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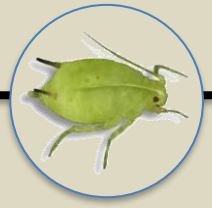
Extending Knowledge, Changing Lives: Insecticide Resistance to Soybean Aphid in North Dakota



T.J. Prochaska[1], J. Knodel[2], P. Beauzay[2], L. Lubenow[3], A. Chirumamilla[4], and S. Lahman[5]

[1]North Dakota State University Extension, NCREC, Minot, ND
[2]North Dakota State University Extension, Fargo, ND
[3]North Dakota State University Extension, LREC, Langdon, ND
[4]North Dakota State University Extension, Cavalier County, ND
[5]North Dakota State University Extension, Pembina County, ND

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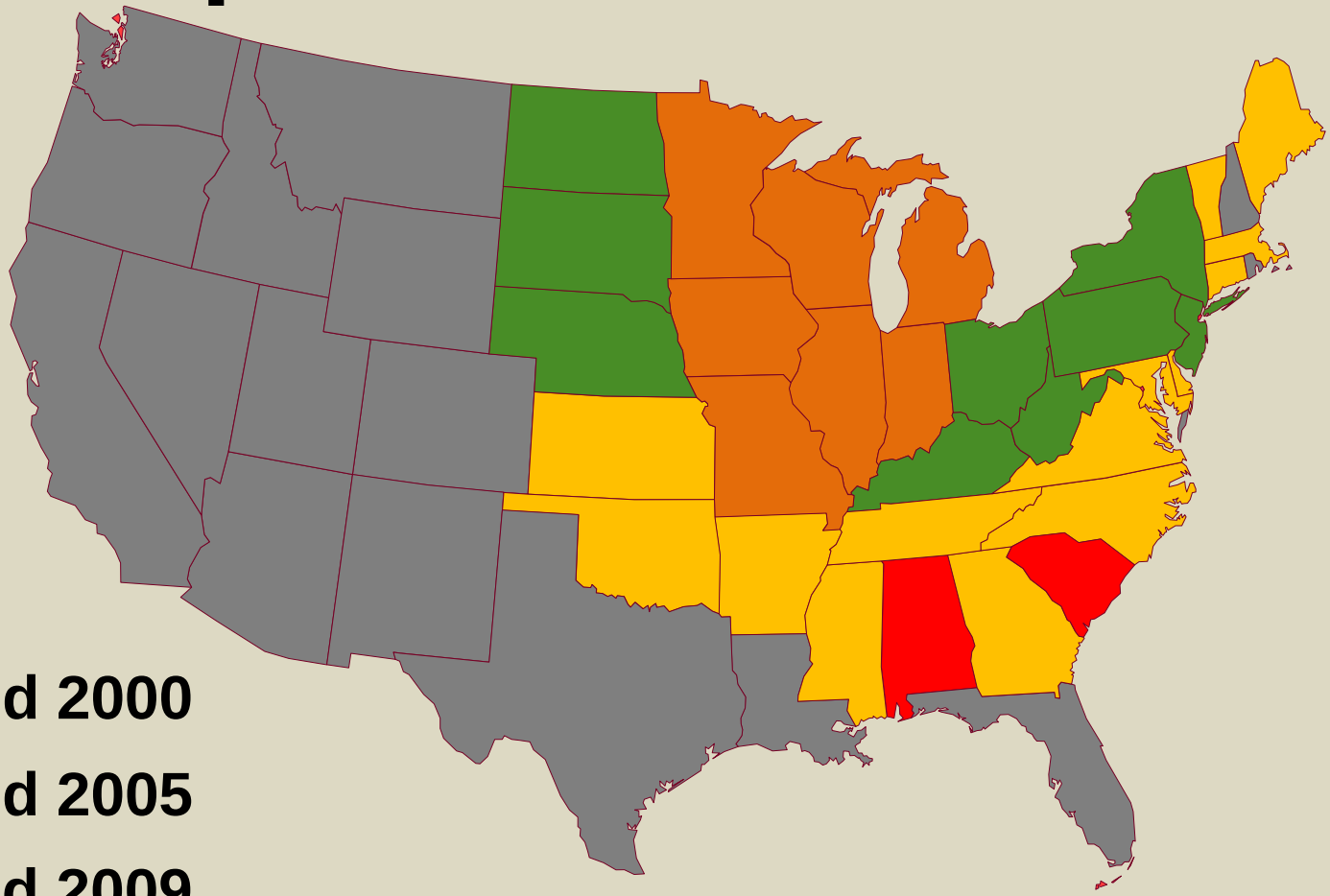
Aphid Background

- *Aphis glycines* Matsumura
- Primary host plant:
  - ★ *Rhamnus cathartica* L. (buckthorn)
- Secondary host plant:
  - ★ *Glycine max* Merr (soybean)
- Reproductive potential McCornack *et al.* 2004
  - ★ Population doubles, 1.5 days
  - ★ 27.8° C

Aphid Distribution



Aphid 2000

Aphid 2005

Aphid 2009

Aphid 2013

North Dakota State University;
Ragsdale *et al.* 2011
Pioneer DuPont 2013

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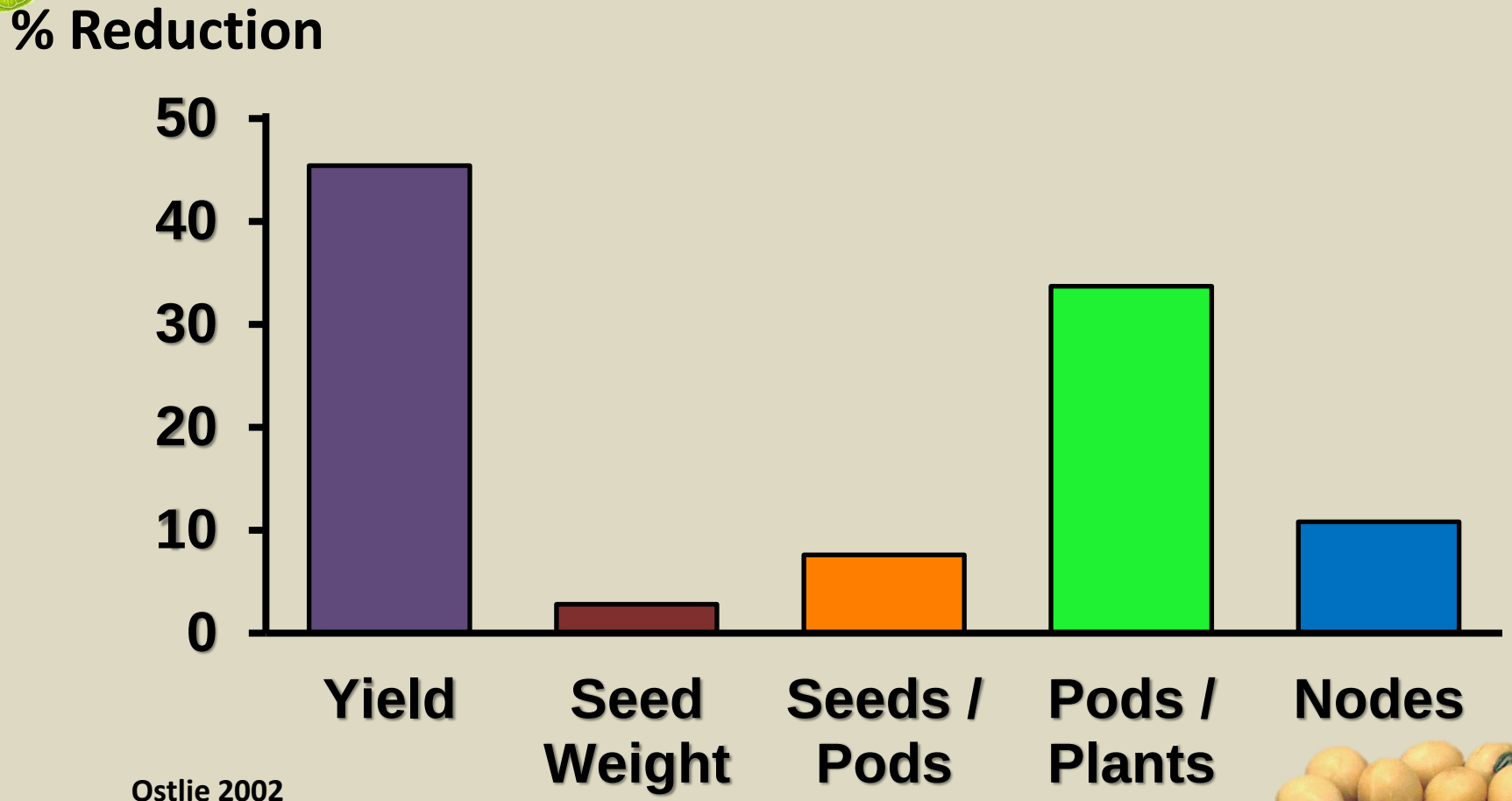
Soybean Injury



Ostlie 2002

Pesticide Treadmill

1. Continuous use of a pesticide leads to the evolution of resistance in the target pest (and in non-target pests?)
2. Once resistance is established, that pesticide is ineffective
3. Switch to a new pesticide mode of action
4. Repeat

Selection for Resistance

- Selection for resistant individuals
- Susceptible individuals selected against
- Resistant individuals reproduce

Resistant fly

Susceptible fly

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Selection for Resistance

- Growing population of resistant individuals

Resistant fly

Susceptible fly

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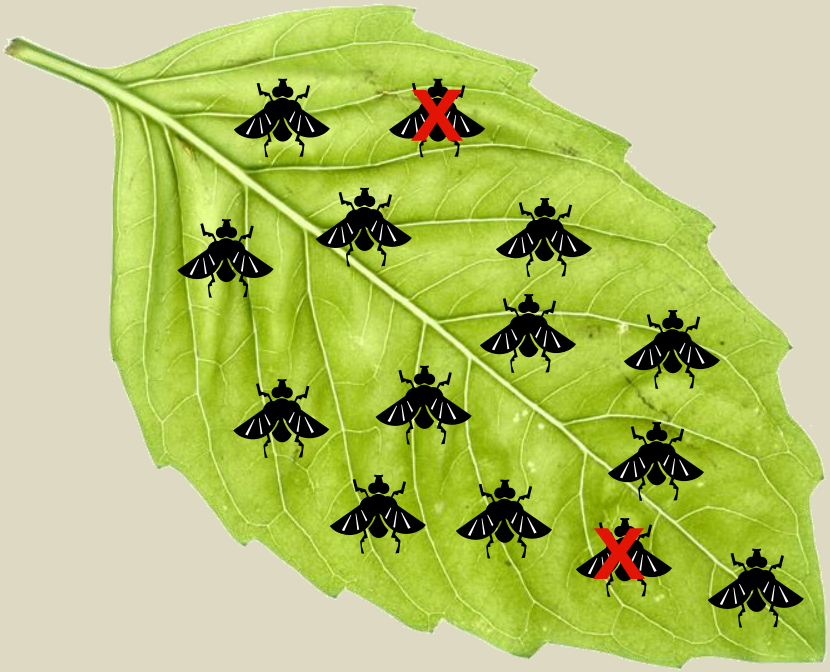
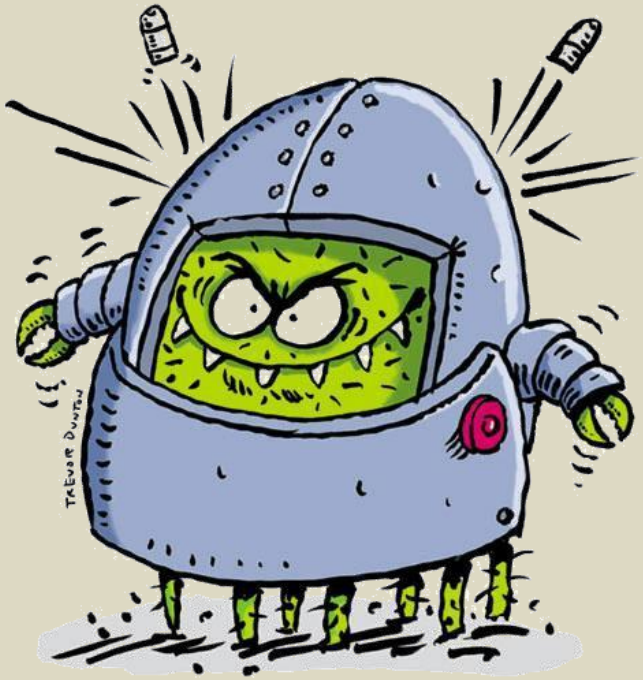
Selection for Resistance



- Population dominated by resistant individuals



Resistant fly

Susceptible fly

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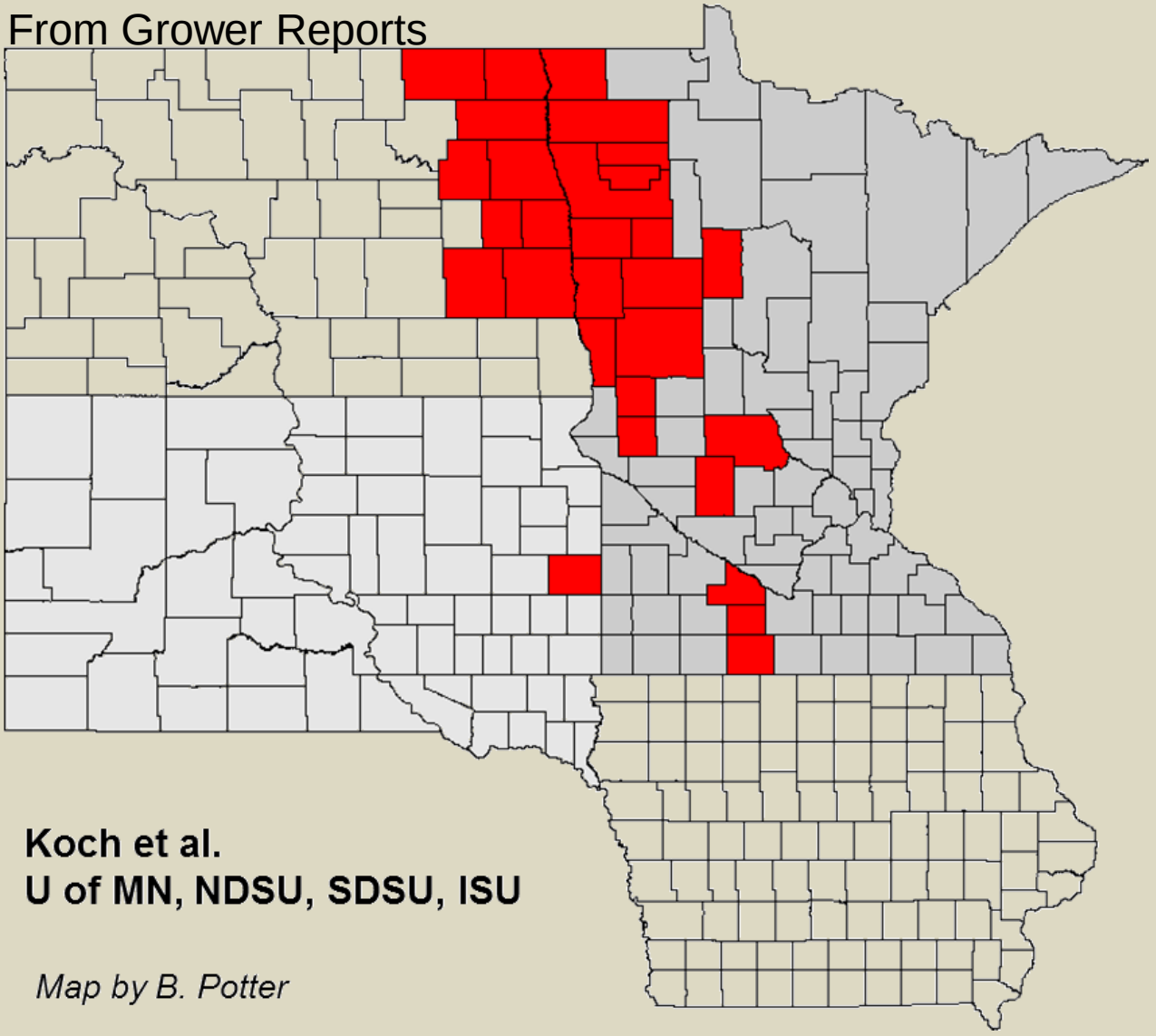
Objective

- **To determine the level of pyrethroid insecticide resistance in populations of soybean aphids in North Dakota and where pyrethroid resistance exists in the major soybean producing counties of North Dakota.**

2017 Soybean Aphid Counties with Pyrethroid Performance Issues

From Grower Reports



Koch et al.
U of MN, NDSU, SDSU, ISU

Map by B. Potter

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Materials & Methods

- In 2017, collected populations of soybean aphids from 6 soybean fields with pyrethroid control problems in eastern ND.
- Use a standard experimental procedure called the ‘diagnostic dose glass-vial bioassay’

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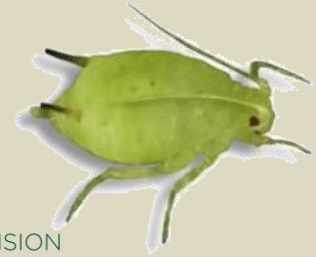
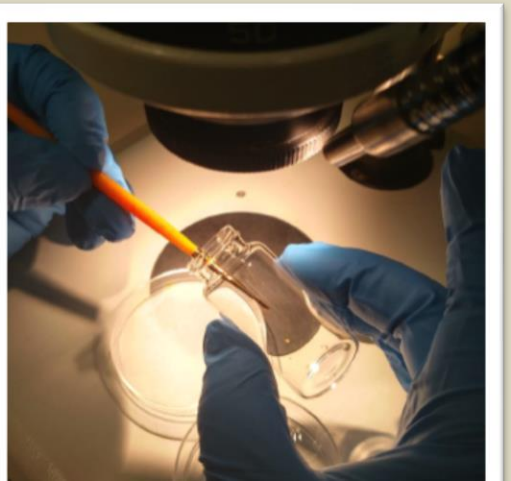
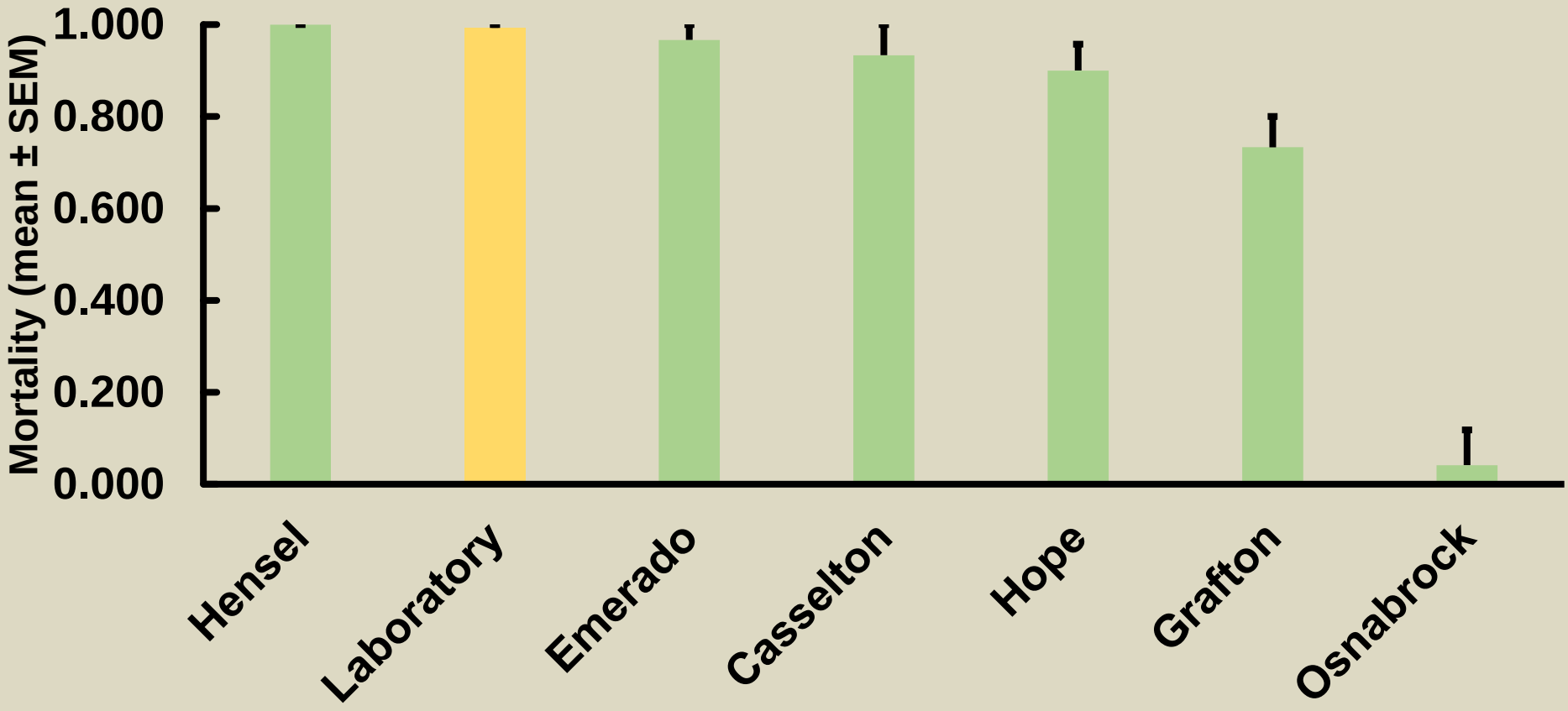
Materials & Methods

- Pyrethroids tested: λ-cyhalothrin and bifenthrin
- Each assay consists of three replications of three insecticide concentrations:
  - ★ Acetone control
  - ★ 99% mortality (LC99)
  - ★ Twice the concentration of 99% mortality (2 x LC99)
- Assess the mortality of 10 wingless (apterous) adult soybean aphids per vial
  - ★ After 4 hours and 24 hours of exposure





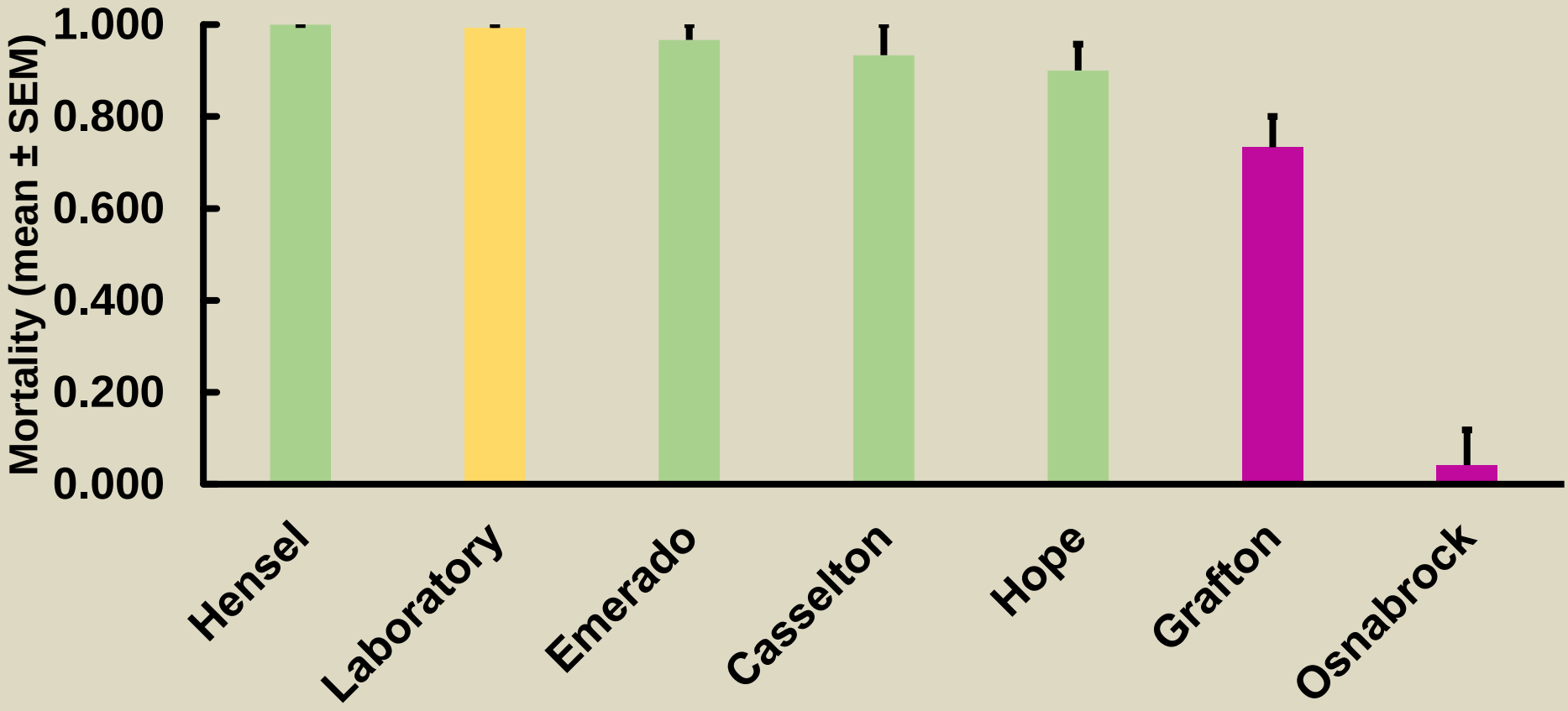
2017 4-hr. Results: λ-cyhalothrin (at LC99 for laboratory aphids)



X^2=440; df=18; P<0.00001
Biased-reduced general linear model with binomial response for Henderson-Tilton adjusted mortality.

Koch et al.

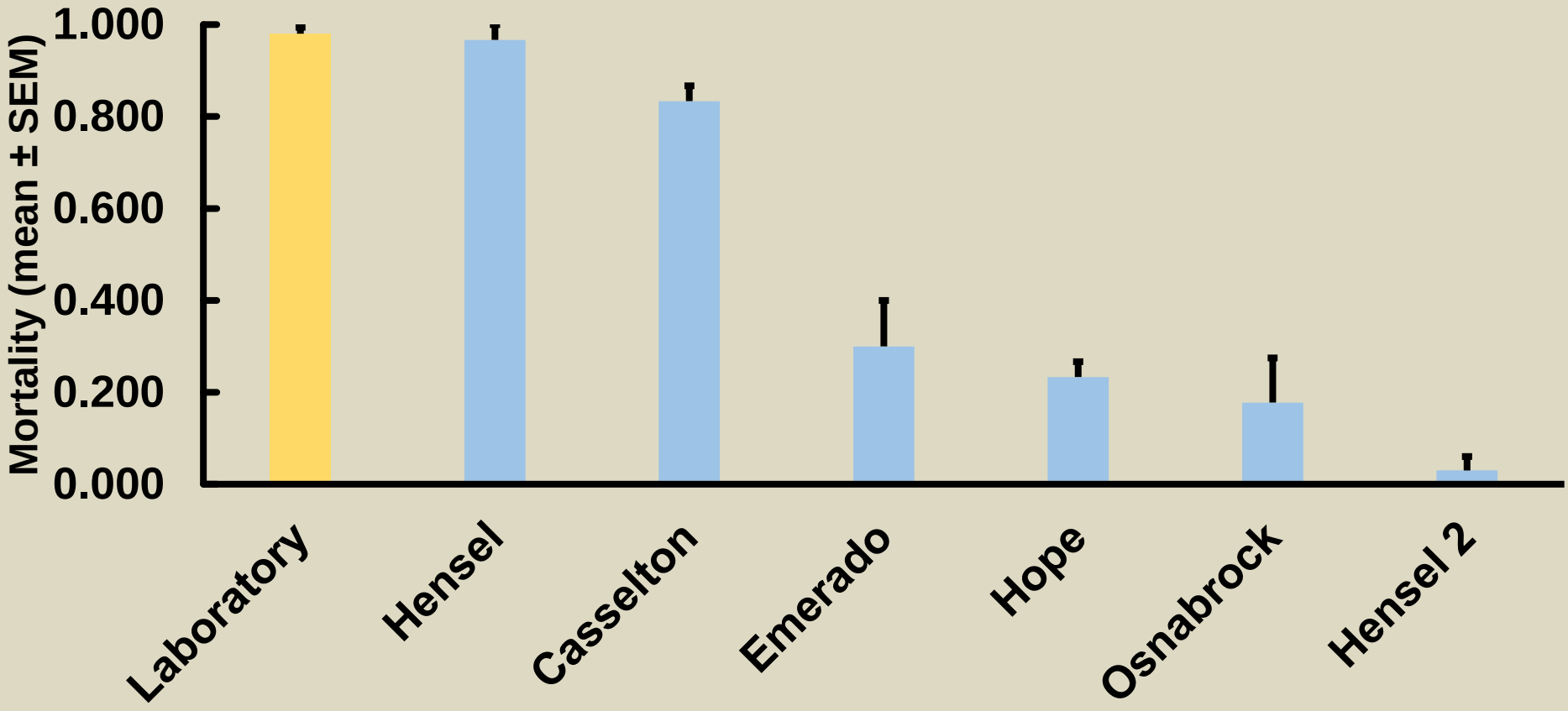
2017 4-hr. Results: λ-cyhalothrin (at LC99 for laboratory aphids)



X^2=440; df=18; P<0.00001
Biased-reduced general linear model with binomial response for Henderson-Tilton adjusted mortality.

Koch et al.

2017 4-hr. Results: Bifenthrin (at LC99 for laboratory aphids)



X^2=440; df=18; P<0.00001
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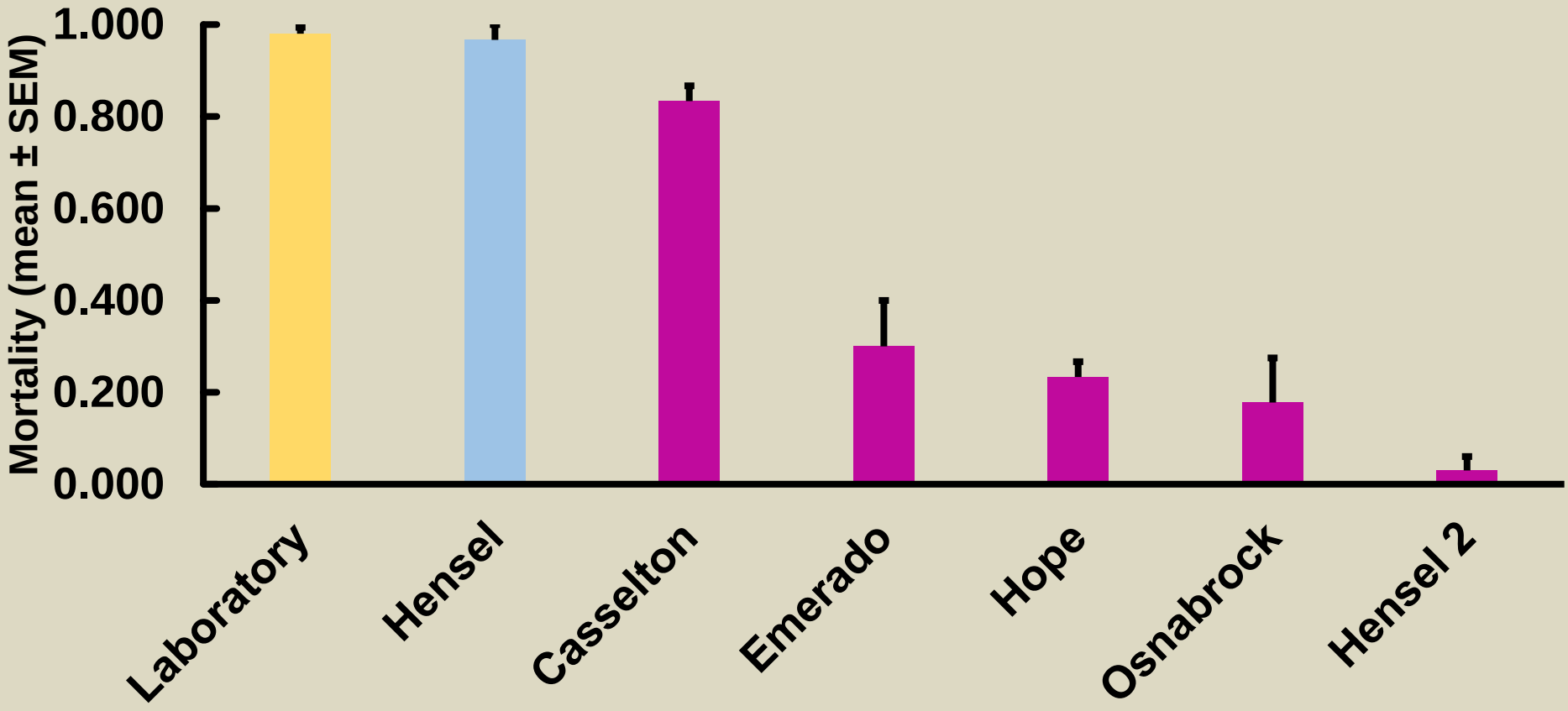
Koch et al.

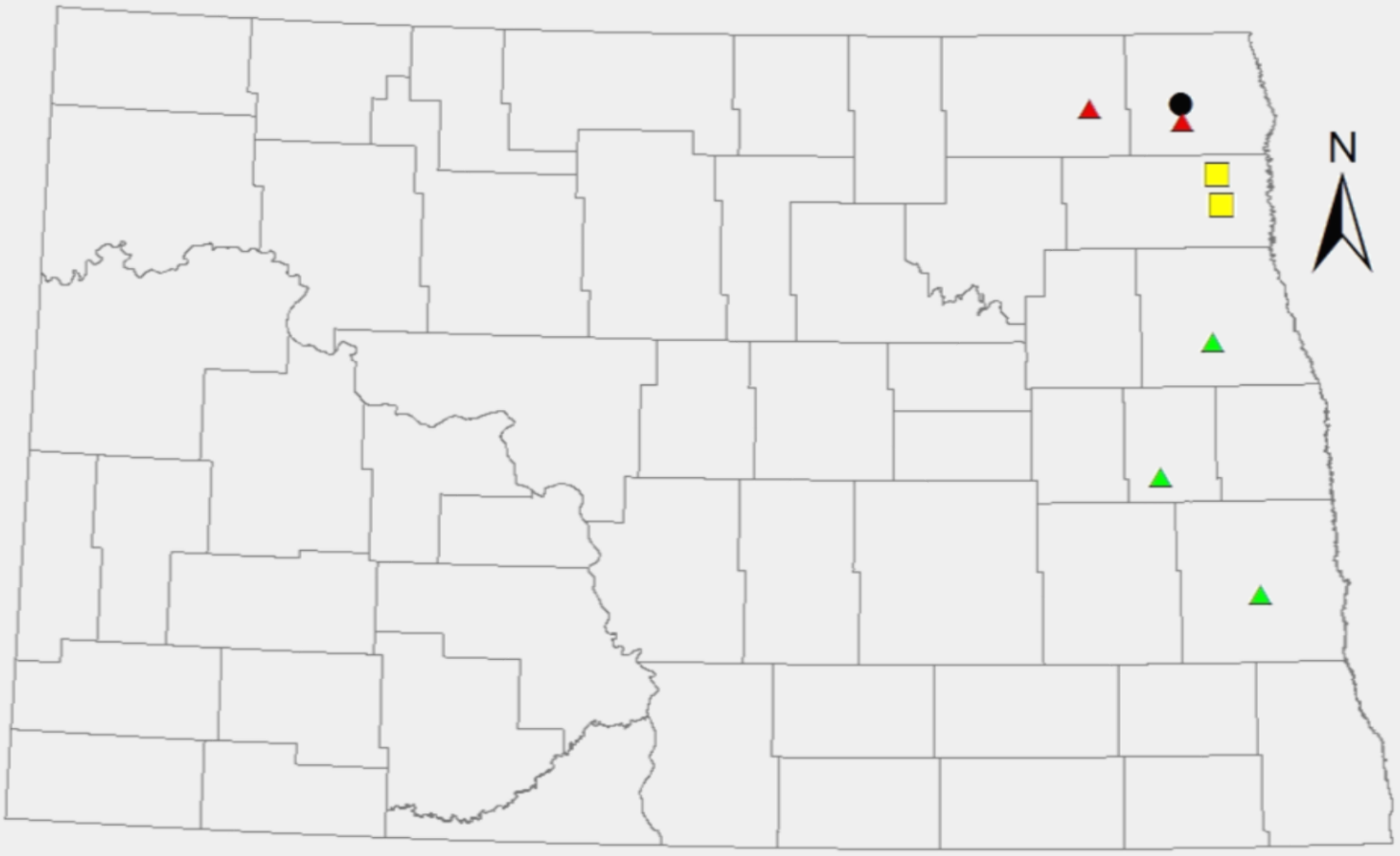
2017 4-hr. Results: Bifenthrin (at LC99 for laboratory aphids)



X^2=440; df=18; P<0.00001
Biased-reduced general linear model with binomial response for Henderson-Tilton adjusted mortality.

Koch et al.

2017 Pyrethroid Resistant Soybean Aphids in ND



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USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture
Crop Protection and Pest Management Program
[grant no. 2017-70006-27144/accession 1013592]
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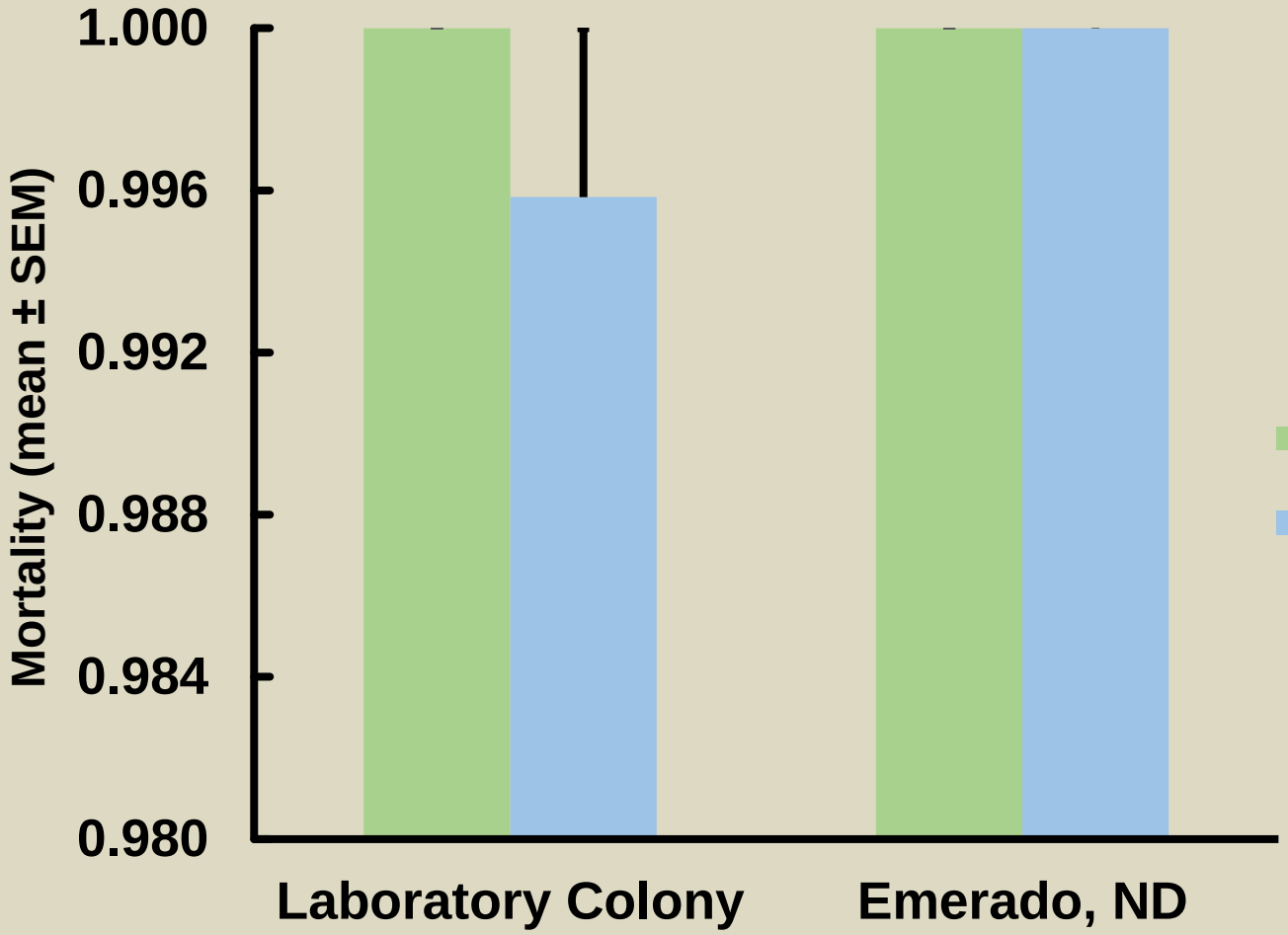
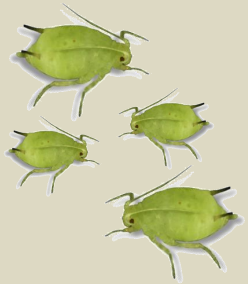
2018 Results

- Low aphid populations in North Dakota
- Established 2017 colonies (from collected populations) bioassays show susceptibility to both insecticides
- Suggests populations not overwintering, but resistant populations migrating in
- 2019 - precipitation

2018 4-hr. Results λ-cyhalothrin & Bifenthrin Resistance (LC99)





Koch et al.

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Biased-reduced general linear model with binomial response for Henderson-Tilton adjusted mortality.

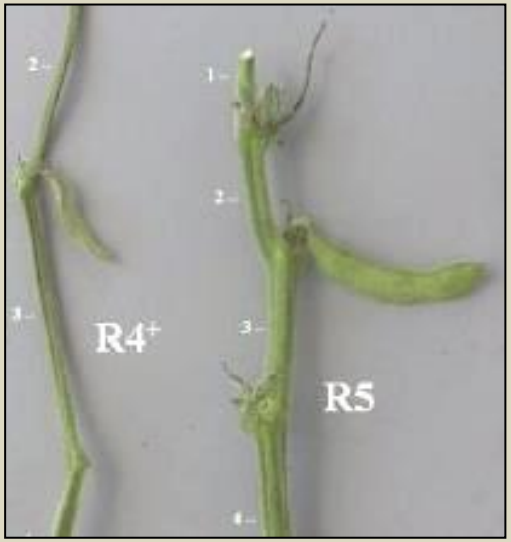
Insecticide Resistance Management – An IPM Approach

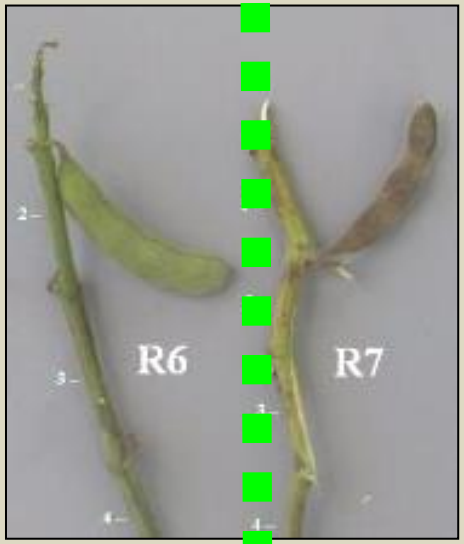
- Know your pests and use labeled products and rates
- Scout fields regularly
- Use the Economic Threshold to aid in decision-making, prevent unnecessary insecticide applications and conserve natural enemies
  - ★ Should NOT add insecticide to tank during herbicide application
- Rotate mode of action (or insecticide class) if more than one applications is necessary in a season

Thresholds for Soybean Aphids

E.T. = 250 aphids per plant
E.I.L. = 670 aphids per plant

Do Not treat





Veg stages

R1 – R2 bloom

R3-R4 pods forming, growing

R5 seeds Forming, filling

R6 full seed

R7 maturing

R8 mature

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Insecticides: Mode of Actions

Crop – Soybean

Pest – Soybean aphid

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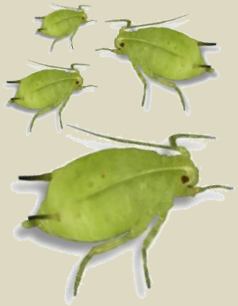
IRAC Group	Class	Active Ingredient	Products
1A	Carbamate	Methomyl	Lannate
1B	Organophosphate	Acephate	Acephate
		Chlorpyrifos	Lorsban Advanced, Chlorpyrifos, Govern, Hatchet, Nufos, Vulcan, Warhawk, Whirlwind, Yuma
		Dimethoate	Dimethoate
3A	Synthetic Pyrethroid	Alpha-cypermethrin	Fastac
		Beta-cyfluthrin	Baythroid
		Bifenthrin	Tundra, Sniper, Fanfare, Discipline, Brigade, Bifenture
		Cyfluthrin	Tombstone
		Deltamethrin	Delta Gold
		Esfenvalerate	Asana XL, Adjourn
		Gamma-cyhalothrin	Declare, Proaxis
		Lambda-cyhalothrin	Warrior II, Grizzly Z, LambdaStar, Lambda-Cy, Lamcap, Province, Silencer VC, Taiga Z
		Permethrin	Arctic
		Zeta-cypermethrin	Mustang Maxx, Respect
4A	Neonicotinoid	Imidacloprid	Prey, Admire Pro, ADAMA Allas, Wrangler, Nuprid, Sherpa
4D	Butenolide	Flupyradifurone	Sivanto Prime
9B	Pyropenes	Afidopyropen	Sefina Inscalis



IPM Toolbox – IRM Approach

Pest Identification

Pest Monitoring

Economic Thresholds

Predictive Models

Cultural Control

Biological Control

Host Plant Resistance

Chemical Control

Acknowledgements

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University of Minnesota Extension
Driven to Discover℠

- Dr. Robert Koch
- James Menger

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Soybean Gall Midge

T.J. Prochaska[1], J. Knodel[2],

P. Beauzay[2], and A.J. McMechan[3]

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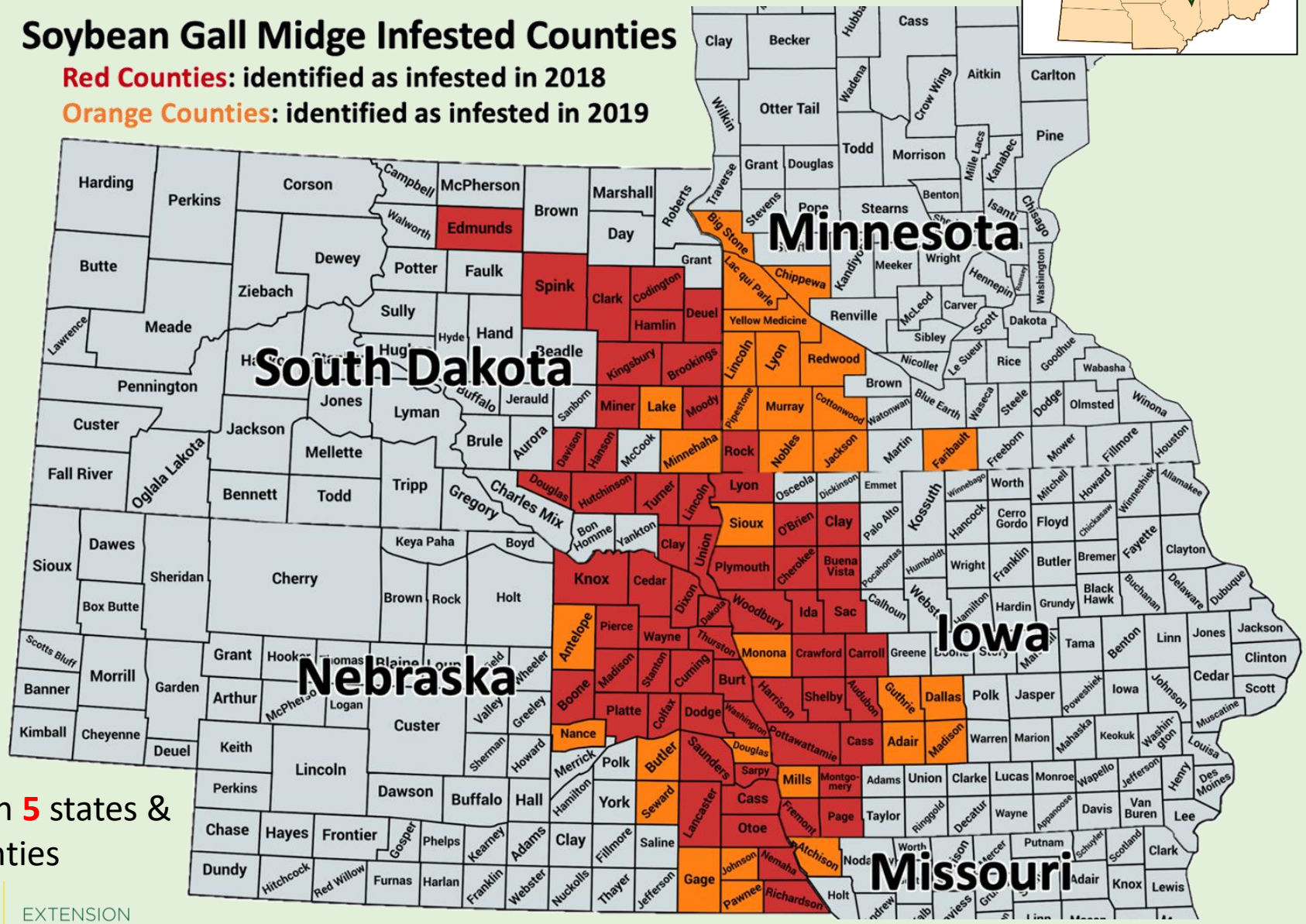
[1]North Dakota State University Extension, NCREC, Minot, ND
[2]North Dakota State University Extension, Fargo, ND
[3]University of Nebraska Extension, Lincoln, NE

Soybean Gall Midge

- Resseliella maxima (Gagné); Also known as gall gnats
- New soybean pest described by Gagné & Yukawa 2019
- 16 species in USA
- Not Found in North Dakota

Kolesik and Baker 2013

Distribution



- Found in **5** states & **92** Counties

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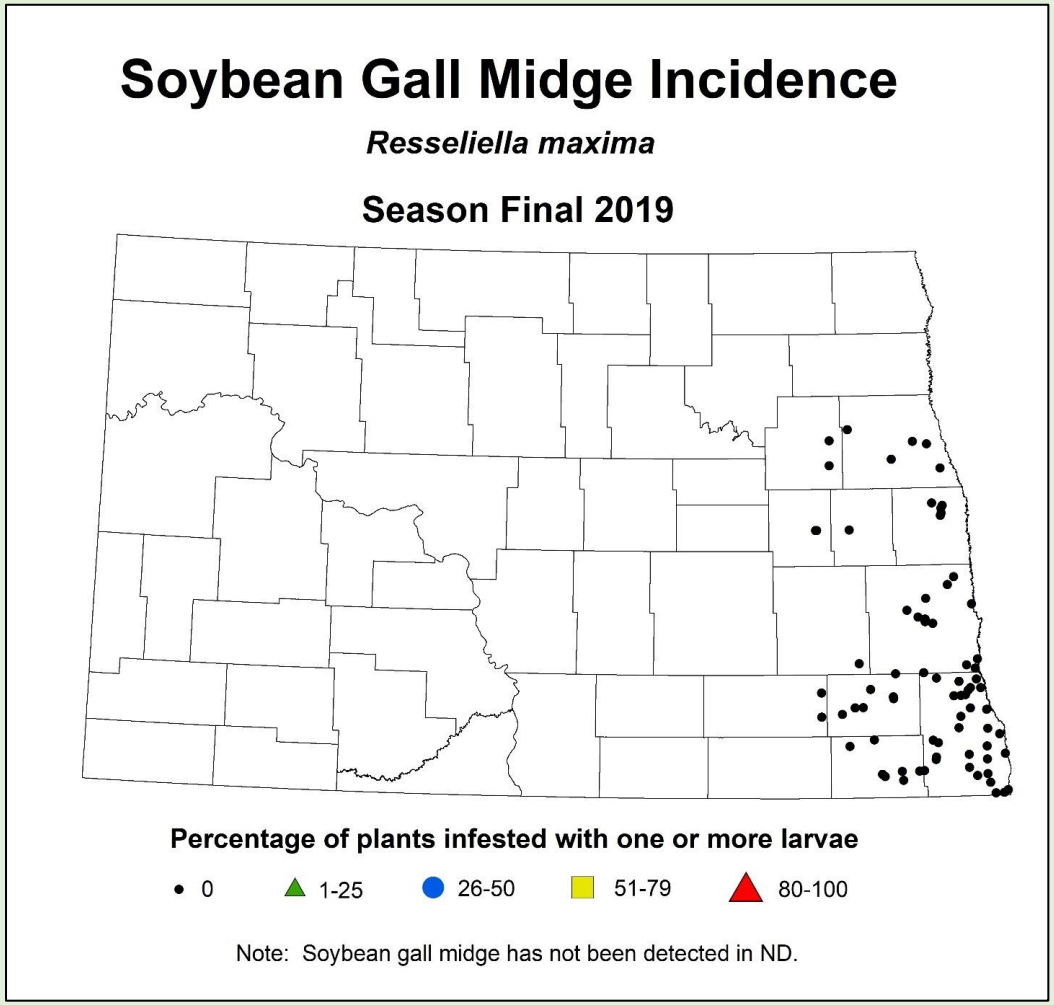
A.J. McMechan 2019; Nebraska Extension

2019 Soybean Gall Midge Survey in Soybeans in North Dakota

- R2 (full bloom) to R8 (maturity)
- >100 plants per field on field edge
- 78 fields in 11 counties
- Plan to continue to survey work in 2020



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Identification

- About ¼ inch long
- Black and white banding on legs; reddish abdomen
- 2 other Cecidomyiid pests of ND crops
  - Hessian fly
  - Wheat midge
- 2-3 generations per year

A.J. McMechan

Life Cycle

- Complete metamorphosis
- Likely overwinter as larval cocoons in the soil
  - Like wheat midge
- 2-3 generations per year
  - In 2019, adult emergence of the 1st generation ranged from mid-June in Nebraska through early July in Minnesota
  - Larvae were observed in soybean stems from late June though July in Minnesota

Crop Damage

- Entomologists are not sure how the larvae get into the stem, maybe from naturally occurring cracks in epidermis or other wounds like hail injury
- Soybeans with severe feeding injury will wilt and die
- Lodging at soil level is also a symptom of heavily infested stems with soybean gall midge larvae

A.J. McMechan

Soybean Gall Midge Field Symptoms

- **Damage greatest at the field edge**
  - **Plants easily snapped off**
  - **Some plants with swollen stems (galls)**

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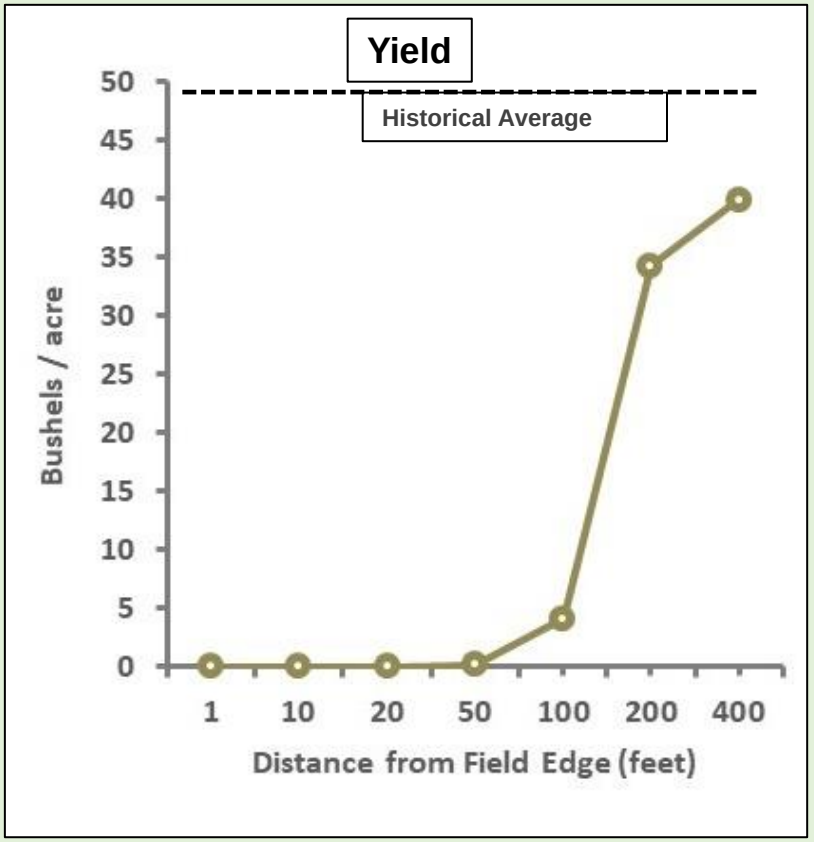
Source: Dr. Justin McMechan, University of Nebraska

Soybean Gall Midge: Yield Impacts

- **Small, dead plants and reduced pods/seeds translate to yield loss ranging from 20-100% on field edges**



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Source: Dr. Justin McMechan, University of Nebraska

Scouting

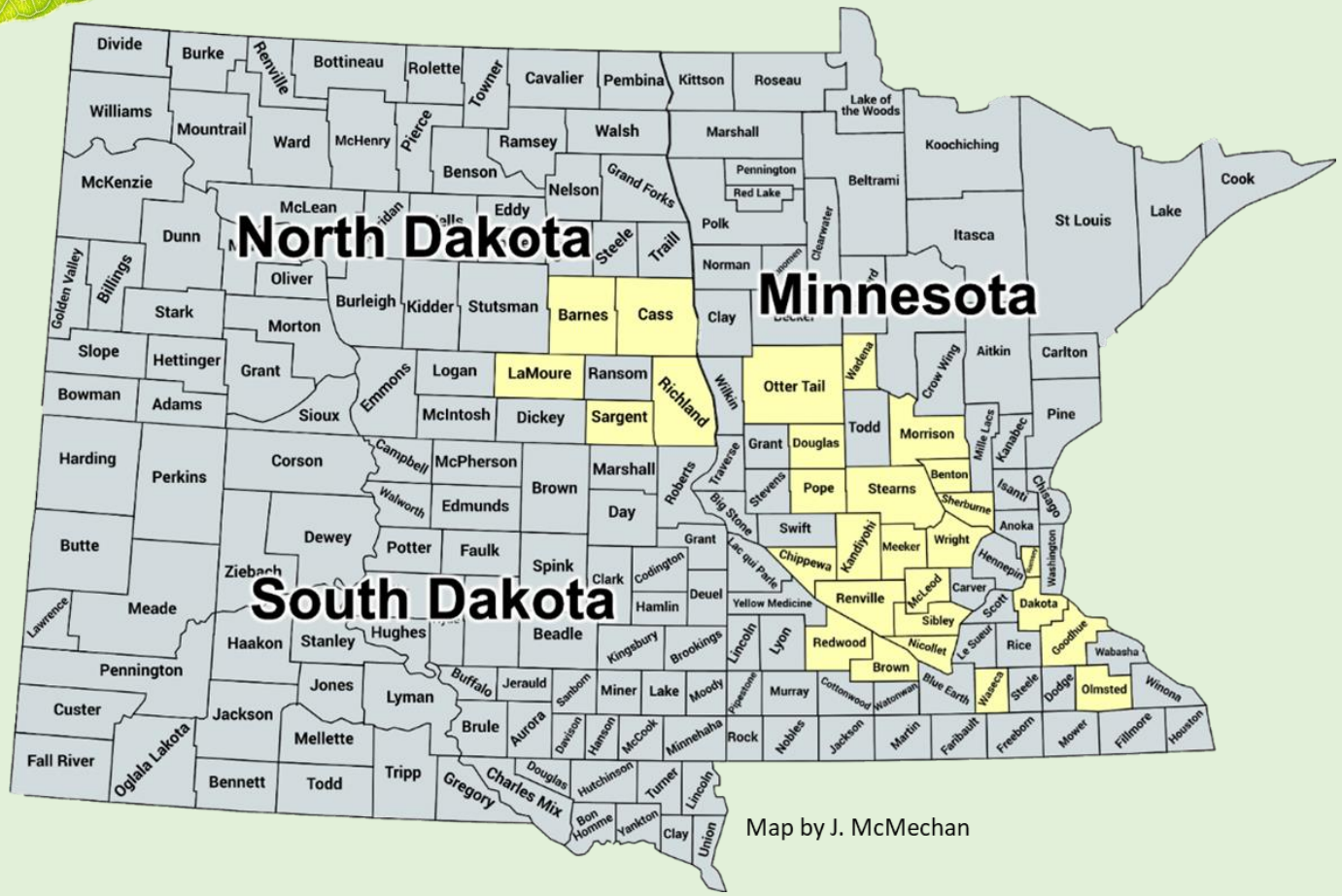
- Easy insect to scout for since infestations
  - On field edges
  - Adjacent to infested soybeans from last year
- Early instar larvae are white; mature orange to red
- Walk along field edges and look for plants with darken stems at the base near the soil level
- If you peel back the stem epidermis with your fingernail, the larva will be visible
- Soybeans with severe feeding injury will wilt and die

White Mold Gall Midge *Karshomyia caulicola* on Soybeans

- Genus *Karshomyia*
  - Holarctic distribution
    - New Jersey, NE USA
    - Europe: United Kingdom, Netherlands, Germany, Russia, Latvia, Lithuania & Ukraine
  - 51 species worldwide
- Mycetophagous
  - Associated with plants infected with the fungus *Sclerotinia sclerotiorum*
  - Soybeans, dry beans, canola, potatoes and sunflowers, poppy
- Confuse with larvae of soybean gall midge?

Source: Dr. Koch, University of Minnesota

Detections from 2018-2019



Map by J. McMechan

- Val-Saint-François, Québec, 2018-2019
- Pierce Co., Wisconsin, 2019
- Additional detections
  - ✓Manitoba, 2014 & 2016
  - ✓Minnesota, sporadically over 25 years

Koch et al. in review, Jensen 2019, Hamilton 2019, Gavloski & Bajracharya 2016

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Gall Midge Infestations

Gagné et al. 2019,
Koch et al. in review

	K. caulicola	*R. maxima*
Timing	After flowering & onset of Sclerotinia stem rot	As early as 3rd leaf stage
Location in field	Throughout field where Sclerotinia stem rot present	Field edges, especially near previous year's soybean
Location on plant	On/in Sclerotinia-infected stems & pods	Under epidermis of stem near base of plant

Identification of Gall Midge Larvae

Gagné et al. 2019,
Koch et al. in review

	K. caulicola	R. maxima
Color	Less intense orange	More intense orange

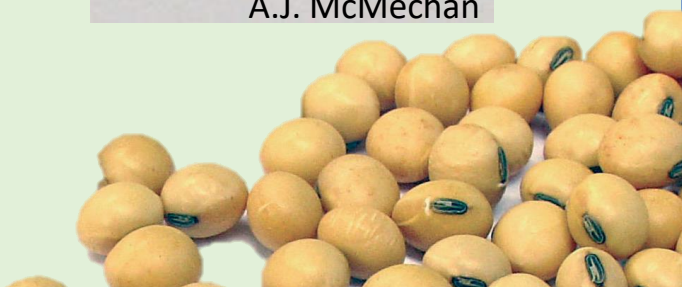
Identification of Gall Midge Adults

	K. caulicola	R. maxima
Antennae & legs	Uniformly gray	Striped
Wings	Uniformly gray	Mottled
Abdominal tergites & sternites	Subdivided horizontally	Uniformly sclerotized
Key to genera	Gagné 2018	

Gagné et al. 2019,
Koch et al. in review


J. Moisan-De Serres


A.J. McMechan



Everything You Want to Know About Foliage-Feeding Caterpillars in Soybeans

Janet J. Knodel

Professor and Extension Entomologist

NDSU | EXTENSION

Foliage-feeding Caterpillars


Thistle caterpillar


Alfalfa webworm

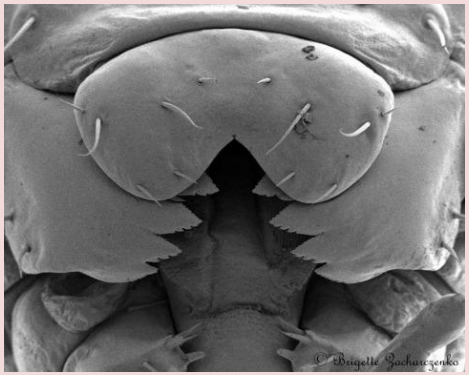

Green cloverworm

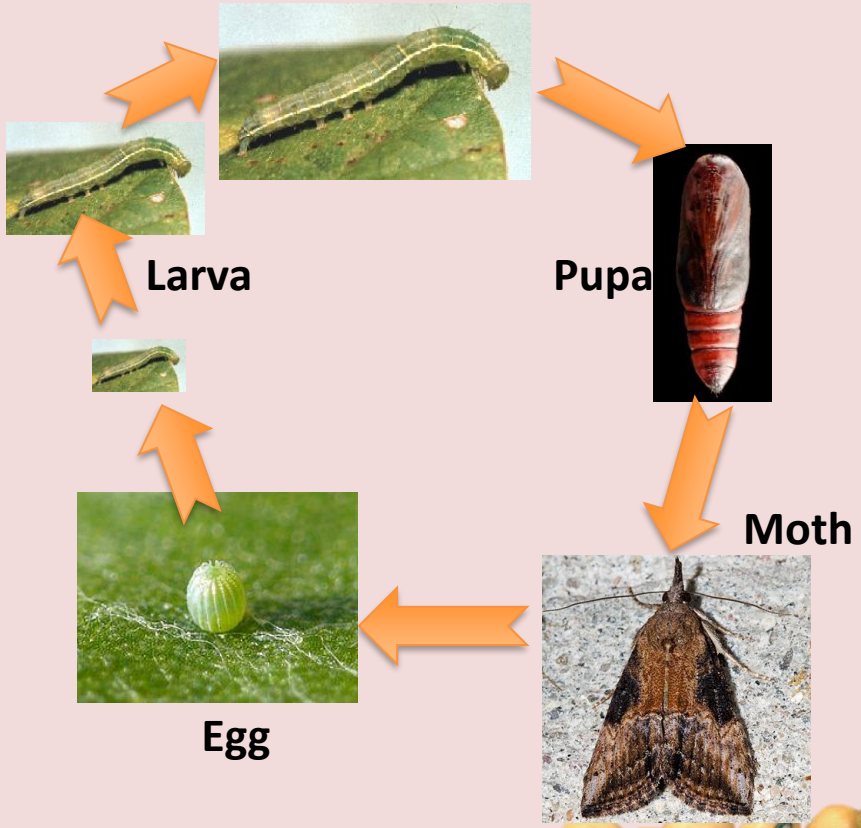

Veletbean caterpillar


Soybean looper

Life Cycle of Foliage-feeding Caterpillars

- **Complete Metamorphosis**
  - ★ Egg to larval stages to pupae to adult
  - ★ Larvae look different from adult
    - ✷ Chewing mouthparts
  - ★ Pupal stage, called chrysalis for butterfly (inactive)
  - ★ Adult moth / butterfly emerges from pupa / chrysalis

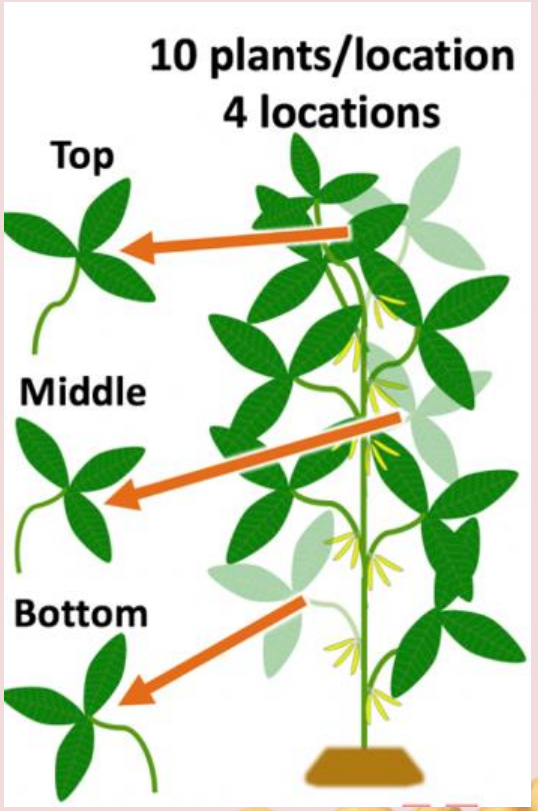




Estimating Insect Defoliation in Dry Beans

1. Scout from late vegetative to R6 crop stage
2. Walk at least 10 rows into field
3. W pattern in fields and sample 10 plants per location & 4 locations.
4. Remove leaves from top, middle and bottom of a randomly-selected plant.

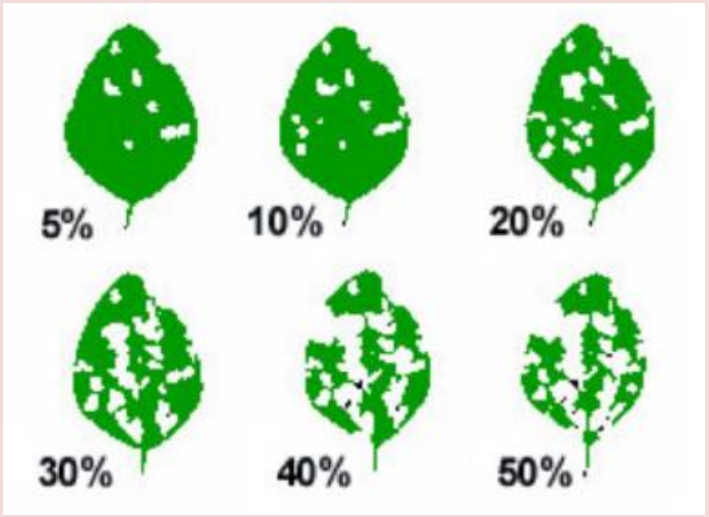
Source: A.J. McMechan, UNL



Estimating Insect Defoliation in Dry Beans

3. Remove highest and lowest defoliated trifoliate. Keep other leaflet.
4. Repeat 1-3 on remaining plants
5. Repeat at remaining locations and record defoliation of all 40 leaves.
6. Calculate the average defoliation per field

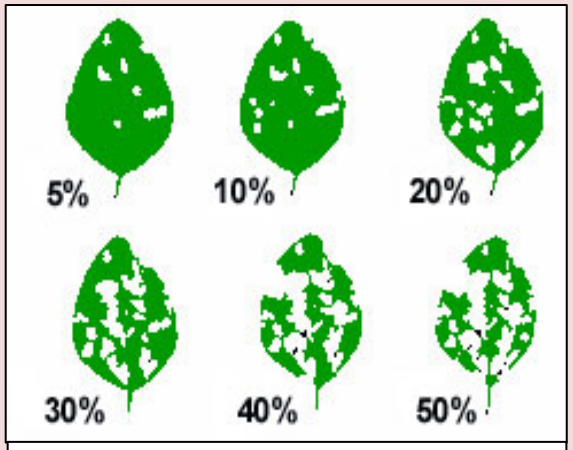
Source: A.J. McMechan, UNL



Economic Thresholds for Foliage-feeding Caterpillars in Soybeans

- **Lump all defoliating insects together**
  - ⋆ **Grasshoppers, bean leaf beetle**
- **Percent Defoliation**
  - ⋆ **Vegetative = above 30% defoliation**
  - ⋆ **Reproductive stage = above 20% defoliation**
- **Larvae (or caterpillars) per row foot**
  - ⋆ **An average infestation of 4 to 8 larvae per row foot (or 13-27 larvae per row meter) typically cause**

    20-30% defoliation.
- **As plants reach flowering and pod filling, defoliation poses a greater risk for yield loss.**



Guide to estimating damage caused by defoliating insects.

Natural Control

- **Diseases**
  - ★ **Fungal (*Nomuraea rileyi*)**
  - ★ **Viral**
    - ✷ **Nuclear polyhedrosis virus**
  - ★ **Favored by high humidity and warm temperatures**
- **Parasitic wasps**
- **Predators**

Soybeans Insecticide Recommendations

Registered Insecticides - 2020

Foliar Insecticides

Pyrethroids: Asana XL*, Declare*, Fastac EC*, Baythroid XL* & generics*, Tundra* & generics*, Bifender FC*, Tombstone Helios*, Warrior II* & generics*, Mustang Maxx*, Delta Gold*, Permethrin*

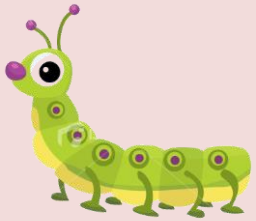
Carbamate: carbaryl (Sevin)

Organophosphate: Lorsban*

Oxadiazine: Steward EC

Premix Products with two a.i.:

Brigadier*, Skyraider*, Swagger*; Hero*; Match-up*; Leverage 360*; Tundra Supreme*; Cobalt Advanced*; Stallion*, Endigo ZC*



Always Read and Follow Labels.

** Restricted Use Pesticide*

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Questions?

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