North Dakota Soybean Council
Progress Report – June 2024

Title: Pyrethroid Resistant Soybean Aphids and Soybean Gall Midge Survey

Investigator: Dr. Janet J. Knodel, Professor and Extension Entomologist
Co-Investigators: Patrick Beauzay, IPM State Coordinator and Research Specialist

Research Overview:
Pyrethroid resistant soybean aphids continues to threaten effective pest management of soybean aphids in eastern ND. The first goal of this research is to provide soybean growers with 'updated' insecticide efficacy for successful management of pyrethroid resistant soybean aphids in their fields, and to mitigate the development of resistance to other insecticides. By understanding which insecticides manage pyrethroid resistant soybean aphids, soybean yields can be maximized. We will evaluate a broad range of registered and experimental insecticides with different modes of action. The second goal of this research is to continue survey work for the invasive soybean gall midge, a new economic insect pest of soybeans. Soybean gall midge was recently discovered and confirmed in Sargent County, ND in 2022. The third goal is to continue to provide new extension outreach resources for improved and relevant education of growers, crop consultants, scouts and other stakeholders.

Objectives:

1) To determine which insecticides and mode of actions are the best tools for management of pyrethroid resistant soybean aphids.

2) To continue survey work for the detection of the new soybean insect pests, soybean gall midge and soybean tentiform leafminer.

3) To develop extension outreach material on soybean insect pests for NSDC and growers.

Completed Work: Deliverables and/or Milestone
The following soybean insect pest articles were written and distributed to stakeholders through the NDSU Extension *Crop & Pest Report* (distribution of >6,500 subscribers) during the 2023 field season.

Knodel, J. 2023. Bean leaf beetle active in soybeans. NDSU Extension *Crop and Pest Report* #6 (June 15, 2023).

Knodel, J. 2023. Scout for soybean aphids. NDSU Extension *Crop and Pest Report* #7 (June 22, 2023).

Knodel, J. 2023. Scout for soybean aphid. NDSU Extension *Crop and Pest Report* #10 (July 12, 2023).

Knodel, J. 2023. Continue to scout for soybean aphids. NDSU Extension *Crop and Pest Report* #11 (July 20, 2023).

Knodel, J. 2023. Continue to scout for soybean aphids and cereal aphids. NDSU Extension *Crop and Pest Report* #12 (July 27, 2023).

Knodel, J. 2023. Soybean gall midge update. NDSU Extension *Crop and Pest Report* #12 (July 27, 2023).

Knodel, J., and Beauzay, P. 2023. Soybean aphids increasing. NDSU Extension *Crop and Pest Report* #13 (August 3, 2023).
Knodel, J., and Beauzay, P. 2023. Soybean aphids - beware of pyrethroid resistance. NDSU Extension *Crop and Pest Report* #13 (August 3, 2023).
Knodel, J. 2023. Scout for all soybean insect pests. NDSU Extension *Crop and Pest Report* #14 (August 10, 2023).
Knodel, J. 2023. Late season insect pests in dry beans and soybeans. NDSU Extension *Crop and Pest Report* #15 (August 24, 2023).
Knodel, J., and Beauzay, P. 2023. 2023 IPM Crop Survey - soybean and sunflower insect pests. NDSU Extension *Crop and Pest Report* #17 (September 21, 2023).

Other articles:

2023. Soybean gall midge likely to be in North Dakota. The North Dakota Soybean Grower Magazine, June 2023.
2023. More moths in F-M area is typical for time of year, expert says. The Forum, Sept. 19.

Progress of Work and Result to Date

Objective One: To determine which foliar insecticides and mode of actions are the best tools for management of pyrethroid resistant soybean aphids.

This objective was **completed** and results will be presented to stakeholders at several upcoming extension and commodity meetings.

Several insecticides were tested for control of soybean aphids at the NDSU AES Farm near Casselton, ND. We examined the efficacy of pyrethroids alone, aphid-specific insecticides alone, pyrethroid/aphid-specific premixes, and acephate, a systemic organophosphate insecticide. Insecticides, rates, chemical classes (modes of action), and active ingredients are listed in Table 1.

Table 1. Insecticide treatments, chemical classes (IRAC modes of action), and active ingredients.

Group	Insecticide Treatment and Rate	Chemical Class (IRAC #)	Active Ingredient(s)
Pyrethroids	Baythroid XL 2.8 fl oz/acre	Pyrethroids (3A)	Beta-cyfluthrin
Pyrethroids	Brigade 3.2 fl oz/acre	Pyrethroids (3A)	Bifenthrin
Pyrethroids	Warrior II 1.6 fl oz/acre	Pyrethroids (3A)	Lambda-cyhalothrin
Pyrethroids	Mustang Maxx 4 fl oz/acre	Pyrethroids (3A)	Zeta-cypermethrin
Pyrethroids	Hero 10.3 fl oz/acre	Pyrethroids (3A)	Bifenthrin Zeta-cypermethrin
Pyrethroids	Asana XL 9.6 fl oz/acre	Pyrethroids (3A)	Esfenvalerate
Premix	Leverage 360 2.8 fl oz/acre	Pyrethroids (3A) Neonicotinoids (4A)	Beta-cyfluthrin Imidacloprid

Group	Insecticide Treatment and Rate	Chemical Class (IRAC #)	Active Ingredient(s)
Premix	Skyraider 3.2 fl oz/acre	Pyrethroids (3A) Neonicotinoids (4A)	Bifenthrin Imidacloprid
Premix	Endigo ZC 4 fl oz/acre	Pyrethroids (3A) Neonicotinoids (4A)	Lambda-cyhalothrin Thiamethoxam
Premix	Ridgeback 10.3 fl oz/acre	Pyrethroids (3A) Sulfoxamines (4C)	Bifenthrin Sulfoxaflor
Premix	Renestra 6.8 fl oz/acre	Pyrethroids (3A) Pyropenes (9D)	Alpha-cypermethrin Afidopyropen
Aphid-specific insecticides	Belay 6 fl oz/acre	Neonicotinoid s(4A)	Clothianidin
Aphid-specific insecticides	Transform WG 1 oz/acre	Sulfoxamines (4C)	Sulfoxaflor
Aphid-specific insecticides	Sivanto Prime 5 fl oz/acre	Butenolides (4D)	Flupyradifurone
Aphid-specific insecticides	Sefina 3 fl oz/acre	Pyropenes (9D)	Afidopyropen
Acephate	Acephate 16 fl oz/acre	Organophosphates (1B)	Acephate

Materials & Methods: The trial was arranged as a randomized complete block design with four replicates. Plots were 20 feet long x 5 feet (2 30-inch rows) wide. Guard plots were planted between all treatment plots to prevent spray drift and to allow for an untreated reservoir of soybean aphids through the trial. Soybean aphids began increasing in the trial block in early July. By mid-July, we felt that the aphid population was high enough to assess insecticide efficacy, even though the population was not at the economic threshold of 250 aphids per plant. Given the lack of soybean aphids over the past five years, we decided to make applications pre-threshold. Also, early applications allowed us to assess insecticide residual activity for a longer period than we have been able to in the past.

Pre-spray counts were made on July 19, and revealed an average of 25 aphids per plant distributed fairly evenly across the trial. Insecticide applications were made on the morning of July 21 with a backpack CO_2 sprayer using TeeJet AIXR 11015 AIXR nozzles at 40 PSI and a spray volume of 20 GPA. Aphid counts were made at 4, 7, 11, 14 and 21 days after treatment (DAT). Soybean aphids were sampled by counting the total number of aphids on ten randomly selected plants per plot, except the pre-spray count where we sampled five plants per plot. The total number of aphids per plant was recorded and averaged on a per plot basis for analysis. Plots were harvested on October 10 using a Zurn 150 plot combine with a HarvestMaster grain gauge. Grain weight, moisture and test weight were recorded for each plot. Yield was adjusted to 13% standard grain moisture. All data were analyzed using the GLM procedure in SAS statistical software. Fisher's LSD test was used to compare treatment means.

Results: All tested products gave control of soybean aphids and had significantly fewer aphids per plant than the untreated check (Table 2, Figure 1). Acephate and all pyrethroids alone, with the exception of Asana XL (esfenvalerate), had significantly more aphids per plant compared to the aphid-specific insecticides and the pyrethroid/aphid-specific premixes across all sampling dates. These data indicate that the soybean aphid population at Casselton had a low level of pyrethroid resistance, and resistance was observed in all pyrethroids except esfenvalerate. Residual data also indicates that all foliar insecticides tested had a long residual of 21 days. The P-value for yield was not significant. Soybean aphid numbers did not reach economic threshold, so we did not expect to see any yield differences due to soybean aphid feeding injury. Numerically, grain yield for the untreated check came out in the middle of the pack and was not significantly different from any other treatment.

Table 2. Treatment means for aphids per plant at 4, 7, 11, 14 and 21 days after treatment (DAT), and grain yield at Casselton.

Treatment	4 DAT	7 DAT	11 DAT	14 DAT	21 DAT	Yield (bu/acre)
Untreated Check	66.3 a	117.1 a	153.7 a	191 a	114.8 a	54.3 abc
Baythroid XL @ 2.8 fl oz/acre	23.3 b	8.4 bc	11.3 bc	11.2 b	4.7 b	51.8 abc
Brigade @ 3.2 fl oz/acre	6.4 b-e	14.5 bc	10.3 bc	4.7 b	12.7 b	58.3 ab
Warrior II @ 1.6 fl oz/acre	11.3 b-e	16.1 bc	34.2 b	17.9 b	27.6 b	54.5 abc
Mustang Maxx @ 4 fl oz/acre	20.5 bcd	18.8 b	23.8 bc	12.7 b	18.1 b	51 abc
Hero @ 10.3 fl oz/acre	21.2 bc	9.3 bc	16.8 bc	19.7 b	10.5 b	50.4 bc
Asana XL @ 9.6 fl oz/acre	5.4 cde	5.8 bc	4.6 c	4.6 b	1.6 b	53.3 abc
Leverage 360 @ 2.8 fl oz/acre	6.2 cde	0.2 bc	0.5 c	0.9 b	1.1 b	53.5 abc
Skyraider @ 3.2 fl oz/acre	3.9 de	0.1 bc	0.8 c	1.6 b	0.8 b	49.4 c
Endigo ZC @ 4 fl oz/acre	1.2 e	0.1 bc	0.3 c	0.7 b	1 b	56 abc
Ridgeback @ 10.3 fl oz/acre	0.4 e	1.2 bc	2 c	2.2 b	3.7 b	50.4 bc
Renestra @ 6.8 fl oz/acre	3.7 de	1.9 bc	2.5 c	3.3 b	2.5 b	59.4 a
Belay @ 6 fl oz/acre	7.9 b-e	0.2 bc	0.3 c	0.6 b	0.6 b	53.1 abc
Transform WG @ 1 oz/acre	8.9 b-e	0.3 bc	2.4 c	1.6 b	1.4 b	52.1 abc
Sivanto Prime @ 5 fl oz/acre	1.9 e	0.1 c	0.7 c	1 b	0.6 b	51.2 abc
Sefina @ 3 fl oz/acre	5.5 cde	0.5 bc	0.4 c	0.9 b	0.3 b	50.2 bc
Acephate @ 16 fl oz/acre	14.9 b-e	5.7 bc	11.7 bc	6.2 b	6.4 b	47.5 c
F-value	**6.76**	**17.81**	**17.69**	**45.10**	**5.97**	**1.01**
P-value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.4625**
LSD	**17.1**	**18.8**	**24.8**	**19.2**	**31.9**	**8.8**

Means within a column that share the same letter are not significantly different ($P<0.05$).

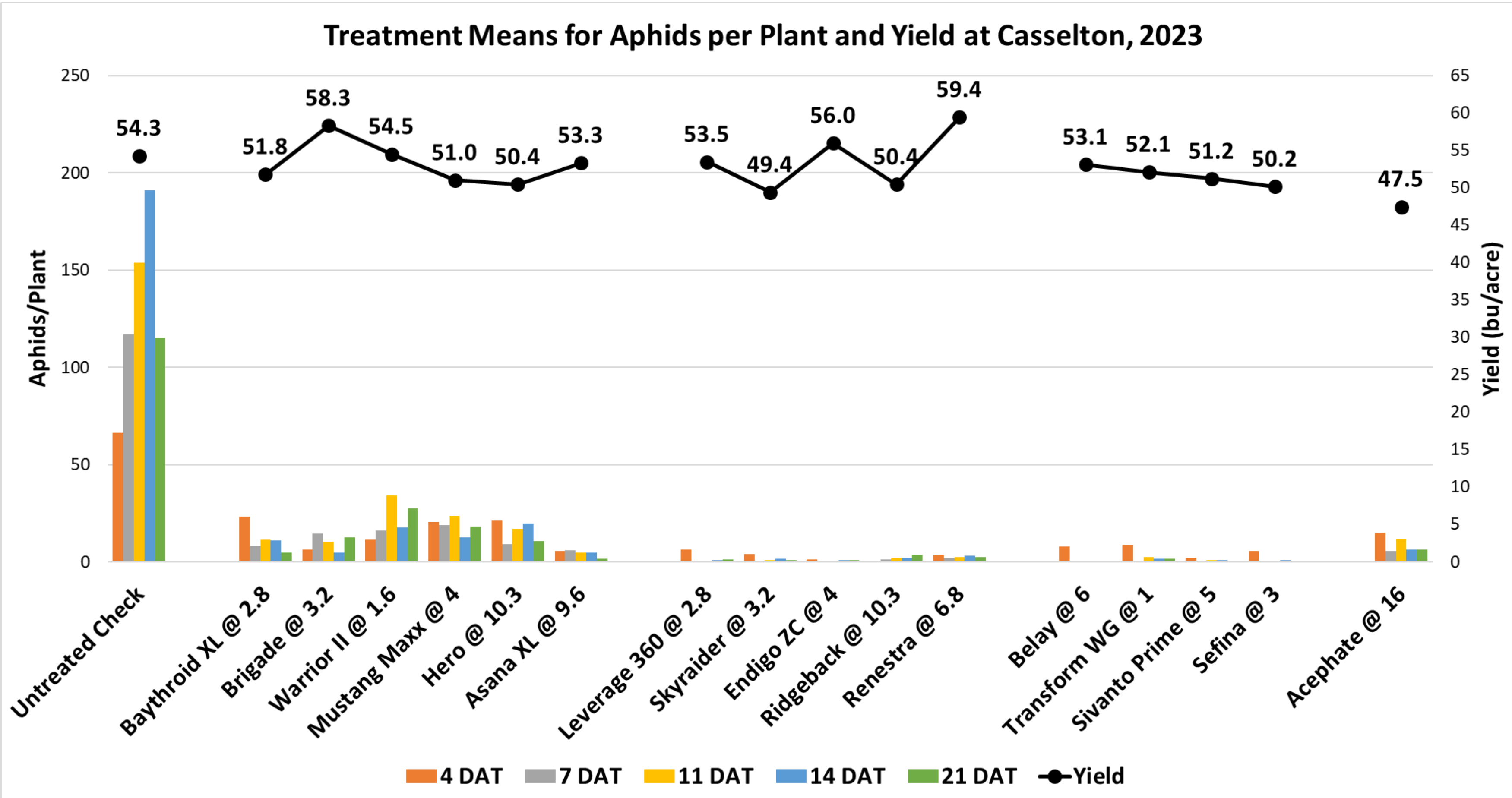

Figure 1. Treatment means for soybean aphids per plant at 4, 7, 11, 14 and 21 days after treatment (DAT), and grain yield at Casselton.

Objective Two: To continue survey work for the detection of new soybean insect pests, soybean gall midge and soybean tentiform leafminer.

This objective was **completed in 2023**. However, we want to continue survey work for soybean gall midge and soybean tentiform leafminer into 2024 season.

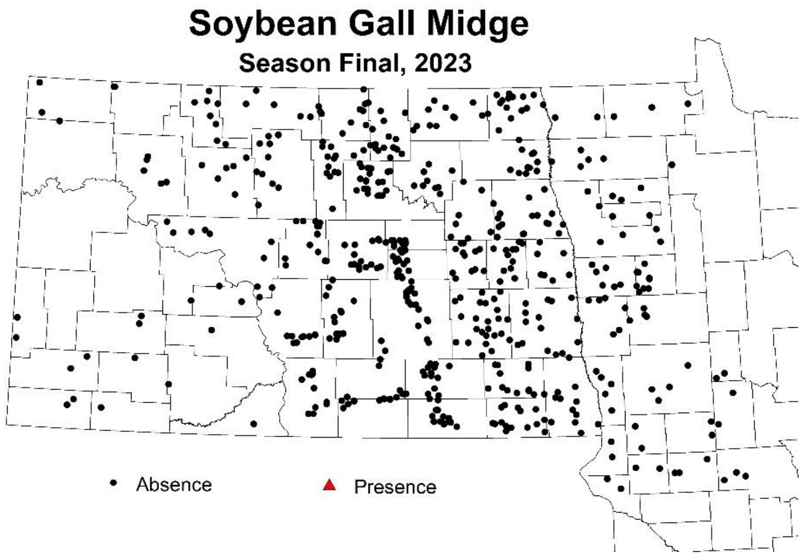

Figure 2. Survey of soybean gall midge in soybean fields 2023.

A total of 581 soybean fields in North Dakota during 2023. The survey was initiated in early June and continued through August 18. Crops were surveyed from the 2-leaf stage through R6 growth stage in soybeans. The most intense survey was conducted in counties of the southeastern part of the state. The assistance of the trained IPM scouts was utilized since my Post-Doctoral Scientist left in July.

Results from the 2023 soybean gall midge survey were **negative** for all soybean fields surveyed in the state (Fig. 2). Survey field data were mapped using ArcMap to show its absence/presence. Maps were posted weekly on the IPM website - Soybeans. This is good news for North Dakota soybean growers. We postulate that the recent drought helped slow its spread into North Dakota from neighboring infested states, e.g. Minnesota and South Dakota.

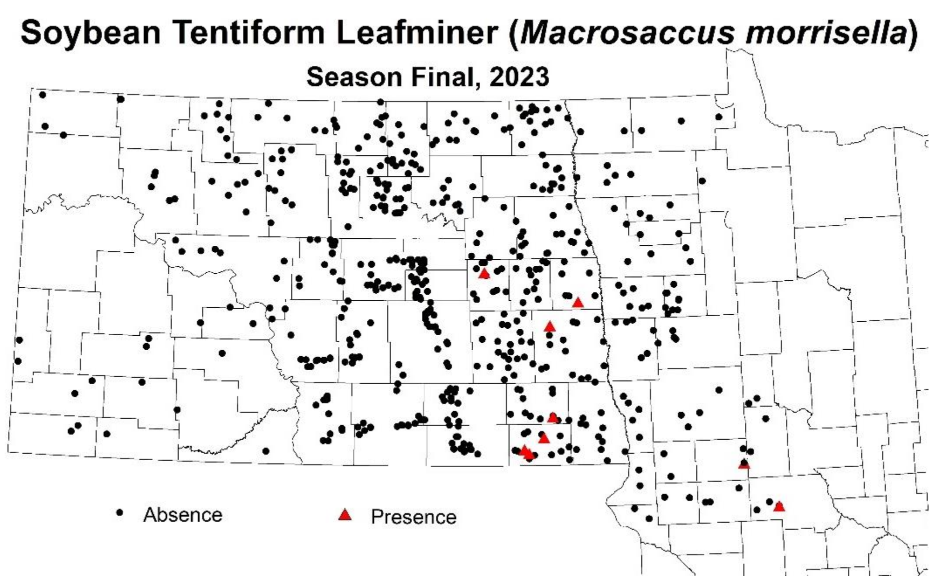

Figure 3. Survey of soybean tentiform leafminer in soybean fields.

During the field survey 2023, we also found another new insect of soybean, the soybean tentiform leafminer (*Macrosaccus morrisella*, Lepidoptera: Gracillariidae). This insect was first detected feeding on soybean in Minnesota in 2022. The soybean tentiform leafminer was observed in five counties (Cass, Griggs, Ransom, Sargent and Trail) of North Dakota in 2023 (Fig. 3). Larvae create leafminer in leaf causing defoliation. Little is known in the literature about its biology. Current observations suggest that its pest status is 'unknown' since the insect is not causing any yield losses at this time.

Work to be completed:

Objective Two: To continue survey work for the detection of new soybean insect pests, soybean gall midge and soybean tentiform leafminer.

We plan to continue the survey detection for soybean gall midge and soybean tentiform leafminer into 2024 season with an extra surveyor in southeastern North Dakota.

Objective Three: To develop extension outreach material on soybean insect pests for NSDC and growers.

For extension outreach, we are working on completing three extension outreach resources this winter:

1. The NDSU Extension *Soybean Aphid IPM* publication will be updated with new research.
2. The *Soybean Insect Diagnostic Series* also is in progress and should be available the summer of 2024. The *Soybean Insect Diagnostic Series* will cover IPM of the major insect and mite pests including soybean aphids, spider mites, foliage-feeding caterpillars, bean leaf beetles and grasshoppers.
3. The second large banner titled *Integrated Pest Management (IPM) of Soybean Arthropod Pests* also will be completed. The large banner discusses IPM of cutworms, bean leaf beetles, foliage-feeding caterpillars (green cloverworm, thistle caterpillar), potato leafhoppers in soybean fields.

Other relevant information: potential barriers to achieving objectives, risk mitigation strategies or breakthroughs.

My Post-Doctoral Scientist, Dr. Calles Torrez, left in July 2023. She was responsible for conducting the detailed survey for soybean gall midge. She left my program during a key time for surveying for soybean gall midge in late summer. As a result, fewer soybean fields were surveyed in southeastern North Dakota due to her absence and reduced summer work force.

Summary

- In summary, this research identified the best insecticide management practices for pyrethroid resistant soybean aphids. All foliar insecticides tested provided increase control of soybean aphids and had significantly fewer aphids per plant compared to the untreated check. The aphid-specific insecticides (Belay, Sefina, Sivanto Prime, Transform XL) and the pyrethroid/aphid-specific premixes (Leverage 360, Skyraider, Endigo ZC, Ridgeback, Renestra) had lowest counts of soybean aphids across all sampling dates. These data indicate that the soybean aphid population had a low level of pyrethroid resistance, and resistance was observed in all pyrethroids except esfenvalerate. Residual data also indicates that all foliar insecticides tested had a long residual of 21 days. Soybean aphid numbers did not reach economic threshold, so we did not see any yield differences due to soybean aphid feeding injury. By understanding the producer's increasing risk of insecticide resistant soybean aphids, management of soybean aphids can be optimized through Integrated Pest Management (IPM) and maximize soybean profits.

- Survey work for the soybean gall midge and soybean tentiform leafminer is crucial so that soybean producers are aware of its current geographical distribution and prevalence in North Dakota. So far, we have good news for the North Dakota soybean growers due to its limited distribution of soybean gall midge, only found in Sargent County in 2022, and the negative data from the 2023 survey. The new soybean tentiform leafminer was first detected in 2023 in five southeastern counties of ND. We plan to continue the survey detection for soybean gall midge and soybean tentiform leafminer into 2024 season.
- Updated and new soybean insect pest Extension resources will be provided to key benefactors including farmers, agronomists, extension specialists, scouts, ag chemical company representatives, crop consultants, pesticide applicators and others.