Research and Extension on Emerging Soybean Pests in the North Central Region 2021-2024
Reporting period: Final Report

Program I. Soybean Gall Midge

1.1 Soybean Gall Midge Alert Network

Participants: Justin McMechan,* Thomas Hunt, Robert Wright (University of Nebraska); Erin Hodgson (Iowa State University); Bruce Potter, Bob Koch (University of Minnesota); Adam Varenhorst (South Dakota State University). *Project leader

A network of 12–20 monitoring sites (depending on year) across four states successfully tracked the first emergence of adult soybean gall midges, the duration of emergence from overwintering sources, and adult activity throughout the growing season. Our team documented a shift in first emergence from early to mid-June to mid- to late May—critical information for understanding this pest's impact on early-planted soybeans. Over the past three years, the duration of emergence has remained steady, averaging 24–30 days from an overwintering source. Adult activity persisted consistently throughout the season, with consistent activity from first emergence until early September. These findings highlight key challenges in managing this pest. Despite these challenges, some growers reported successful insecticide applications after receiving alerts through the Soybean Gall Midge Blackboard Connect system, demonstrating the value of timely monitoring and communication. The Blackboard Alert Network grew from 452 in 2021 to 613 in 2024 (35% increase in subscribers). In addition, soybeangallmidge.org website has had over 14,000 unique visitors with >28,000 page views from 72 countries and visitors from all US states. Unique visitors grew by 9,312 between 2021 and 2024.

1.2 Midge-Resistant Soybean Germplasm

Participants: George Graef,* Justin McMechan (University of Nebraska); Erin Hodgson (Iowa State University); Adam Varenhorst (South Dakota State University) *Project leader

Over the past three years, accession and elite line testing has been conducted in Nebraska, Iowa, and South Dakota. Results from accession line testing between 2022 and 2024 indicate promising developments. In 2023, validation testing of 110 accession lines revealed a significant number of entries with low levels of injury, with a few showing no wilting or plant death. Low levels of plant injury or death were observed across a wide range of maturity groups. However, soybean gall midge larvae were present on all varieties, confirming that no germplasm source completely eliminates larval presence. That being said, the proportion of infested plants was lower for some accession lines with low injury scores. Elite line testing showed similar trends, with several lines exhibiting low plant injury. In 2024, a comparison of hilled and non-hilled elite lines demonstrated notable protection, though overall pest pressure was lower than anticipated, highlighting the need for further research.

Additionally, in 2024, we conducted the first commercial variety test at the request of a farmer near Wahoo. The results aligned with our germplasm research, with plant mortality rates ranging from 17% to 70% by the end of the season. While this work does not replace the need for improved germplasm, it provides a list of varieties that growers in high-risk areas could consider planting. We anticipate that commercial testing will expand in the coming years.

1.3 Tillage and Mowing as Control Strategies for Soybean Gall Midge
Participants: Justin McMechan,* Tom Hunt (University of Nebraska); Erin Hodgson (Iowa State University); Bruce Potter, Bob Koch (University of Minnesota); Adam Varenhorst (South Dakota State University) *Project leader

Tillage studies were conducted annually in Iowa and Nebraska throughout the project. While results were generally inconclusive, there was some numerical evidence suggesting that spring tillage treatments reduced adult soybean gall midge numbers compared to no-till. To address the high variability in adult emergence, Nebraska implemented stem burial treatments. Although no significant differences were observed, the increased adult emergence in these treatments improved confidence in the study's findings and provided a clearer direction for future research in this area.

Mowing studies conducted in Nebraska and Minnesota revealed varying results both between sites within the same year and across different years. These differences may be influenced by the extent of plant growth before mowing or the environmental conditions at the time of adult emergence. In Nebraska, some years showed a significant reduction in larval abundance and plant injury in areas adjacent to mowed sections compared to unmowed areas. However, yield differences at the end of the season were minimal across all cases.

In the second and third years of the study, tillage and hilling were introduced in Nebraska to better isolate the impact of overwintering adults. Although unintended, tilled areas in the current year's soybean fields exhibited lower plant injury and larval presence. It was concluded that the softer soil from tillage may have contributed to a deeper planting depth or improved soil coverage at the base of the stem. Follow-up studies are now underway to explore this potential management strategy further.

1.4 New Detection/Injury Survey
Participants: Justin McMechan* (University of Nebraska); Janet Knodel (North Dakota State University); Brian McCornack (Kansas State University); Kevin Rice (University of Missouri), Bryan Jensen (University of Wisconsin); Nicholas Seiter (University of Illinois) *Project leader

As a result of survey efforts, soybean gall midge was detected on an additional 3.9 million acres of soybean at the county level, bringing the total affected area to 19.2 million acres across the United States. Notably, this expansion included the first confirmed detections of soybean gall midge in North Dakota and Kansas. As part of the survey, potential host plants such as sweet clover, leadplant, dry bean, and alfalfa were monitored. A significant portion of new county detections in 2024 resulted from the presence of soybean gall midge on sweet clover. Unpublished research from the University of Nebraska–Lincoln suggests that soybean gall midge can move between sweet clover and soybean. Additionally, leadplant showed some potential for supporting increased populations, though its impact may be limited to areas with reduced direct sunlight.

Injury surveys indicate that the frequency of dead or dying plants has declined since soybean gall midge was first identified as a new species in 2019. In Nebraska, areas with significant injury remain, but the location and severity of damage vary from year to year. In historically infested counties, soybean gall midge presence remains high, with 70–80% of randomly selected soybean fields showing a positive larval presence.

Program II. Easier Scouting Methods

2.1 Pheromone-Baited Traps for Stink Bug Monitoring and Thresholds
Participants: Kevin Rice* (University of Missouri); Kelley Tilmon (Ohio State University); Robert Wright (University of Nebraska); Janet Knodel, Deirdre Prischmann-Voldseth (North Dakota State University); Matt O'Neal (Iowa State University); Robert Koch (University of Minnesota); Brian McCornack (Kansas State University); Nicholas Seiter (University of Illinois); Shawn Conley (University of Wisconsin); Raul Villanueva (University of Kentucky); Christina DiFonzo (Michigan State University); John Tooker (Penn State University) *Project leader

We conducted a three years of field studies across 12 states in the North Central Region comparing stink bug captures on clear sticky traps with in field sweep net sampling. The purpose of this work is to develop pheromone lures as an easier scouting method than the currently recommended sweep-netting. We found that there was a strong correlation between brown marmorated stink bugs caught on cards and found in sweeping. The correlation for other stink bug species was not as strong. This indicates that in areas where brown marmorated stink bugs are the primary stink bug pest species in soybean (roughly the eastern half of the Midwest) sticky cards with lures on field edges is an appropriate/accurate monitoring tool. A scientific journal paper is in preparation describing these results. Once published, it will serve as the basis for future extension materials.

Program III. Soybean Aphid

3.1 Aphid Insecticide Resistance and Soybean Tentiform Leafminer
Participants: Robert Koch* (University), with contributions from all team members *Project leader

This objective focused on establishing baseline susceptibilities for soybean aphid to newer insecticide products (e.g., Transform, Sivanto and Sefina). The emergence of soybean aphid resistance to pyrethroids will drive more use of these newer products and consequently selection for resistance to these products too. This work is providing a foundation for resistance monitoring for these products. In year 1, we developed a concentration-response bioassays to characterize the susceptibility of a known insecticide-susceptible population of soybean aphid to each of these insecticides. In year 2, we used the concentration-response bioassays to assess the susceptibility of field-collected populations from Minnesota to each of the three insecticides. A scientific paper is being drafted on these results.

In year 3, the initial plan was to expand the bioassay work to include soybean aphid populations from multiple states. However, with the emergence of the soybean tentiform leafminer as a new pest of soybean, we received approval to pivot the remaining year of this objective to focus on soybean tentiform leafminer. Because this pest is so new to soybean, its potential impacts to soybean yields have not yet been quantified. In 2024, we performed complementary experiments in the field using insecticides and cages to manipulate leafminer abundance on soybean to quantify the effect of feeding injury from this pest on soybean yield. The resulting pest infestations were lower than we had hoped. The experiments will be repeated in coming years. In addition, to improve the understanding of soybean tentiform leafminer biology and provide a foundation for development of management programs, the genomics of this insect were characterized. The full genome of soybean tentiform leafminer was sequenced. In addition, the genomic variability of populations from soybean and American hogpeanut from three locations in Minnesota were compared. These results show little differentiation among the

populations. A scientific paper summarizing these results has been accepted by G3: Genes, Genomes, Genetics.

3.2 Aphid-Resistant Varieties

Participants: Andy Michel* (Ohio State University); Matt O'Neal* (Iowa State university); Louis Hesler (USDA-ARS South Dakota); Deirdre Prischmann-Voldseth (North Dakota State University) *Project leaders

Across the three years, none of the locations showed a significant difference in yield between aphid resistant varieties that were sprayed vs. unsprayed. Corteva seed had the same yield with or without an insecticide tank mixed with a fungicide (note we did not include a no fungicide control). Our data suggests that Corteva seed with soybean aphid resistance does not need nor benefit from an insecticide at the R3 growth stage. This is also consistent with research showing that aphid susceptible soybean does not benefit from an insecticide if there are no insect pests, including soybean aphids. Indeed, our sweep collecting found very few insect pests, and low levels of defoliation through the course of the study.

Our surveys found low aphid populations on Corteva seed throughout the study. While most trials did not include a susceptible soybean control, a few areas did report high aphid populations in other areas (ND and SD). Although direct comparisons are lacking, our surveys combined with observational data suggest that few soybean aphids can survive and persist on Corteva seed. In our aphid screening, we recovered one aphid that passed our initial test, but we were unable to establish a colony on Corteva seed. Our data suggests that any virulence in soybean aphid populations is extremely low.

One trial conducted in Ohio compared the yield of the Corteva aphid resistant lines with the yield of an agronomically popular variety of the same maturity group. There was no difference in yield, indicating that the Corteva lines are good performers strictly from a yield point of view. This matters because if a farmer wants to plant a Corteva aphid-resistant variety as a safeguard, that doesn't mean that there will be a yield penalty.

3.3 Suction Trap Network for Monitoring Aphids and Thrips

Participants: Nick Seiter* and Doris Lagos-Kutz (University of Illinois); Glen Hartman (USDA-ARS Illinois); with cooperation from other team members *Project leader

The Midwestern USA aphid suction trap network (STN) is broad in geographic area and has been in continuous operation since 2005. Between 2021 and 2024 the network operated in 10 states with a total of 30 locations (Table 1). The operation of the STN was made possible through NCSRP funding and through the devoted collaboration of farmers, extension, and research personnel. In collaboration with Joseph LaForest (Department of Entomology, Center for Invasive Species and Ecosystem Health, University of Georgia; Southern IPM Center) in kind support, a voluminous collection of records of sample identifications and observations from the STN are now available at https://suctiontrapnetwork.org/ and https://www.eddmaps.org. This data allows for studies on distribution of known species and new or non-identified species captured by the suction traps. This project made it possible to conduct studies on soybean aphid population dynamics (which have been published), and has allowed us to monitor soybean thrips and the virus they carry, soybean vein necrosis virus.

Program IV. Extension and Outreach

5.1 Extension Deliverables and Other Outputs
Participants: Kelley Tilmon* (Ohio State University), with contributions from all team members *Project leader

In Year 1 and 2 of the project, we produced a new edition of the field guide "Stink Bugs of the North Central Region." During the reporting period, a print run of 3,800 guides was made and copies distributed to 13 Land Grant universities and 15 state checkoff boards. A pdf is also available online at SRIN. We produced a Soybean Gall Midge Alert Card to educate farmers about this new pest. This had a national distribution of 67,000 copies, plus online posting on SRIN. We developed a 3-D printed "Guide to Defoliation" keychain set and information card to educate farmers about scouting for defoliating insects in soybean and accurately assessing damage. The design file was made available to all project participants for in-state printing and distribution. In an example of leveraging, we partnered with NCSRP to print 30,000 copies for distribution to QSSBs around the country. This was also featured in checkoff ads, postcards, and signage. It has proved to be one of the most asked-for items at farmer events. Testing in Ohio showed that crop professionals who used the defoliation guide keychain were on average 30% more accurate at diagnosing soybean defoliation – which could lead to more accurate management decisions. We also designed a 3-D printed keychain showing how soybean gall midge larvae look inside of a soybean stem, to help with pest diagnosis in the field. This has also proved to be an extremely popular learning tool for farmers and crop consultants.

The first regional Soybean Gall Midge field day was held at the Eastern Nebraska Research Extension and Education Center near Mead, NE with 101 total attendees that placed a $4,507,592 value to education. Of the respondents, 24% rated the field day as one of the best educational opportunities they had ever attended; all other attendees rated it as above average. The event was sponsored by NCSRP, and data from this project was presented at the field day. We also conducted a webinar series for soybean gall midge in 2024 with speakers from NE, IA, SD, and MN. The Soybean Gall Midge Website: >14,000 unique visitors with >28,000 page views from 72 countries and visitors from all US states. Unique visitors grew by 9,312 between 2021 and 2024. The gall midge Blackboard Alert Network: Grew from 452 in 2021 to 613 in 2024 (35% increase in subscribers).

In Year 3 of the project, budget cuts resulted in a scale-back of the development and distribution of new extension deliverables. However, we continued to use information from this and past NCSRP-funded projects in our state-based research and extension and education deliverables. To summarize these, which all used NCSRP research results:

49 undergraduates trained in soybean field research
12 graduate students trained in soybean research
30 peer reviewed scientific publications
147 extension talks for farmers featuring NCSRP results
15 extension bulletins using NCSRP results
4 field guides
2 fact sheets
3 pest alert cards
27 multimedia products (such as videos and podcasts)
25 newsletter articles
11 popular press articles in farm journals

Executive Summary

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Executive Summary

Program I. Soybean Gall Midge

1.1 Soybean Gall Midge Alert Network

A network of 12–20 monitoring sites (depending on year) across four states successfully tracked soybean gall midge emergence and adult activity throughout the growing season. Understanding the timing of this insect is important for understanding the pest's impact. For example, earlier emergence may disproportionately affect early-planted soybeans. Over the past three years, the timespan of adult duration of emergence has remained steady, averaging 24–30 days from an overwintering source population. Adult activity persisted throughout the season. These findings highlight key challenges in managing this pest. Despite these challenges, some growers reported successful insecticide applications after receiving alerts through the Soybean Gall Midge Blackboard Connect system, demonstrating the value of timely monitoring and communication. The Blackboard Alert Network grew from 452 in 2021 to 613 in 2024 (35% increase in subscribers). In addition, soybeangallmidge.org website has had over 14,000 unique visitors with >28,000 page views from 72 countries and visitors from all US states. Unique visitors grew by 9,312 between 2021 and 2024.

1.2 Midge-Resistant Soybean Germplasm

Over the past three years, accession and elite line testing has been conducted in Nebraska, Iowa, and South Dakota. We have discovered a significant number of soybean accessions with low levels of gall midge damage. Though no varieties eliminated gall midge larvae entirely, for some lines there was significantly lower damage. Additionally, in 2024, we conducted the first commercial variety test at the request of a farmer near Wahoo. The results aligned with our germplasm research, with plant mortality rates ranging from 17% to 70% by the end of the season. While this work does not replace the need for improved germplasm, it provides a list of varieties that growers in high-risk areas could consider planting. We anticipate that commercial testing will expand in the coming years.

1.3 Tillage and Mowing as Control Strategies for Soybean Gall Midge

Tillage studies were conducted annually in Iowa and Nebraska throughout the project. While results were generally inconclusive, there was some evidence that that spring tillage treatments reduced adult soybean gall midge numbers compared to no-till. We also conducted stem burial tests, to protect the zone of the plant where the adult midges lay eggs. Although no significant differences were observed, the the study's findings and provided a clearer direction for future research in this area.

Mowing studies conducted in Nebraska and Minnesota showed variable results depending on location and year. These differences may be influenced by the extent of plant growth before mowing or the environmental conditions at the time of adult emergence. In Nebraska, some years showed a significant

reduction in larval abundance and plant injury in areas adjacent to mowed sections compared to unmowed areas. However, yield differences at the end of the season were minimal across all cases.

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2.1 Pheromone-Baited Traps for Stink Bug Monitoring and Thresholds

We conducted a three years of field studies across 12 states in the North Central Region comparing stink bug captures on clear sticky traps plus pheromone lures on the field edge, with in-field sweep net sampling. The purpose of this work is to develop pheromone lures as an easier scouting method than the currently recommended sweep-netting. We found that there was a strong correlation between brown marmorated stink bugs caught on cards and found in sweeping. The correlation for other stink bug species was not as strong. This indicates that in areas where brown marmorated stink bugs are the primary stink bug pest species in soybean (roughly the eastern half of the North Central Region) sticky cards with lures on field edges is an appropriate/accurate monitoring tool. A scientific journal paper is in preparation describing these results. Once published, it will serve as the basis for future extension materials.

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3.2 Aphid-Resistant Varieties

Across the three years, none of the locations showed a significant difference in yield between aphid resistant varieties that were sprayed vs. unsprayed, suggesting that insecticide is not needed to augment the effectiveness of aphid resistant varieties. Corteva resistant lines had the same yield with or without an insecticide tank mixed with a fungicide. Our data suggests that Corteva resistant lines do not need nor benefit from an insecticide at the R3 growth stage.

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