Soybean Aphid Management: Is It Becoming More Complicated?

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Today's agenda

Soybean aphid

- Detection, biology and ecology

Management

Resistance to Insecticides

- Pyrethroids

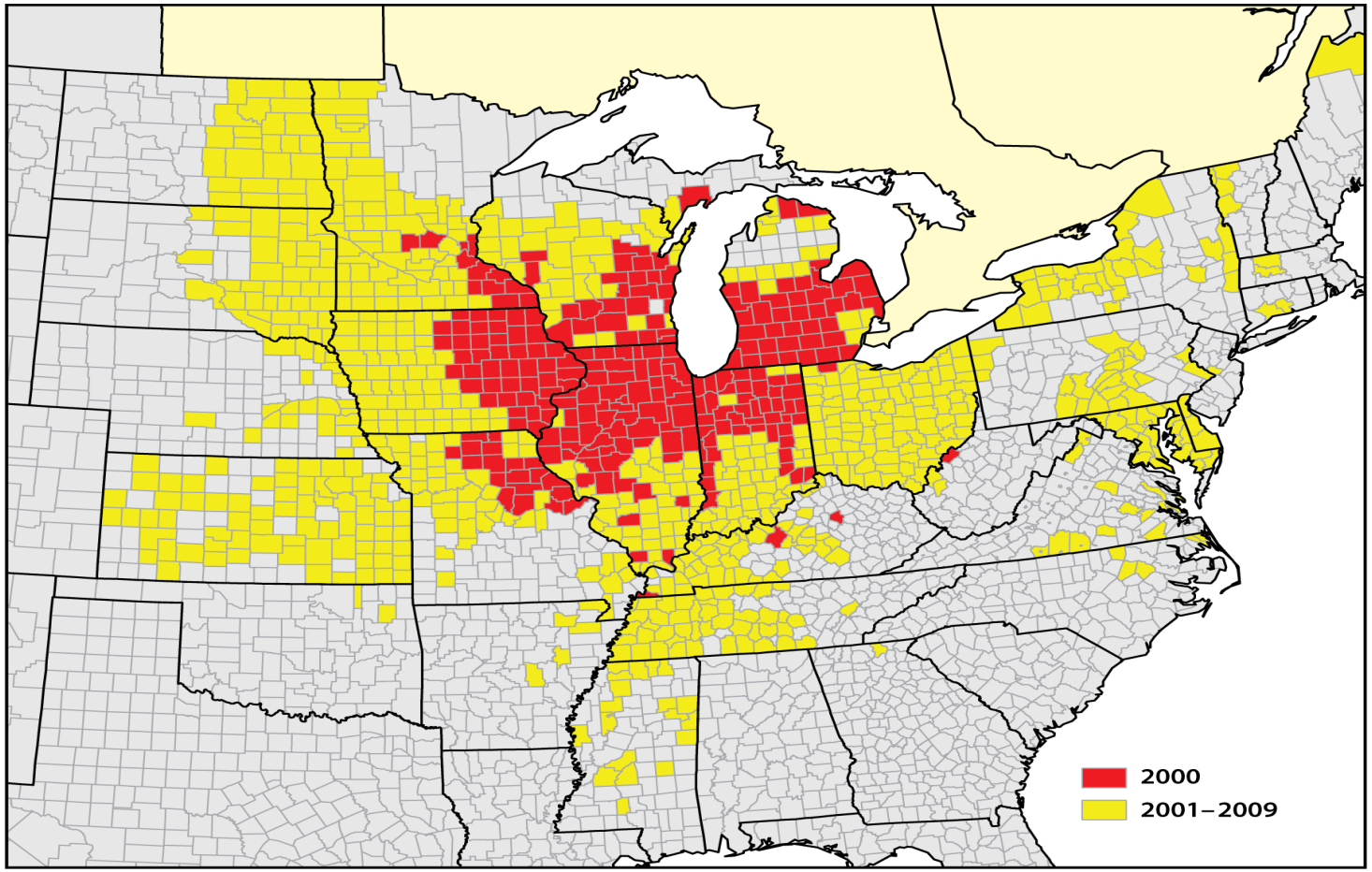
Host plant resistance

- Soybean aphid biotypes

Future Directions

Soybean aphid, *Aphis glycines*

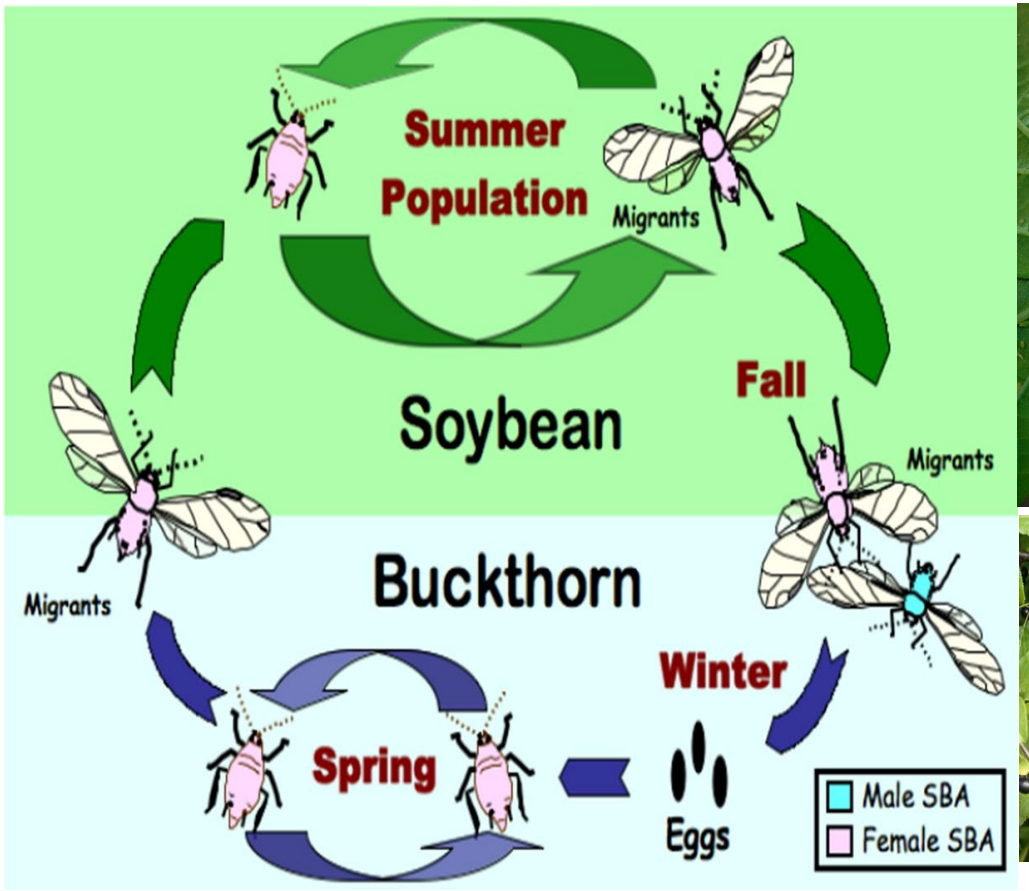
- Invasive from Asia
- Initial detection in 2000
- Now established across the Midwest
- One of most important soybean insect pest in the North Central US



Ragsdale et al. 2011

Soybean aphid: A complex life cycle

- Up to 18 generations a year
- It requires two species of host plant to complete its life cycle
- Soybeans
- Common buckthorn (*Rhamnus cathartica* L.)



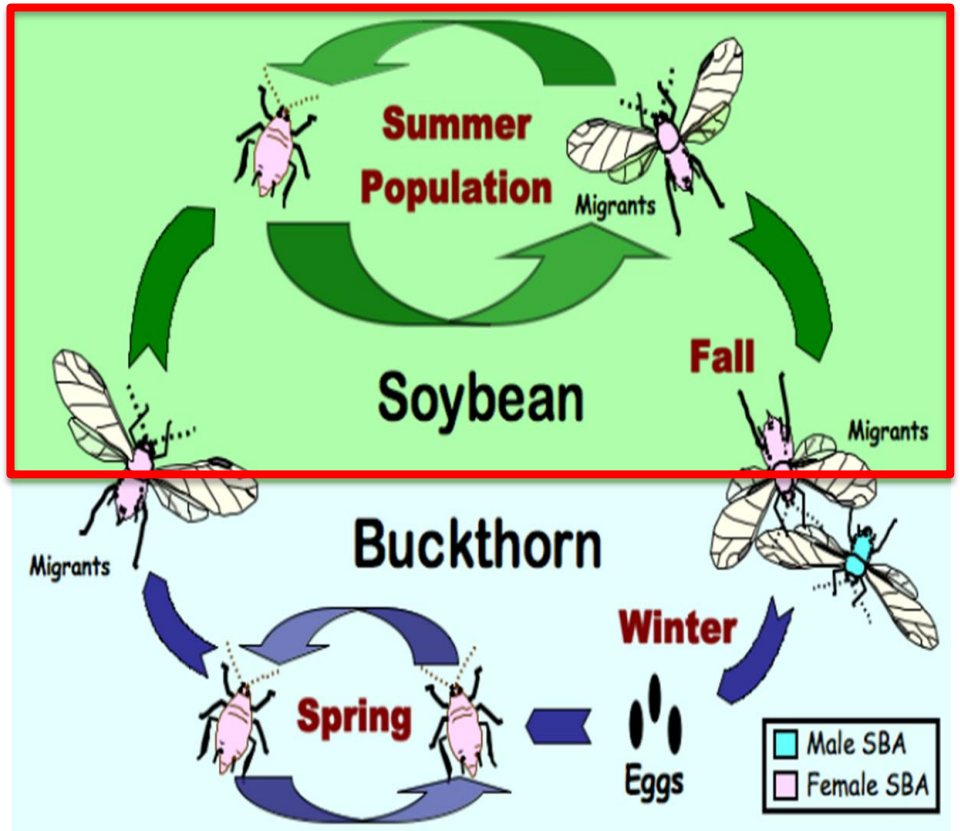
https://extension.entm.purdue.edu/publications/E-217.pdf

Ragsdale et al. 2011

Soybean aphid: A complex life cycle

- Colonizes soybean during Summer
- ~15 generations
- Soybean aphids reproduce asexually (without mating) on soybean (aphids are all females)
- **Population doubling time**

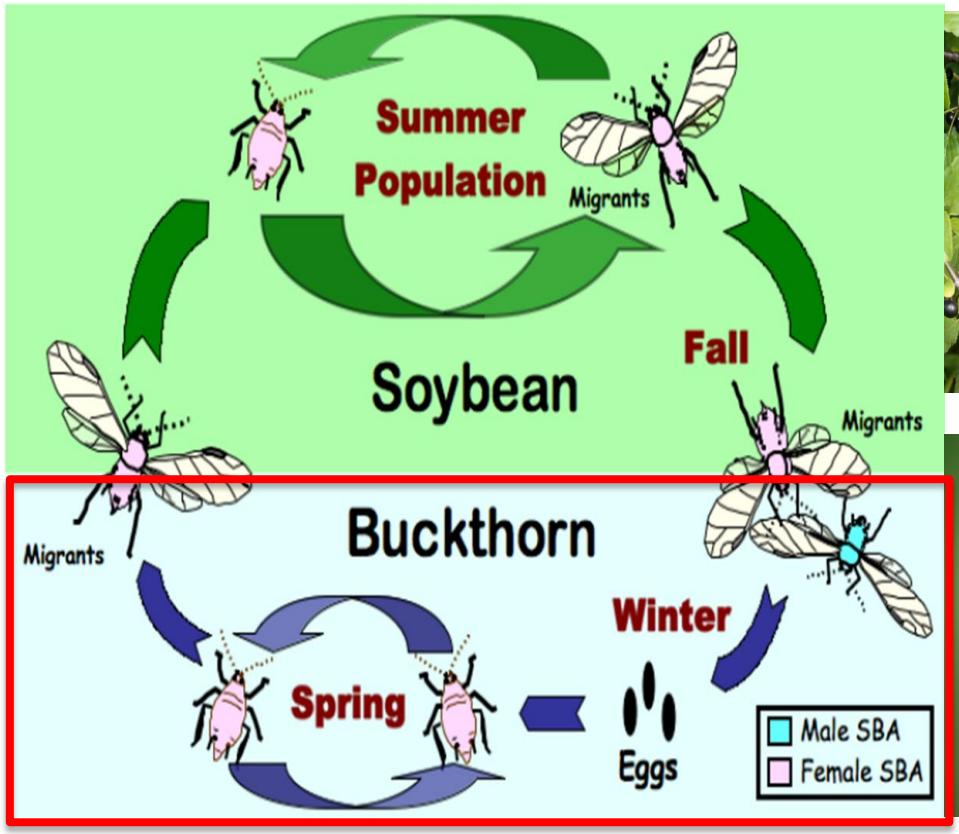
6-7 days - ability to increase very rapidly when conditions are favorable



https://extension.entm.purdue.edu/publications/E-217.pdf
Ragsdale et al., 2011

Soybean aphid: A complex life cycle

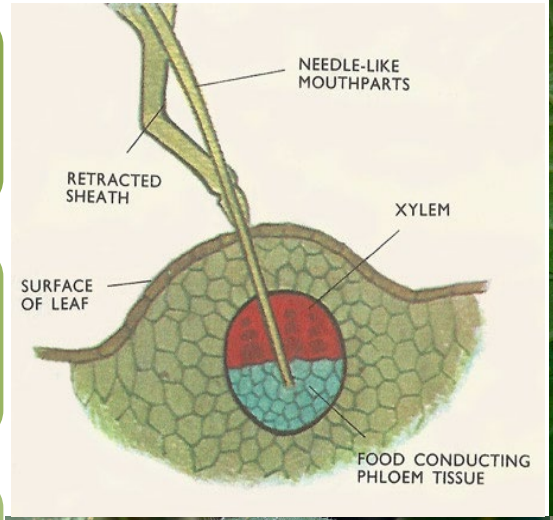
- At the end of the soybean growing season, aphids migrate to common buckthorn
- Sexual reproduction
- Overwinter as egg stage
- Eggs hatch during the Spring
- Three or more generations develop on buckthorn before migrating to soybeans

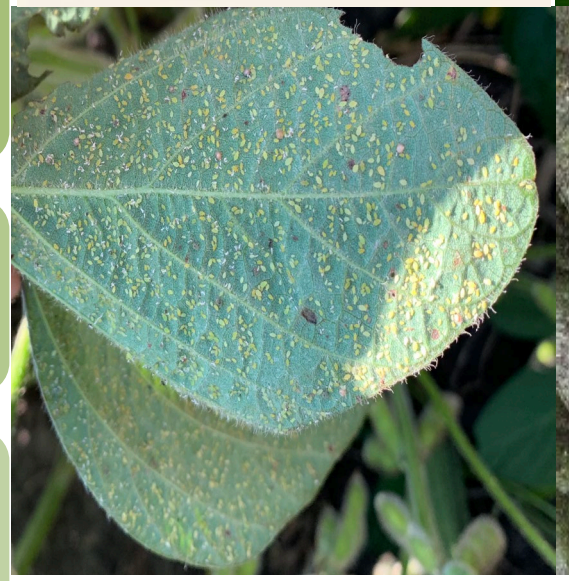


https://extension.entm.purdue.edu/publications/E-217.pdf
Ragsdale et al., 2011
Tilmon et al., 2011

Soybean aphids feed on phloem

- Negatively affect photosynthetic rates
- Reduce plant height
- Black sooty mold growth on honeydew
- Reduce pod number
- Seed quality and size





Soybean aphid honeydew can promote black sooty mold on soybean (left leaf). Photo credit to Brian P. McCornack.

Beckendorf et al., 2018; Tilmon et al., 2011.

Impact on soybeans

Negatively affect photosynthetic rates

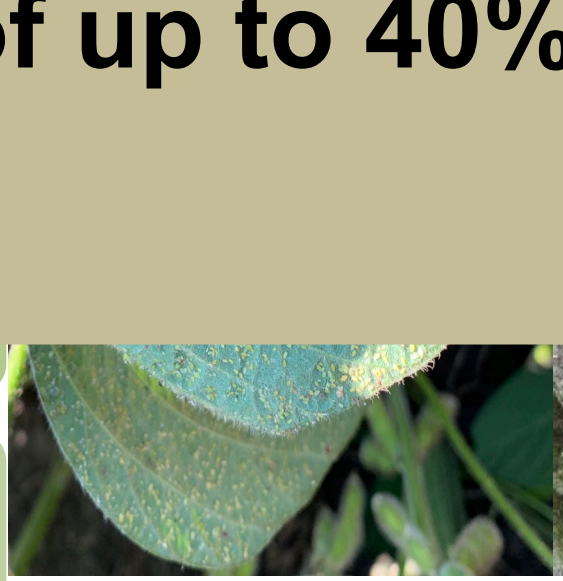
Red

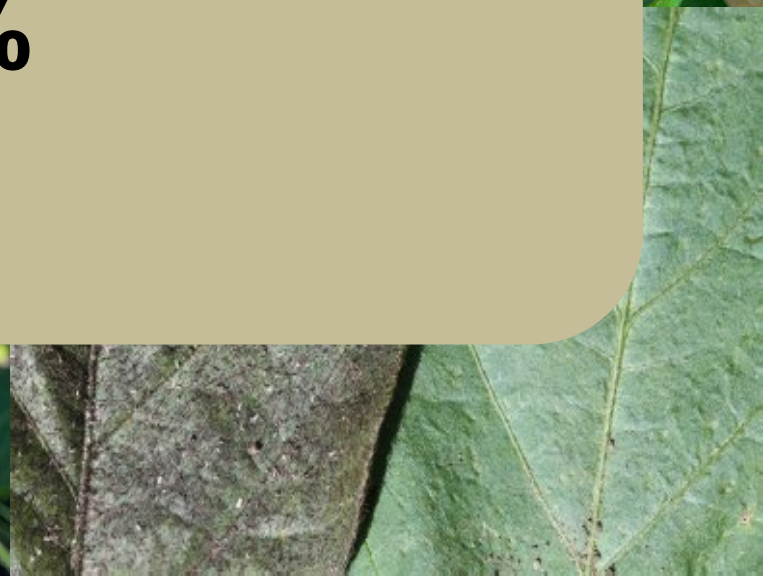
Blac

Red

Seed quality and size

Heavy infestations can result in yield losses of up to 40%



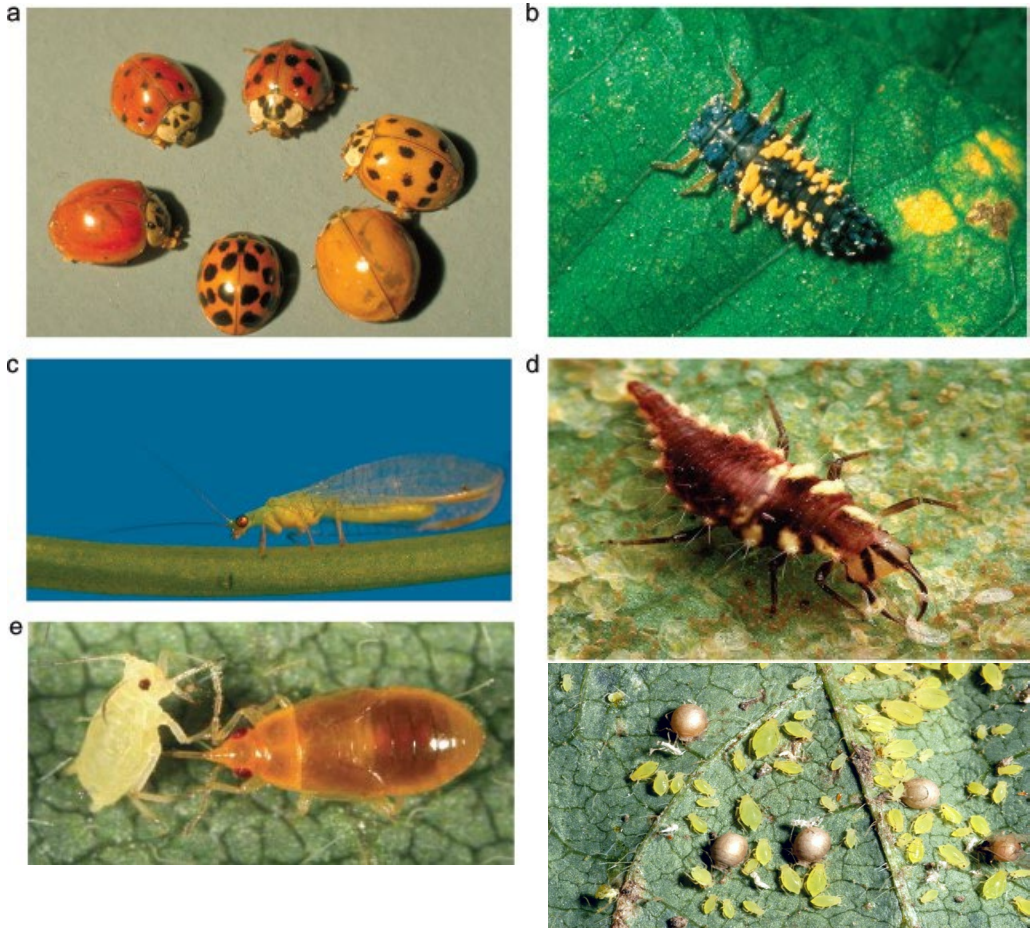


Soybean aphid honeydew can promote black sooty mold on soybean (left leaf). Photo credit to Brian P. McCornack.

Beckendorf et al., 2018; Tilmon et al., 2011.

Soybean aphid management
Natural enemies

- Diverse community of natural enemies
- Contribute to soybean aphid suppression
- Need to integrated other management practices when populations reach economic threshold levels



a) Labybeetle photo by Bill Ree, Bugwood.org (b) Asian ladybeetle larva. Photo by Allan Knutson, Bugwood.org (c) Green lacewing adult. Photo by Sonya Broughton, Bugwood.org (d) Green lacewing larva. Photo by USDA-ARS (e) immature Orius sp. bug feeding on a soybean aphid. Photo by Robert O' Neil

Soybean aphid management
Insecticides

Seed treatment

Soybean aphid arrival may not often align with the window of seed treatment efficacy

Foliar insecticides are currently the most used control method for soybean aphid

Source: https://ipcm.wisc.edu/wp-content/uploads/sites/54/2015/06/Spraying-Soybean.jpg

Economic threshold

250 aphids/plant

Table 4. Pesticide costs (2018 figures)

Pesticide type	Cost (US$ ha^{-1})	$N^{§}$
Herbicides[†]	104.16	2
Conventional	118.61	1
Herbicide-tolerant	89.70	1
Insecticides[‡]	22.88	8
Group 1B	21.98	3
Group 3A	13.83	4
Group 4C	61.78	1

Pyrethroids

Least expensive option

(Dean et al., 2021)

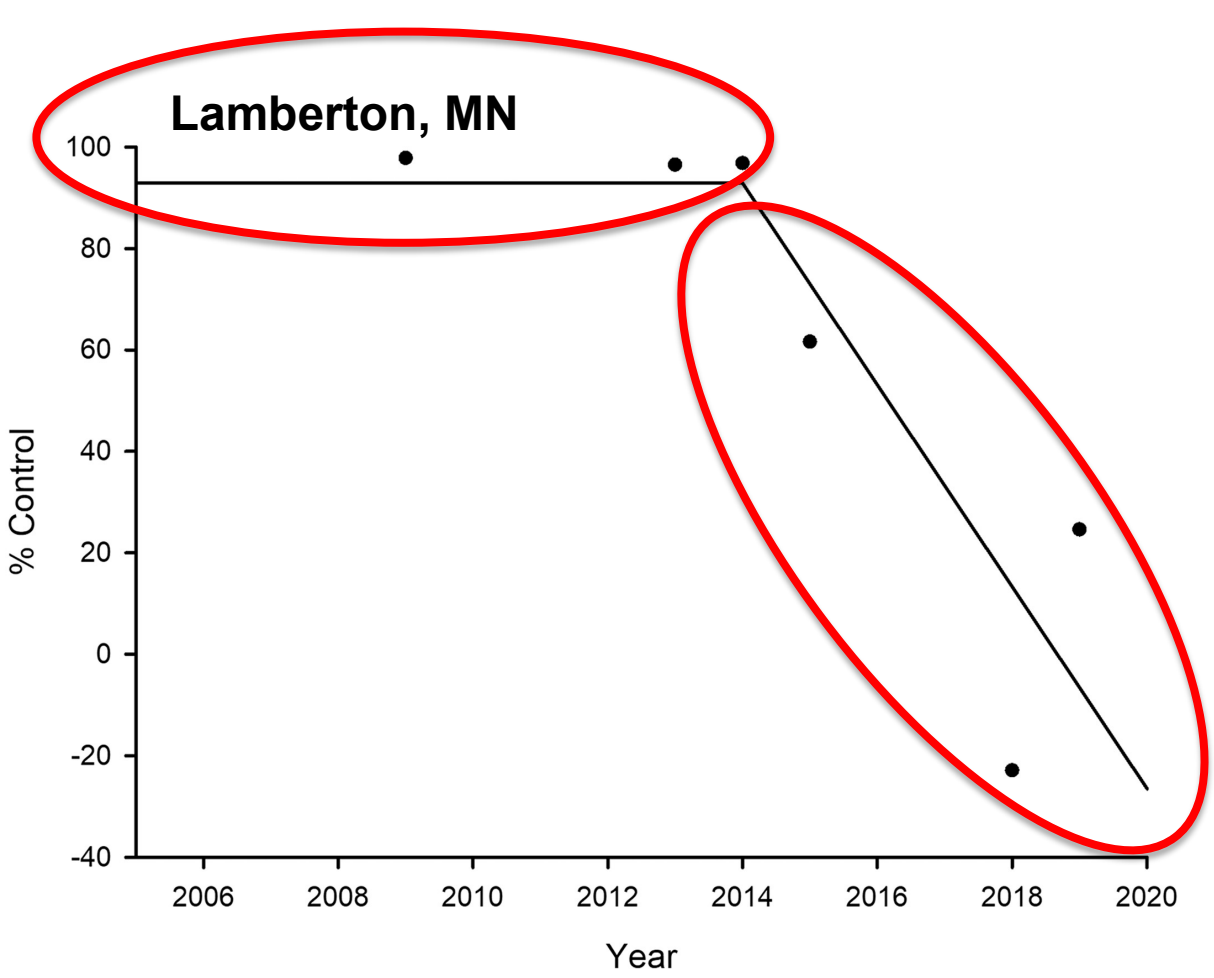
Soybean aphid management
Insecticides

Overreliance on the same method can lead to…

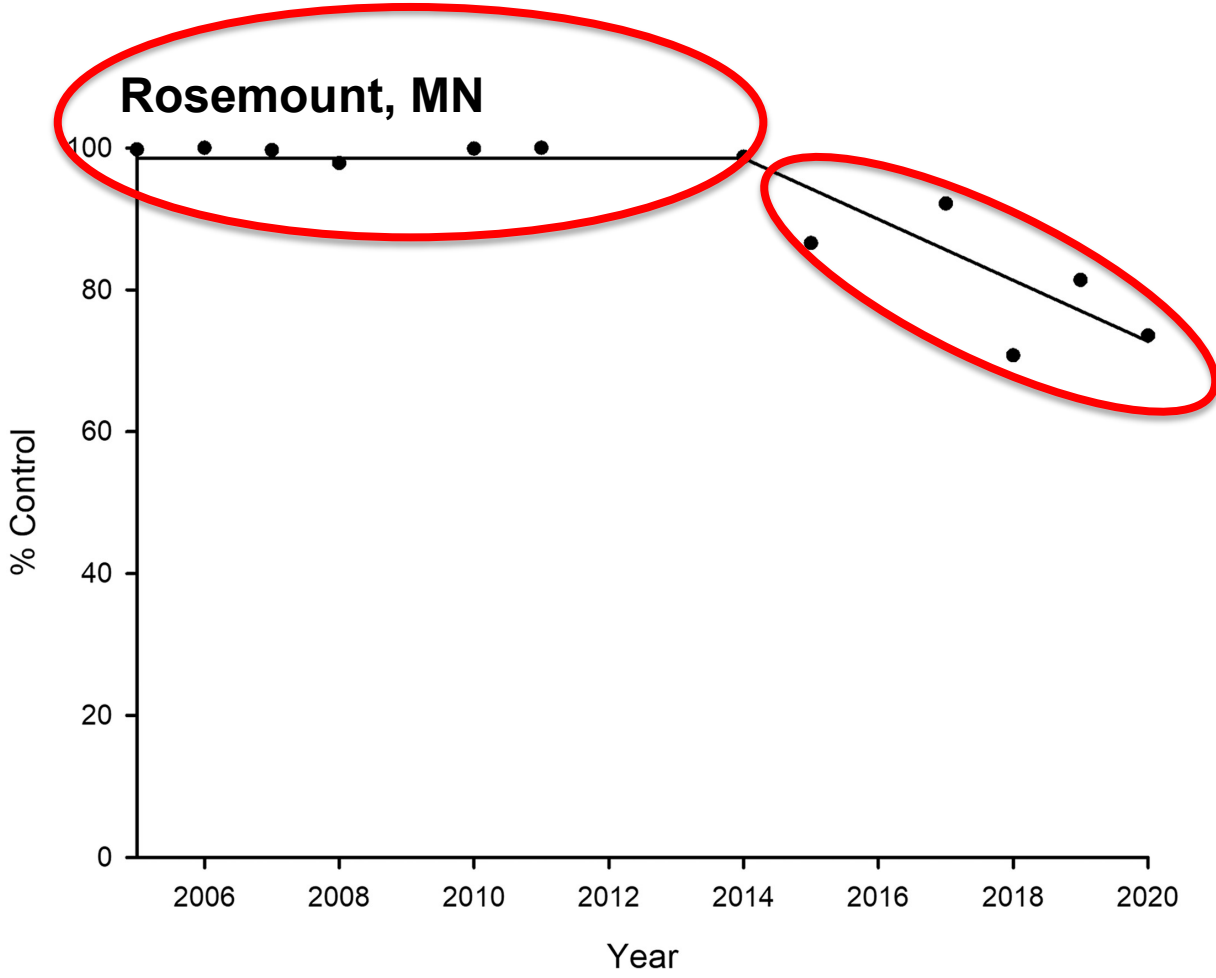
Resistance evolution

More expensive insecticides

A significant reduction in pyrethroid efficacy was detected in 2014



Decreased at a rate of 19.9% per year



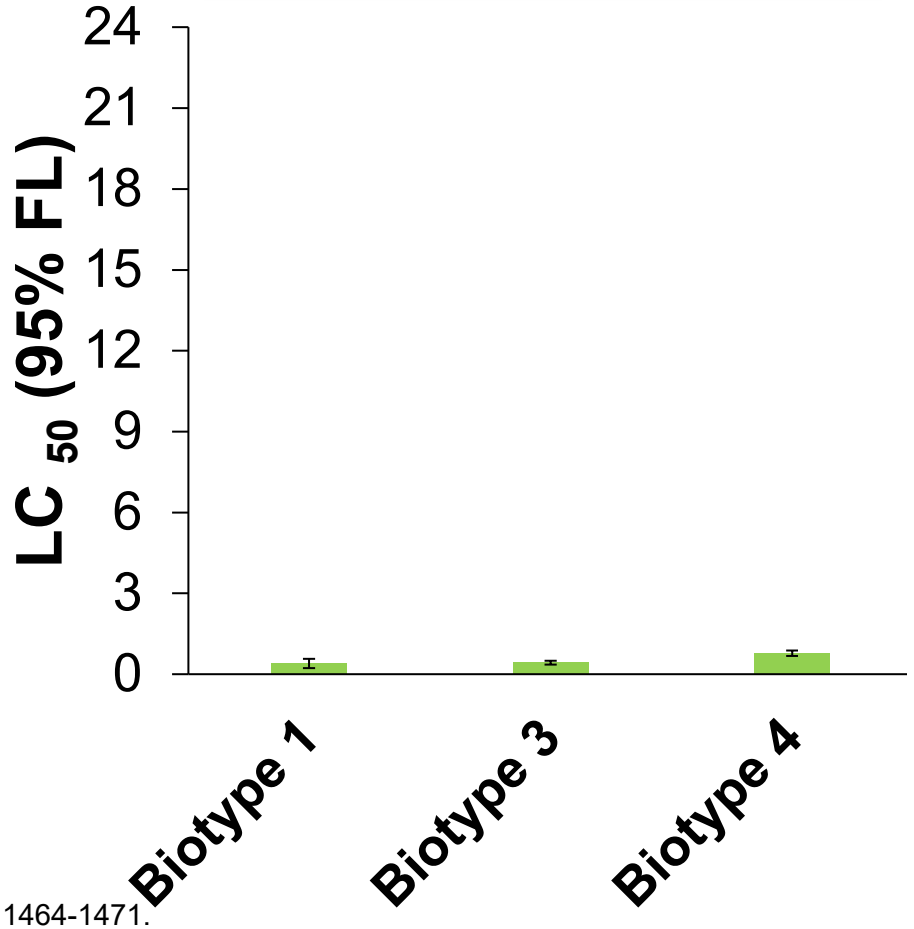
Decreased at a rate of 4.3% per year

Menger et al., 2022

Field populations are resistant to λ-cyhalothrin

Lab populations

Concentration (µg/mL) causing 50% mortality of soybean aphids



Valmorbida et al. 2020. *Pest Manag. Sci.* 76:1464-1471.
Valmorbida et al. 2022. *Sci. Rep.* 12:12020.

Field populations are resistant to λ-cyhalothrin

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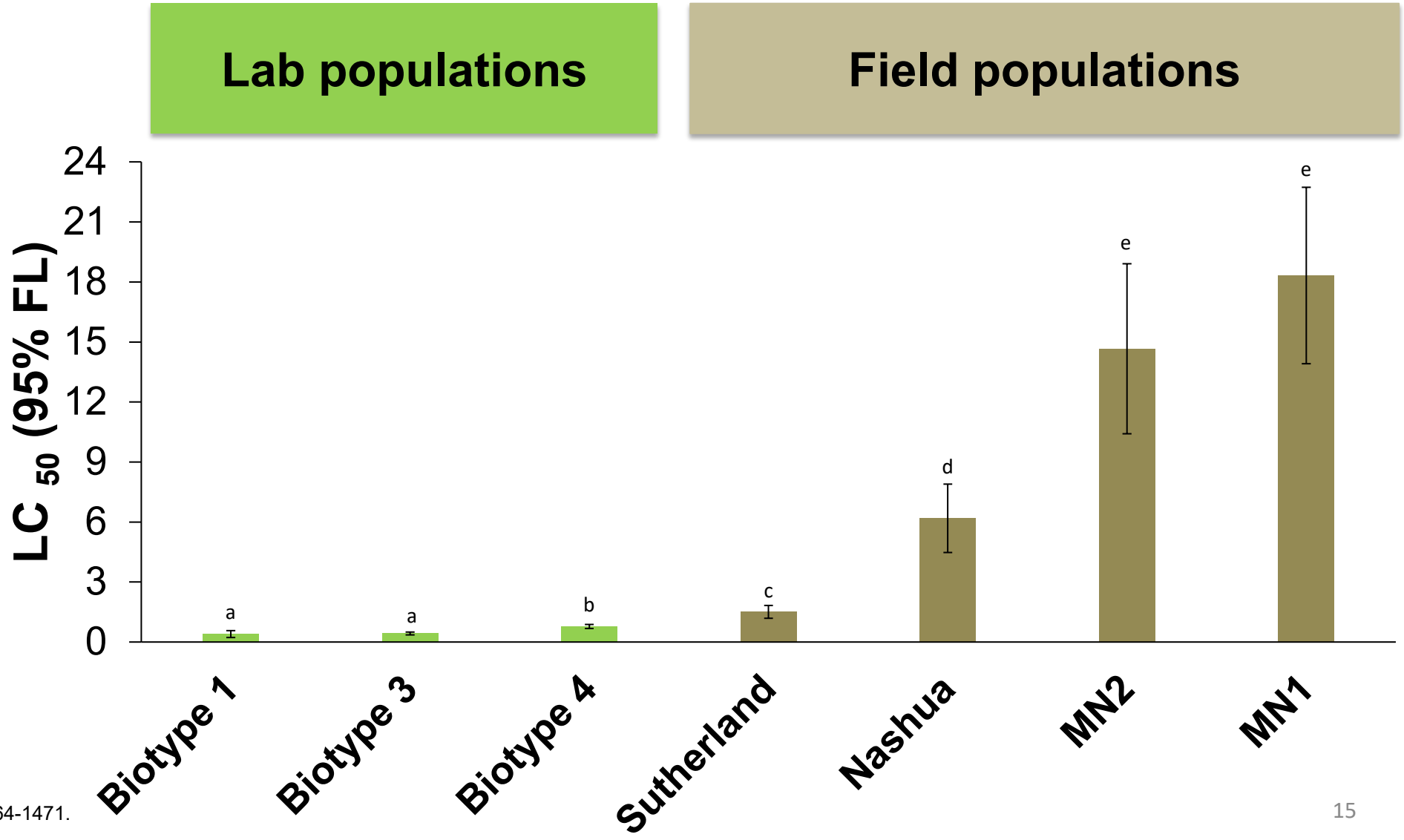


Valmorbida et al. 2020. *Pest Manag. Sci.* 76:1464-1471.
Valmorbida et al. 2022. *Sci. Rep.* 12:12020.

Field populations are resistant to pyrethroids

Confirmed resistance to pyrethroids, with multiple phenotypes

Pyrethroid-resistant aphids found throughout the Midwest

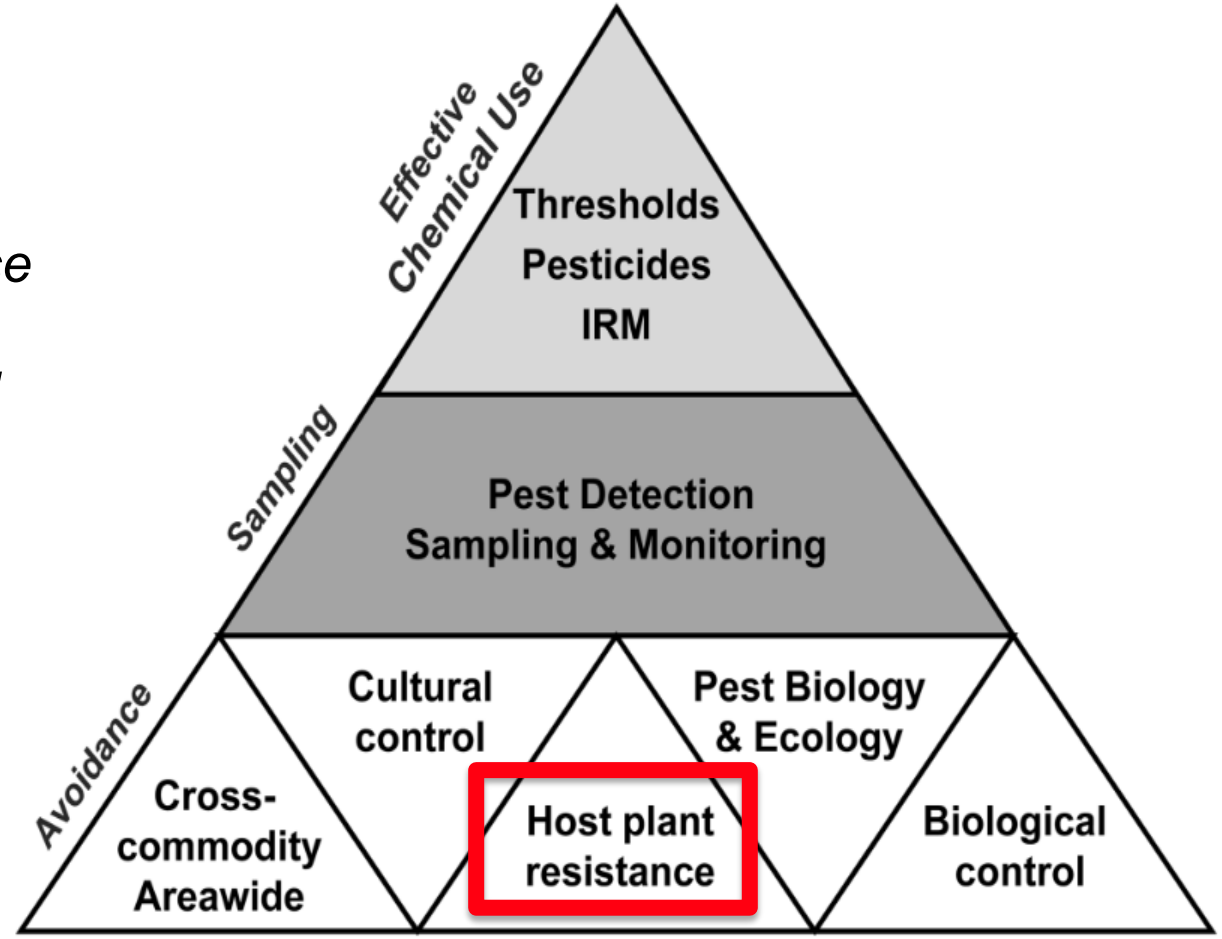
Resistance to pyrethroids is primarily associated with non-synonymous mutations in the voltage-gated sodium channels (Paula et al., 2021, Valmorbida et al. 2022).

Valmorbida et al. 2020. *Pest Manag. Sci.* 76:1464-1471.
Valmorbida et al. 2022. *Sci. Rep.* 12:12020.

What other tools could farmers use?

IPM Perspective

"A decision support system for the selection and use of ***pest control tactics, singly or harmoniously coordinated into a management strategy,*** *based on cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment"* (Kogan, 1998).

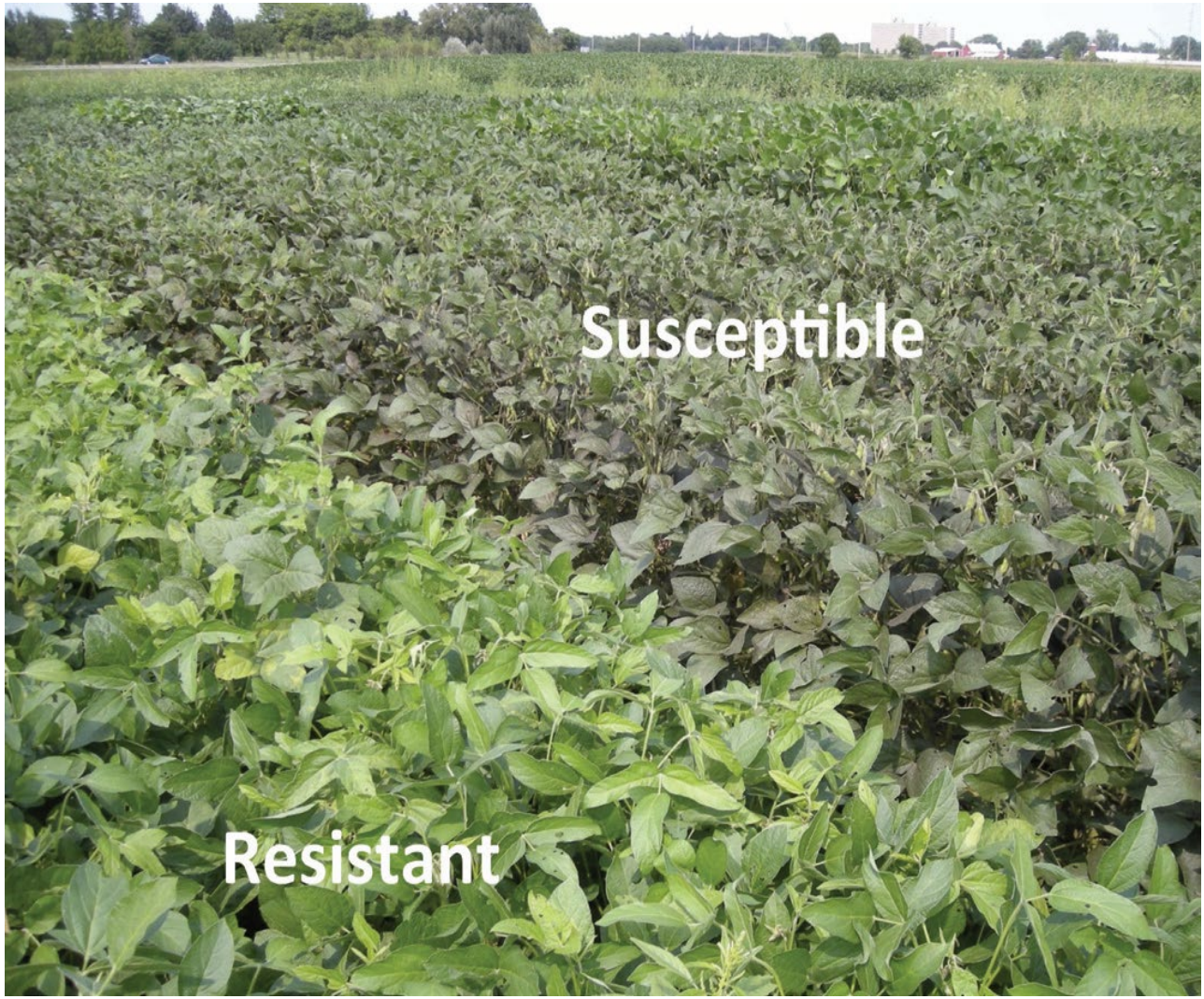


Naranjo, S. 2011. *J. Agric. Food Chem.* 59:5842-5851.

Aphid-resistant varieties

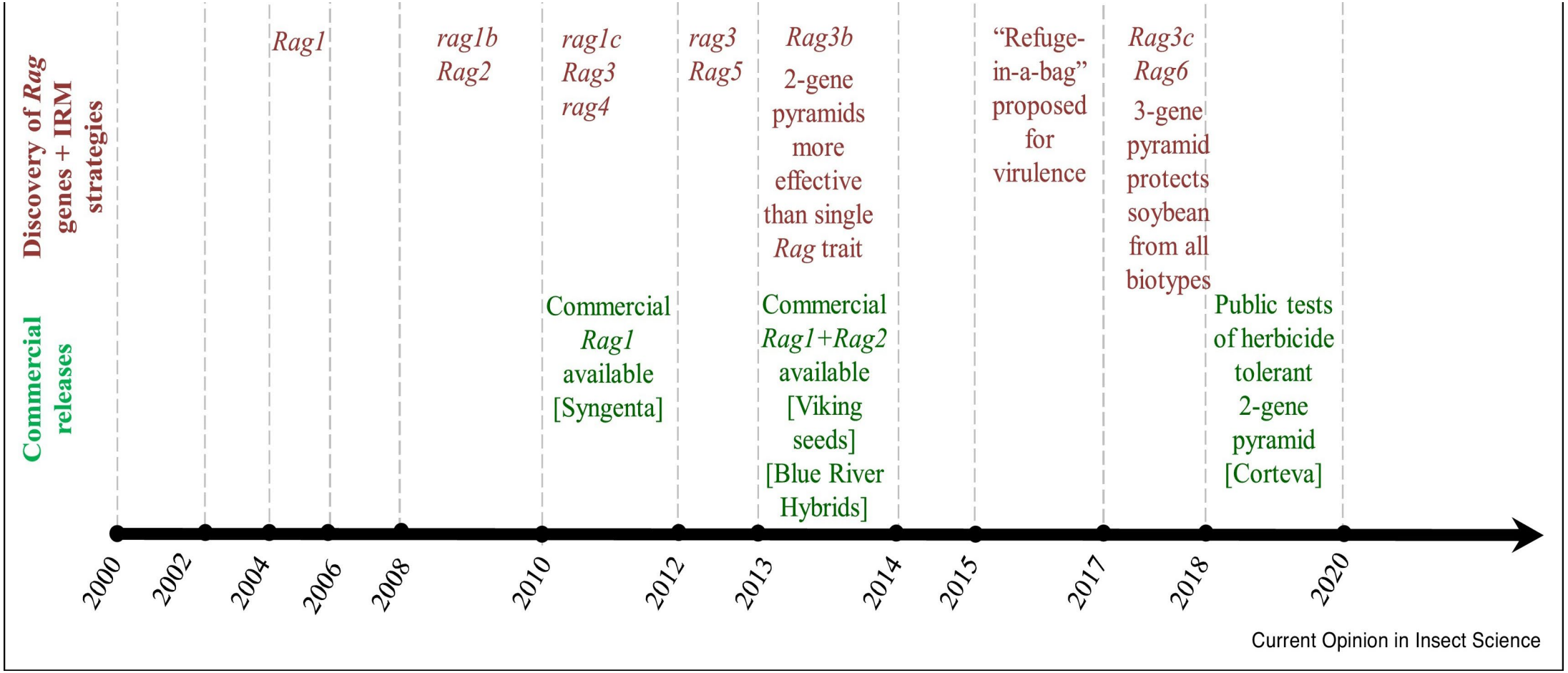
- Screening for resistance genes in soybean lines
- Discovered of several *Rag* genes
- *Rag-genes* (resistance to *Aphis glycines)*
- Antibiosis and antixenosis

(Hesler et al., 2013)



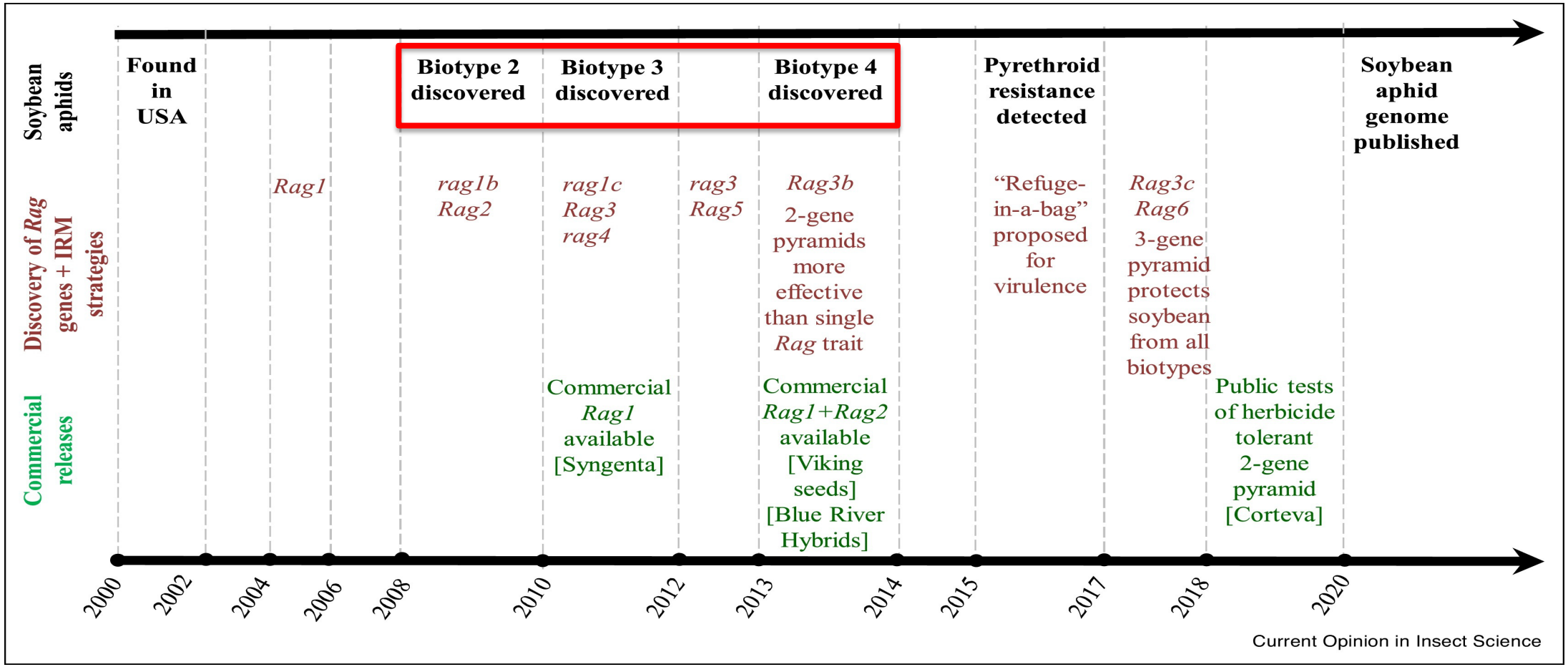
O'Neal et al. 2018

A brief history of the discovery and use of aphid-resistant varieties



Note that a gene identified with a capital R is transmitted in a dominate fashion, and those with a r are recessive (Tilmon et al., 2021).

Discovery of virulent soybean aphids



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What are the soybean aphid biotypes?

Soybean aphid Biotype: *A subpopulation or clonal lineage that is phenotypically defined based on the response to Rag-HPR soybean* (Tilmon et al., 2021)

What are the soybean aphid biotypes?

Biotypes

- Three virulent biotypes[2]

Biotype 1: Cannot survive on any *Rag genes* variety (Avirulent)

Biotype 2: Survives on *Rag1*

Biotype 3: Survives on *Rag2*

Biotype 4: Survives on *Rag1+2*

[1]Hesler et al., 2013
[2]Cooper et al., 2015

Geographic distribution of soybean aphid biotypes

Biotypes

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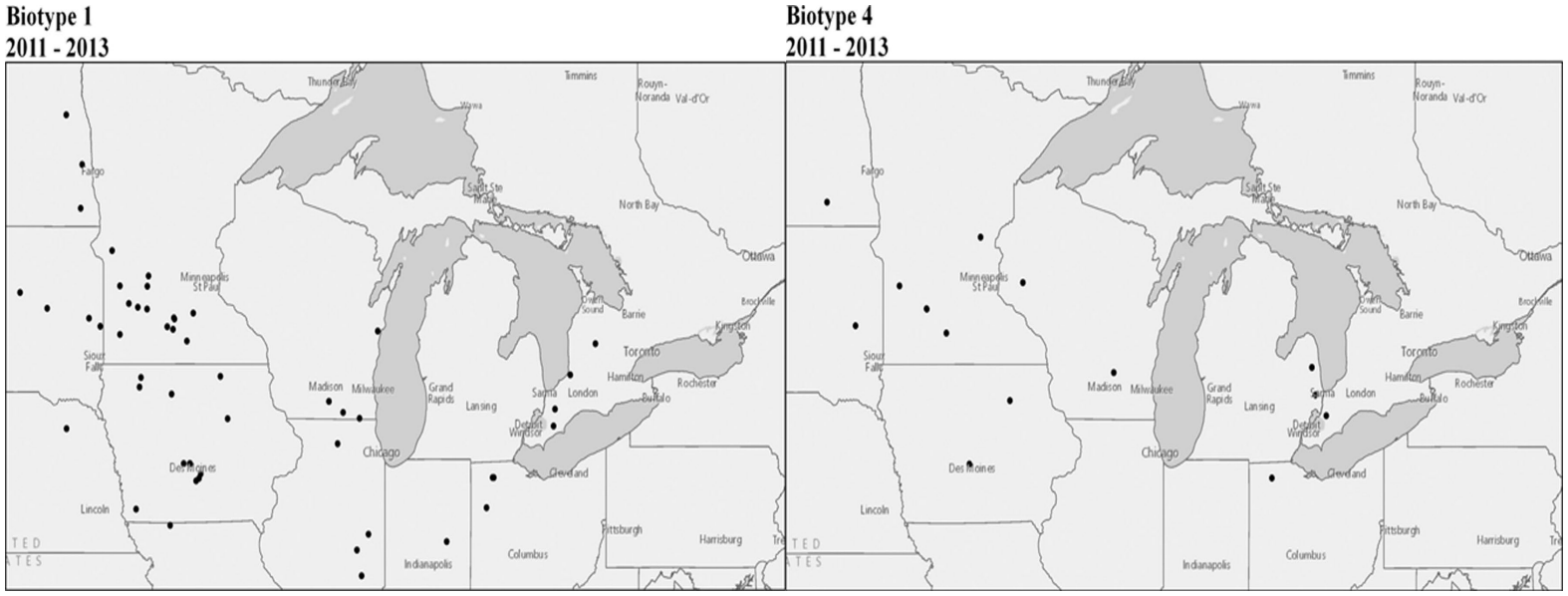
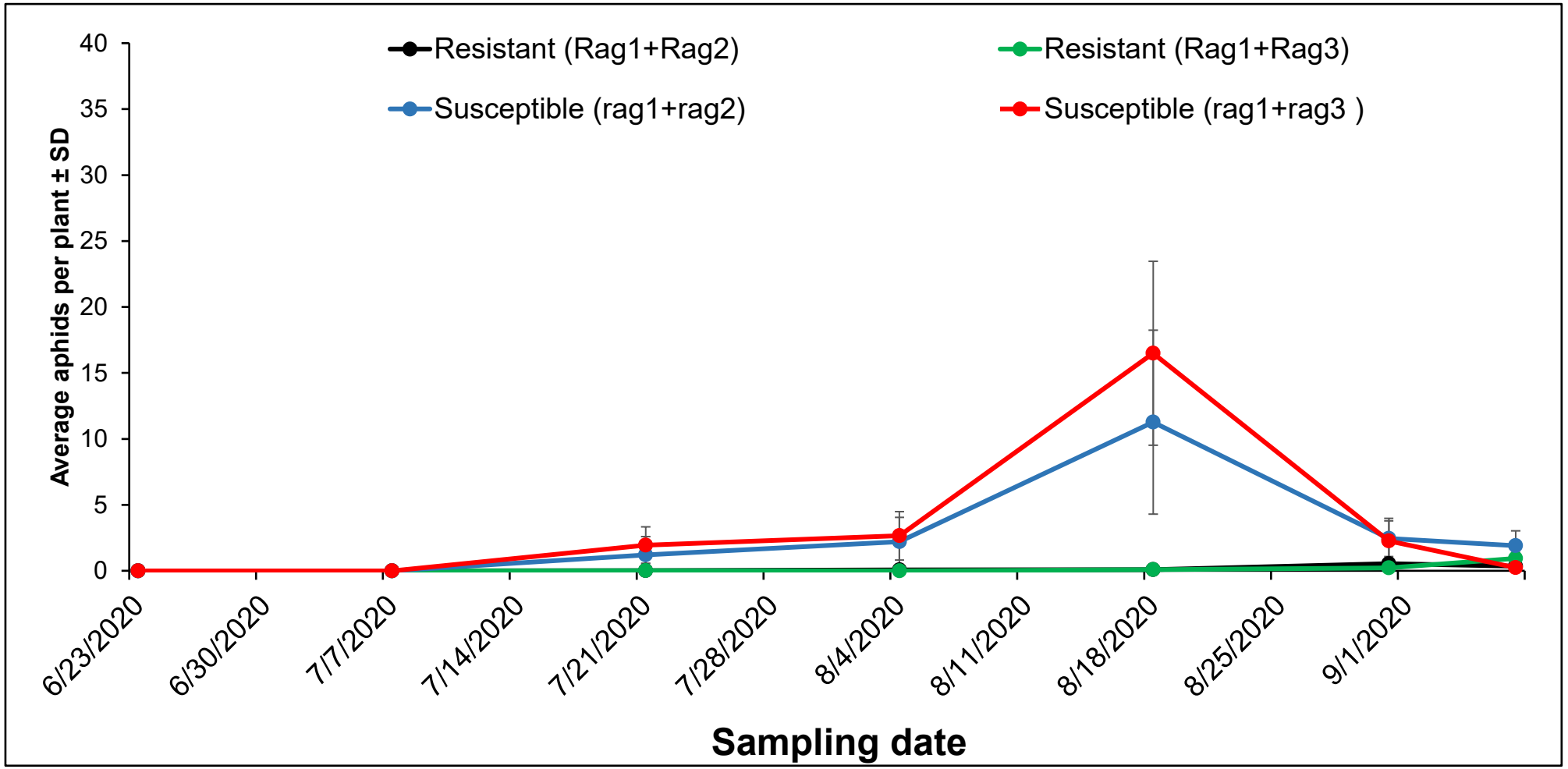


Soybean aphid biotypes are known to vary across years, locations, and single fields (Alt et al., 2019)

Resistance varieties reduced aphid populations



Is the soybean aphid management becoming more complicated?

The seasonal life cycle of the soybean aphid is complex

Many populations of soybean aphids are resistant to pyrethroids

Not many aphid-resistant varieties available

Concerns regarding soybean aphid biotypes

IRM for insecticides and aphid-resistant varieties

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Expanding Opportunities. Delivering Results.

NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

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