rootworms

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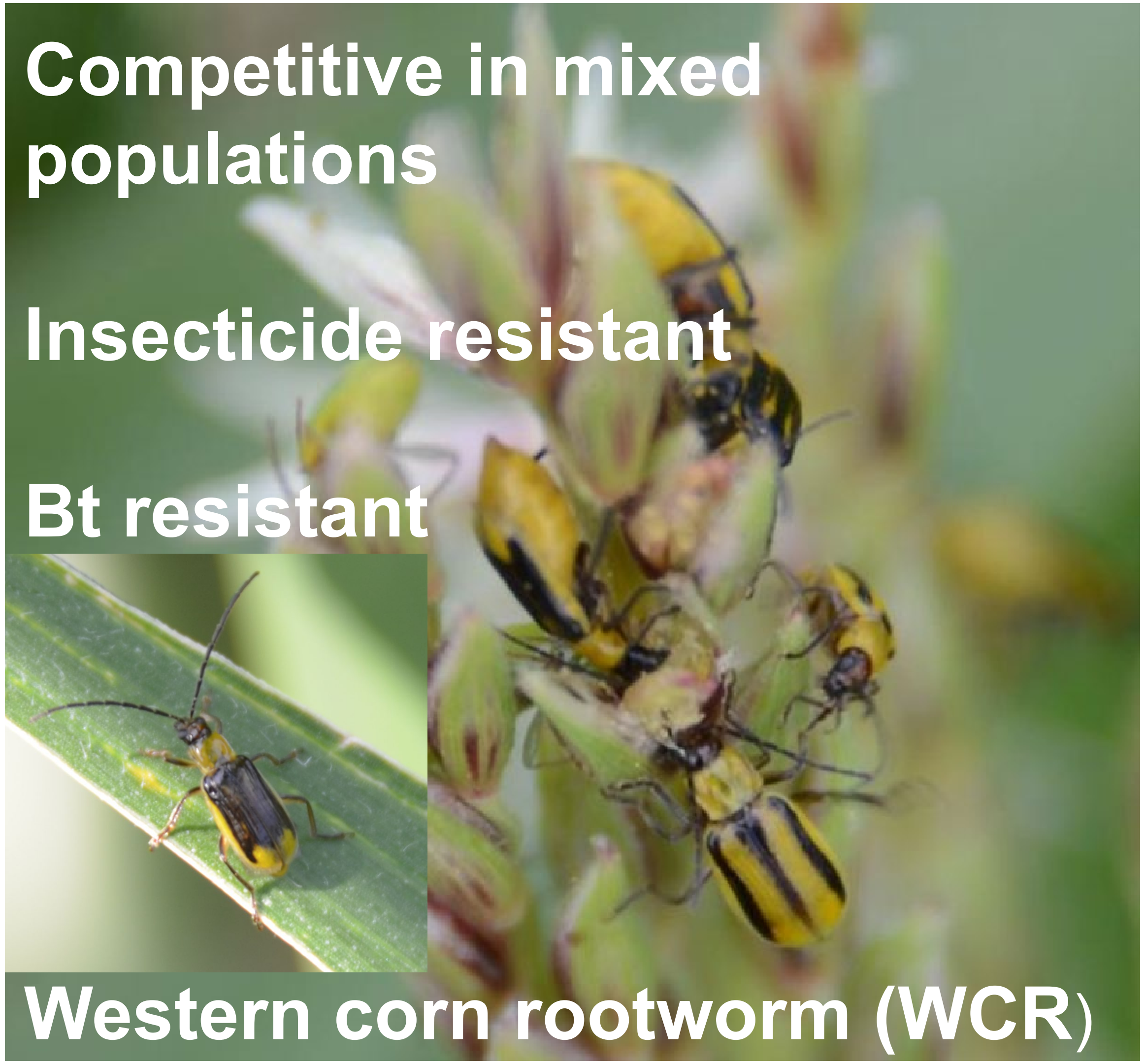
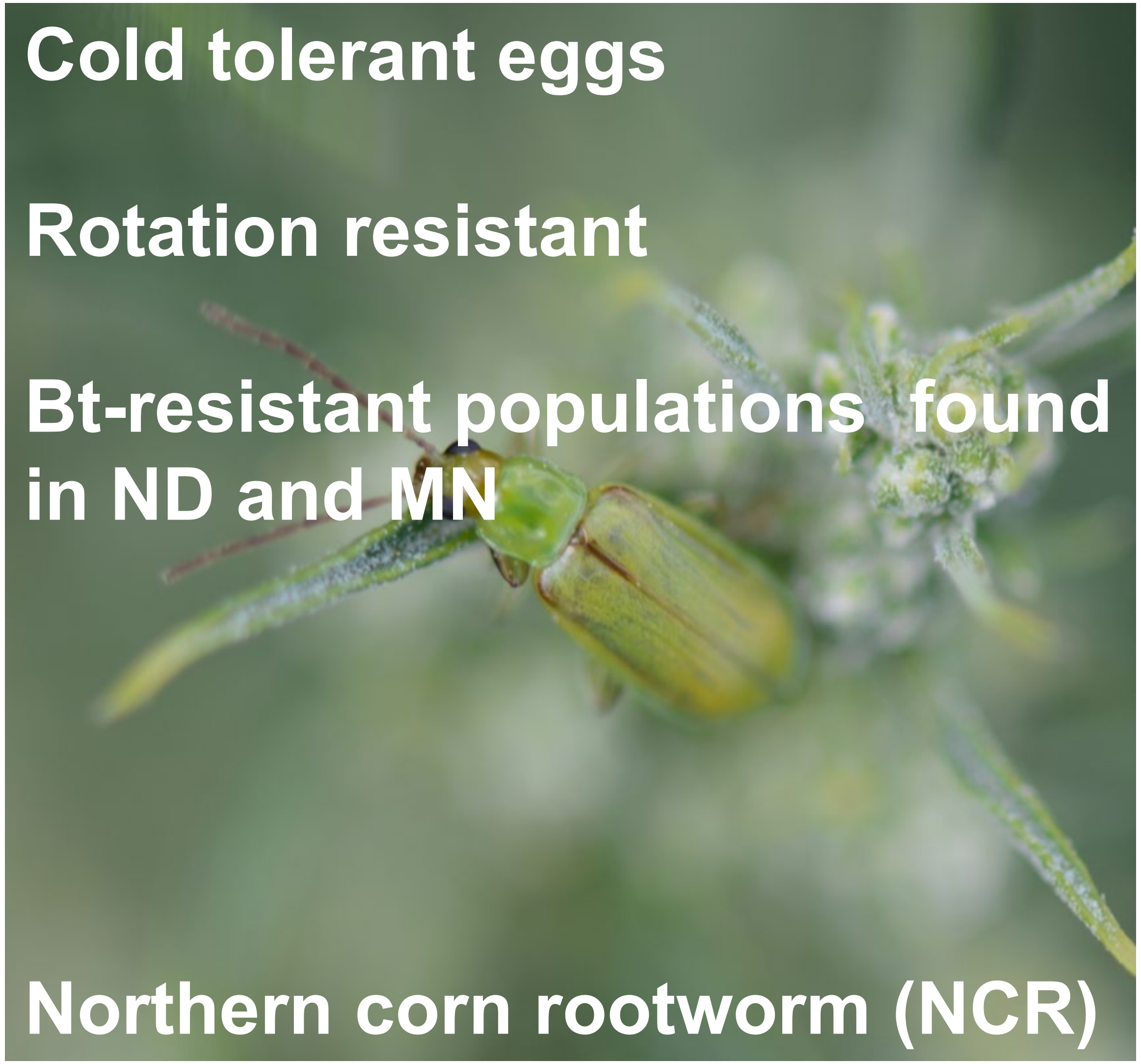
A tale of two rootworms





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Managing corn rootworms

What are you trying to manage?

- Lodging/harvest efficiency
- Yield
- Economics
- RW Populations
- Resistance

Your Tools

✓ Crop rotation

✓ Hybrid selection

Root architecture

RW Traits

✓ Insecticide

Seed-applied

At-plant

Adult control

✓ **Knowledge**

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Heat matters

Winter egg mortality

- Temperature and duration
- WCR mortality begins < 20º F
- At 0.5º F WCR 100%, NCR 20-50%

Egg development (WCR)

- Begins at ~ 52º F
- 380 DDs egg hatch begins
- 684-767 DDs 50% hatch
- Geographic differences

Ellsbury and Lee 2004
Godfrey et al. 1995
Woodson and Gustin 1993
Lawson 1986 Unpublished

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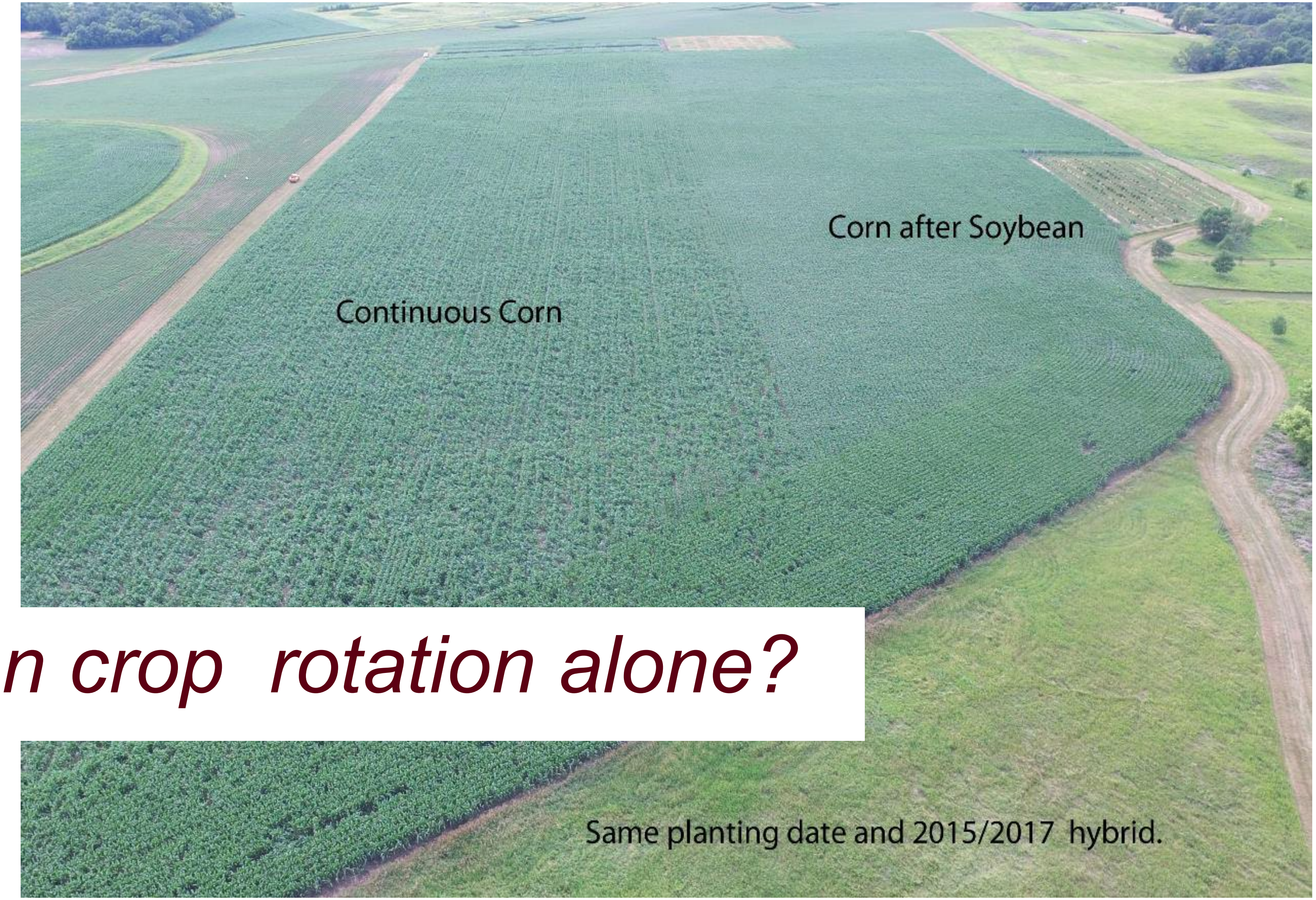
Simple solutions

Crop rotation can still manage WCR.



Can we rely on crop rotation alone?

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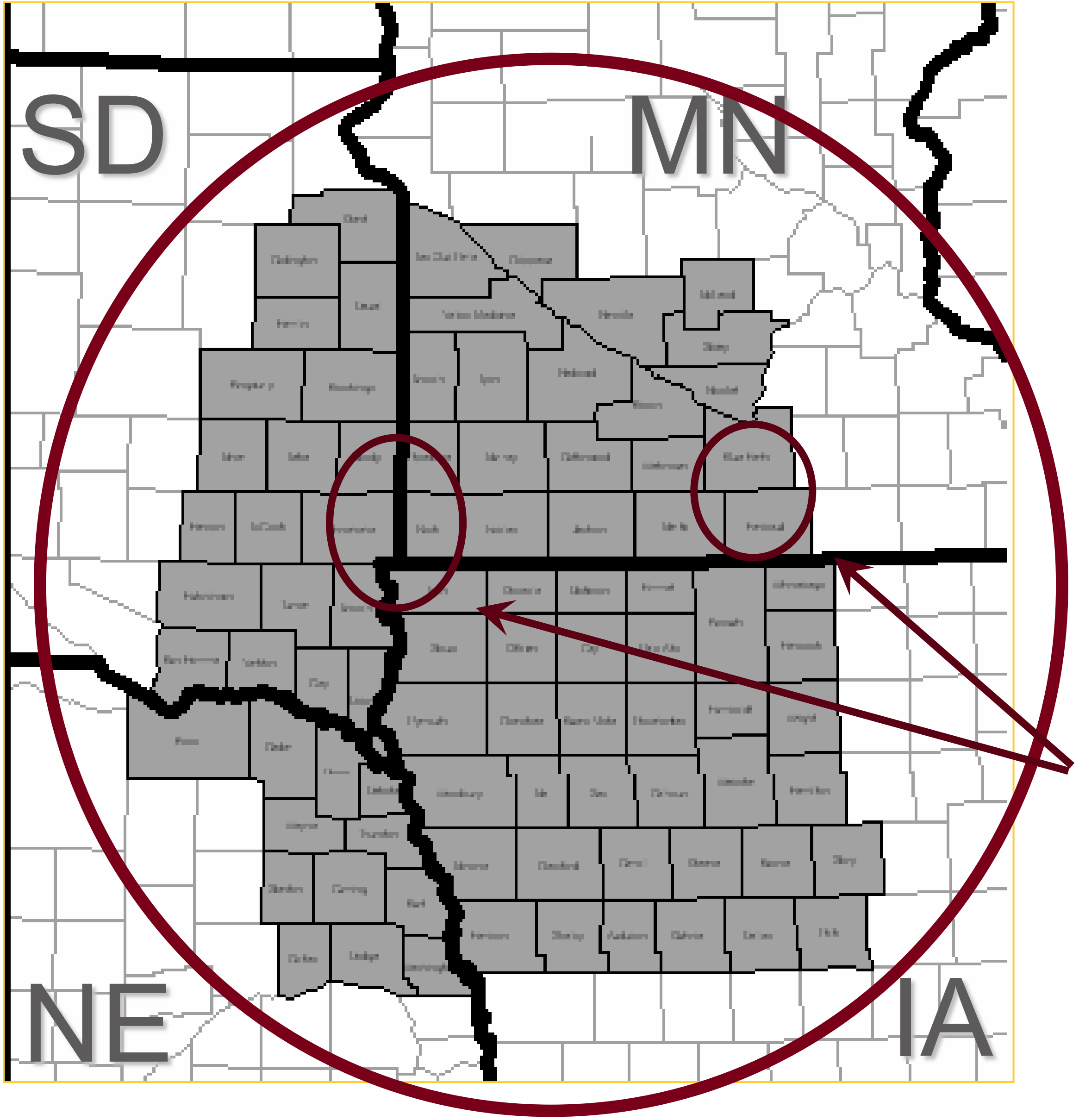
What is NCR extended diapause?



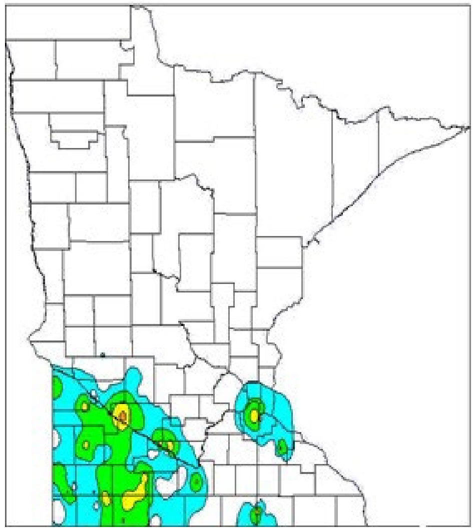
Where does NCR extended diapause occur?

Original Problem Areas (1970s)

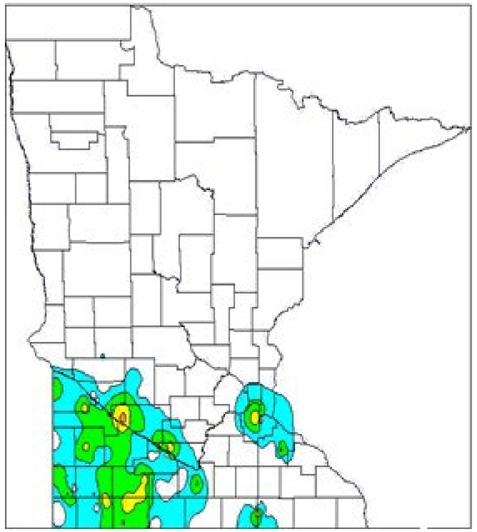
Figure from Ostlie 2005

Biggers, 1932
Boetel, et al., 1992
Fisher, et al., 1994
Branson, 1976
Gustin, 1984
Krysan, 1978, 1982
Krysan et al, 1984
Levine, et al., 1992
Ostlie, 1987
Shaw. 1978

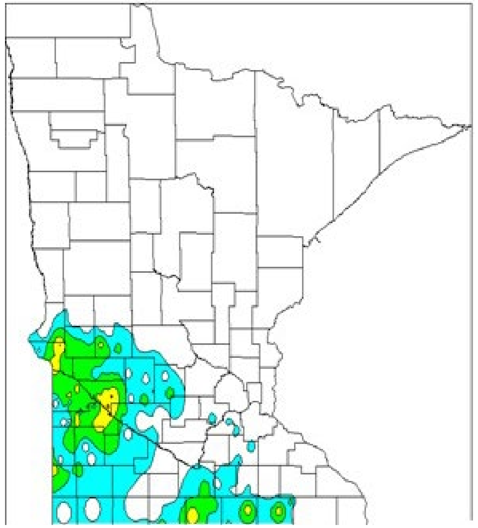
Extended diapause



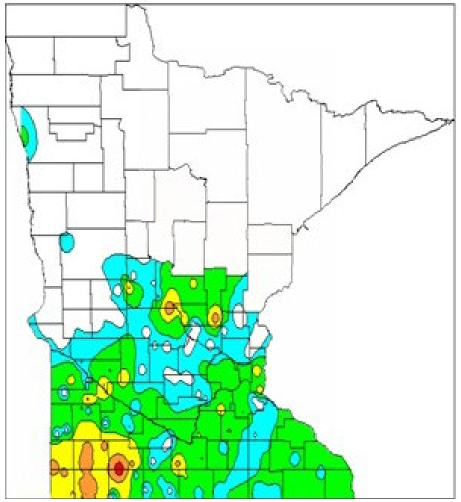
2000



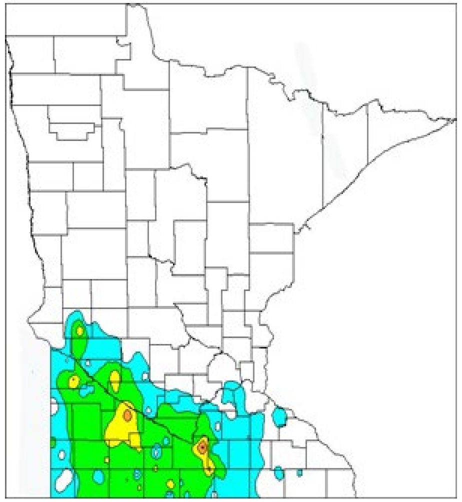
2002



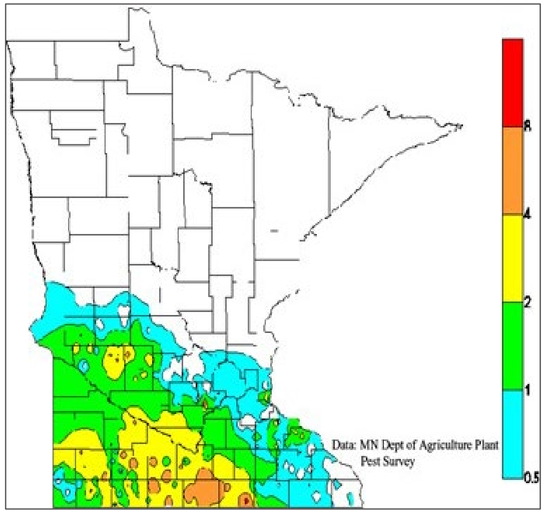
2004



2001



2003



2005

Genetic trait

Temporal and spatial fluctuation

SW and SC MN ~1979 -1986

SW, SC, C, and WC MN ~1999 – 2006

SW, SC, C, WC MN 2021-?*

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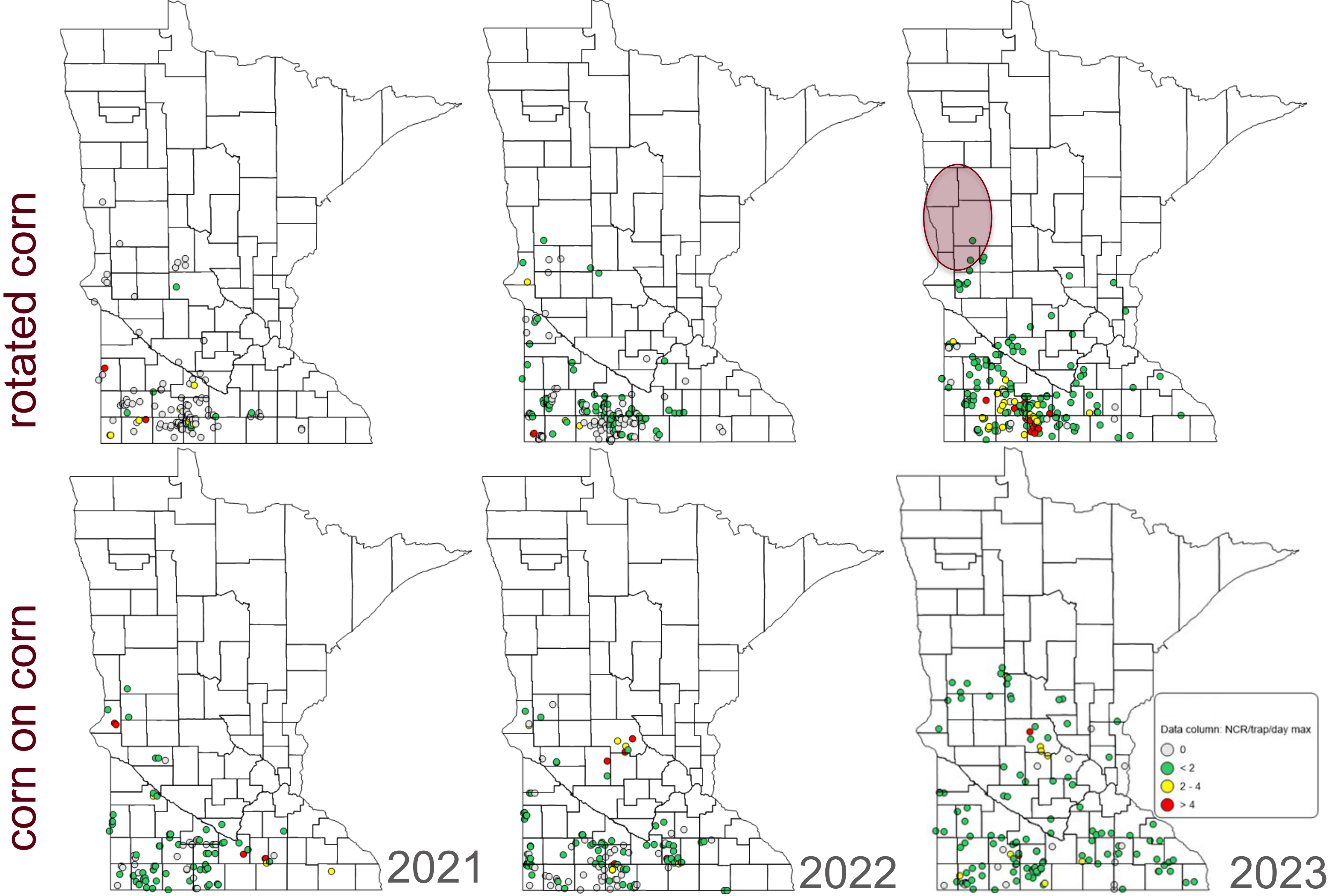
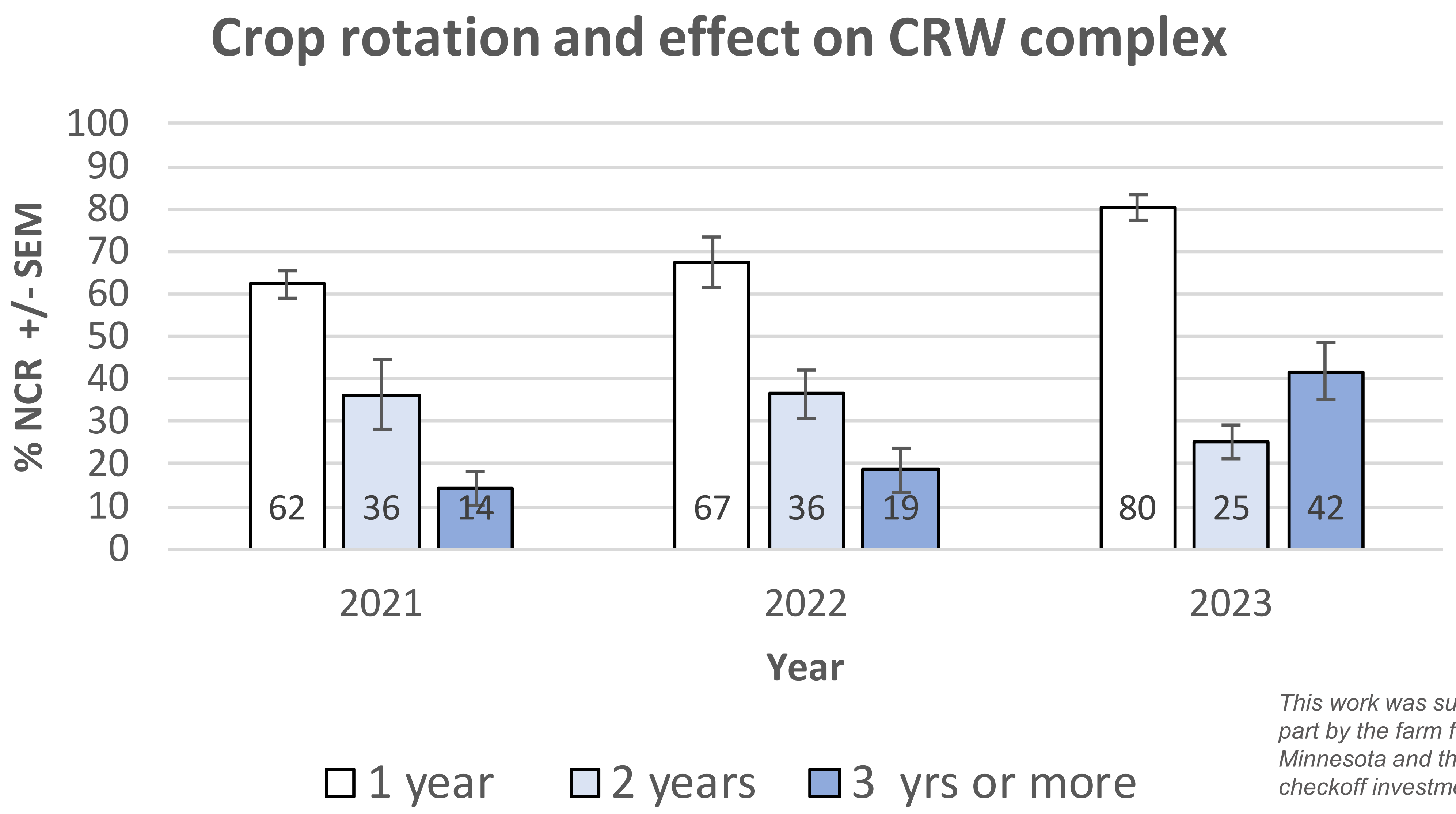
NCR beetles (#/trap/day)

MN cooperative trap network (2021-2023)



This work was supported, in part by the farm families of Minnesota and their corn checkoff investment



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ED- Why not just plant more Bt?

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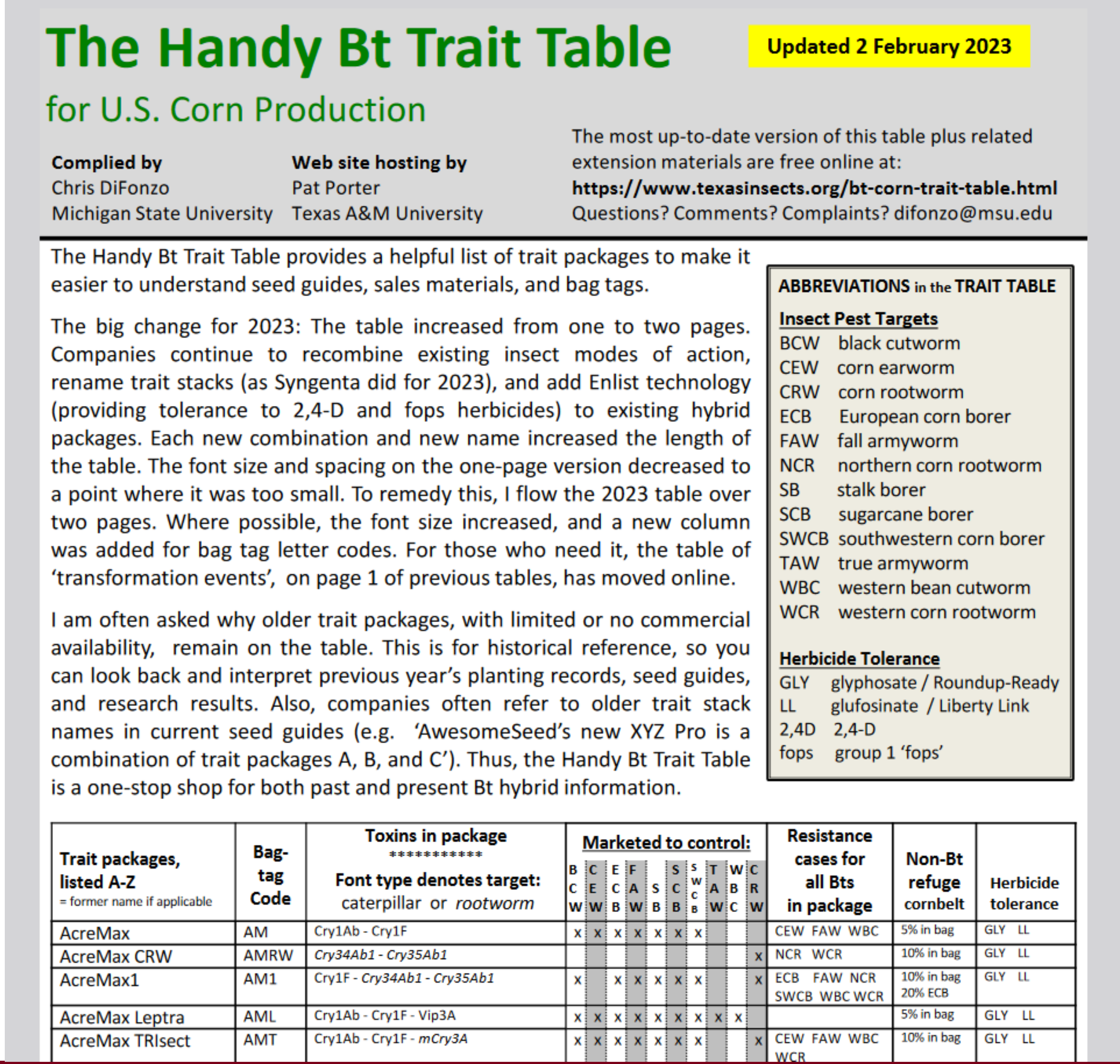

The Handy Bt Trait Table

for U.S. Corn Production

Updated 2 February 2023

Complied by
Chris DiFonzo
Michigan State University

Web site hosting by
Pat Porter
Texas A&M University

The most up-to-date version of this table plus related extension materials are free online at:
https://www.texasinsects.org/bt-corn-trait-table.html
Questions? Comments? Complaints? difonzo@msu.edu

The Handy Bt Trait Table provides a helpful list of trait packages to make it easier to understand seed guides, sales materials, and bag tags.

The big change for 2023: The table increased from one to two pages. Companies continue to recombine existing insect modes of action, rename trait stacks (as Syngenta did for 2023), and add Enlist technology (providing tolerance to 2,4-D and fops herbicides) to existing hybrid packages. Each new combination and new name increased the length of the table. The font size and spacing on the one-page version decreased to a point where it was too small. To remedy this, I flow the 2023 table over two pages. Where possible, the font size increased, and a new column was added for bag tag letter codes. For those who need it, the table of 'transformation events', on page 1 of previous tables, has moved online.

I am often asked why older trait packages, with limited or no commercial availability, remain on the table. This is for historical reference, so you can look back and interpret previous year's planting records, seed guides, and research results. Also, companies often refer to older trait stack names in current seed guides (e.g. 'AwesomeSeed's new XYZ Pro is a combination of trait packages A, B, and C'). Thus, the Handy Bt Trait Table is a one-stop shop for both past and present Bt hybrid information.

ABBREVIATIONS in the TRAIT TABLE

Insect Pest Targets

BCW	black cutworm
CEW	corn earworm
CRW	corn rootworm
ECB	European corn borer
FAW	fall armyworm
NCR	northern corn rootworm
SB	stalk borer
SCB	sugarcane borer
SWCB	southwestern corn borer
TAW	true armyworm
WBC	western bean cutworm
WCR	western corn rootworm

Herbicide Tolerance

GLY	glyphosate / Roundup-Ready
LL	glufosinate / Liberty Link
2,4D	2,4-D
fops	group 1 'fops'

Trait packages, listed A-Z (= former name if applicable)	Bag-tag Code	Toxins in package *********** Font type denotes target: caterpillar or *rootworm*	Marketed to control: BCW	CEW	ECB	FAW	SB	SCB	SWCB	TAW	WBC	CRW	Resistance cases for all Bts in package	Non-Bt refuge cornbelt	Herbicide tolerance
AcreMax	AM	Cry1Ab - Cry1F	x	x	x	x	x	x	x				CEW FAW WBC	5% in bag	GLY LL
AcreMax CRW	AMRW	*Cry34Ab1 - Cry35Ab1*										x	NCR WCR	10% in bag	GLY LL
AcreMax1	AM1	Cry1F - *Cry34Ab1 - Cry35Ab1*	x		x	x	x	x	x			x	ECB FAW NCR SWCB WBC WCR	10% in bag 20% ECB	GLY LL
AcreMax Leptra	AML	Cry1Ab - Cry1F - Vip3A	x	x	x	x	x	x	x	x	x			5% in bag	GLY LL
AcreMax TRIsect	AMT	Cry1Ab - Cry1F - *mCry3A*	x	x	x	x	x	x	x			x	CEW FAW WBC WCR	10% in bag	GLY LL

The Handy Bt Trait Table for Bt and RNAi traits in corn hybrid trait packages

- Herbicide tolerance
- Insects Controlled
- Documented insect resistance

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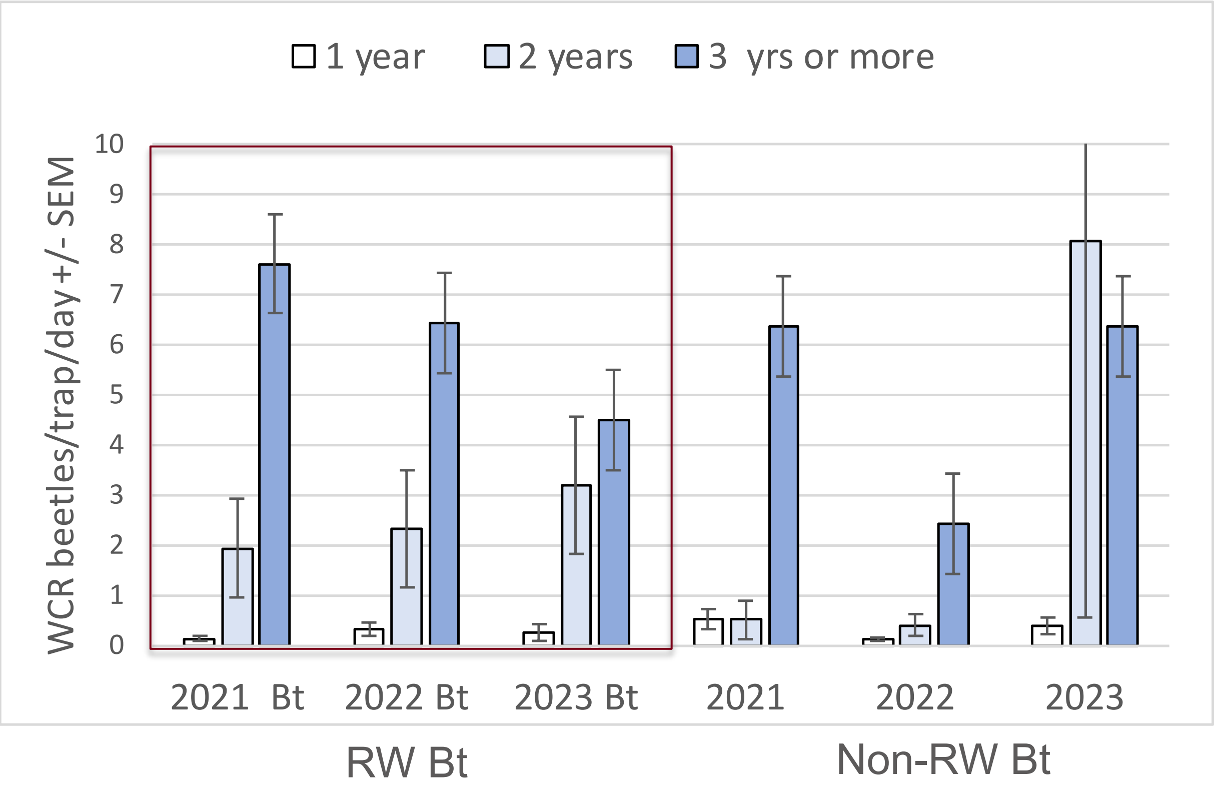
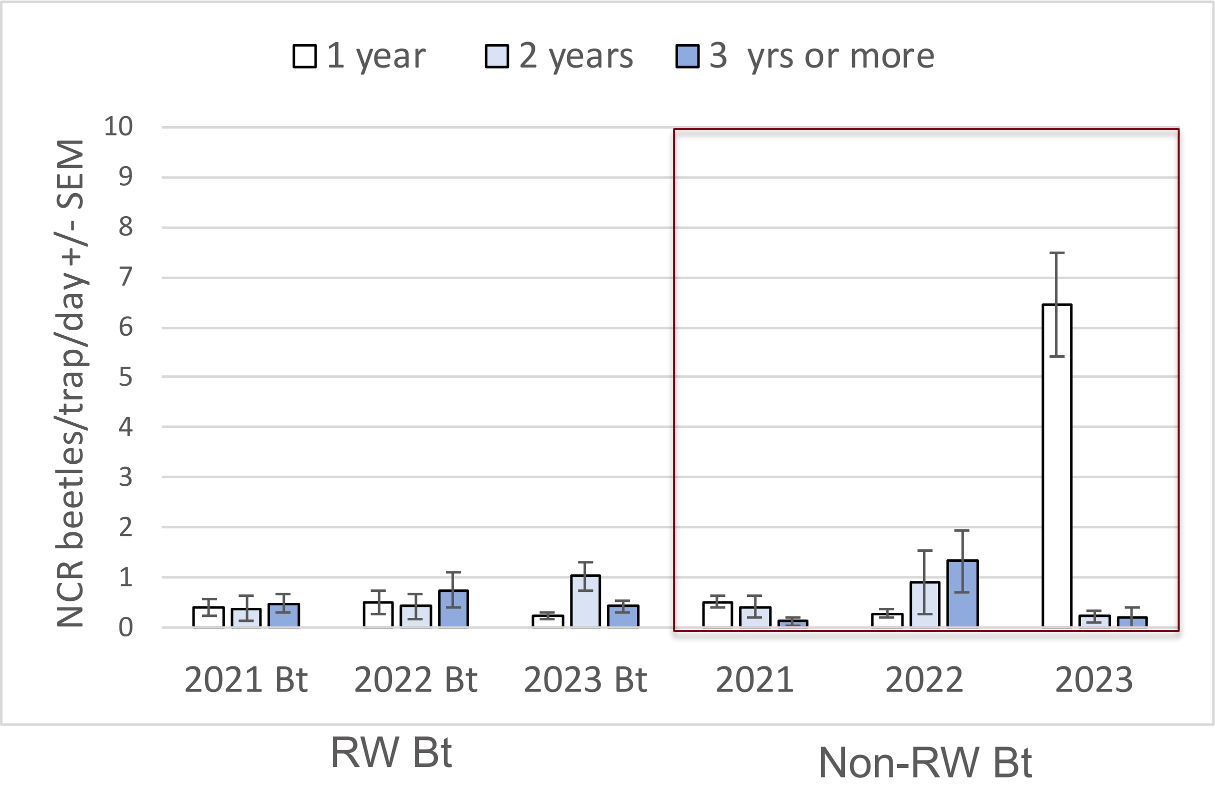
Effect of crop rotation (and Bt) on CRW

MN cooperative trap network





This work was supported, in part by the farm families of Minnesota and their corn checkoff investment

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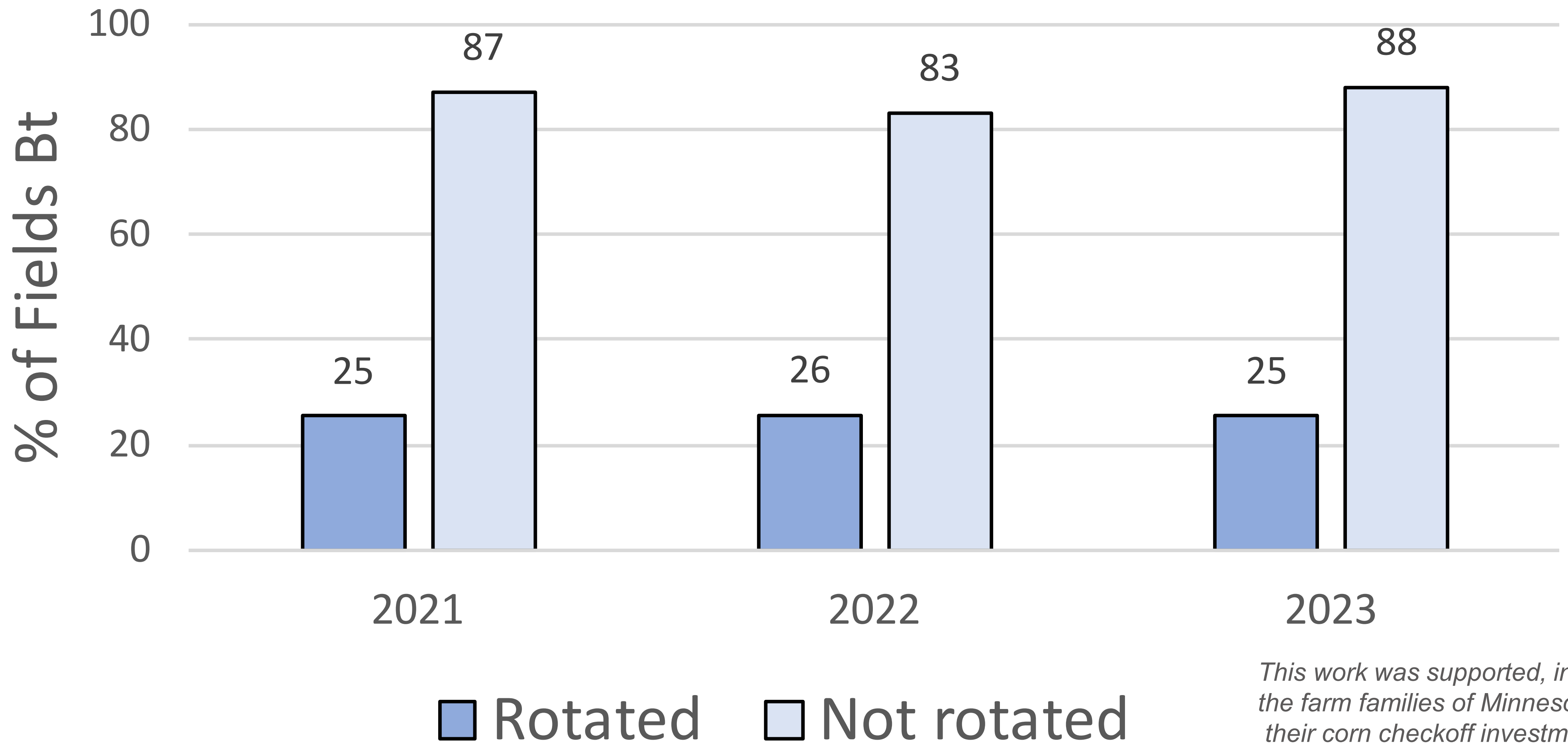
Bt-RW Placement (Select Southern MN trap sites)



This work was supported, in part by the farm families of Minnesota and their corn checkoff investment

Commercialization timeline (USA)	
Year	**Protein toxin(s)/Trait**
2003	***Cry3Bb1*** YieldGard RW (in VT3P)
2006	***Cry34/35Ab1*** Herculex RW
2007	***mCry3A*** Agrisure RW
2010	***Cry3Bb1 + Cry34/35Ab1*** SmartStax
2012	***mCry3A + Cry34/35Ab1*** AcreMax Extreme
2014	***mCry3A + eCry3.1Ab1*** Duracade
2022	***Cry3Bb1 + Cry34/35Ab1 + DvSnf7*** SmartStax Pro

WCR Field-evolved resistance

2009 - *Cry3Bb1* resistance was documented in IA field populations only *six years after release!* (Gassmann et al. 2011)
2011 NE (Wangila et al. 2015)
MN (Zukoff et al. 2016)
2016* ND (Calles-Torrez et al. 2019).

***Cry3* cross-resistance**
2011 IA (Gassmann et al. 2014)
MN (Zuckoff et al. 2016)

***Cry3Bb1* + *Cry34/35Ab1* resistance**
2013 MN (Ludwig, et al. 2017)
2016 ND (Calles-Torrez et al. 2019)
2017 IA (Gassmann et al. 2019)
2018 NE (Reinders et al. 2021)

Commercialization timeline (USA)	
Year	**Protein toxin(s)/Trait**
2003	***Cry3Bb1*** YieldGard RW (in VT3P)
2006	***Cry34/35Ab1*** Herculex RW
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2014	***mCry3A + eCry3.1Ab1*** Duracade
2022	***Cry3Bb1 + Cry34/35Ab1 + DvSnf7*** SmartStax Pro

NCR Field-evolved resistance

***Cry3Bb1* + *Cry34/35Ab1* resistance**

2018 ND (Calles-Torrez et al. 2019)

2018 IA and 2019 MN* (Pereira et al. 2023)

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Extension Resources

- NDSU Extension IPM Crop Survey

Hartstack Wire Trap ECB

Corn rootworm

Corn Insect Trapping Network - IPM Crop Survey Maps

2023 IPM CROP SURVEY MAPS - CORN

- Growth Stages +
- European Corn Borer - Iowa (or Z-race) +
- European Corn Borer - New York (or E-race) +
- Northern & Western Corn Rootworms +
- Northern Corn Rootworm +
- Western Corn Rootworm +

Corn Insect Trapping Network maps are supported by the ND Corn Council.

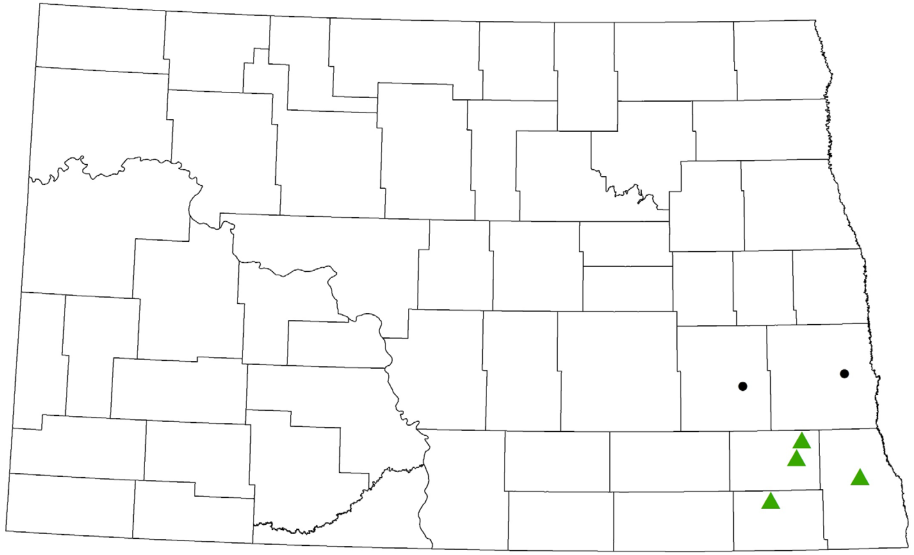
NORTH DAKOTA CORN COUNCIL

NDSU Extension IPM Crop Survey

Corn Rootworm Trapping

Season Final, 2023

July 17 - August 23, 2023



Total number of beetles per trap site per season

• 0 ▲ 0.1-10 ● 10.01-28 ■ 28.01-56 ▲ >56

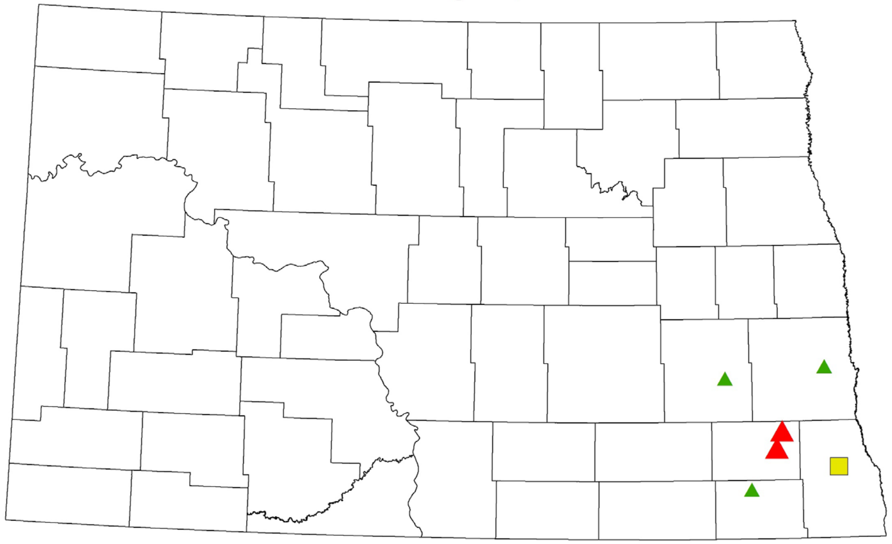
69% northern corn rootworm
31% western corn rootworm

European Corn Borer Trapping

Iowa (or Z-race)

Season Final, 2023

June 14 - August 7, 2023



Total number of moths per trap site per season

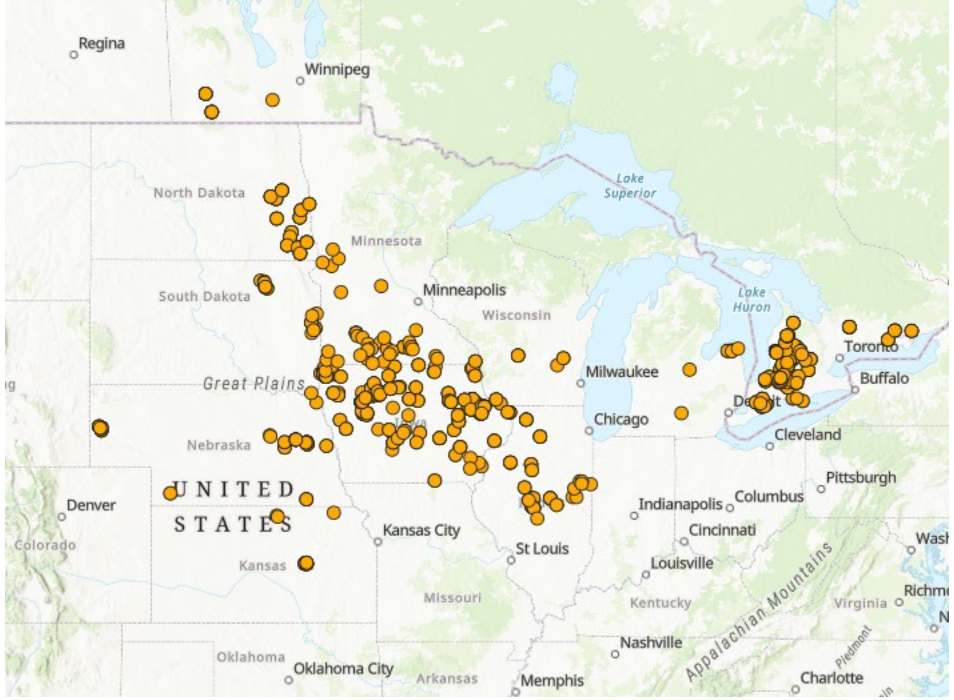
• 0 ▲ 0.1-5 ● 5.01-10 ■ 10.01 - 50 ▲ > 50

37% fewer moths than 2022

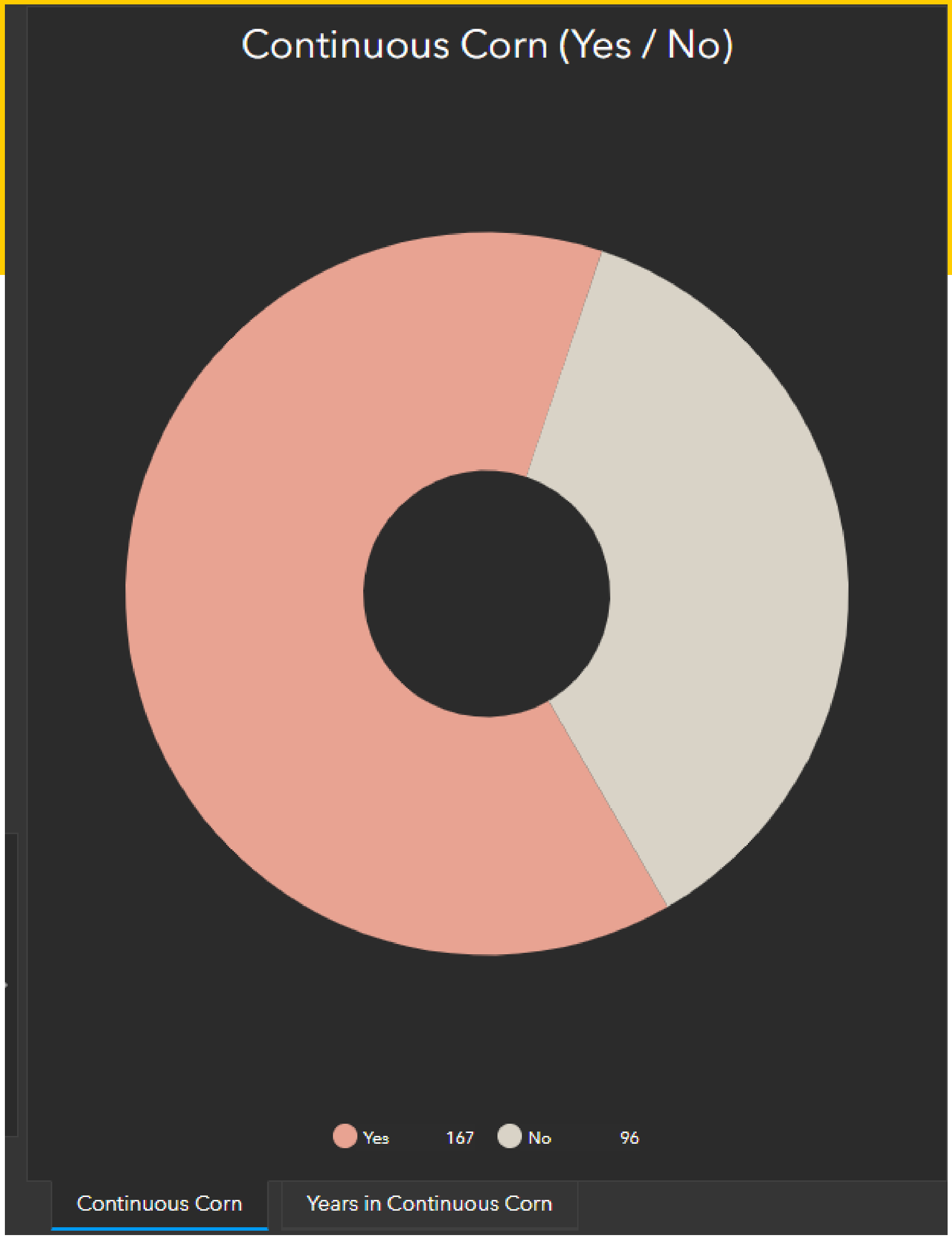
Extension Resources

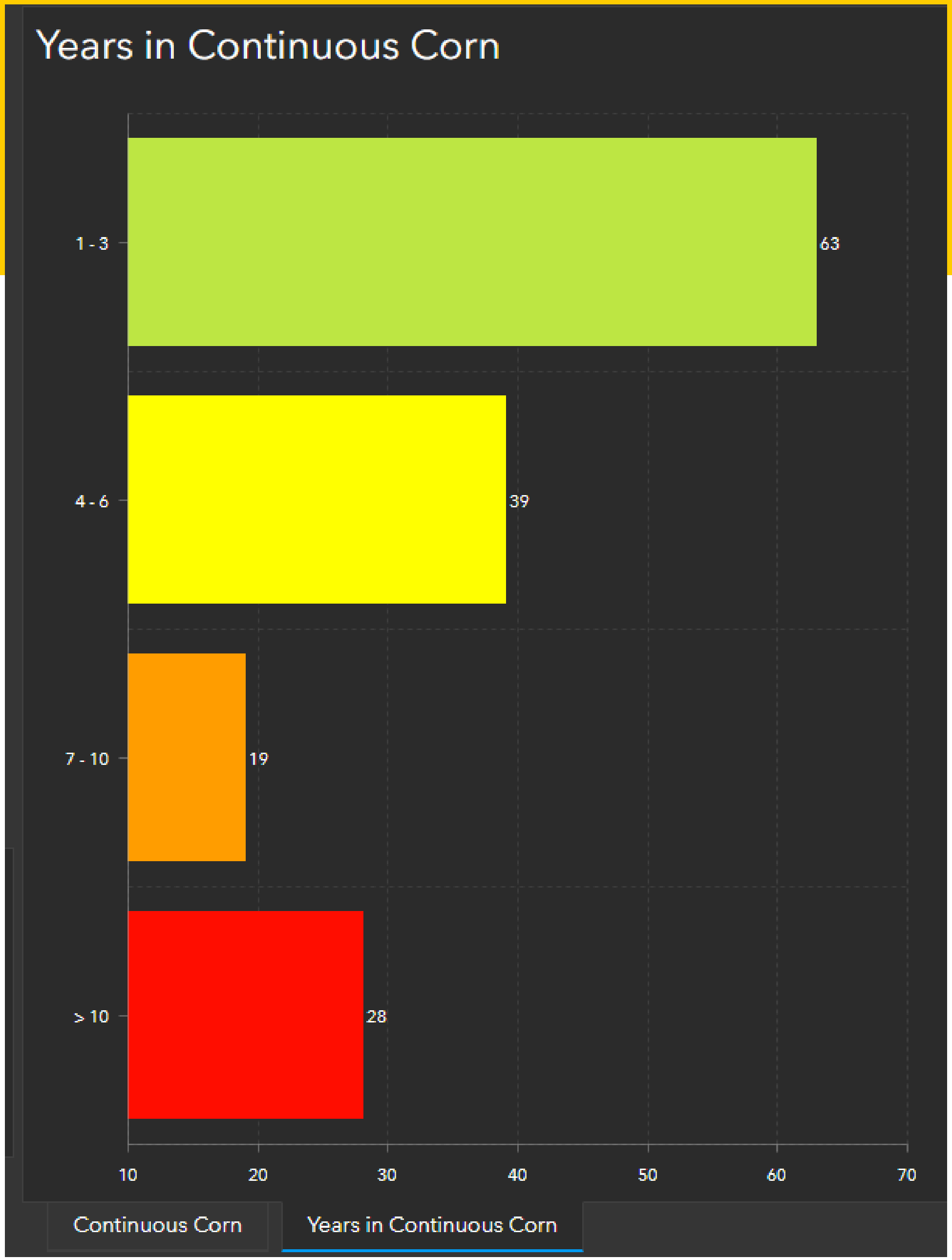
- Corn Rootworm Adult Monitoring Network – Iowa State University
  - https://www.arcgis.com/apps/MapSeries/index.html?appid=008cd878003f44fca4d8a6b5f0fe7b1c

Yellow sticky trap

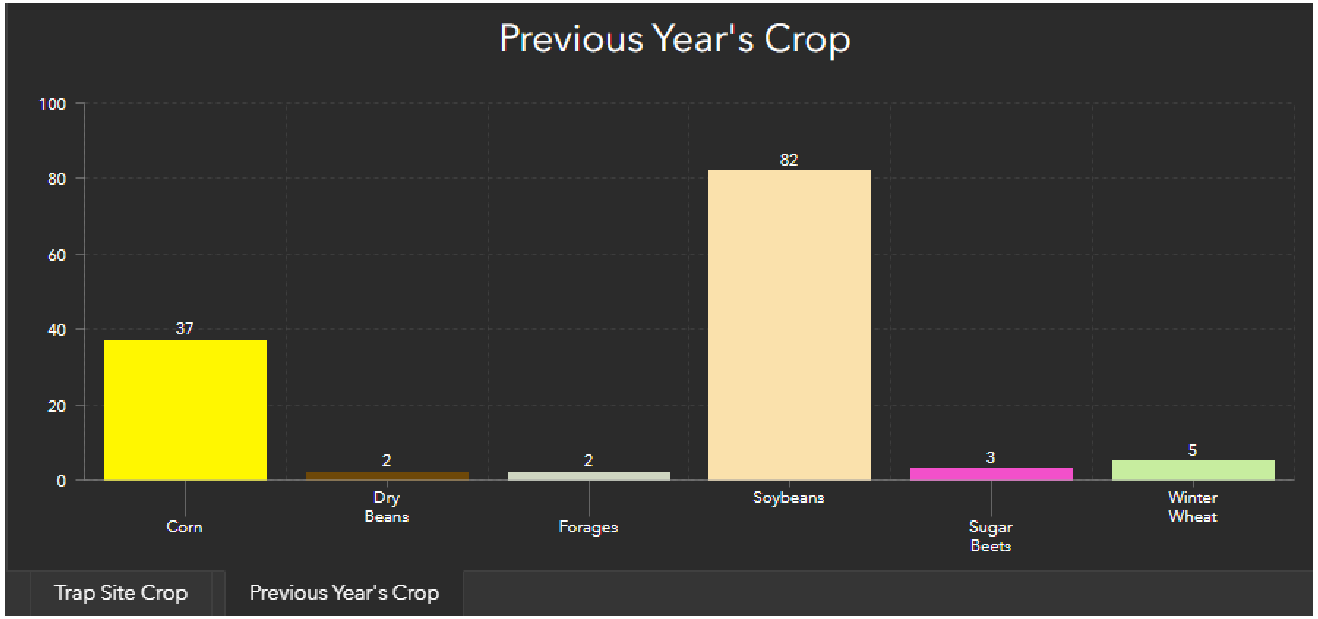


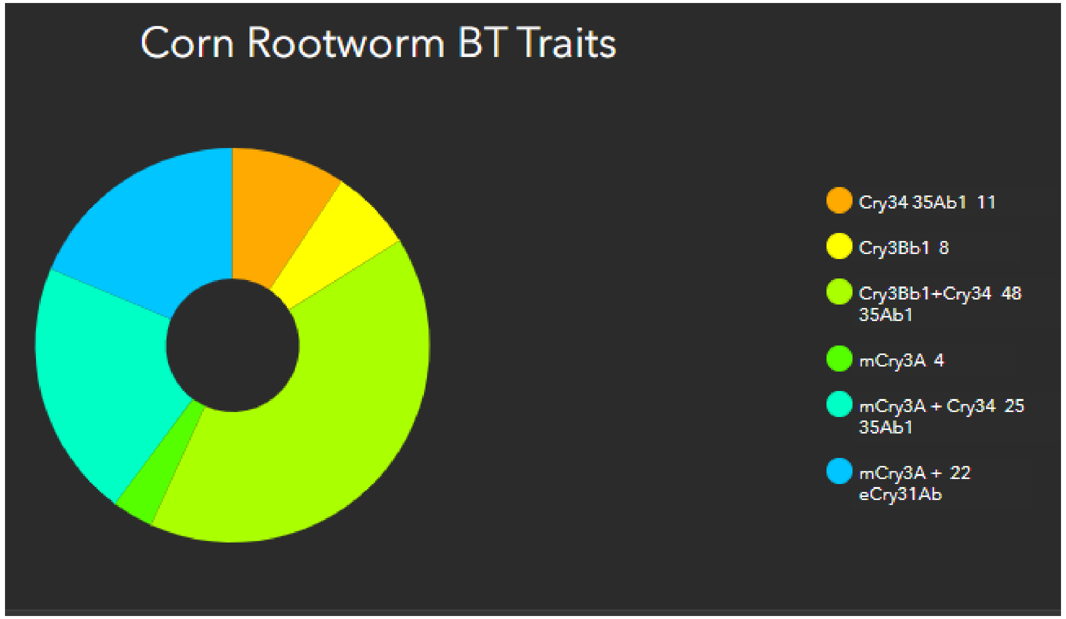
Corn Rootworm Adult Monitoring Network





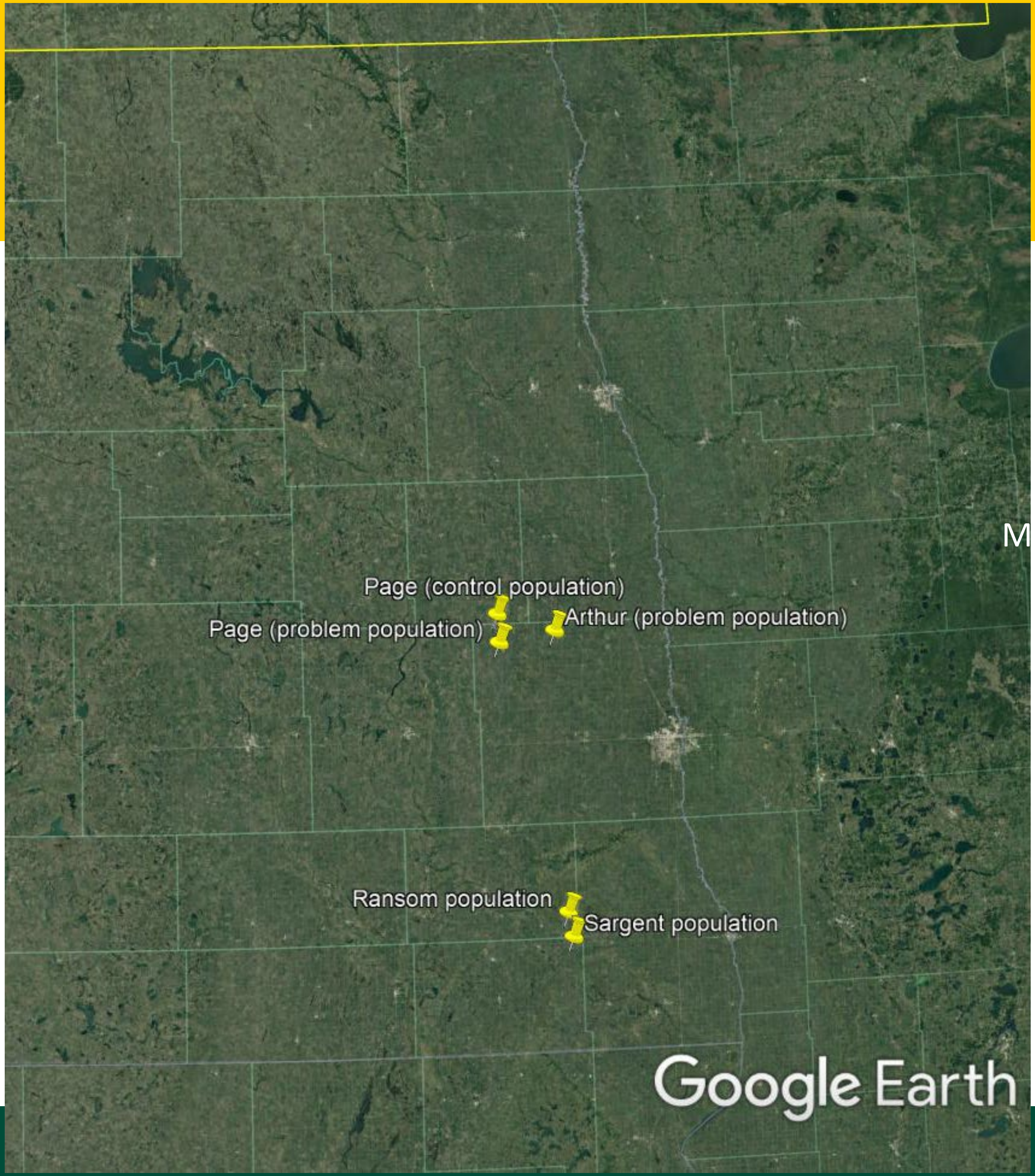
Corn Rootworm Adult Monitoring Network



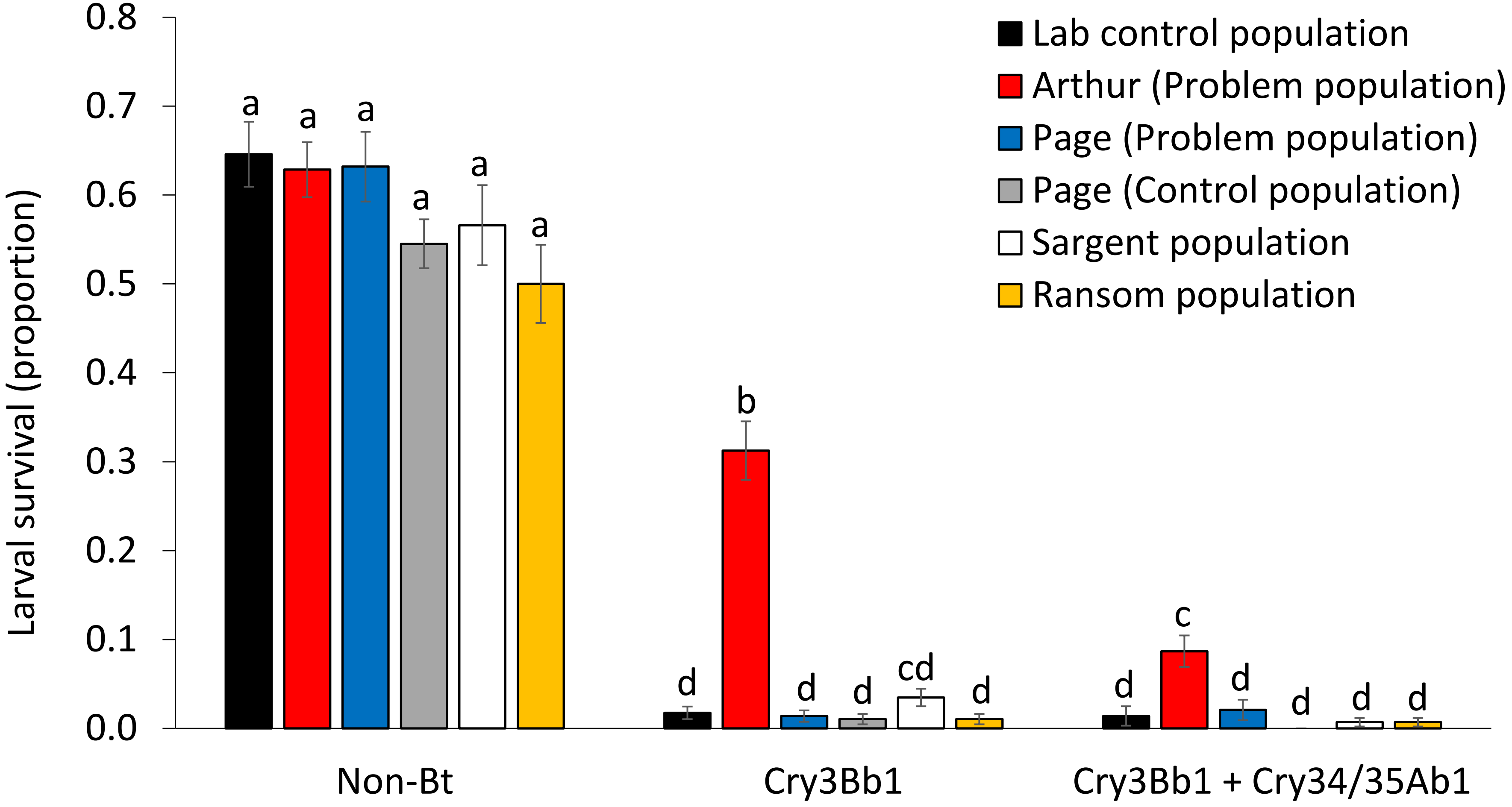


Field sites

Corn rootworms (Western & Northern)



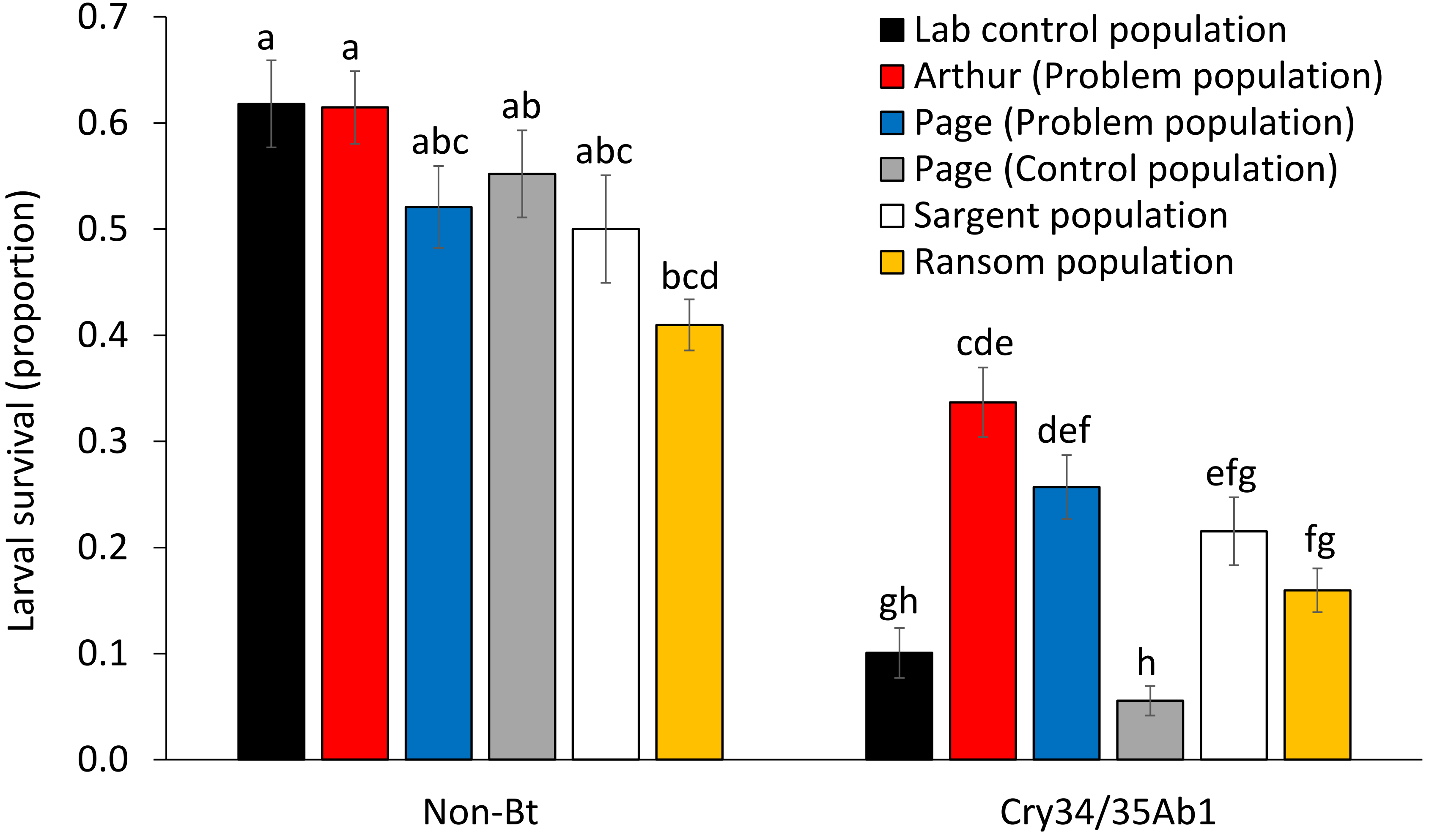
Proportional larval survival of NCR populations on Cry3Bb1, Cry3Bb1 + Cry34/35Ab1, and non-Bt corn hybrids in ND, 2017



Bars sharing a letter are not significantly different based on a two-way mixed-model ANOVA (*P* < 0.05) and LSMEANS (with the PDIFF option). Alpha values were adjusted by using a Bonferroni correction.

Calles-Torrez et al. 2019. J. Econ. Entomol. 112(4): 1875–1886

Proportional larval survival of NCR populations on Cry34/35Ab1 and its non-Bt corn hybrid in ND, 2017



Calles-Torrez et al. 2019. J. Econ. Entomol. 112(4): 1875–1886

Bars sharing a letter are not significantly different based on a two-way mixed-model ANOVA ($P < 0.05$) and LSMEANS (with the PDIFF option). Alpha values were adjusted by using a Bonferroni correction.

Corrected larval survival of ND NCR populations on Cry3Bb1, Cry34/35Ab1, and Cry3Bb1 + Cry34/35Ab1 corn, 2017

	Corrected proportional larval survival (mean ± SEM)		
Population site	Cry3Bb1	Cry34/35Ab1	Cry3Bb1 + Cry34/35Ab1
Arthur (problem population)	0.51 ± 0.05a	0.54 ± 0.04a	0.13 ± 0.03a
Page (problem population)	0.02 ± 0.01b	0.51 ± 0.05a	0.04 ± 0.02b
Sargent	0.09 ± 0.04b	0.45 + 0.06a	0.01 ± 0.01b
Ransom	0.03 ± 0.02b	0.41 ± 0.05a	0.02 ± 0.02b
Lab (control population)	0.03 ± 0.02b	0.18 ± 0.05b	0.02 ± 0.02b
Page (control population)	0.03 ± 0.01b	0.13 ± 0.05b	0.00 ± 0.00b

Means sharing a letter within a Bt corn hybrid are not significantly different based on a one-way mixed-model ANOVA ($P < 0.05$) and LSMEANS (with PDIFF option). Alpha values were adjusted by using a Bonferroni correction test.

Calles-Torrez et al. 2019. J. Econ. Entomol. 112(4): 1875–1886

Conclusions

- The first known cases of field-evolved resistance in NCR populations to Cry3Bb1 (Arthur population) and Cry34/35Ab1 (Arthur, Page problem population, Ransom, and Sargent populations) were characterized in ND.

- Increased larval survival on pyramided Cry3Bb1 + Cry34/35Ab1 corn was observed in NCR species.


Photo: Eric Quale, CS AgriSolutions

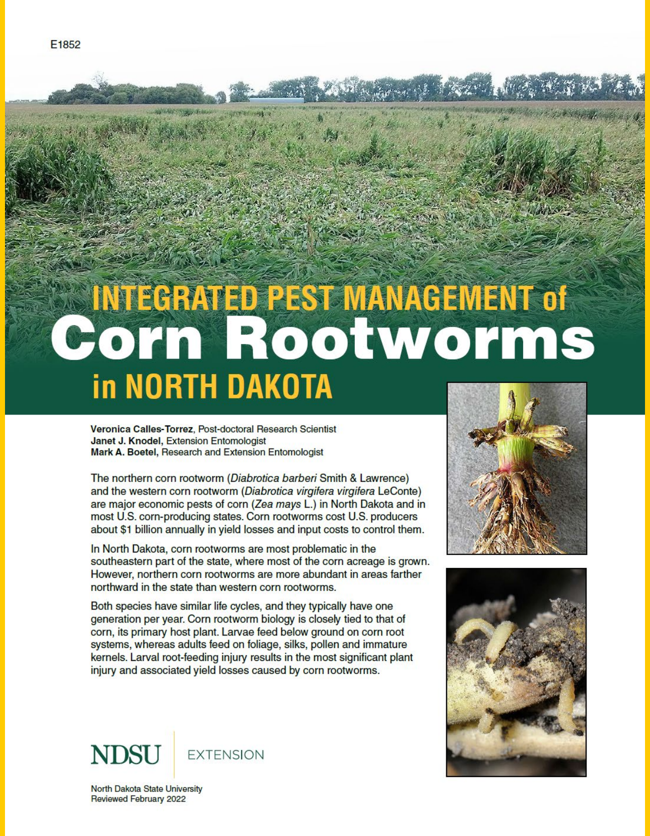
Journal of Economic Entomology, 112(4), 2019, 1875–1886
doi: 10.1093/jee/toz111
Research

OXFORD

Insecticide Resistance and Resistance Management

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

Veronica Calles-Torrez,[1,6] Janet J. Knodel,[2] Mark A. Boetel,[1] B. Wade French,[3] Billy W. Fuller,[4] and Joel K. Ransom[5]


E1852

INTEGRATED PEST MANAGEMENT of
Corn Rootworms
in NORTH DAKOTA

Veronica Calles-Torrez, Post-doctoral Research Scientist
Janet J. Knodel, Extension Entomologist
Mark A. Boetel, Research and Extension Entomologist

The northern corn rootworm (*Diabrotica barberi* Smith & Lawrence) and the western corn rootworm (*Diabrotica virgifera virgifera* LeConte) are major economic pests of corn (*Zea mays* L.) in North Dakota and in most U.S. corn-producing states. Corn rootworms cost U.S. producers about $1 billion annually in yield losses and input costs to control them.

In North Dakota, corn rootworms are most problematic in the southeastern part of the state, where most of the corn acreage is grown. However, northern corn rootworms are more abundant in areas farther northward in the state than western corn rootworms.

Both species have similar life cycles, and they typically have one generation per year. Corn rootworm biology is closely tied to that of corn, its primary host plant. Larvae feed below ground on corn root systems, whereas adults feed on foliage, silks, pollen and immature kernels. Larval root-feeding injury results in the most significant plant injury and associated yield losses caused by corn rootworms.

NDSU EXTENSION

North Dakota State University
Reviewed February 2022

THANK YOU

NORTH DAKOTA CORN COUNCIL

Send any questions to:
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701-231-7915

EXTENDING KNOWLEDGE ❯❯ CHANGING LIVES

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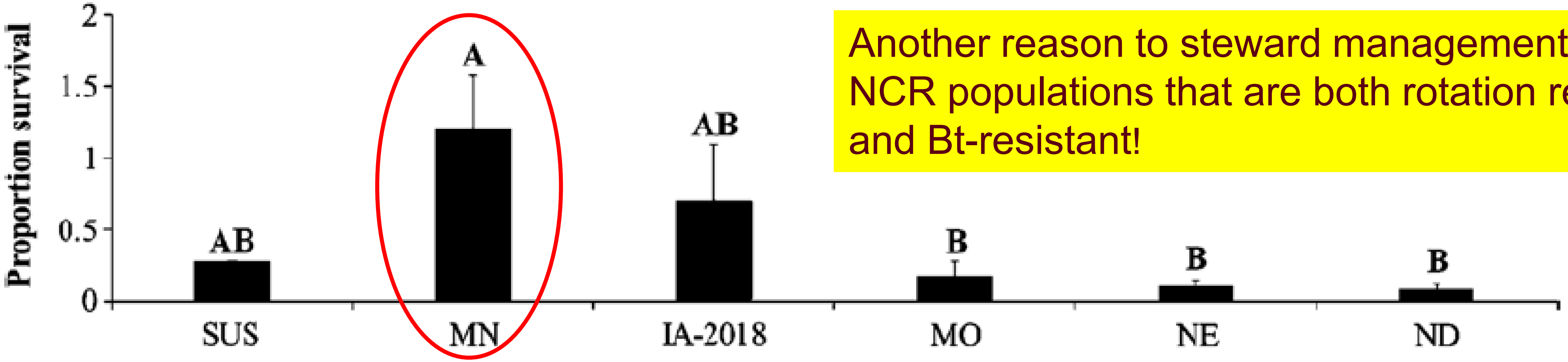
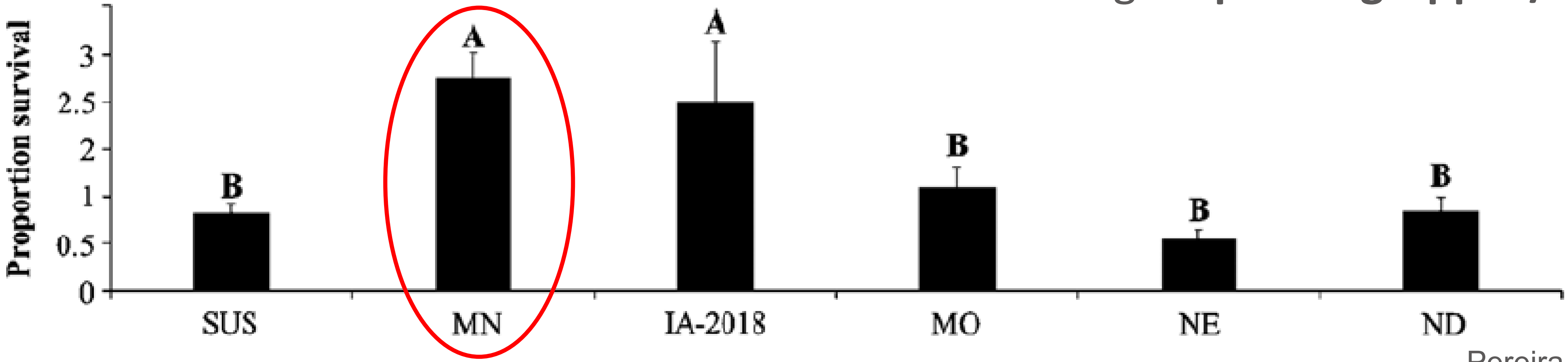
Survival of NCR larvae that fed on maize seedlings **expressing Cry3Bb1**



Another reason to steward management tools - NCR populations that are both rotation resistant and Bt-resistant!

Survival of NCR larvae that fed on maize seedlings **expressing Gpp34/Tpp35Ab1**



Pereira.et al. 2023.

Slide courtesy Dr. Fei Yang

Rootworm Traits with RNAi Mode of Action

SmartStax Pro
Bayer

Limited release: 2022

Commercial release: 2023

Above-ground:
Cry1A.105, Cry2Ab2, Cry1F

Below-ground:
Cry3Bb1, Cry34/35Ab1, DvSnf7 dsRNA

Herbicide:
glyphosate, glufosinate

SmartStax PRO With RNAi TECHNOLOGY

Vorceed Enlist
Corteva

Limited release: 2023

Larger release in subsequent years

Above-ground:
Cry1A.105, Cry2Ab2, Cry1F

Below-ground:
Cry3Bb1, Cry34/35Ab1, DvSnf7 dsRNA

Herbicide: glyphosate, glufosinate, 2,4-D

VORCEED Enlist

VT4Pro
Bayer

Estimated commercial release in 2024

Above-ground:
Cry1A.105, Cry2Ab2, Vip3Aa20

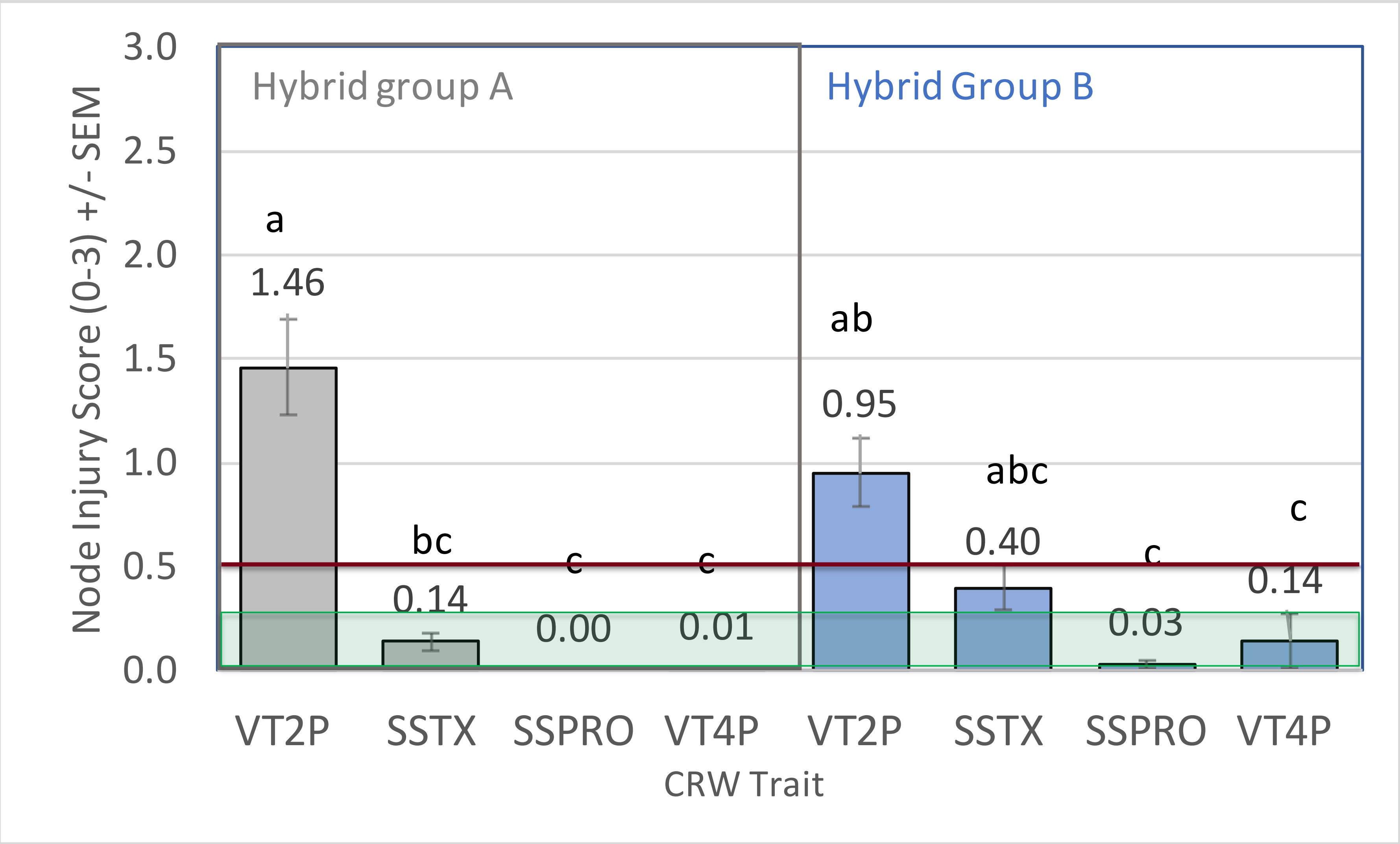
Below-ground:
Cry3Bb1, DvSnf7 dsRNA

Herbicide:
glyphosate

VT4PRO With RNAi TECHNOLOGY

Slide courtesy Dr. Fei Yang

RW trait efficacy Lamberton, MN 2023



RW TOXINS

VT2P - None

SSTX - Cry3Bb1+ Cry34/35Ab1

SSPRO - CryBb1 + Cry34/35Ab1 +RNAi

VT4P - Cry3Bb1 +RNAi

NIS < 0.25 = Low risk
NIS > 0.50 UIR

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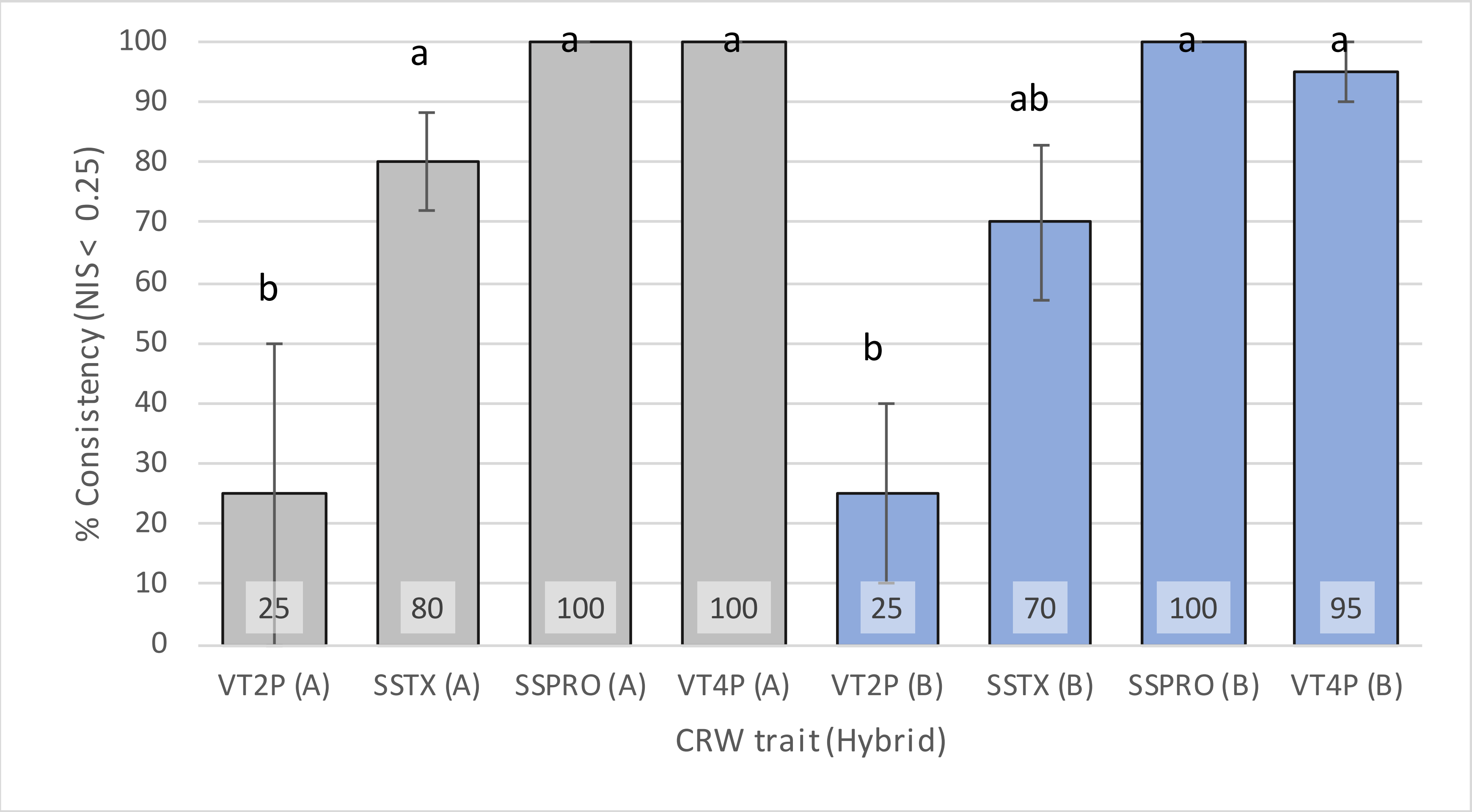
What about traits (consistency)?



Lamberton, MN 2023

How about efficacy of RNAi

- Compared to Bt, RNAi is slow in killing CRW (-5 days)
- Sublethal effects? Potential resistance?

- Resistant WCR was developed in lab from field-collected beetles
- Reduced uptake of dsRNA
- No cross-resistance to Bt traits
- Cross-resistant to other dsRNAs

PLOS | ONE

RESEARCH ARTICLE

Development and characterization of the first dsRNA-resistant insect population from western corn rootworm, *Diabrotica virgifera virgifera* LeConte

Chitvan Khajuria*, Sergey Ivashuta, Elizabeth Wiggins, Lex Flagel, William Moar, Michael Pleau, Kaylee Miller, Yuanji Zhang, Parthasarathy Ramaseshadri, Changjian Jiang, Tracey Hodge, Peter Jensen, Mao Chen, Anilkumar Gowda, Brian McNulty, Cara Vazquez, Renata Bolognesi, Jeffrey Haas, Graham Head, Thomas Clark

Monsanto Co., 700 Chesterfield Parkway West, Chesterfield, Missouri, United States of America

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Citation: Khajuria C, Ivashuta S, Wiggins E, Flagel L, Moar W, Pleau M, et al. (2018) Development and characterization of the first dsRNA-resistant insect population from western corn rootworm, *Diabrotica virgifera virgifera* LeConte. PLoS ONE 13 (5): e0197059. https://doi.org/10.1371/journal.pone.0197059

Editor: Subba Reddy Palli, University of Kentucky, UNITED STATES

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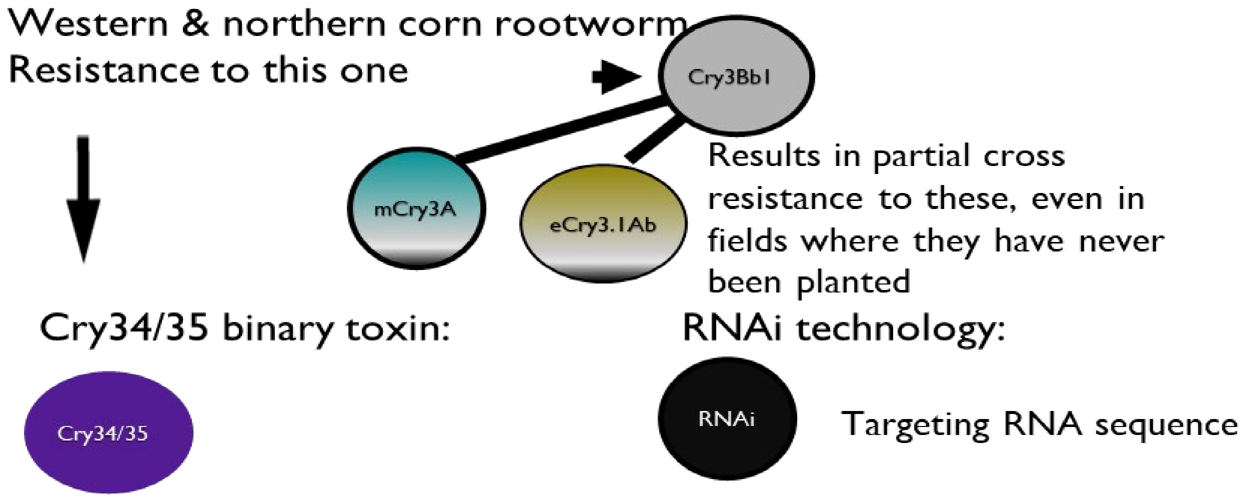
Abstract

The use of dsRNA to control insect pests via the RNA interference (RNAi) pathway is being explored by researchers globally. However, with every new class of insect control compounds, the evolution of insect resistance needs to be considered, and understanding resistance mechanisms is essential in designing durable technologies and effective resistance management strategies. To gain insight into insect resistance to dsRNA, a field screen with subsequent laboratory selection was used to establish a population of DvSnf7 dsRNA-resistant western corn rootworm, *Diabrotica virgifera virgifera*, a major maize insect pest. WCR resistant to ingested DvSnf7 dsRNA had impaired luminal uptake and resistance was not DvSnf7 dsRNA-specific, as indicated by cross resistance to all other dsRNAs tested. No resistance to the *Bacillus thuringiensis* Cry3Bb1 protein was observed. DvSnf7 dsRNA resistance was inherited recessively, located on a single locus, and autosomal. Together these findings will provide insights for dsRNA deployment for insect pest control

Slide courtesy of Dr. Fei Yang

For the three Cry3-type toxins:



Below-ground (coleoptera):

Cry3: Cry3Bb1, mCry3A, eCry3.1Ab

Cry34/35Ab1: Gpp34/Tpp35Ab1

RNAi: snf7 gene

Cry75Aa: Mpp75Aa1

Vip4: Vpb4Da2

MON 95275 (Canada)

Government of Canada | Gouvernement du Canada

Search Inspection.canada.ca

MENU

Canada.ca > Canadian Food Inspection Agency > Plant varieties > Plants with novel traits > Notices of submission

Notice of submission from Bayer CropScience Inc. for novel food, livestock feed and environmental safety approval for commercial planting purposes of a plant genetically modified for insect resistance

June 15, 2023

Cry75Aa (MPP75Aa)

Spotlight Selection | Applied and Industrial Microbiology | Research Article | 12 February 2021

Cry75Aa (Mpp75Aa) Insecticidal Proteins for Controlling the Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae), Isolated from the Insect-Pathogenic Bacterium *Brevibacillus laterosporus*

Authors: David Bowen, Yong Yin, Stanislaw Flasinski, Catherine Chay, Gregory Bean, Jason Milligan, William Moar, SHOW ALL (19 AUTHORS), James Roberts | AUTHORS INFO & AFFILIATIONS

Vpb4 (Vip4)

A new *Bacillus thuringiensis* protein for Western corn rootworm control

Yong Yin, Stanislaw Flasinski, William Moar, David Bowen, Cathy Chay, Jason Milligan, Jean-Louis Kouadio, Aihong Pan, Brent Werner, Karrie Buckman, Jun Zhang, Geoffrey Mueller, Collin Preftakes, [...], James Roberts [view all]

Published: November 30, 2020 • https://doi.org/10.1371/journal.pone.0242791

IPD072Aa (Not a Bt protein)

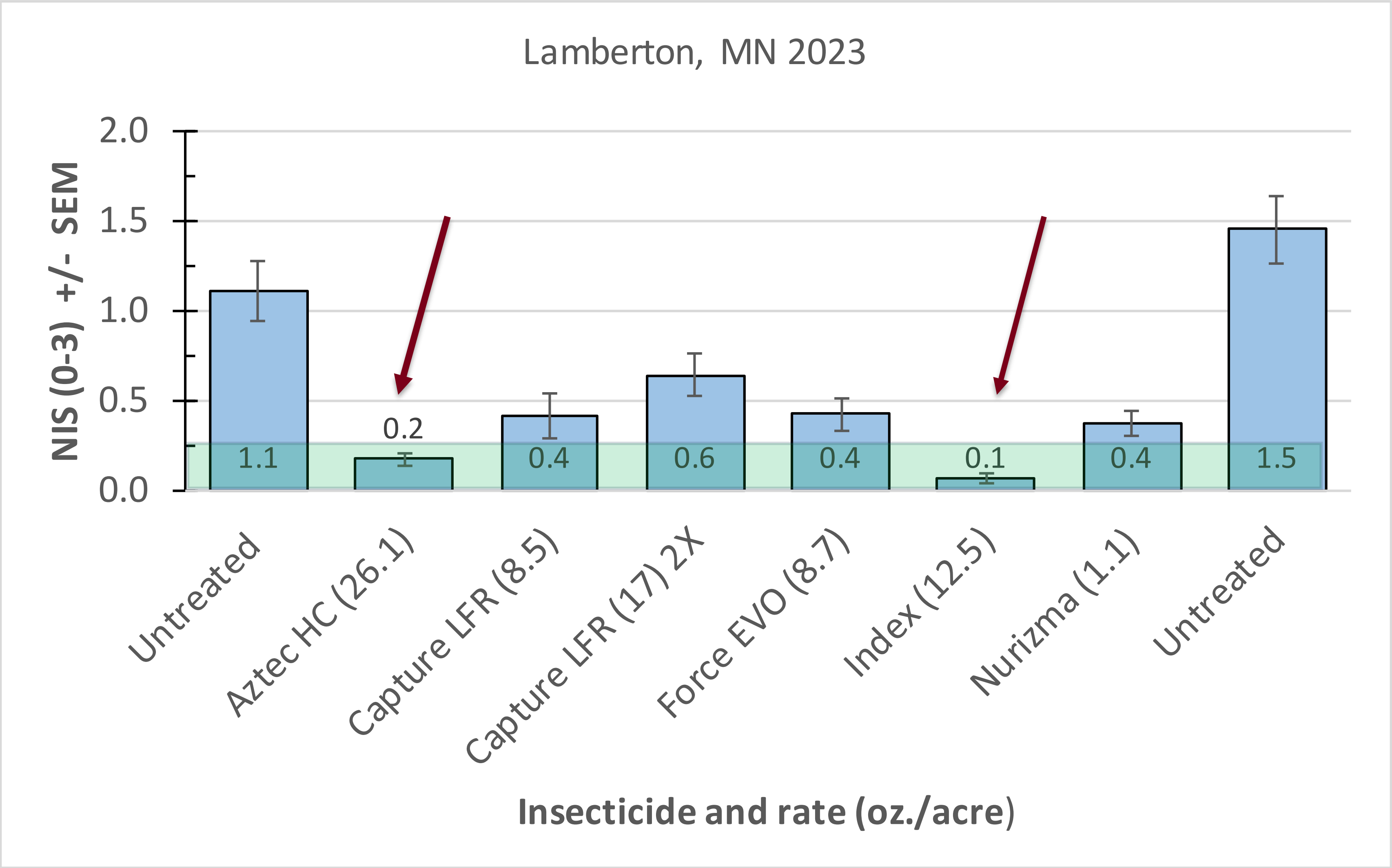
IPD072Aa from *Pseudomonas chlororaphis* Targets Midgut Epithelial Cells in Killing Western Corn Rootworm (*Diabrotica virgifera virgifera*)

Nuria Jiménez-Juárez, Jarred Oral, Mark E. Nelson, Albert L. Lu

Corteva Agriscience, Johnston, Iowa, USA

Slide courtesy Dr. Fei Yang

Insecticide efficacy on WCR



Bruce Potter 2024

Benefits of RW control in SW MN

High pressure (1.4 - 2.0 NIS) WCR populations

Cry3 resistant populations w/ evidence of Cry 34/35 resistance

Management	**Benefit of treatment**
Bt traits*	0.5 to 2.0 nodes (24 -100%)
Granules	up to 1.7 nodes (34 -99%)
Liquids	up to 1.3 nodes (0 - 98%)
Seed applied (RW rate)	up to 0.6 nodes (24 -33%)

*Traits may be even less effective on some populations

Management practices are not necessarily additive.

Bruce Potter 2024

Managing CRW: Reducing egg-laying

HOW

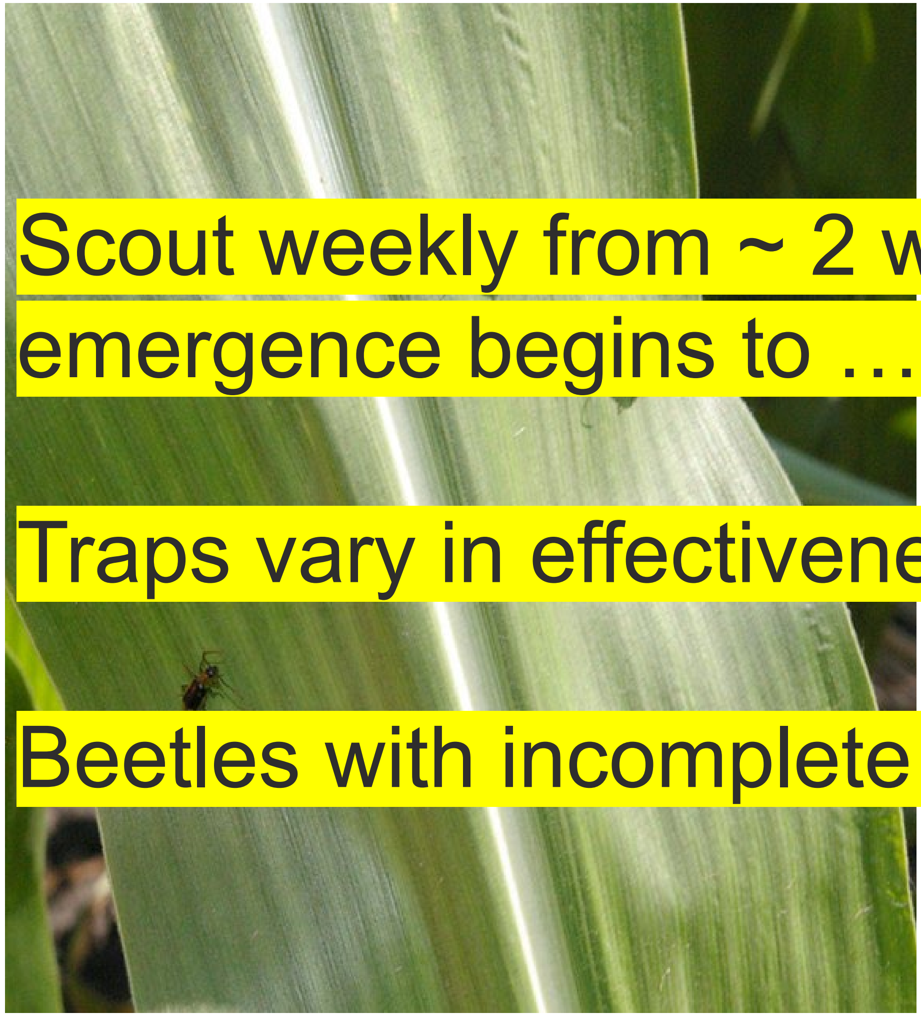
- Egg laying ~ 2 weeks after beetles emerge
- Scout twice a week
  - ✓ 10% of females gravid
  - ✓ 1 beetle/plant
- Re-spray as needed

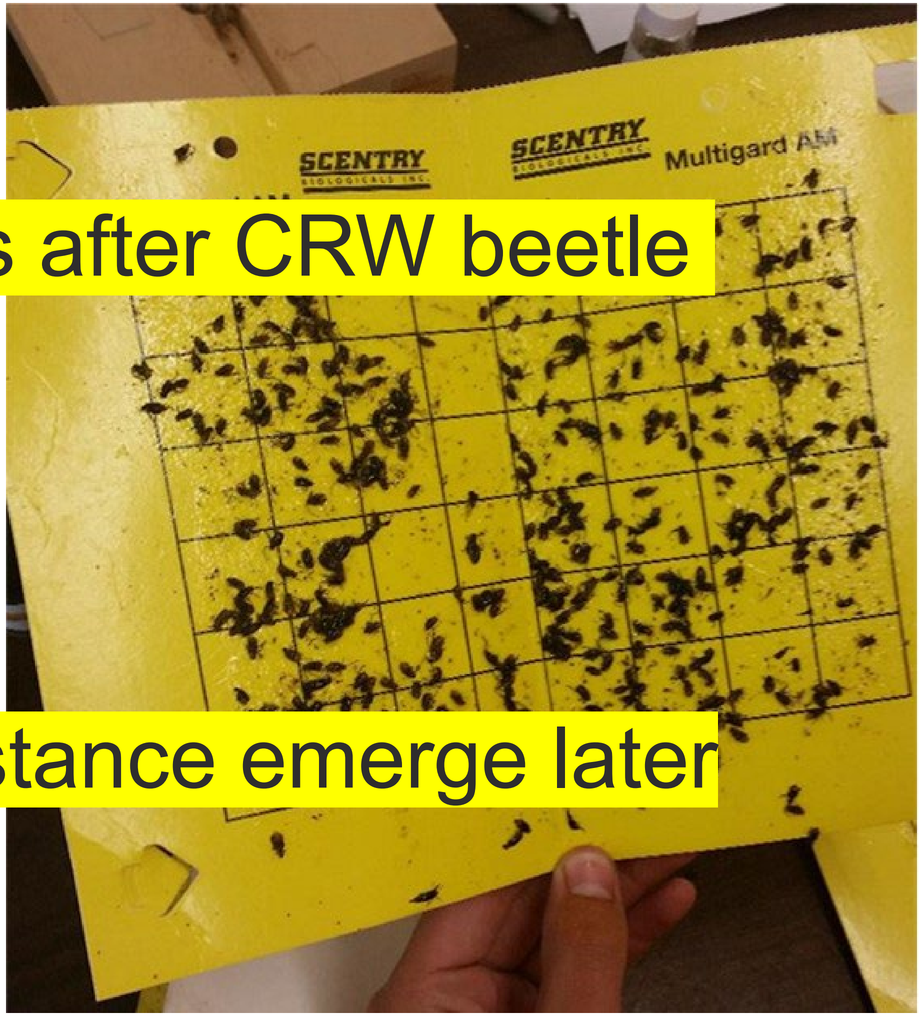
Ostlie and Leaf rev. 2022

Bruce Potter 2024

Knowledge Is: Power, Safety, and Happiness!

(Thomas Jefferson)





Scout weekly from ~ 2 weeks after CRW beetle emergence begins to …

Traps vary in effectiveness

Beetles with incomplete resistance emerge later

Managing CRWs: Decisions…Decisions

Beetle populations

- Field and area

Root evaluation

- Ongoing problem?
- Management issues?

Species ID

- Will rotation or Bt work?

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Managing ED: Decisions…Decisions

- **Monitor both species in corn**

  Scout efficiently

- **Field-based management but…**

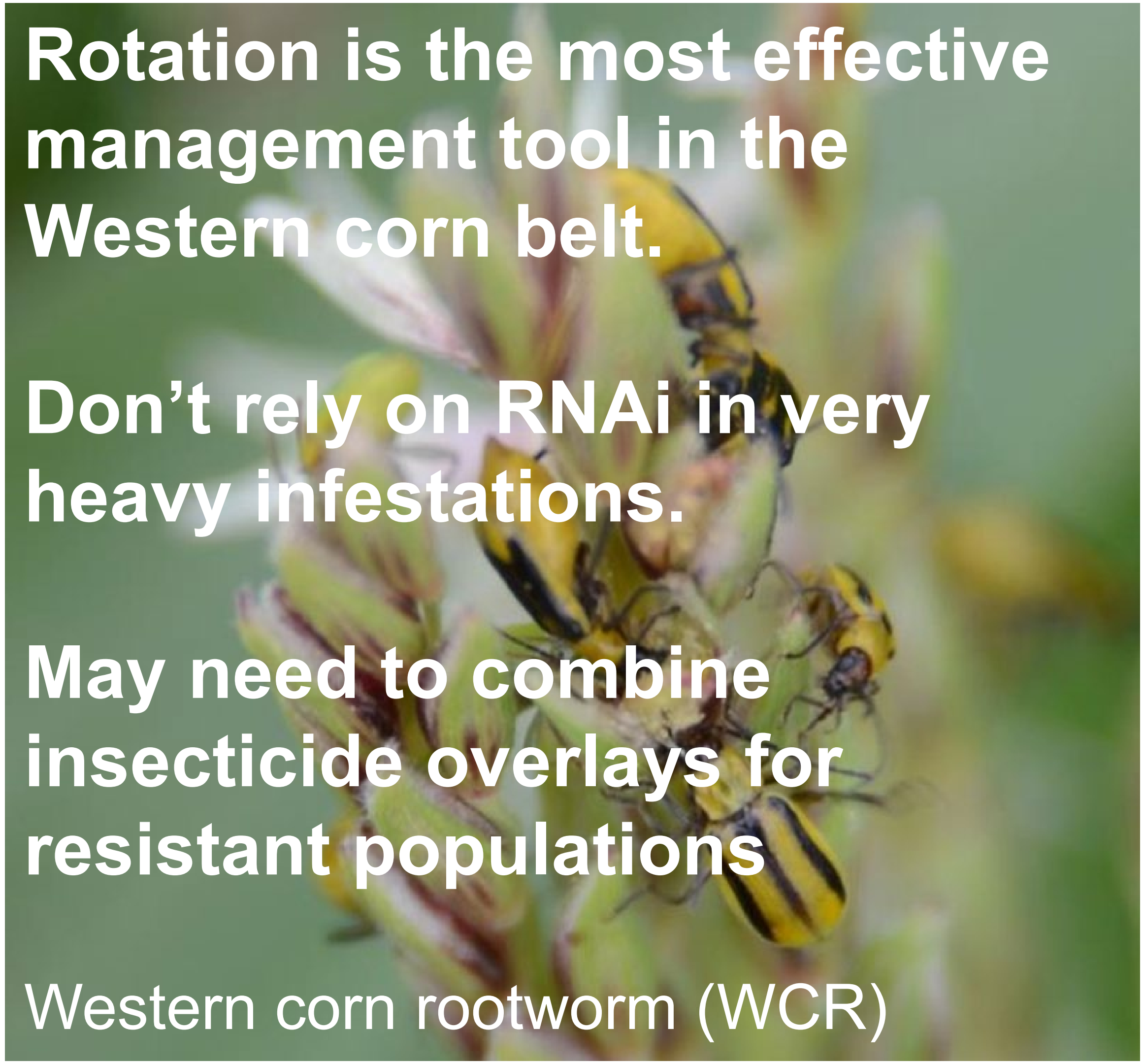
  ED varies by geography and field

- **Logistics, capabilities, attitude**

  How many fields can you scout?

Bruce Potter 2024

A tale of two rootworms

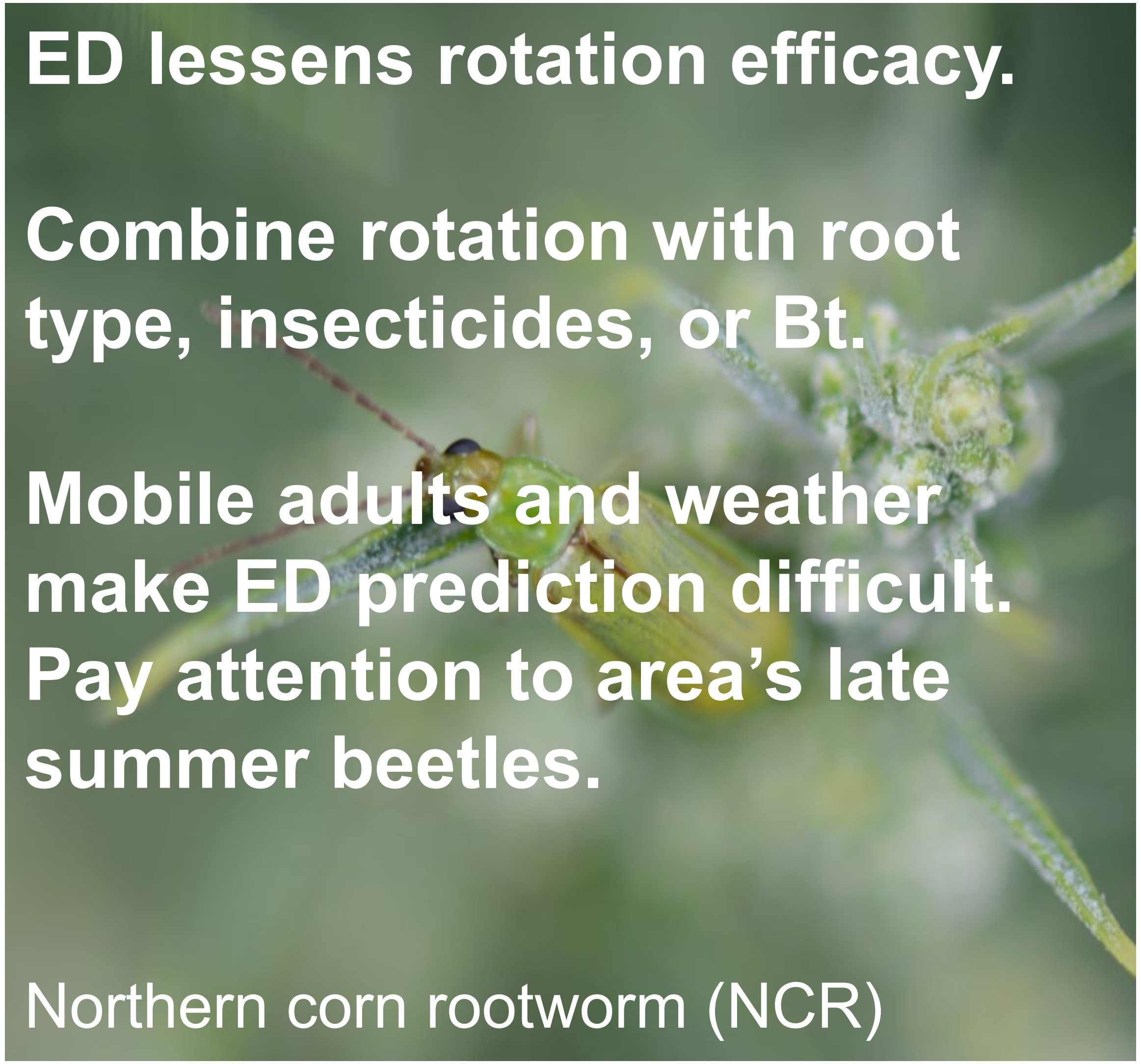


Rotation is the most effective management tool in the Western corn belt.

Don’t rely on RNAi in very heavy infestations.

May need to combine insecticide overlays for resistant populations

Western corn rootworm (WCR)



ED lessens rotation efficacy.

Combine rotation with root type, insecticides, or Bt.

Mobile adults and weather make ED prediction difficult. Pay attention to area’s late summer beetles.

Northern corn rootworm (NCR)

Bruce Potter 2024

A guide to less corn rootworm stress

- ✓**Know your risk**
  - Your fields are unique
  - “No problem” is a data point
- ✓**Be unpredictable**
  - Use the whole toolbox
- ✓**Be adaptable**

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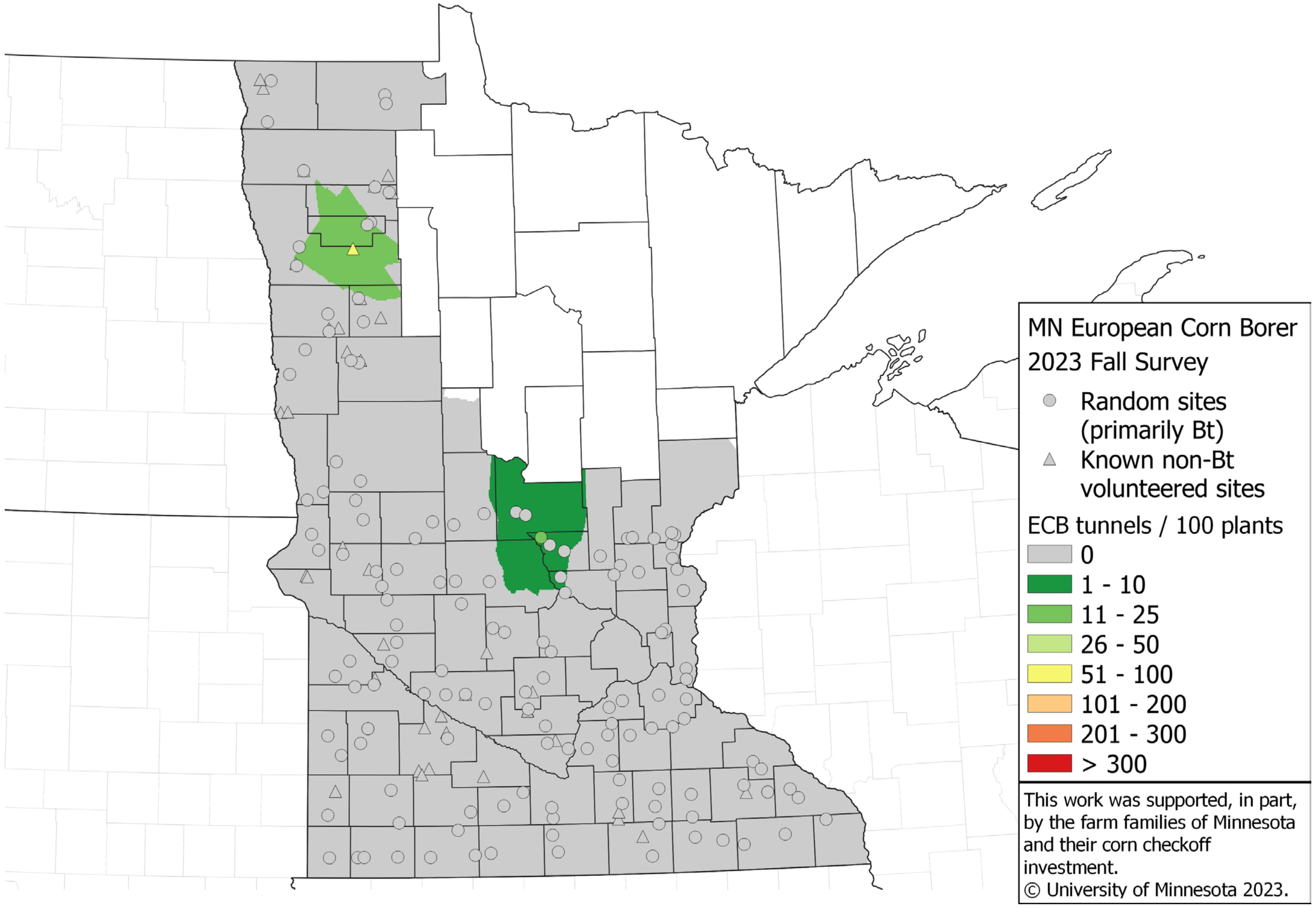
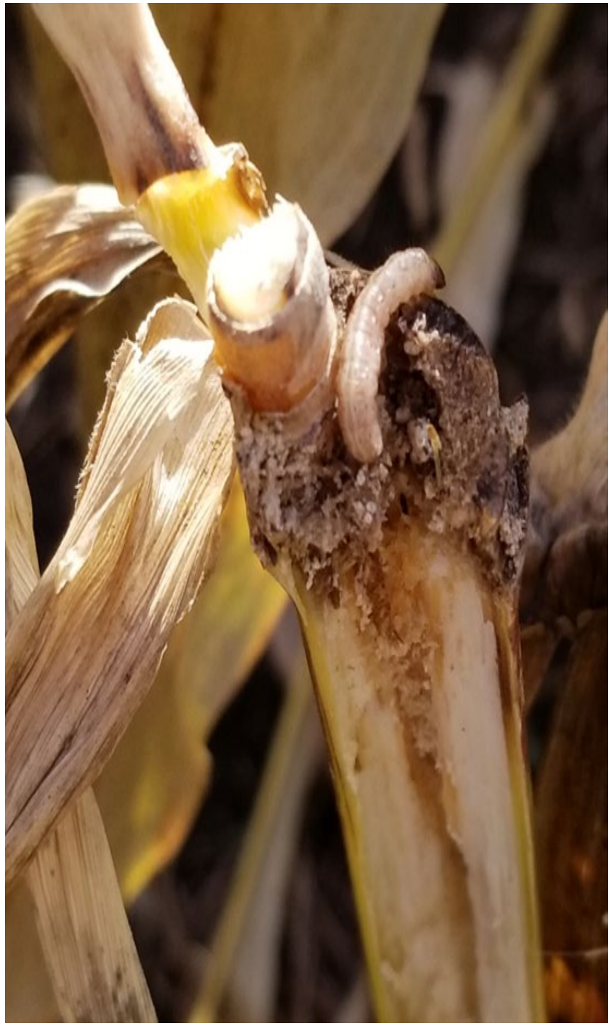
Thank you for your attention!

Any questions?

European corn borer



Map from Smith and Farhan 2023



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Slide courtesy of Dr. Fei Yang

- During 2019-2022, practical **Cry1F resistance** in ECB has expanded into other locations in Canada.
  - Cry1F resistance in 52% of strains (12 of 23)
  - 10 in NS, 1 in QC**, 1 in MB**

JOURNAL ARTICLE

Monitoring resistance of *Ostrinia nubilalis* (Lepidoptera: Crambidae) in Canada to Cry toxins produced by Bt corn FREE

Jocelyn L Smith, Yasmine Farhan

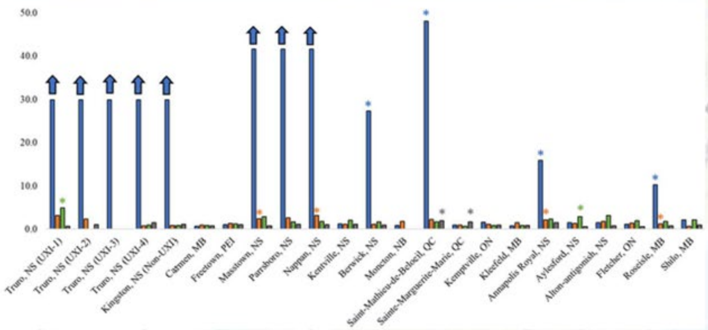
Journal of Economic Entomology, toad046, https://doi.org/10.1093/jee/toad046

Published: 20 March 2023 **Article history** ▾

EARLY WARNING OF RESISTANCE*

- Cry1Ab resistance in 23% of strains (5 of 22)
  - 4 in NS, 1 in MB
- Cry1A.105 resistance in 45% of strains (9 of 20)
  - 7 in NS, 1 in PEI, 1 in QC
- Cry2Ab resistance in 14% of strains (3 of 21)
  - 1 in NS, 2 in QC

RR Range	
Cry1Ab	0.5 - 3.9
Cry1A.105	0.5 – 5.8
Cry2Ab	0.5 – 2.0



Smith and Farhan 2023 JEE 116(3): 916-926. *Tabashnik and Carriere 2019 JEE 112(6):2513-2523

Pioneer 7844 AM
- Cry1F x Cry1Ab
- 5% Integrated Refuge
- 2225 CHU

Sept 1, 2022

Approximately 10-15% plants with ECB injury
- Broken tassels
- Shot hole leaf feeding
- Borer holes on stalk
- 1-3 ECB per stalk

Bruce Potter 2024

- Non-Bt field in Crookston, MN
- 1000 plants sampled on Oct 1-2, 2023
- Approximate 30-35% corn plants damaged by ECB
- 130-140 ECB larvae were collected and reared in the lab
- Results in spring

Slide courtesy Dr. Fei Yang

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