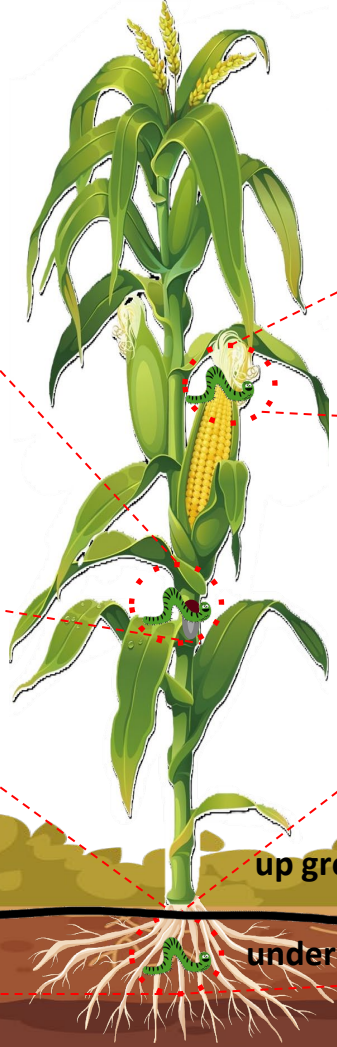
Update on new corn insect pests and emergence of resistance in corn borers and rootworms

Fei Yang, Assistant Professor & Extension Entomologist, UMN Entomology

Corn insect pest

European corn borer

Corn earworm



Northern corn rootworm

Western corn rootworm

up ground

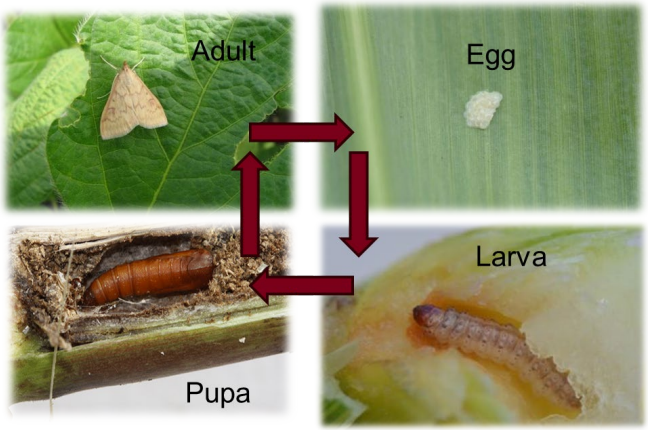
under ground

Emergence of Bt resistance in European corn borer populations

European corn borer

Ostrinia nubilalis (Hübner)

- Lepidoptera: Crambidae
- A major target of Bt corn
- Univoltine or multivoltine



ECB suppression with Bt corn

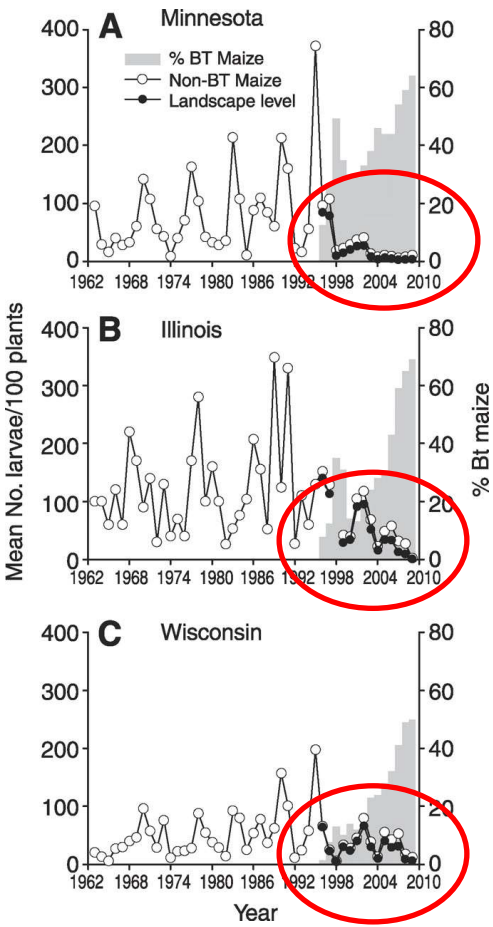
- First Bt corn product developed in 1996
  - ✓ **Cry1:** Cry1Ab, Cry1F, Cry1A.105
  - ✓ **Cry2:** Cry2Ab
- Transgenic Bt corn has provided excellent control for ECB for > 29 years in the U.S.

YieldGard Corn Borer

HERCULEX® RW Rootworm Protection HX™

VTDoublePRO®

SmartStax®



ECB resistance in Canada and U.S.

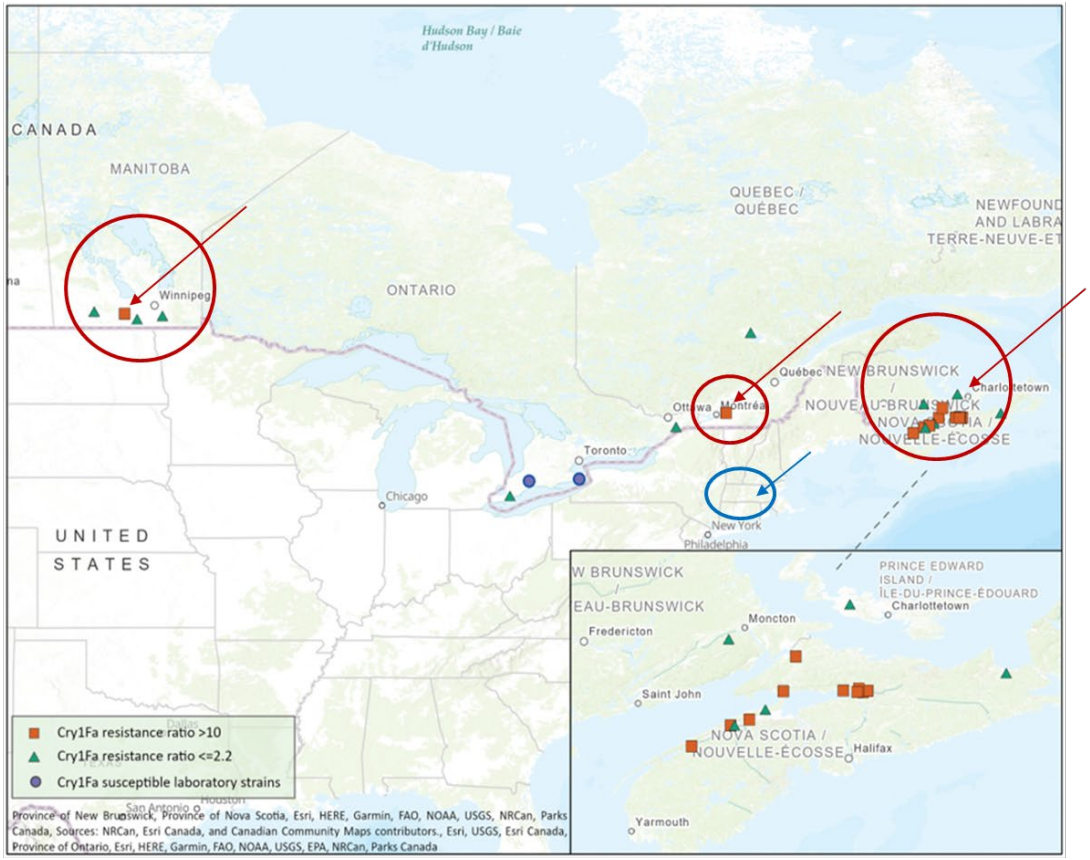
- 2018: Cry1F resistance identified in Nova Scotia in Canada
- 2019-22: Cry1F resistance expanded into three Canadian provinces
- 2023: Early warning of Cry1Ab, Cry1A.105, and Cry2Ab2 resistance in Canada
- 2023-2024: Practical resistance to Cry1Ab, Cry1A.105 and Cry2Ab2 in Connecticut
  - First case of Bt resistance in U.S.

Smith et al., Sci. Rep., 9: 18247 (2019)
Smith and Farhan, J. Econ. Entomol., 116: 916-926 (2023)

The 'Billion-Dollar Pest' Reappears in Canada, Connecticut

European corn borer once wreaked havoc on corn until the introduction of Bt corn. Is the pest making a reappearance?

By Sophie Winkelpleck | Published on February 10, 2025



High risk to Corn Belt:

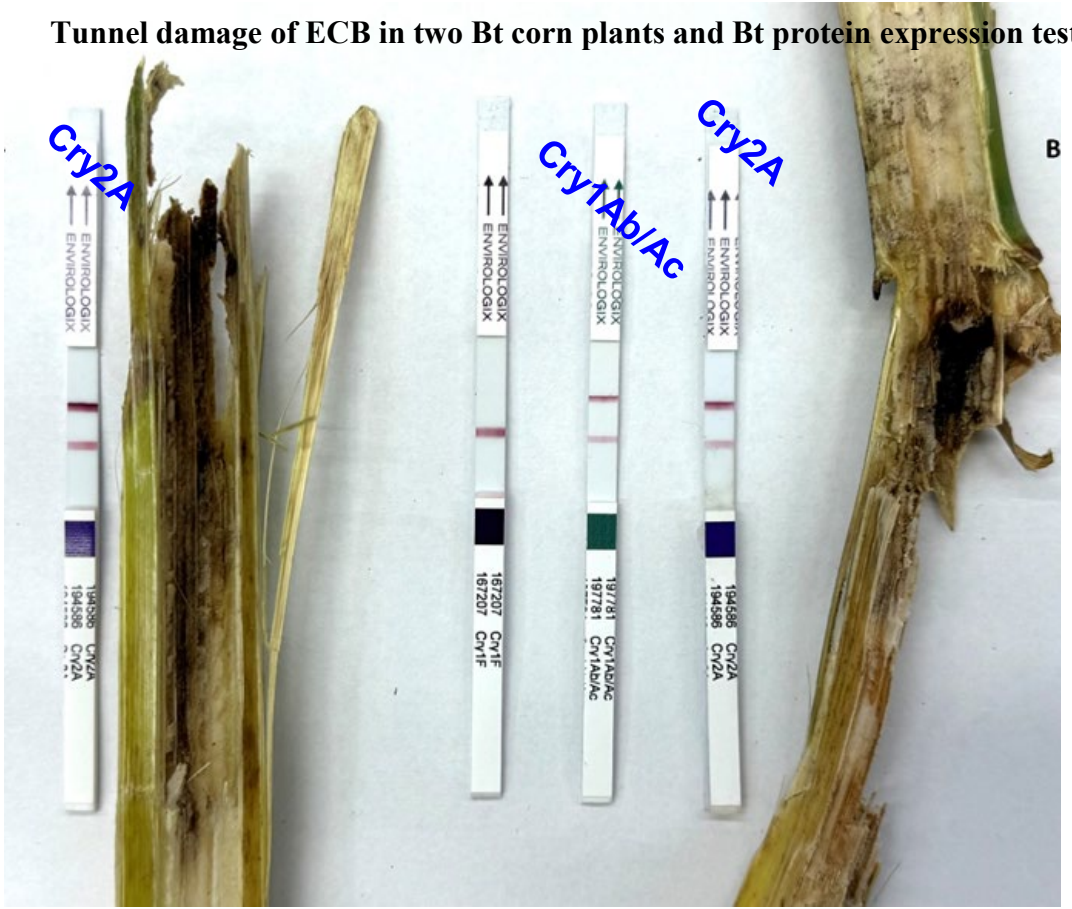
1) Long-term usage increases selection pressure
2) ECB moth highly mobile

Smith & Farhan 2023

ECB survey in MN in 2025

Presence of ECB and damage in refuge plants

Tunnel damage of ECB in two Bt corn plants and Bt protein expression test



Susceptibility bioassays

Larvae Collection

Rearing

Single Pairing

F_1 Family

Sib-mate F_1 population

F_2 Family

- 60 ng/cm^2 Cry1F
- 20 ng/cm^2 Cry1Ab
- 20 ng/cm^2 Cry1A.105
- 270 ng/cm^2 Cry2Ab2

Diagnostic Diet-Overlay Bioassay

~~56.25% SS~~
~~37.5% SR~~
6.25% RR

Full-Range Assays

Summary for ECB Bt resistance

- Resistant to Cry1 (Cry1F, Cry1Ab, Cry1A.105) proteins is low.
- Resistant to Cry2Ab2 is relatively high.
- No cross-resistance of Cry2Ab2 to Cry1F, Cry1Ab, or Cry1A.105.

VTDoublePRO® Trecepta®

POWERCORE® Enlist® VORCEED® Enlist® genuity™ SmartStax™

Cry1+Cry2

Cold tolerance and rotation resistance of western and northern corn rootworm

Major corn rootworm species in Minnesota

Western corn rootworm
(*Diabrotica virgifera virgifera*, WCR)

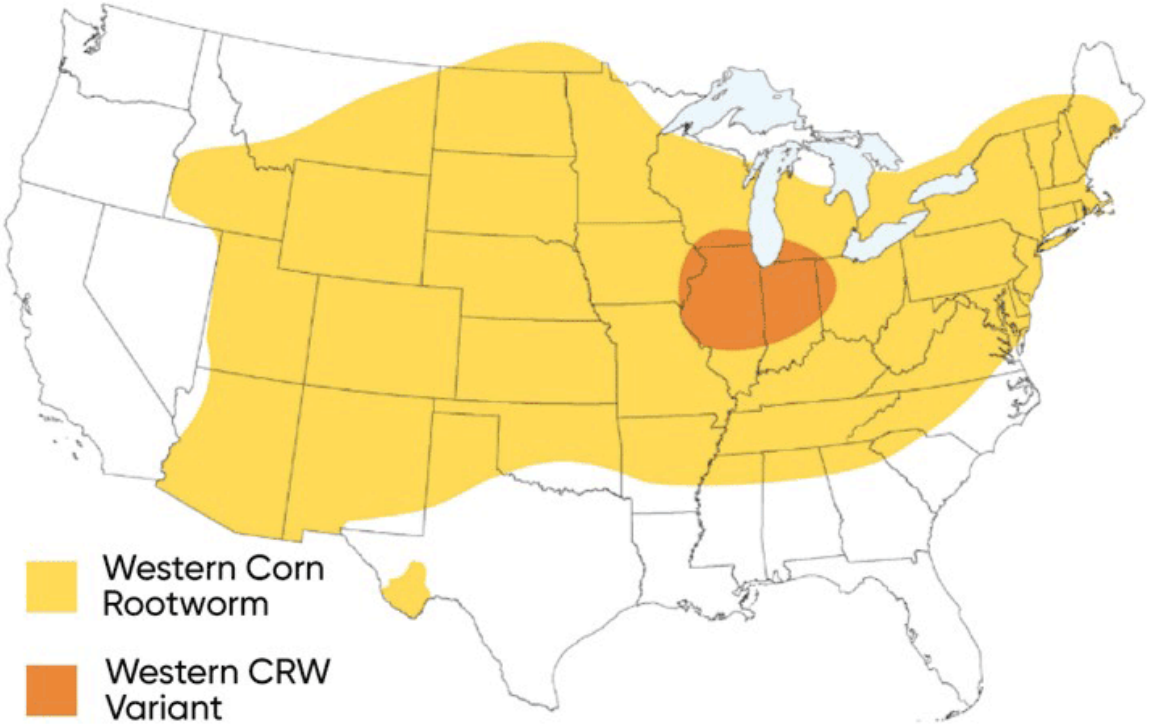
- Continuous corn
- Adults local
- Rotation resistance: variant
- Widespread resistance to Bt: Cry3Bb1, Cry34/35

Northern corn rootworm
(*Diabrotica barberi*, NCR)

- Continuous and rotated corn
- Adults mobile
- Rotation resistance: extended diapause
- A few cases of Bt resistance

Crop rotation & CRW management

Rotation-resistance: WCR Variants

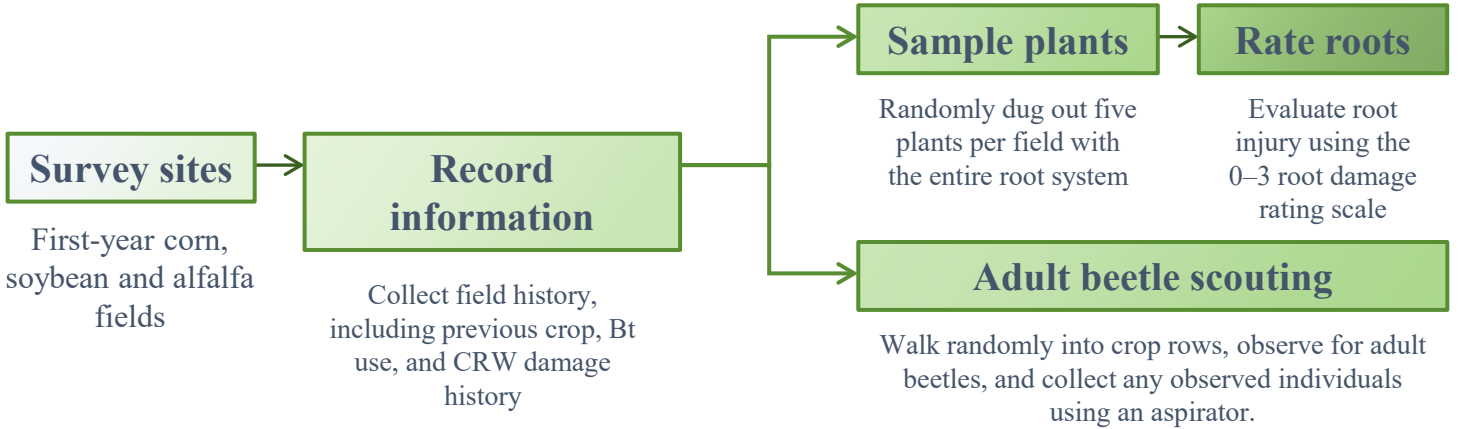


Field survey of variant WCR populations in MN

Objective

To investigate the occurrence of variant WCR populations in Minnesota in 2025.

Methods:

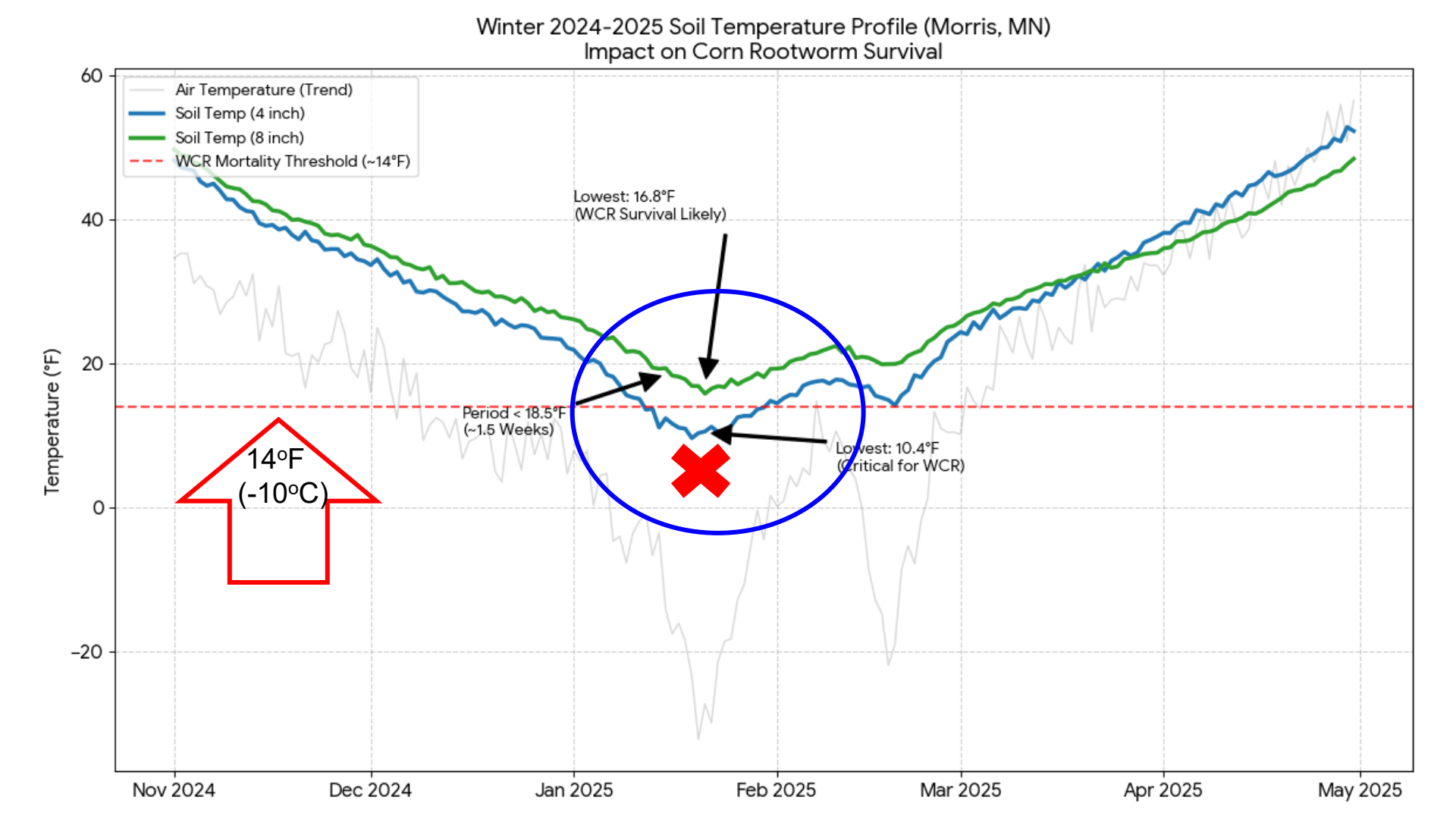


Field survey of variant WCR populations in MN

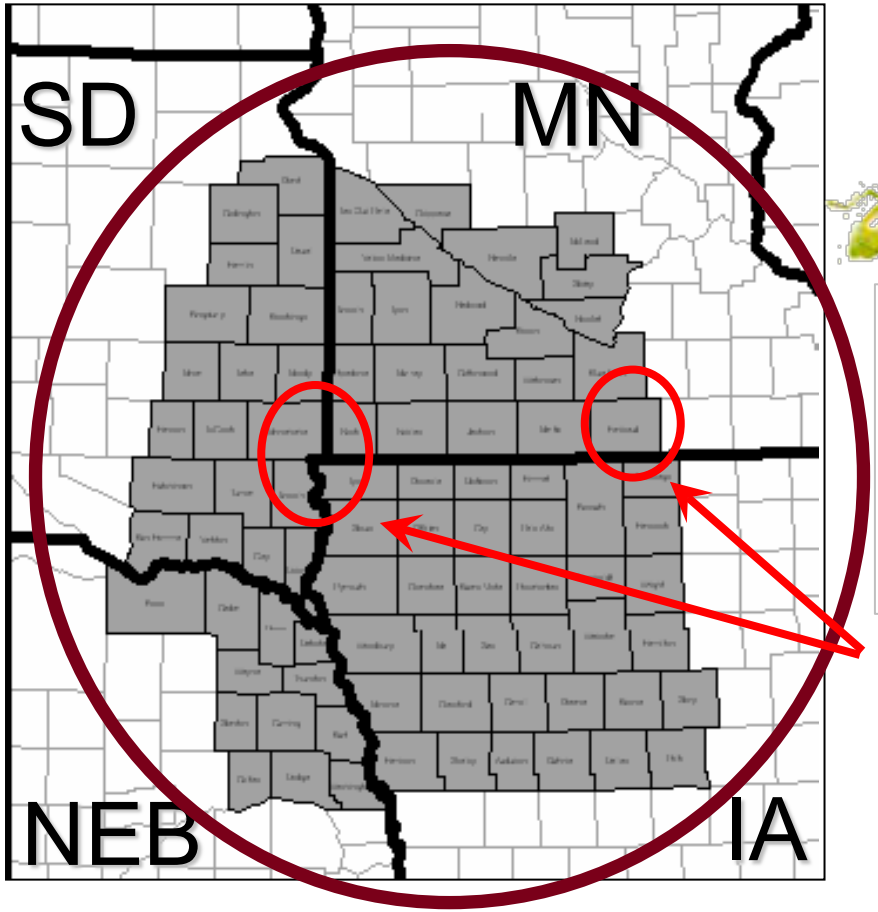
Results:

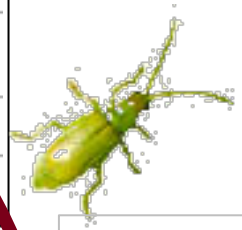
Table 1. Survey of variant WCR populations in Minnesota in 2025

Crop	Number of fileds	NIS	Species
1st Year Corn	19	0	NCR
Soybean	11	/	None
Alfalfa	2	/	None


Winter 2024-2025 Soil Temperature Profile (Morris, MN)
Impact on Corn Rootworm Survival
Air Temperature (Trend)
Soil Temp (4 inch)
Soil Temp (8 inch)
WCR Mortality Threshold (~14°F)
Lowest: 16.8°F
(WCR Survival Likely)
Period < 18.5°F
(~1.5 Weeks)
Lowest: 10.4°F
(Critical for WCR)
14°F
(-10°C)
Temperature (°F)
60
40
20
0
-20
Nov 2024
Dec 2024
Jan 2025
Feb 2025
Mar 2025
Apr 2025
May 2025

Rotation-resistance: NCR Extended Diapause (2025)



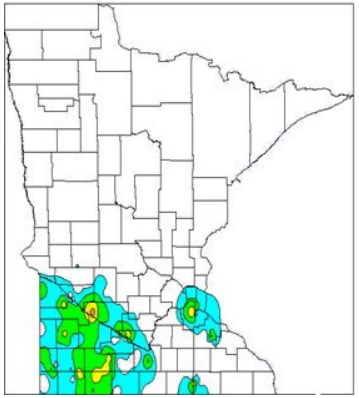


Where does NCR extended diapause occur?

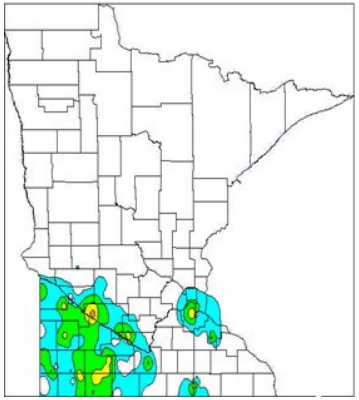
Original Problem Areas (1970s)

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

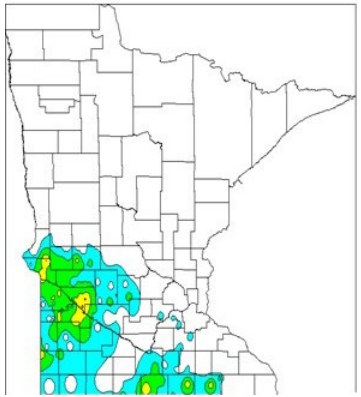
Figure from Ostlie 2005



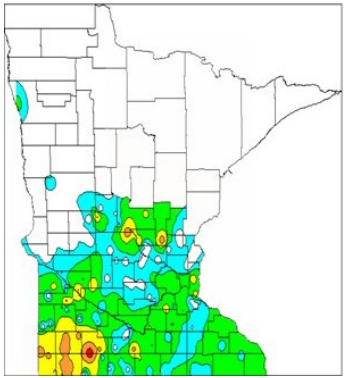
2000



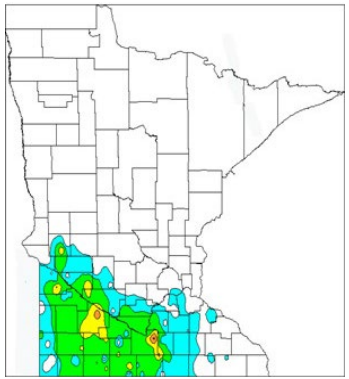
2002



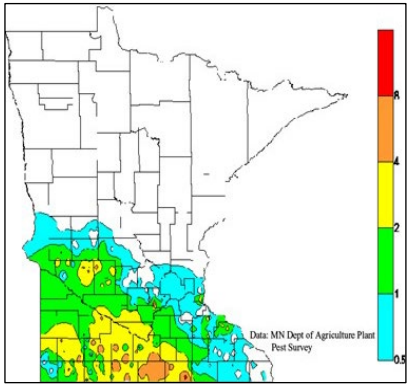
2004



2001



2003



2005

NCR extended diapause

Problems fluctuate temporally and spatially isolated
Known early (1930s IL)

SW and SC MN
~1979 -1986

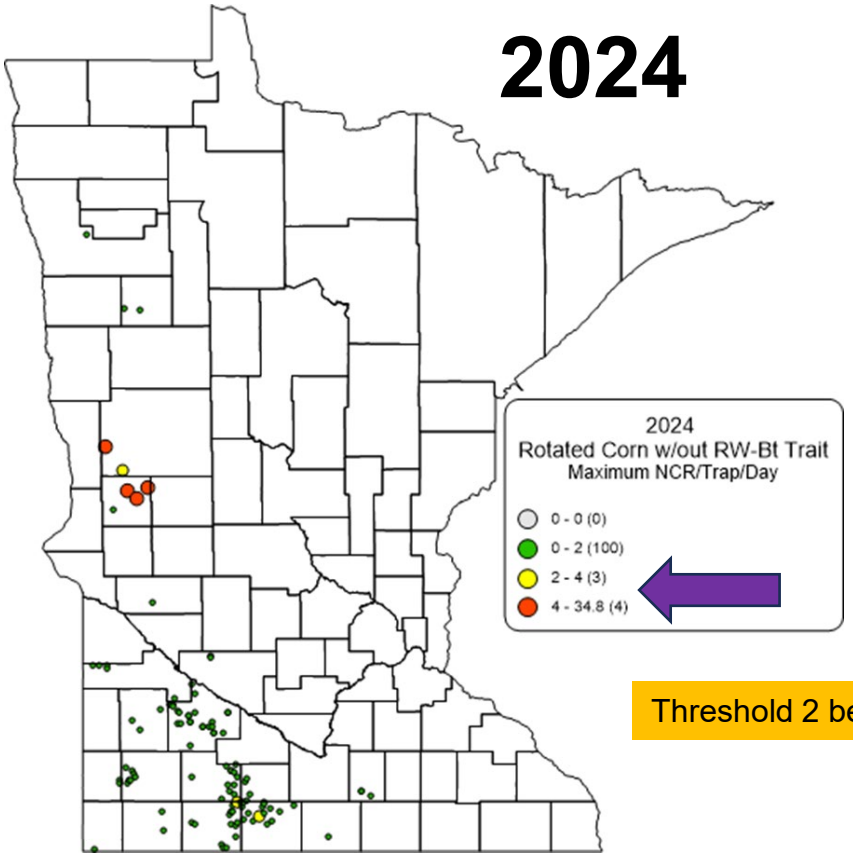
SW, SC, C, and WC MN
~1999 – 2005

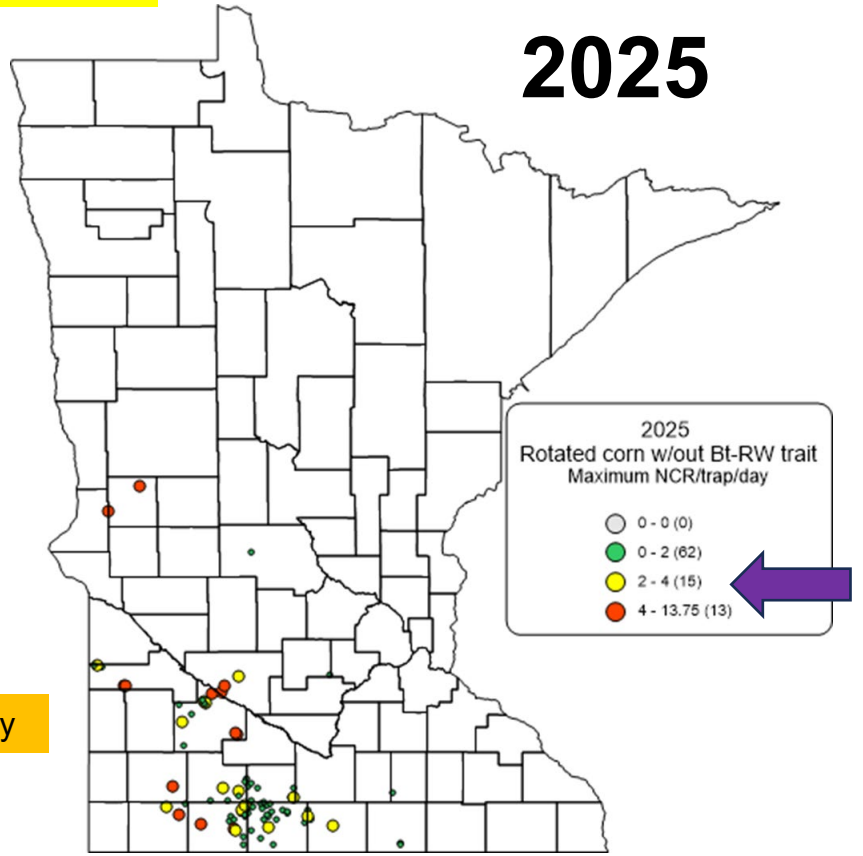
2023 into new area of WC/NW MN.

Bigger 1932
Krysan, etal. 1984-18986

Rotation-resistance: NCR Extended Diapause (2024-25)

First-year corn: NCR





Threshold 2 beetle/trap/day

2025

2025(All Sites)						
Bt RW Trait	Rotated	Number of Fields	Beetles/Trap/Day (highest week's capture)			
			WCR	NCR	All RW	% WCR
NO	YES	91	0.3	2.1	2.2	20.3
	NO	9	0.6	1.1	1.5	42.2
	ALL	100	0.3	2.0	2.2	22.5
Overall		**206**	**0.5**	**1.2**	**1.6**	**34.5**

Recurrence of Extended Diapause: odd-numbered years

Table 2. Fate of *D. barberi* eggs from Champaign, Ill., through 5 yr

Stage of experiment[a]	No. eggs remaining	Dead	Lost	Hatch	% Total hatch[b]
Oviposition, Sept. 1985	1,211	—	—	—	—
May 1986	1,076	109	26	0	
Sept. 1986	526[c]	130	27	393	50.6
May 1987	482	14	10	0	
Sept. 1987	115	37	10	320	41.2
May 1988	104	7	4	0	
Sept. 1988	18	24	0	62	8.0
May 1989	7	11	0	0	
Sept. 1989	2	3	0	2	0.3
May 1990	0	2	0	0	

[a] Eggs laid in September 1985 and placed in an environmental chamber simulating natural soil temperature conditions at the 10-cm depth at Urbana, Ill.

[b] Calculated as a percentage of the number of eggs that hatched (total hatch, $n = 777$).

[c] Twenty of these eggs were stained and examined microscopically in September 1986 to determine viability (30.0% viable).

1 yr

2 y

Table 3. Fate of *D. barberi* eggs from Madison, S. Dak., through 4 yr

Stage of experiment[a]	No. eggs remaining, $\bar{x} \pm$ SEM	No. dead, $\bar{x} \pm$ SEM	No. hatch, $\bar{x} \pm$ SEM	% Total hatch[b]
Sept. 1985	100.0 ± 0.0[c]	—	—	
May 1986	97.2 ± 1.3	2.8 ± 1.3	0	
Sept. 1986	42.4 ± 5.5	24.4 ± 8.7	30.4 ± 6.9	48.9
May 1987	39.0 ± 5.2	3.4 ± 2.4	0	
Sept. 1987	25.0 ± 5.9	1.2 ± 1.6	12.8 ± 3.6	20.6
May 1988	24.4 ± 6.1	0.6 ± 0.9	0	
Sept. 1988	10.0 ± 3.1	1.4 ± 2.1	13.0 ± 2.1	20.9
May 1989	9.8 ± 3.0	0.2 ± 0.4	0	
Oct. 1989	2.6 ± 2.0	1.2 ± 0.8	6.0 ± 2.1	9.6

[a] Eggs laid in September 1985 and buried in the soil at a depth of 20 cm at Brookings, S. Dak. until 12 May 1986; eggs then placed in an environmental chamber that mimicked field soil temperature conditions at a depth of 15 cm at Brookings, S. Dak. until October 1989.

[b] Calculated as a percentage of the number of eggs that hatched (total hatch, $n = 311$).

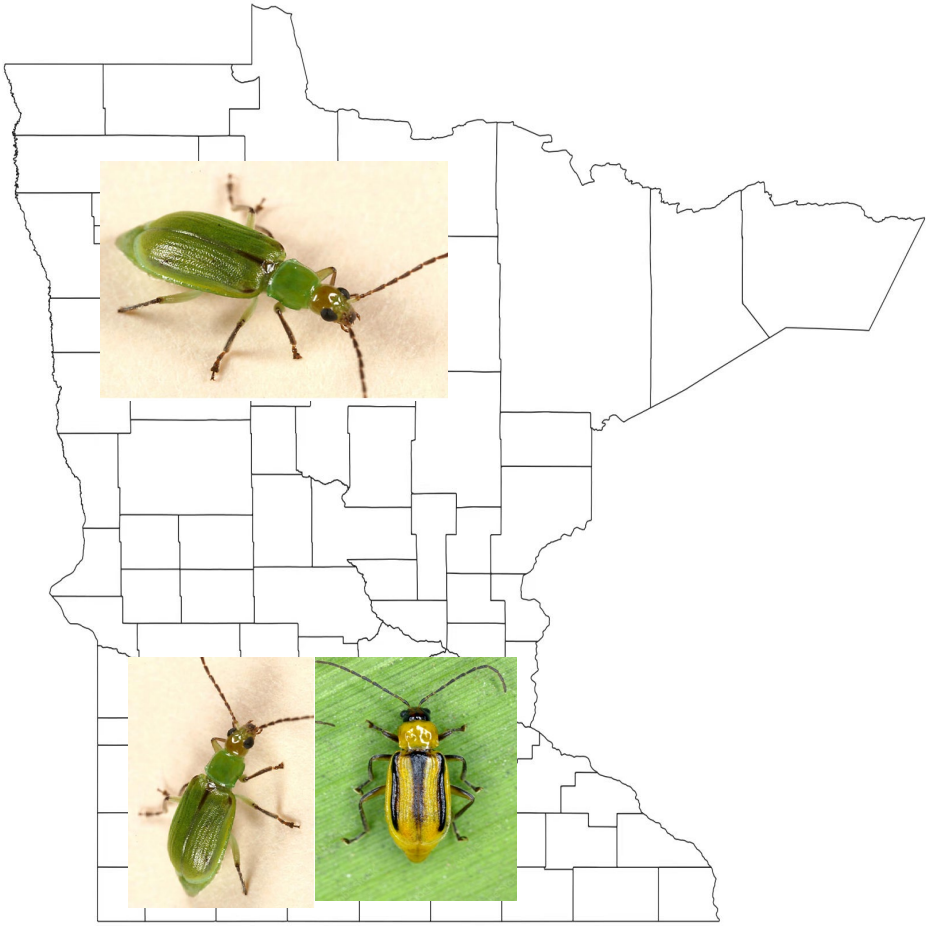
[c] Five replications of 100 eggs each.

1 yr

2 yrs

Eli Levine, et al., 1992

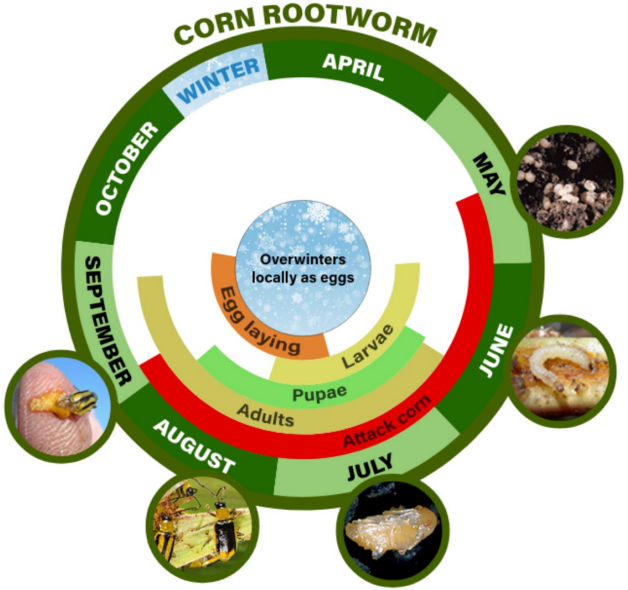
Distribution and abundance of WCR and NCR in Minnesota



Meloche et al., 2004

Mechanisms of cold tolerance in insects

Mechanism	Function
Supercooling ability	Prevents ice formation in body fluids by lowering the freezing point.
Water content regulation	Reduces body water to minimize the chance of freezing.
Cryoprotectant accumulation	Produces protective compounds (e.g., glycerol, trehalose) to stabilize cells and prevent ice damage.
Protein protection and repair	Maintains protein stability and repairs cold-induced cellular damage.



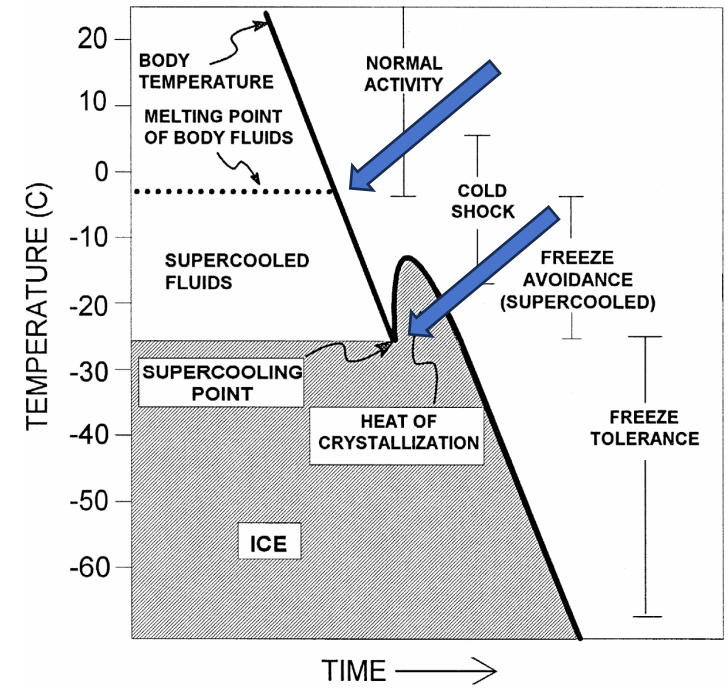


Fig. 2. Generalized diagram of insect response to subzero temperature. Heavy line represents insect body temperature and shaded area is zone where ice nucleation occurs. Adapted from Lee (1989).

The supercooling point of corn rootworm (CRW) eggs is the temperature at which the fluids inside the eggs freeze, causing their metabolism to stop and prevent them from surviving.

Conclusion

- **The SCPs of WCR were generally lower than those of NCR.**
- **The egg hatching rates of NCR were higher than those of WCR.**

Mechanism	Function
Supercooling ability	Prevents ice formation in body fluids by lowering the freezing point.
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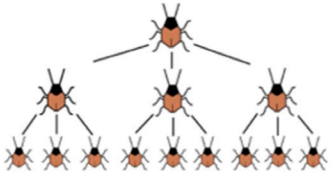
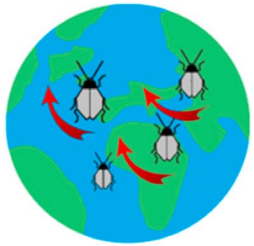
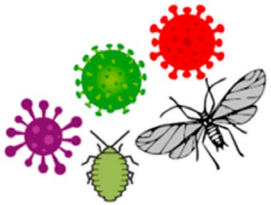
HOW DOES TEMPERATURE INCREASE AFFECTS INSECT PESTS?



Increased number of generations

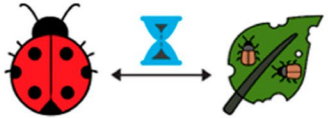


Expansion of geographic range



Outbreak of plant diseases transmitted by insects

Increased overwintering survival



Desynchronization of insects and their natural enemies

Loss of synchrony with the host plant

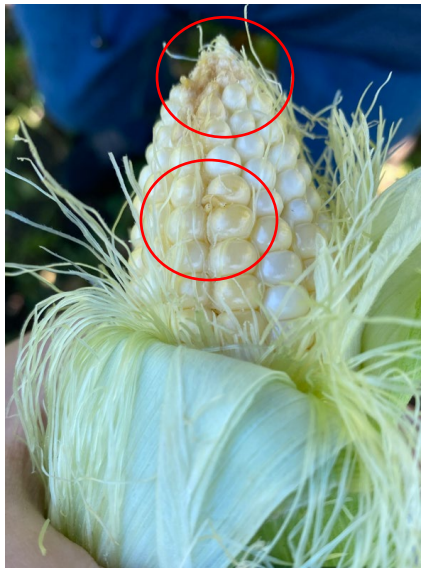
Skendžić et al, Insects (2021)

Cornsilk fly: A New Insect Pest discovered in MN in 2024

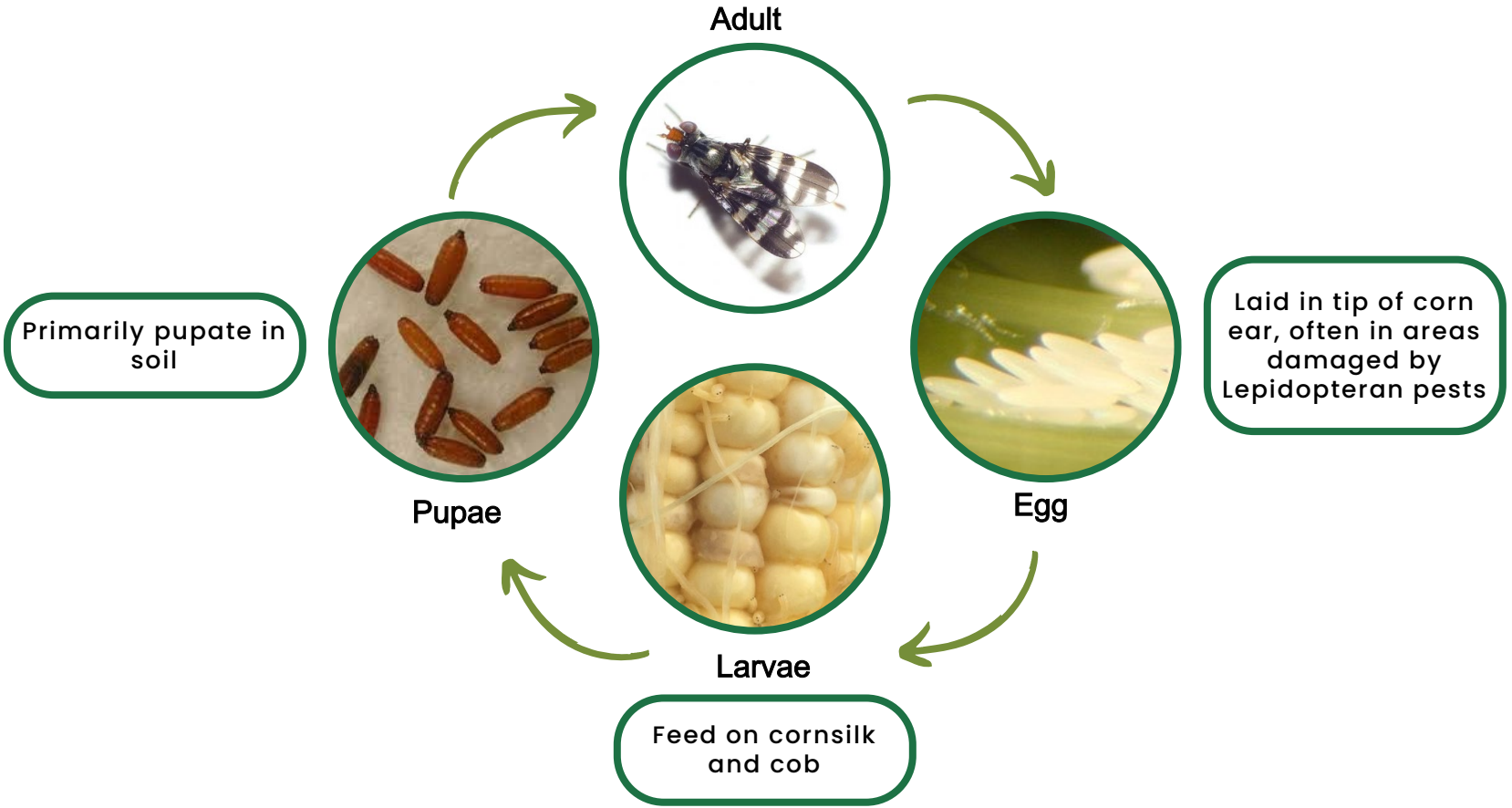
Corn insect pests monitoring

Cornsilk Fly in Minnesota

- September 2024: Larvae recovered from sweet corn plot in Rosemount, MN
- Sentinel plots used for monitoring of CEW and ECB resistance to Bt corn.



Cornsilk Fly: Life Cycle

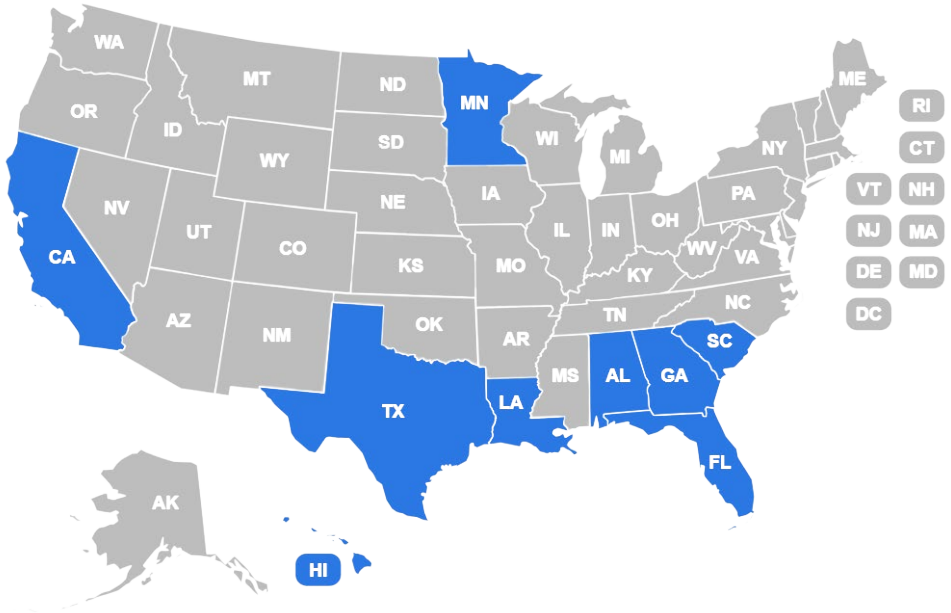


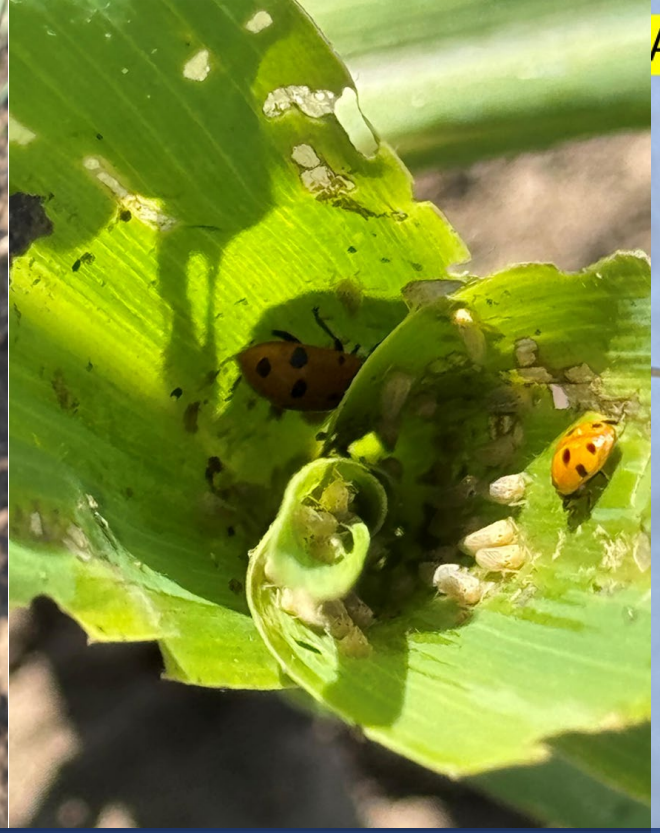
Cornsilk Fly: Geographic Range

- Found in tropical/sub -tropical regions in North and South America
- Recurring pest in TX and FL

<u>September 2024</u> : First record of cornsilk fly larvae in MN

Credit: Gregg Nuessly, University of Florida





Corn Leafhopper: A New Insect Pest discovered in MN in 2024 and 2025

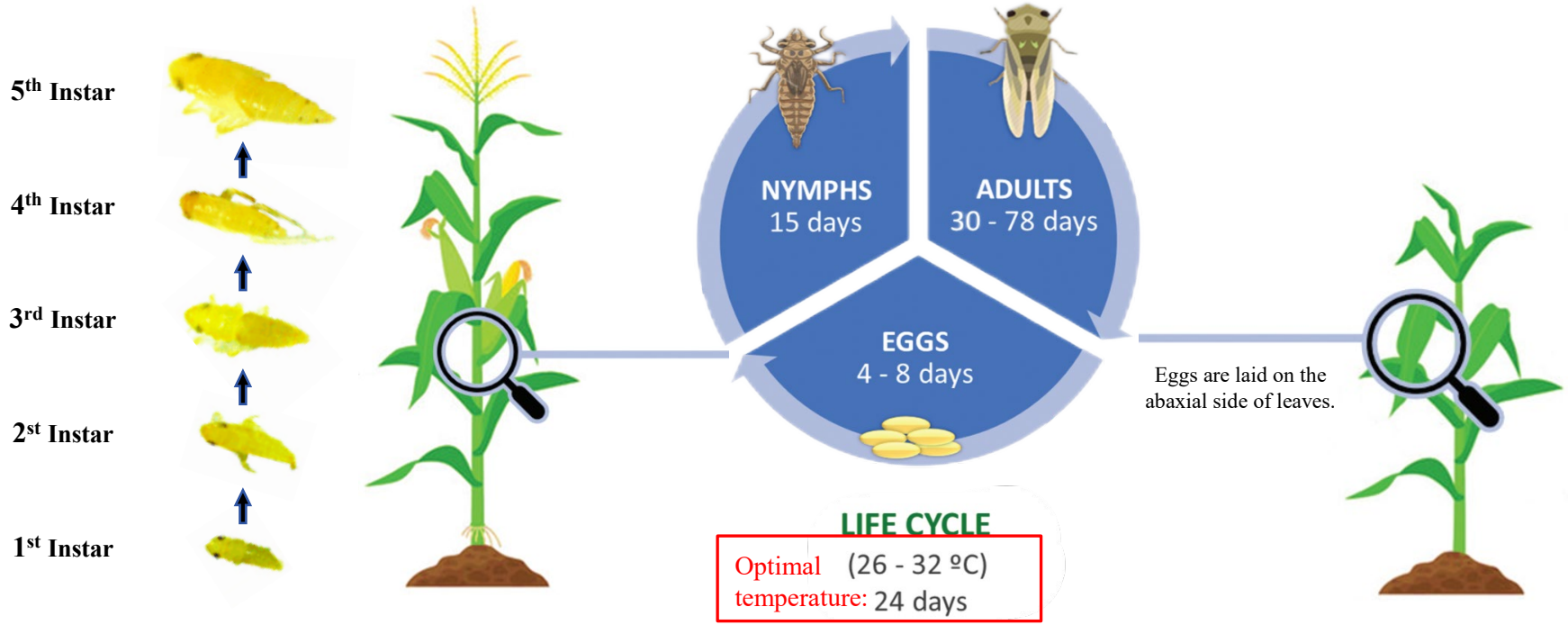
First detection of corn leafhopper in Minnesota, 2024

- **September 2024**
  - Corn field on **St. Paul, UMN**
  - Significant infestation of adults and nymphs on V4-V5 stage corn plants
- **September 2025**
  - Corn field on **Waseca County, MN**
  - Adults from yellow sticky traps R5-R6 corn

Corn leafhopper

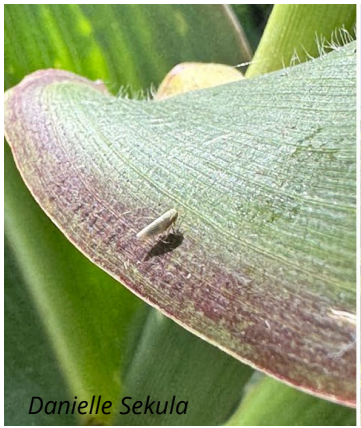
Dalbulus maidis (DeLong & Wolcott) (Hemiptera: Cicadellidae)

A sucking pest of corn crops:



Nymph (5 instars)

- Vectored diseases (biggest threat): **red stunt**
  - **Malformed tassels and pollen formation, sterility**
  - **Four corn pathogens:** 2 bacterial & 2 viral
  - **Bacterial:**
    - ✓ Corn stunt spiroplasma (CSS)
    - ✓ Maize bushy stunt phytoplasma (MBSP)
  - **Viral:**
    - ✓ Maize rayado fino virus (MRFV)
    - ✓ Maize striate mosaic virus (MSMV)



Northward Expansion (2024–2025)

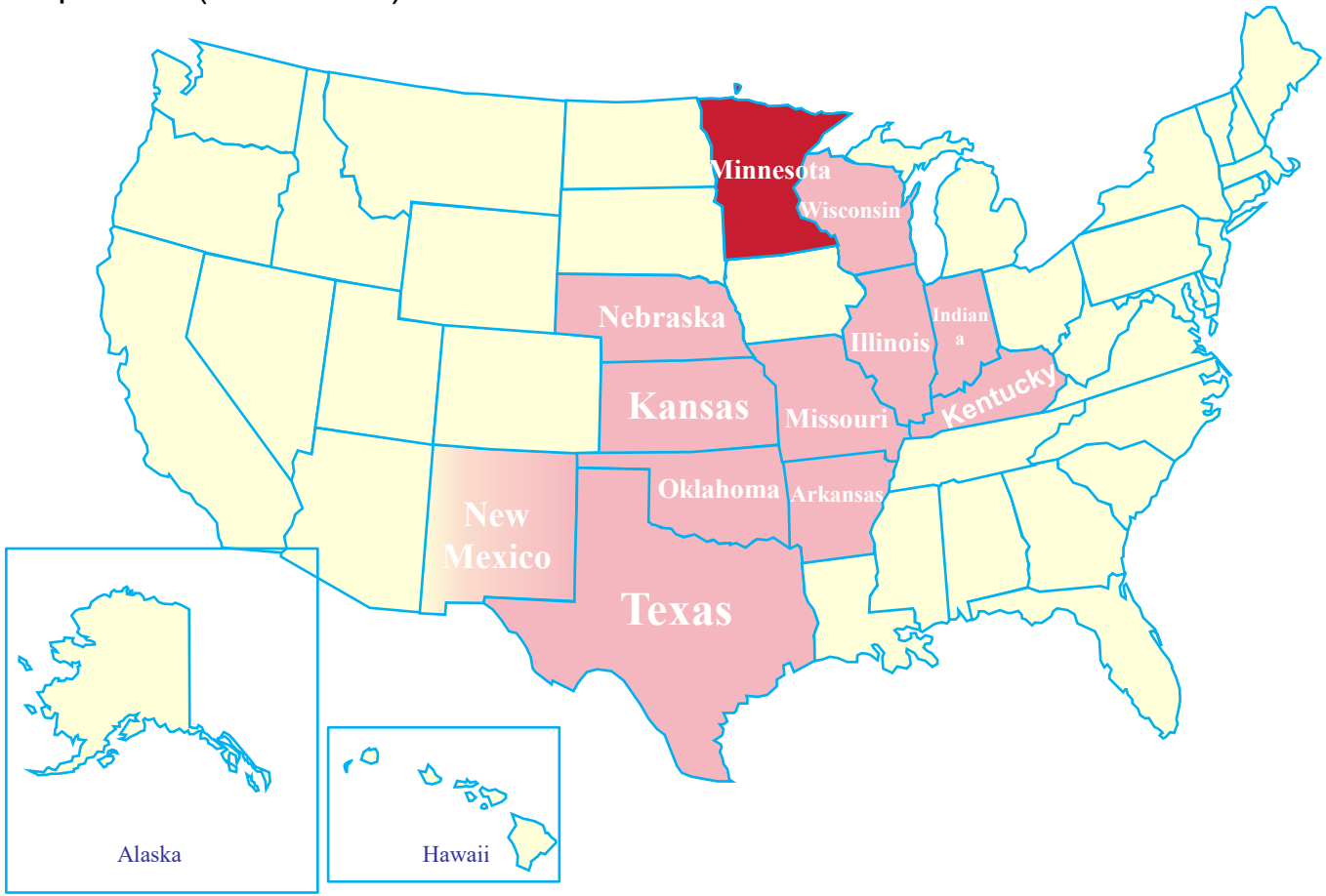


Figure 1. Geographic distribution of corn leafhopper infestations in the United States in 2025

Acknowledgements

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