Applied soybean disease and insect management research – 2021

Final report

Submitted by Bruce Potter, University of Minnesota Extension IPM Specialist, May 31, 2022

Objective I. Evaluate insecticide and fungicide efficacy in an ongoing and systematic way

Introduction

Management-resistant weeds, insects, mites, plant pathogens, and nematodes have been selected through the reliance on single management tactics for crop pests and the 'insurance' application of pesticides and host plant resistance genes. Additionally, new soybean pest problems continue to emerge, and old pests become unexpected problems under favorable environmental conditions.

Together, the goal of the following studies on insects and plant disease is to improve understanding of how plant disease and insects affect yield, profitability, and management practices of Minnesota soybean growers by examining 1) The efficacy and potential economic benefits of pesticide applications and 2) Short and long-term changes in the insects and pathogens affecting Minnesota soybean production.

I a) Foliar fungicide studies

Background

The potential benefit of foliar fungicide applications to soybeans is a topic often discussed among growers and academics. To help answer this question, soybean foliar fungicide studies have been conducted since 2016 at three University of Minnesota Research &and Outreach Centers (ROCs) located across southern Minnesota. Annually, results are presented at winter extension meetings and extension newsletters, and at the Minnesota Ag Expo, the annual meeting for Minnesota corn and soybean associations. Additionally, a subset of data from previous years of these studies was included in a regional metanalysis of soybean fungicide applications (Kandel, et al., 2021).

Methods

The 2021 study sites were located at Lamberton (SWROC), Waseca(SROC), and Rosemount (RROC) in Southwest (Redwood County), South Central (Waseca County), and Southeast (Dakota County) Minnesota, respectively. These sites were not selected based on the expectation of a particular disease (e.g., *Sclerotinia* white mold, frogeye leaf spot).

Individual plots were four 30-inch rows wide by 30-foot long in a randomized block design with four replications at all sites. Three soybean varieties of different relative maturities and genetic backgrounds (1- 1.5 RM XtendFlex®, 2- 2.0 RM Enlist E3®, and 3-2.3 RM -Roundup Ready2 Xtend®) were seeded at 165,000 seeds/acre. Individual plots of each variety received one of three fungicide treatments (water only, Miravis® Neo @13.7 fl. oz./A, and Delaro®325 @8.0 fl. oz./A). The resulting treatment combinations comprised a 3x3 (variety x fungicide) factorial.

Delaro®325 is a premix of trifloxystrobin [FRAC group 11 (strobilurin/QoL)] + prothioconazole [FRAC group 3 (DMI)] fungicide. Miravis® Neo is a premix of azoxystrobin (QoL) + propiconazole (DMI) + pydiflumetofen [FRAC group 7 (SDHI)] fungicide. At each study site, fungicides were applied once all varieties reached the R3 stage with a self-propelled plot sprayer using 15 GPA, 30 PSI, and 8002 flat fan nozzles on 30-inch spacings.

This study was not intended to be a product comparison of soybean varieties or fungicides. Rather, the varieties were selected to include varying soybean maturities and other genetic factors. These fungicides were selected because of a long-term history in these studies (Delaro), and to include a group 7 fungicide.

All sites were long-term corn-soybean rotations with a tillage system commonly used in the geography of the study (fall disk-ripped corn residue followed by a field cultivator in spring). Weed control was not a factor in this study and varied by site with post-emerge weed control being based on glyphosate.

Yields and moistures were obtained with plot combines (manufacturer and model varied by ROC). Yields and moistures were normalized on the site means for analysis across sites.

Results and discussion

An early-season drought affected all three sites but moderated at different times during the season. The drought moderated during July at SROC, early August at the RROC, and late August at the SWROC. Higher yielding sites had an earlier onset of rain. Stem and foliar disease pressures were at the lowest levels since we initiated these multi-site studies in 2016.

Grain moisture varied among varieties at the higher-yielding SROC and RROC sites and overall. There were no moisture differences among varieties at the low-yielding SWROC site.

Fungicide applications significantly (p=0.05) affected grain moisture only at the RROC site, but individual fungicide treatments produced differing results among the three varieties.

There were no moisture differences among varieties or fungicide treatments at the low-yielding SWROC site. Over the three sites, varieties differed in moisture, but these differences varied by site. (Table 1, Figure 1.) Moisture data are presented as individual sites due to significant variety x fungicide and fungicide x site interactions.

Significant yield differences (p= 0.10) were observed among varieties overall and at the SWROC and SROC sites. However, no significant differences in yield among the untreated check and the two fungicides were observed, including at Waseca, the wettest and highest yielding site (Table 1, Figure 2).

MOISTURE	Combined	Lamberton	Waseca	Rosemount
Variety	**0.0049********	0.1171*	**< 0.0001********	**< 0.0001********
Fungicide	0.3696	0.7186	0.1140*	**0.0239*****
Variety * Fungicide	0.6981	0.8852	**0.0648****	**0.0326*****
YIELD				
Variety	**0.0882****	**0.0814****	**0.0006********	0.1164*
Fungicide	0.9185	0.8443	0.8166	0.7372
Variety * Fungicide	0.7176	0.4362	0.2454	0.8988

Table 1. Factorial analysis of variance for variety and fungicide effects on soybean yield at three southern Minnesota sites during 2021. (p=0.20, p= 0.10**, p= 0.05***, (p = 0.001****)*

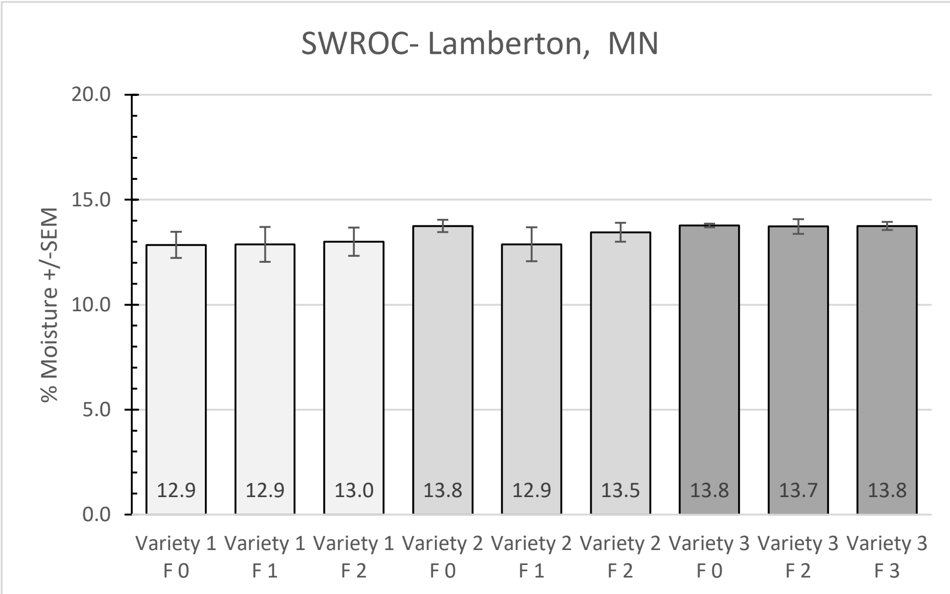
Although none of the previous years of this study saw heavy disease pressure, dry weather greatly limited foliar disease in 2021. The lack of soybean yield response to foliar fungicide applications during 2021 is not surprising with low disease pressure.

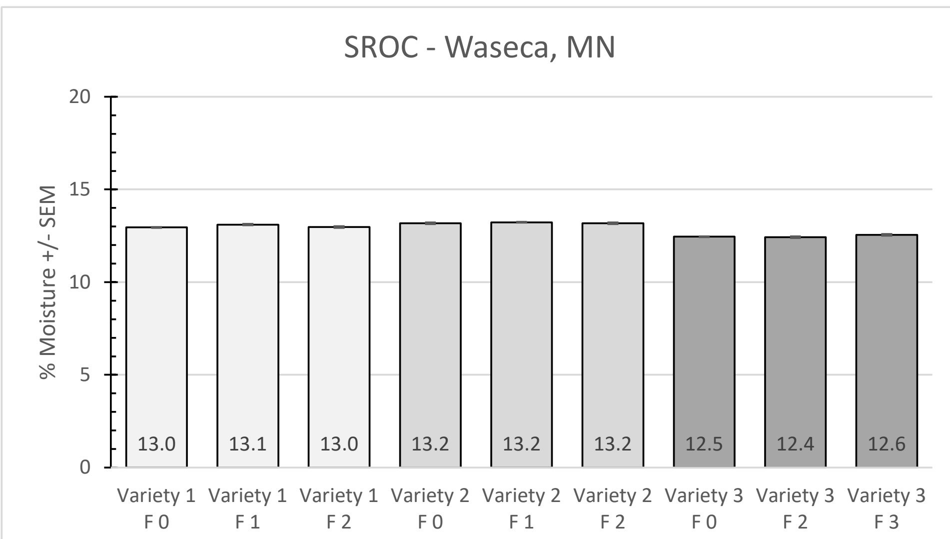
Small yield responses to foliar fungicide applications have been common in previous years of this study in southern MN. Before 2021, one of both fungicides had a significant ($p = 0.10$) positive yield response in 10 of 13 site-years (76.7%). These significant responses ranged from 2.2 to 6.2 bushels/acre, averaging 4.2 bushels/acre. The drier 2021 season lowered the percentage of a significant yield response. When 2021 results are combined with previous years only 9 of the 16 individual studies (56%) had a significant yield response with an average 3.2-bushel benefit.

These data show that foliar fungicides can help maintain soybean yield in some southern Minnesota environments and provide economic benefit if used selectively**.** However, consistent, profitable yield responses are unlikely to be obtained when, as in this study, applications are not well targeted to specific environments and diseases. They do not provide evidence that insurance applications of foliar fungicides will compensate for bad weather or poor agronomic decisions. This 2021 data do not counter the hypothesis that grain moisture and harvestability influence yield responses to foliar fungicides when disease pressure is low.

Upcoming 2022 results will be also combined with previous years. A comparison of yield results with planting date, seasonal rainfall, seasonal temperatures, and overall yield is planned. Foliar fungicides can be targeted toward known or expected diseases based on field history, weather, or symptoms with some expectation of yield protection. However, in many cases, applications are before the type and severity of the disease are known. Analyses of these longer-term studies may provide clues to help growers increase the probability of positive economic returns while minimizing the development of pesticide resistance.

An updated University of Minnesota Extension Crop News article on soybean foliar fungicides is in prep for early June 2022. The article will include information developed by this long-term study.





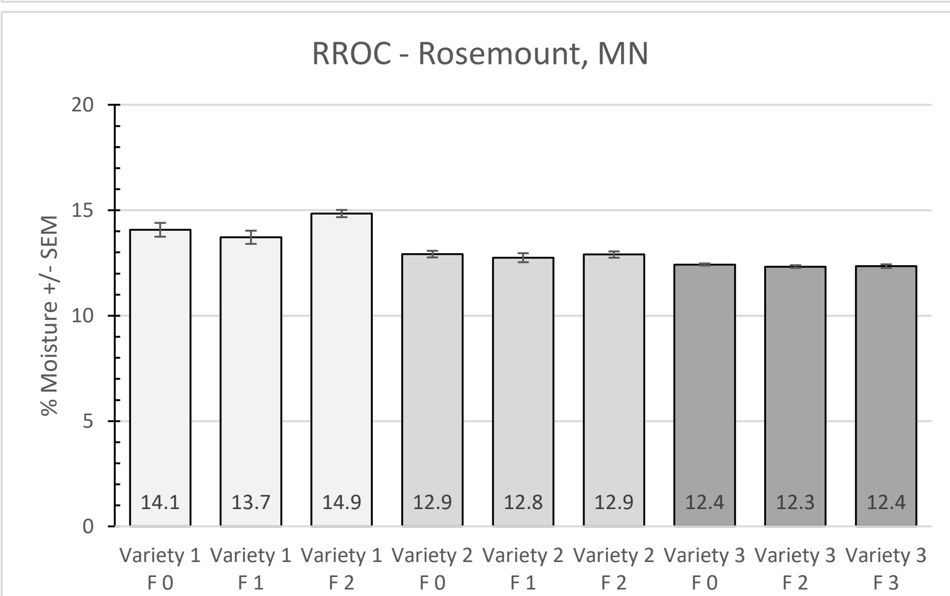


Figure 1. Moistures of harvested grain at three southern Minnesota sites in 2021.

Variety 1 - 1.5 RM XF
Variety 2 - 2.0 RM E3
Variety 3 – 2.3 RM RR2X

F 0 – No fungicide
F 1 – Miravis Neo @ 13.7 fl oz
F2 – Delaro 325 @ 8 fl oz

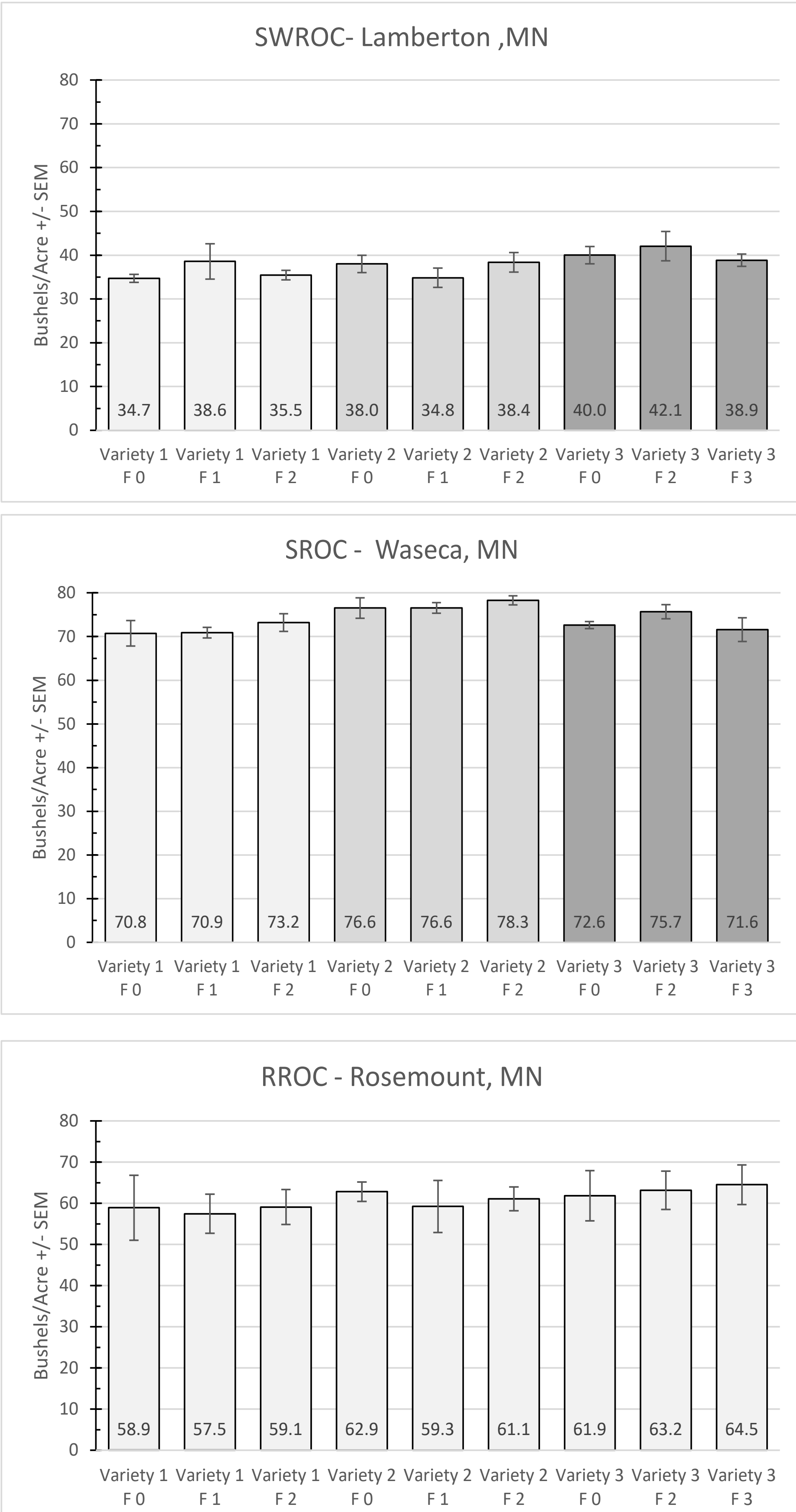


Figure 2. Moistures of harvested grain at three southern Minnesota sites in 2021.

Variety 1 - 1.5 RM XF
Variety 2 - 2.0 RM E3
Variety 3 – 2.3 RM RR2X

F 0 – No fungicide
F 1 – Miravis Neo @ 13.7 fl oz
F2 – Delaro 325 @ 8 fl oz

I b) Insecticide efficacy

Background

Ongoing insecticide efficacy studies for soybean aphids have been conducted in Southwest Minnesota since 2003. Funding from Minnesota Soybean Research & Promotion Council NSR&PC has provided support to ensure the studies continued. These long-term studies have monitored annual changes in aphid populations, the long-term efficacy of insecticides, and the relative performance of new compounds. In 2015, The University of Minnesota SWROC site was the first location to document putative pyrethroid resistance with replicated field data. Specimens from this site were also used in assays to confirm pyrethroid insecticide resistance (Hanson, et. al. 2017), fitness costs (Menger, et al., 2022a), and long-term data were used to examine the onset of resistance development (Menger, et al., 2022b)

Methods

2021 soybean aphid (*Aphis glycines*) populations throughout Minnesota, were too low to conduct a planned insecticide efficacy study. However, two-spotted spider mites (*Tetranychus urticae*) flourished in the same warm, dry, often windy weather and drought-stressed soybeans. A planned aphid insecticide protocol was modified, and shifted to a two-spotted spider mite population at the University of Minnesota SWROC near Lamberton, MN.

The performance of eleven foliar insecticides and acaricides (Table 2) was compared to an untreated check. These treatments included compounds labeled for two-spotted spider mite in soybean, an insecticide that was not expected to provide mite control (sulfoxaflor), and varying rates of the pyrethroid bifenthrin alone and in combination with other insecticides.

Pesticide treatments were applied to R4 and R5 stage soybeans on August 3 using a self-propelled plot sprayer using 15 GPA, 30 PSI, and 8002 flat fan nozzles on 30-inch spacings. Applications were made to a very high population mite population where it was likely that some soybean yield loss had already occurred.

Two-spotted spider mite population densities on soybean plants were sampled at 0, 3, and 8 days after pesticide application (DAA). Five trifoliolates from the top, middle, and bottom of the canopy were collected from each plot. The center leaflets of these trifoliolates were detached, the five leaflets processed through a mite brush, and mites and eggs counted on one of the twelve grid sections of the plate.

Soybean yields and moistures were obtained with a plot combine (Almaco, Nevada, IA) on October 5.

Results and discussion

Meaningful data analyses for this study are complicated and limited by the collapse of the mite population eight days after the application of the pesticides. The most likely cause for the rapid decline of mites at the study site and in nearby commercial soybean fields, is an entomopathogenic fungal disease, possibly *Neozygites*. Mite populations were already declining at 3 DAA and even within untreated plots had declined by 60% and completely collapsed by 8 DAA (Figure 3). Even though the site was under prolonged drought, it appears that several heavy dews allowed beneficial fungi to create an epizootic.

Disease terminated the study early. The 3 DAA data is likely confounded by the epizootic to some extent and as a result, has very limited utility. Soybean yield was negatively correlated ($p=0.10$) with mite populations on the upper leaves but not significantly correlated with treatment. Although long-term efficacy and statistical significance among treatments could not be determined from this data, there were no anomalies numerically. Sulfoxaflor alone and etoxazole (which does not provide control of adult mites) were most similar to the untreated check.

This study site showed reduced chlorpyrifos field efficacy against two-spotted spider mite during 2012 (Potter unpublished) which was confirmed with assays (MacRae, unpublished). These data present no evidence that chlorpyrifos resistance has persisted at this location and mirrored observations from most commercial fields where chlorpyrifos was applied. As a result, there was no apparent advantage to combining bifenthrin with chlorpyrifos. However, due to recently revoked crop tolerances, chlorpyrifos is no longer a treatment option for soybean pests.

Although they may not be cutting-edge science, sometimes, there can be information gathered from “failed” efficacy studies like this. In this case, it provided a glimpse into the benefits that biological control, normally working unrecognized in the background, can provide soybean growers.

	Active ingredient (IRAC group) applied rate in oz. active ingredient/acre					
PRODUCT	sulfoxaflor (4C)	bifenthrin (3A)	chlorpyrifos (1B)	dimethoate (1B)	etoxazole (10B)	abamectin (6)
UNTREATED						
Ridgeback® 6.9 fl oz	0.27	0.80				
Ridgeback® 8.55 fl oz	0.33	0.99				
Ridgeback® 10.3 fl oz	0.40	1.20				
Transform 0.75 oz	0.38					
Sniper® 4.8 fl oz		1.20				
Sniper® 6.4 fl oz		1.60				
Zeal® SC 4 oz					1.44	
Agri-Mek® SC 3.5 fl oz						0.31
Lorsban® Advanced 16 fl oz			7.51			
Dimethoate 4EC 16 fl oz				8.00		
Lorsban® Advanced+ Sniper® 16 fl oz + 4.8 fl oz		1.20	7.51			

Table 2. Insecticides and acaricides evaluated for two-spotted spider mite control in soybean in 2021. UMN SWROC., Lamberton, MN.

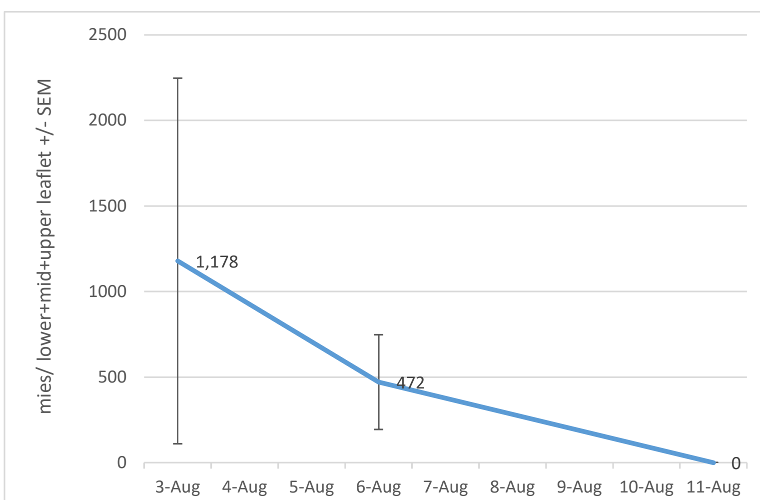


Figure 3. Rapid population collapse of two-spotted spider mite populations in a soybean canopy. Lamberton, MN 2021.

Objective II. Monitor soybean pests and pathogens both short and long-term.

This objective supports objectives Ia, Ib, and objective IIIb might also be considered part of this objective. Long-term pest information is useful in understanding changes in pest populations. The long-term fungicide studies include disease susceptible varieties. These types of information could be part of, and benefit from, broader public-private cooperative efforts on crop pest information management.

Methods.

Plots at the fungicide study sites were visually rated for the presence of diseases and insect pests during the early vegetative (ca. V3) stage, at the time of fungicide application (R3), and late in the season (ca. R6). Stem diseases were evaluated by destructively sampled stems from plots bordering the fungicide study during the late season rating. Diseases and pests were not at levels that required more intensive sampling.

Results.

While they are not positioned in areas where soybean losses from any pathogens or insect pests are expected, the plots in these studies continue to reflect general local disease and insect pressure in local areas. Disease incidence was very low overall, particularly at the very dry SW MN location and none reached levels expected to reduce soybean yields.

Arthropod pest populations at these study sites did not reach economic threatening levels.

As typical, Japanese beetles (*Popillia japonica)* and their defoliation were only observed at the RROC site in SE MN. However, increased bean leaf beetle (*Cerotoma trifurcata*) populations were observed at all three sites and were observed at the SWROC for the first time since these studies were initiated in 2016. Aggregate defoliation from leaf-feeding arthropods did not reach 1% at any site. Soybean aphid populations remained below economic levels in 2021. Two-spotted spider mites (*Tetranychus urticae)* took advantage of the same weather and were present at all sites. Sub-economic spider mite defoliation injury to soybean foliage was visible at the RROC and SWROC sites but mite populations in some nearby fields required treatment.

Objective III. Examine the distribution and potential host range of the soybean gall midge (SGM) in Minnesota.

III a) SGM hosts

Background

The SGM is a new pest of soybeans in the Midwest. The insect is new to science, with the species description of this fly in the gall midge family (Diptera: Cecidomyiidae) published in 2019 (Gagne', et al., 2019). In soybean, SGM larvae typically infest the lower stems of soybean plants where the injury caused by their feeding can cause plants to lodge, or wilt and die. The SGM can cause near-total yield loss on field borders and up to 35% whole-field yield loss. Management of this insect has proven difficult because susceptible soybean plants are exposed to multiple and extended adult flight periods. Although an injury to the stem may provide an attractive site for SGM to lay eggs, naturally occurring fissures are produced near the base of soybean stems as they expand during the V2, and later growth stages also provide egg-laying sites. (McMechan et al., 2021)

SGM has been confirmed in 5 states and 140 counties Soybean gall midge alert network). 29 of those counties are Minnesota where damage levels in most infested soybean fields have remained low to this point. Management of this insect has proven difficult because susceptible host plants are exposed to multiple and extended adult flight periods.

It is not known if SGM is native to North America or an introduced pest and little is known about the host range of this new crop pest. In addition to soybean, the SGM has been found to infest sweet clover and, much less frequently, alfalfa. There is a single anecdotal report from bean (Tiger Eye, a dry bean cultivar believed to have originated in Chile or Argentina) in NE (*Dr. Tom Hunt, UNL, pers. comm.*).

This project would supplement other work on this insect, focusing on the possibility that dry bean or annual legumes can be infested and potentially suffer yield loss from SGM. Secondarily, annual legume crops or native prairie legumes found infested may provide clues to the geographic area of the SGM.

Mobile sentinel plants

Methods

The following in-field methods were selected for this pilot study, in part, because SGM has not yet successfully been maintained as a laboratory colony. Additionally, the known MN infestations with consistently high population densities are located in commercial soybean seed production fields, limiting what could be seeded, and where herbicide applications could injure some species.

Fifteen varieties/cultivars of nine annual legume species (Table 3) were greenhouse-grown in potting mix (ScottsMiracle-Gro) within 4-inch square injected molded pots (CN SQK-40 Greenhouse Megastore, Sacramento, CA) at the University of Minnesota Southwest Research and Outreach Center, Lamberton, MN. Plants were thinned to two plants/pot after emergence. Multiple planting dates with 6 replicates of each plant type were planted to ensure soybeans in the V3-V4 stage were available when adults were active. Unfortunately, plant mortality from greenhouse overheating/overwatering created an uneven number of replicates for plant types.

During the period that emergence cages (Soybean Gall Midge Alert Network) detected overwintering generation and 1st generation SGM, the containers with seedlings of soybean, and several other potential legume hosts were placed within the border rows of a Rock County Minnesota soybean field with a history of yield-limiting SGM infestations. The containers were placed in a randomized arrangement within carrying trays(CN TRK-1540 Greenhouse Megastore, Sacramento, CA) staked to the soil. Plant types within trays were replicated and the trays and pots were left in the field for 7-10 days and then returned to the greenhouse. It was suspected that interspersing the various potential host species and cultivars might help assess SGM oviposition preferences relative to soybean. After a 4 or 5-day period in the greenhouse to allow egg and some larval development but not pupation, the potted plants were examined for the presence of growth fissures, SGM infestation symptoms, and the stems dissected and any SGM larvae present were counted.

Figure 4. A portion of mobile sentinel legumes awaiting further growth and deployment to a soybean field.

Results and Discussion

Soybean gall midge populations and soybean injury at the Rock County site and elsewhere in Minnesota were dramatically lower in 2021. The reasons for the decline are unclear but a hot, dry spring may be a factor.

When the lower stems of the mobile sentinel plants were dissected, SGM injury symptoms and larvae were only associated with soybean stems.

Sentinels for the SGM overwintering generation were placed in the soybean field on June 17 and removed to the greenhouse on June 24. Stems were dissected on June 28. Soybean sentinel plants did not recruit SGM during overwintering generation adult activity.

Figure 5. SGM larva in the stem of soybean sentinel placed during the 1st generation adult activity.

For the first generation, sentinels from two planting dates were placed in an area of the field where overwintering larvae and their injury to soybean were observed. Based on observation from the overwintering generation, they were left in the field for a longer period. Sentinels for the SGM 1st generation were placed July 13, removed July 23, and stems dissected on July 28. Two of eight stems from V4 stage plants (June 21 planted) had SGM injury symptoms but no larvae were detected when dissected on July 23. Four of eight stems of V7-8 stage plants (June 11 planted) with injury symptoms were observed. Three total larvae were found in two of the four symptomatic plants. Plants from both planting dates were less developed than those in the field. We cannot be sure that these stems were the sites of oviposition or infested by active SGM larvae moving from the field's soybeans.

Stem fissures produced during growth were observed in all soybean plants and a single plant of the dry bean "Tiger Eye". The latter may have been produced by injury rather than the result of a normal growth process and the plant was not infested.

The lack of infestation of plants other than soybean should be considered preliminary. This study will be refined and repeated in 2022.

Genus	**Species**		**Variety/cultivar**	**Area of origin**	**Emergence**
Glycine	*max*	Soybean	AG 20X9	East Asia	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Pinto 'Windbreaker'	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Dark red kidney 'Cabernet'	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Black 'AAC Night Rider'	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Navy 'AAC Protage'	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Cranberry 'Scotty'	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	- 'Tiger Eye'	Argentina/Chile	Epigeal
Phaseolus	*vulgaris*	Bean (dry)	Small red	Meso/South America	Epigeal
Phaseolus	*vulgaris*	Pole/String	'Blue Lake bush'	Meso/South America	Epigeal
Phaseolus	*lunetus*	Lima bean	'Henderson '	Meso/South America	Epigeal
Vicia	*fava*	Broad bean	'Robin hood'	Middle east	Hypogeal
Cicer	*aristinum*	Chick pea	'CDC Frontier'	Middle east	Hypogeal
Vigna	*unguiculata*	Cowpea	'California blackeye'	Africa	Epigeal
Lens	*culinaris*	Lentil		Middle east	Hypogeal
Vigna	*radiata*	Mung bean		East Asia	Epigeal
Vigna	*angularis*	Adzuki bean		East Asia	Epigeal
Pisum	*sativaum*	Pea	Yellow field 'Early Star'	Middle east	Hypogeal

Table 3. Annual legume (Fabales: Fabaceae) crop plants evaluated as potential hosts for the soybean gall midge in 2021. Poor germination limited the number of Dark red kidney bean plants available for this study.

Other observations

Commercial dry bean fields in Cottonwood, Kandiyohi, Lac Qui Parle, Renville, Stevens, and Swift Counties that were encountered during surveys for SGM in soybean were examined. No SGM larvae or signs of infestation were found in dry bean fields in these counties with histories of SGM infestations.

In Minnesota, SGM larvae have been observed in Alfalfa (Rock Co.) and sweet clover (Kandiyohi, Lac Qui Parle, Rock, Yellow Medicine Cos.) but only when nearby soybeans have also been infested. No other legume hosts were found in August 2021 observations of native prairie legumes in WC and SW MN.

A planned remake of a University of Minnesota Extension SGM scouting video was delayed until 2022 because of low SGM population densities and to include developing information on biocontrol.

Objective III b) Continued survey for changes in SGM distribution

MSR&PC funding for this project supplemented survey funding from a North Central Soybean Research Program project on soybean gall midge, particularly in dry bean production areas of WC MN (See Objective IIIa).

Despite the lower SGM infestation levels in 2021, thirteen new counties were confirmed by the SW MN IPM crew, bringing the total to 29 Minnesota counties. Plants with SGM injury symptoms were found in soybean fields in two additional counties in Central and West Central Minnesota counties. Larvae were not found, however, so these counties could not be confirmed.

It is probable that the SGM is even more widely distributed in Minnesota but at very low levels. Also, the distribution of SGM-infested counties may reflect sampling frequency rather than an expansion north and east out of extreme SW MN.

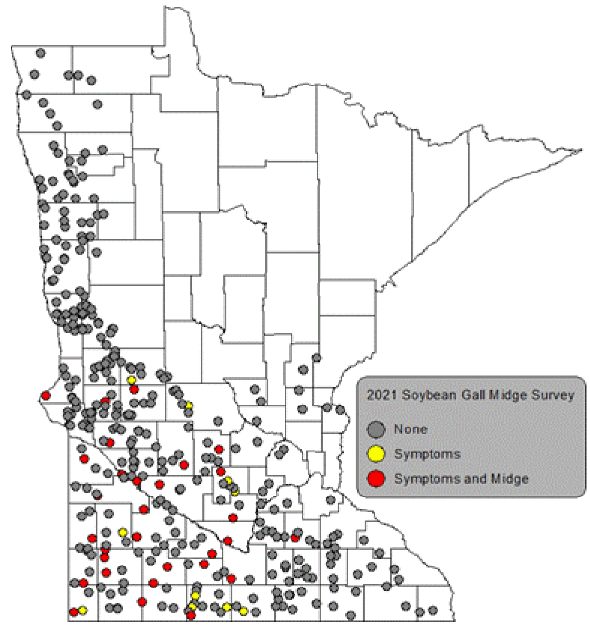


Figure 6. Positive and negative SGM observations. Source: University of Minnesota and private sector cooperators.

In addition to locating new areas with SGM infestations, larvae from each county where soybean gall midge was observed (Figure 6) were collected and preserved in ethanol and submitted to the Koch lab, University of Minnesota Entomology, for future work on parasitism.

Delimiting the range and prevalence of this insect could provide clues to the stability of SGM populations and whether its range is static or expanding. If ongoing, and particularly if new survey tools such as pheromones or weather-dependent predictive models can be developed, SGM surveys might help determine whether growers within a geographic area need to begin aggressive SGM management.

Outreach

Extension publications

Potter, B. 2022. Soybean gall midge. An initial look at changing distribution and host preferences. MN Ag Expo. Mankato, MN. January 20, 2022. Display presentation.

Potter, B., and D. Malvick. 2022. MN Multi-Site fungicide studies: Variety and fungicide effects on soybean yield. MN Ag Expo. Mankato, MN. January 20, 2022. Display presentation.

Potter, B. 2021. Soybean gall midge update. MN Crop News - August 23, 2021.

Potter, B., R .Koch, and K. Ostlie. 2021. Two-spotted spider mites in 2021 MN Crops. MN Crop News - July 28, 2021.

Extension Presentations

Discussions of soybean gall midge distribution and results of the host plant pilot study were included in the following presentations.

Potter, B. 2022. When to surrender to corn rootworms…and other deep thoughts. Multiple locations: February 2, 2022-Lamberton, MN; February 17, 2022-Slayton, MN; March 2, 2022- Faribault, MN; Lafayette, MN-March 4, 2022.

Potter, B. 2022. Pesticide Applicator Training. January 21, 2021. Marshall, MN.

Potter, B. 2021. Sometimes you need a hammer instead of pliers. Corn rootworm management. 2022 Crop management seminar*. Hutchinson, MN. December 10, 2021.

Potter B. 2021. Understanding, detecting, and managing sporadic and developing crop pest problems. Crop Pest Management Short Course. December 8, Minneapolis, MN.

Potter, B. 2021. Some Insect and disease issues for 2021. Brown County Corn and Soybean Growers Annual Meeting. Sleepy Eye, MN. November 22, 2021.

Potter, B. 2021. Some Insect and disease issues during 2021. United Ag Tech Annual Meeting. Sleepy Eye, MN. November 18, 2021.

Potter, B. 2021. "Plot tour" 2021 Ag lenders conference. Lamberton, MN. August 10, 2021.
Tour of fungicide study plot and discussion of soybean insects.

Acknowledgments
Travis Vollmer applied pesticide studies and participated help in SGM survey. Noah Pankonin, Gabe Schumacher, and Nautica Weis provided valuable help in plot maintenance, SGM plant sampling, and SGM survey. We also appreciate the significant contributions of survey data from Jonathan Dregni, Ryan Miller, and Drs. Angie Peltier and Jared Goplen.

The project appreciates the support from Syngenta, Bayer Crop Science, Valent, FMC, and Corteva for providing fungicides and insecticide/miticides for these studies and Meridian Seed, for the contribution of dry bean and pea cultivar seed.

Selected references

Gagné, R.J, J.Yukawa, A. K. Elsayed, and A. J. McMechan. 2019. *Resseliella* (Diptera: Cecidomyiidae) on soybean (Fabaceae) in North America with a description of the genus. Proceedings of the Entomological Society of Washington. 121(2): 168-177. https://doi.org/10.4289/0013-8797.121.2.168

Hanson, A. A., J. Menger-Anderson, C. Silverstein, B. D. Potter, I.V. MacRae, E.W. W Hodgson, and R.L Koch. 2017. Evidence for Soybean Aphid (Hemiptera: Aphididae) Resistance to Pyrethroid Insecticides in the Upper Midwestern United States. Journal of Economic Entomology. 110(5): 2235–2246, https://doi.org/10.1093/jee/tox235

Kandel, Y.R., C. Hunt, K. Ames, N. Arneson, C. Bradeley, E. Byamukama, …. 2021. Meta-analysis of soybean yield response to foliar fungicides evaluated from 2005 t0 2018 in the United States and Canada. Plant disease.105(5) 1382-1389. https://doi.org/10.1094/PDIS-07-20-1578-RE

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