Final report: Soybean pest management research – SW MN 2022

Objective I. Evaluate insecticide and fungicide efficacy in soybean in an ongoing and systematic way. (Team: Bruce Potter, Dr. Dean Malvick, and Dr. Robert Koch with additional University and Industry collaboration).

I a) Foliar fungicide

This project continued standardized, multiple-site soybean foliar fungicide studies across southern Minnesota.

Methods

Field studies were conducted in corn–soybean rotation sites at the Southwest Research and Outreach Center (SWROC), Lamberton, Redwood County; Southern Research and Outreach Center (SROC), Waseca, Waseca County; and the Rosemount Research and Outreach Center (RROC), Dakota County. Plots were four 30-inch rows wide by 30 feet long. Cold, wet spring soil conditions delayed planting. The SWROC, RROC, and SROC were planted on May 24, June 1, and May 31 respectively.

At each site, a 3X3 factorial design with four replications consisted of three diverse soybean varieties (Dairyland Seed DSR 1505E, Stine 19EC12, and Syngenta S20-LLGT27) and three fungicide treatments [Miravis Neo (Syngenta), Delaro 325 (Bayer Crop Science), and a no fungicide control].
Fungicides were applied to the plots on 8/10/2022 at the early to mid R3 stage at 15 GPA/30 PSI with a self-propelled plot sprayer [LeeAgra (Lubbock, TX)]. Insect and disease evaluations were made during June (seedling), late July (R3 stage) and September (R6 stage). Soybeans were harvested by plot combine [ALMACO (Nevada, IA)]. A three-way analysis of variance was conducted to compare the main effects of site, variety, fungicide as well as their interaction effects on soybean moisture and yield.

Results

Effects on soybean harvest moisture

Site and variety were significant for seed moisture at $p < 0.001$. A three-way analysis of variance yielded a significant main effect for study site, $F(2, 76) = 14609.89$, $p < 0.001$. Overall, the percent moisture was greatest at RROC and lowest at SWROC. Variety was significant $F(2, 76) = 58.36$, $p < 0.001$. Varieties 1-3 differed in percent moisture (10.7, 10.8, 11.0 respectively). There was a significant site* variety interaction, $F(4,76) = 24.12$, $p < 0.001$, such that the respective yields of variety 1 and variety 3 differed among the study sites (*Table 1, Table 2*). The effect of variety on moisture was significant at all individual sites: SWROC, $F(2,24) = 0.14$, $p = 0.001$; SROC $F(2,22) = 66.6$, $p < 0.001$; and RROC, $F(2,24) = 3.61$, $p = 0.043$. In 2022, The main effect of fungicide on moisture was not significant ($p < 0.05$) overall in 2022 (Table 1) or any 2022 study site.

Effects on soybean yield

A three-way analysis of variance yielded a significant main effect for study site, $F(2, 76) = 149.64$, $p < 0.001$. Site yields reflected growing season moisture. The main effects of variety and fungicide on soybean yield were not significant at $p < 0.05$ (*Table 1*) at any site.

Discussion

Long-term pesticide application studies can provide growers and their advisors with information on potential returns (Kandel, et al., 2021).

The 2022 growing season was dry over much of southern Minnesota and foliar disease was at very low levels at all study sites. This study did not detect a yield response to fungicide applications nor evidence that fungicide applications provided yield benefits under low disease or moisture stress. For example, at the SROC and RROC sites, untreated control showed numerically greater yield than one of the two fungicide treatments. The ROC study sites were not selected on the expectation of soybean disease (white mold, frogeye leaf spot, etc.). As a result of two consecutive dry years, long-term significant yield benefits for fungicide application were 53% for all 19 site years.

References

Kandel, Y.R., C. Hunt, K. Ames, N. Arneson, C. Bradley, 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

Variable	**Factor**	**d.f.**	***F***	***p***
Moisture	Site	2	14609.89	< 0.001
	Variety	2	58.36	< 0.001
	Fungicide	2	0.16	0.854
	Site* Variety	4	24.12	< 0.001
	Site* Fungicide	4	1.08	0.371
	Variety*Fungicide	4	1.23	0.305
	Site*Variety*Fungicide	8	0.30	0.964
	Error	76		
	Total	105		
Yield	Site	2	149.64	< 0.001
	Variety	2	2.18	0.120
	Fungicide	2	0.31	0.731
	Site* Variety	4	1.44	0.228
	Site* Fungicide	4	2.24	0.072
	Variety*Fungicide	4	2.36	0.061
	Site*Variety*Fungicide	8	0.86	0.555
	Error	76		
	Total	105		

Table 1 . Factorial ANOVA. Minnesota uniform fungicide study - 2022.

		Percent Moisture			Yield (Bushels/Acre)		
Factor	**Variable**	**Mean**	**SEM**	**HSD**	**Mean**	**SEM**	**HSD**
Site	SWROC	8.7	0.02	0.07 c	66.3	0.7	1.7 b
	SROC	10.5	0.05	b	74.4	0.6	a
	RROC	13.3	0.02	a	61.7	0.5	c
Variety	1505E	10.8	0.34	0.07 b	66.7	1.2	*n.s.* a
	19EC-12	11.0	0.32	a	68.3	1.0	a
	S20-LLGT27	10.7	0.32	c	67.3	1.0	a
Fungicide	none	10.8	0.33	*n.s .* a	67.2	1.1	*n.s.* a
	Miravis Neo	10.8	0.33	a	67.8	1.0	a
	Delaro	10.8	0.32	a	67.4	1.1	a
Site * Variety	SWROC - 1505E	8.6	0.02	1.80 f	65.3	1.19	n.s. a
	SWROC - 19EC-12	8.8	0.03	e	68.5	1.05	a
	SWROC - S20-LLGT27	8.7	0.03	ef	66.4	1.14	a
	SROC -1505E	10.4	0.04	c	68.0	0.92	a
	SROC - 19EC-12	10.9	0.06	b	67.6	1.08	a
	SROC - S20-LLGT27	10.2	0.03	d	69.3	1.16	a
	RROC - 1505E	13.3	0.03	a	68.3	0.72	a
	RROC - 19EC-12	13.3	0.03	a	67.3	0.84	a
	RROC - S20-LLGT27	13.2	0.03	a	66.5	0.84	a

Table 2. *Means, Standard Errors, and mean differences (Tukey's HSD p= 0.05). Minnesota Uniform fungicide study 2022.*

I b) Soybean aphid insecticides

This project continued the long-term evaluation of insecticides for soybean pests in SW Minnesota.

Methods

The study site was planted on May 27 at the UMN Southwest Research and Outreach Center near Lamberton, MN. Soybean aphid (SBA) populations were established from nearby buckthorn and from neighboring fields. Pyrethroid resistance has been observed in local SBA aphids since 2015 (Potter, unpublished).

Twelve insecticides, including nine individual insecticide compounds, were compared to a no-insecticide control with respect to their effect on SBA populations and soybean yield. The insecticides were applied to a rapidly increasing SBA population infesting early R5-stage soybeans on August 10 when SBA populations averaged 110 aphids /plant (0-425 SBA). A study area as uniform as possible with respect to soybean canopy and soybean aphid density was selected. Alleys were cut into the field using a tractor-mounted rotary tiller, 6-row plots were marked, and pre-treatment aphid counts were made. The pre-treatment counts found lower SBA populations in areas of the study, presumably due to subsoil differences and moisture-stressed soybeans. Insecticides were applied with a self-propelled plot sprayer (LeeAgra, Inc., Lubbock, TX) using 15 GPA, 30 PSI, and 8002 flat fan nozzles on 15-inch spacings. The center four rows of each six-row plot were sprayed. This design protected against spray particle drift between plots and left a running check on each side of a plot.

Whole plant counts of five randomly selected plants per plot (three plants per plot pre-treatment) were used to estimate populations of SBA adults and nymphs. Aphids were assessed on the day of insecticide application and then at 5, 7, 15, and 21 days after application (DAT).

Aphid population densities over time expressed as cumulative Aphid Days (CAD) were log-transformed before ANOVA, and insecticide treatment means separated with Tukey's HSD (p=0.05). Because SBA population data were not normally distributed, non-parametric analyses were used. Significance probabilities for SBA/plant for each sample date were determined using Kruskal-Wallis one-way AOV and the means separated by Dunn's test (p= 0.05).

A plot combine (ALMACO, Nevada, IA) was used to obtain yields from the two center rows of each plot on October 3. Yields were adjusted to 60 pounds/ bushel and 13% moisture.

Results

Dry weather after the insecticide applications limited aphid population development and increased the spatial variability of both aphid population density and crop yield.

The mean number of SBA/plant, CAD for the evaluation period of this study, and soybean yields are shown in *Table 3*.

At 5 days after treatment (DAT), all insecticides, except for Warrior II (lambda-cyhalothrin) and the low (4.8 oz) rate of Sniper (bifenthrin), had significantly fewer aphids than the untreated control. The two rates of Ridgeback (sulfoxaflor + bifenthrin) had fewer aphids than the untreated control, Warrior II, the 4.8 oz rate of Sniper, Sefina (afidopyropen), and Renestra (afidopyropen + alpha-cypermethrin).

At 7 DAT, Warrior II, and the low rate of Sniper had numerically lower but statistically similar SBA populations compared to no- insecticide and were higher than insecticides with the fewest aphids.

By 15 DAT, SBA populations in the high (6.4 oz) rate of Sniper had increased and all pyrethroid treatments were numerically lower but no longer significantly different than no-insecticide. The SBA populations in the Sefina and Renestra treatments had declined and were similar to other insecticides. Control remained similar through the 21 DAT evaluations when SBA populations had declined in all but the pyrethroid (Warrior II and Sniper) treatments.

The pyrethroid-only (Warrior II and Sniper) and Leverage (imidacloprid + beta-cyfluthrin) treatments had lower CADs *than the control,* but greater accumulations than other insecticides. The addition of the neonicotinoid thiamethoxam to lambda-cyhalothrin (Endigo) or the addition of sulfoxaflor to bifenthrin (Ridgeback) improved control.

Yields varied from 49.7 to 52.6 and were not significantly different. The untreated control accumulated 6208 aphid days during the study period, less than typically needed to produce a soybean yield response (*Table 3*).

Discussion

Long-term studies such as this can help provide growers with information on changes in pesticide efficacy (Menger, et al., 2022). They can also help corroborate field observations. These data suggest pyrethroid resistance continues at some level in local SBA populations. Area growers and ag chemical retailers who applied pyrethroid insecticides to SBA in 2022 reported similar performance issues.

Results from this study and the need for the stewardship of insecticides were discussed at extension meetings and a PDF with details of the study was posted to the UMN Southwest Research and Outreach Center website.

Product	Rate	Mean number of aphids/plant*					CADs[1]	YIELD
		0 DAT 8/10	5 DAT 8/15	7 DAT 8/17	15 DAT 8/25	21 DAT 8/31	0-21 DAT 8/10-8/31	Bu/A 10/3
Untreated Check		182.5 a	321.0 a	269.7 a	407.7 a	142.0 a	6208.0 a	52.6 a
Transform	0.75 OZ /A	75.8 abc	3.4 def	0.6 d	0.0 e	0.0 d	204.5 e	51.4 a
Ridgeback	8.60 FL OZ/A	124.8 abc	2.0 ef	0.4 d	0.2 e	0.1 cd	322.4 de	51.2 a
Ridgeback	10.30 FL OZ/A	110.8 abc	2.1 f	0.4 d	0.3 e	0.5 cd	289.4 de	49.7 a
Sniper	4.80 FL OZ/A	143.8 abc	40.7 abc	39.0 abc	58.3 ab	139.3 ab	1522.8 b	49.9 a
Sniper	6.40 FL OZ/A	101.4 abc	10.9 bcdef	6.4 cd	49.5 abc	136.8 ab	1079.7 bc	51.3 a
Warrior II	1.60 FL OZ/A	97.0 abc	70.1 ab	139.1 ab	57.7 abc	114.0 ab	1929.1 b	50.7 a
Endigo ZC	4.00 FL OZ/A	109.8 abc	15.9 bcdef	2.8 d	3.8 cde	2.1 bcd	376.4 cde	51.8 a
Leverage 360	2.80 FL OZ/A	67.3 abc	39.9 bcde	5.9 cd	7.6 bcd	14.5 bc	433.7 b	51.4 a
Sefina	3.00 FL OZ/A	189.3 ab	20.4 bcd	22.7 bcd	1.0 de	0.1 cd	665.0 bcd	53.1 a
Renestra	6.80 FL OZ/A	56.5 c	24.8 bc	24.8 bcd	6.5 de	0.1 cd	397.4 cde	52.5 a
Sivanto Prime	5.00 FL OZ/A	90.5 abc	8.1 cdef	5.6 cd	3.5 de	2.4 bcd	314.0 de	49.7 a
Sivanto Prime	6.00 FL OZ/A	64.6 bc	4.1 cdef	11.0 bcd	3.4 de	1.1 cd	257.7 de	51.7 a
p value		*0.0005*	*< 0.0001*	*< 0.0001*	*< 0.0001*	*< 0.0001*	*0.0001*	*0.7373*

Means followed by the same letter do not differ significantly.

* Data for 8/25 and 8/32 aphid populations could not be transformed to meet the assupmtions of normality.

*Significance of aphid populations was determined by Kruskal-Wallis non-parametric one-way AOV.

* Means separated by Dunn's pairwise comparison test. alpha= 0.05

[1] Cumulative aphid-days (CADs) significance determined by ANOVA of log transformed data.

[1] Means separated w/ Tukey's HSD alpha = 0.05. Data are reported as the untransformed values.

Table 3. Soybean aphid population and soybean yield response to insecticide treatments. UMN Southwest Research and Outreach Center, Lamberton, MN 2022

References

Menger, J.P., A.V. Ribeiro, B.D. Potter, and R.L. Koch. 2022. Change-point analysis of lambda-cyhalothrin efficacy against soybean aphid (*Aphis glycines* Matsumura): identifying practical resistance from field efficacy trials. Pest Manag Sci, 78: 3638-3643. https://doi.org/10.1002/ps.7006

Objective II. Define the distribution and host range of the soybean gall midge within Minnesota. (Team: Bruce Potter and Dr. Robert Koch)

This project will track changes in the distribution of soybean gall midge [1,4] across Minnesota environments and is the second year of an effort to examine alternative hosts and determine if additional Minnesota crops are at risk.

II a) Soybean survey

Methods

Soybean fields for the survey were selected on characteristics typically associated with SGM infestations such as adjacency to a previous year's soybean field and the presence of perennial vegetation such as field roads, windbreaks, or fence lines. Eighty-six soybean fields in twenty-three Minnesota counties were surveyed during July and August 2022. These included 9 counties, where SGM had not been detected, adjacent to previously confirmed counties (Soybean Gall Midge Alert Network), and Southeast Minnesota counties where SGM had not yet been found.

Results

No new infested Minnesota counties were detected in 2022. The 2022 SGM populations in previously infested Minnesota counties appeared lower, sometimes not observed.

Discussion

Knowledge of a pest's distribution and density changes, and thereby grower risk, is important to the development of sound pest management strategies.

The soybean gall midge (SGM) is new to science (Gagne´, et al.,2019, McMechan et al., 2021). Soybean checkoff funding has been instrumental in understanding the current and potential distribution of this pest. Future efforts will determine whether the lower 2022 Minnesota population densities reflect a temporary or longer-term change.

II b i) Dry edible bean survey

Methods

Dry edible bean (*Phaseolus vulgaris*) and soybean production overlap in parts of Central, West Central, and Northwest Minnesota. Chippewa, Swift, Lac Qui Parle, and Yellow Medicine Counties in West Central Minnesota have a history of SGM infestation in soybean.

Dry bean fields in these counties were surveyed in July and August. When possible, surveyed fields were preferentially selected based on characteristics indicating nearby soybean had a high probability of SGM infestation.

Results

SGM larvae were found in two Lac Qui Parle County navy bean (*P. vulgaris*) fields on August 12. Infestations were located on field edges adjacent to 2021 soybean fields. Nearby soybean field edges were also infested (up to 40% plants) and at a higher rate than the navy bean field (up to 5% plants). SGM larvae were not found in a third nearby field that was not bordered by a 2021 soybean field.

Figure 1. *Soybean gall midge larvae in navy bean stem. Lac Qui Parle Co., August 12, 2022. Photo: B. Potter*

The larvae were confirmed to be SGM by morphology, DNA barcoding, and an adult emerging from field-collected larvae.

Similar to soybean, the larvae infesting navy beans were found beneath the lower stem surface. Larvae in stem axils and stem interiors were also observed (*Figure 1*).

Discussion

These observations represent the first reported infestations of commercial bean (*P. vulgaris*) and they followed shortly after infested sentinel bean plants were obtained in Rock County (see II b iii).

Yield losses from SGM in *Phaseolus* crops have not been documented. However, in areas where SGM occurs on soybean, dry bean growers should be aware of potential field edge injury from SGM larvae.

II b ii) Prairie legume survey

Methods

Sweet clover and prairie legumes were surveyed in the same West Central Minnesota counties as dry bean and in Rock, Lincoln, and Cottonwood Counties in Southwest Minnesota MN. This unstructured survey looked for SGM symptoms on legumes in accessible roadsides and wildlife areas. The legume species examined varied by site.

Results and Discussion**.**

No SGM larvae or injury symptoms were observed on the prairie legumes (lead plant, prairie clovers, tick trefoil, etc.) examined in 2022. These negative observations do not preclude the possibility of a native host.

II b iii) Mobile sentinel plants

Methods

Eighteen potential annual legume hosts of eleven species (i.e., *Glycine max*, *Phaseolus vulgaris*, *P. lunatus*, *Vigna angularis*, *V. radiata, V. unguiculata*, *Vicia fava*, *Pisum sativum*, *Lens culinaris, Cicer arietinum*) were greenhouse-grown in 4-inch pots. While several of these legumes (e.g., lentils, mung) have small diameter stems and were not expected to be suitable hosts, they were included to broaden the diversity of legume genetics and geographic area of origin. Stem diameters and the presence of growth fissures were recorded several times before the plants were placed in the field.

Emergence cages (Soybean gall midge alert network https://soybeangallmidge.org/) were used to determine when overwintering and 1st generation SGM adults were active. The potted sentinel plants were placed within a soybean field in an area where oviposition was expected. After one week, the plants were removed and returned to the greenhouse. Plant stems were dissected and examined for SGM larvae after any eggs or larvae they contained had developed for another week.

Sentinels were placed in the field on June 14 to allow for oviposition by overwintering generation SGM adults. Half of the stems were slit with a razor knife to provide a wound. The plants were removed from the field and replaced in the greenhouse on June 20 and their stems dissected for the presence of SGM larvae on June 28. Soybean gall midge larvae were observed in the stems of all three soybean varieties but no other species (*Figure 2*). These sentinel soybean plants were larger than the field’s soybeans and infested at a rate as high or higher than soybeans in the field.

On July 18, during 1st generation adult activity, the same eighteen plant types were placed in the infested field. Plants were removed from the field and returned to the greenhouse on July 25 and stems dissected for the presence of larvae on August 1.

SGM larvae were found in the stems of the three soybean varieties, four of the seven bean (*P. vulgaris*) cultivars, and lima bean (*P. lunatus*). Additionally, a dead, immature white larva was found in a single stem of Mung bean (*Vigna radiata*).

SGM larvae appeared to develop normally on soybean, bean, and lima bean sentinels. Generally, the bean and lima bean sentinel plants had fewer larvae/plant and a lower proportion of infested plants than soybean (*Figure 2).*

The detection of SGM in commercial navy bean fields suggests that infestation of *Phaseolus* sentinels was from oviposition, not movement of larvae from soybean.

Both manually wounded and unwounded *P. vulgaris* were infested. Bean cultivars that were infested by SGM tended to have larger stem diameters, but this data does not currently allow for correlations.

Discussion

Sentinel plantings can be used to detect changes in pest populations or preferences (Manfield, et al., 2019). Few commercial fields in Minnesota with high SGM population densities and seed production and agronomic reasons prohibited plot scale plantings of potential alternate hosts.

Given the current inability to maintain laboratory colonies of SGM, this use of potted sentinel plants facilitated in-field testing of host suitability. The flexibility in timing and placement of the mobile sentinel method allows the placement of potential annual legume hosts into areas likely to see ovipositing SGM. It minimizes soybean herbicide injury to sensitive species within, or near, commercial soybean fields.

This research expands the known host range of SGM to include two additional crop species: *P. vulgaris* and *P. lunatus*.

REFERENCES

Gagné, R. J., Yukawa Junichi, A.K. Elsayed, and A.J. McMechan. 2019. A new pest species of *Resseliella* (Diptera: Cecidomyiidae) on soybean (Fabaceae) in North America, with a description of the genus. Proceedings of the Entomological Society of Washington. 21(2):168-177.https://doi.org/10.4289/0013-8797.121.2.168

Mansfield, S., M.R. McNeill, L.T. Aalders, N.L. Bell. J.M. Kean, B.I.P. Barratt, K. Boyd-Wilson, D.A.J. Teulon. 2019. The value of sentinel plants for risk assessment and surveillance to support biosecurity. NeoBiota 48:1-24. https://doi.org/10.3897/neobiota.48.34205

McMechan, A.J., E.W. Hodgson, A.J. Varenhorst, T. Hunt, R. Wright and B. Potter. 2021. Soybean Gall Midge (*Resseliella maxima*), a new species causing injury to soybean in the United States. Journal of Integrated Pest Management: Brief Communication. 12 (1): 8;1-4. https://doi.org/10.1093/jipm/pmab001

Soybean gall midge alert network. https://soybeangallmidge.org/

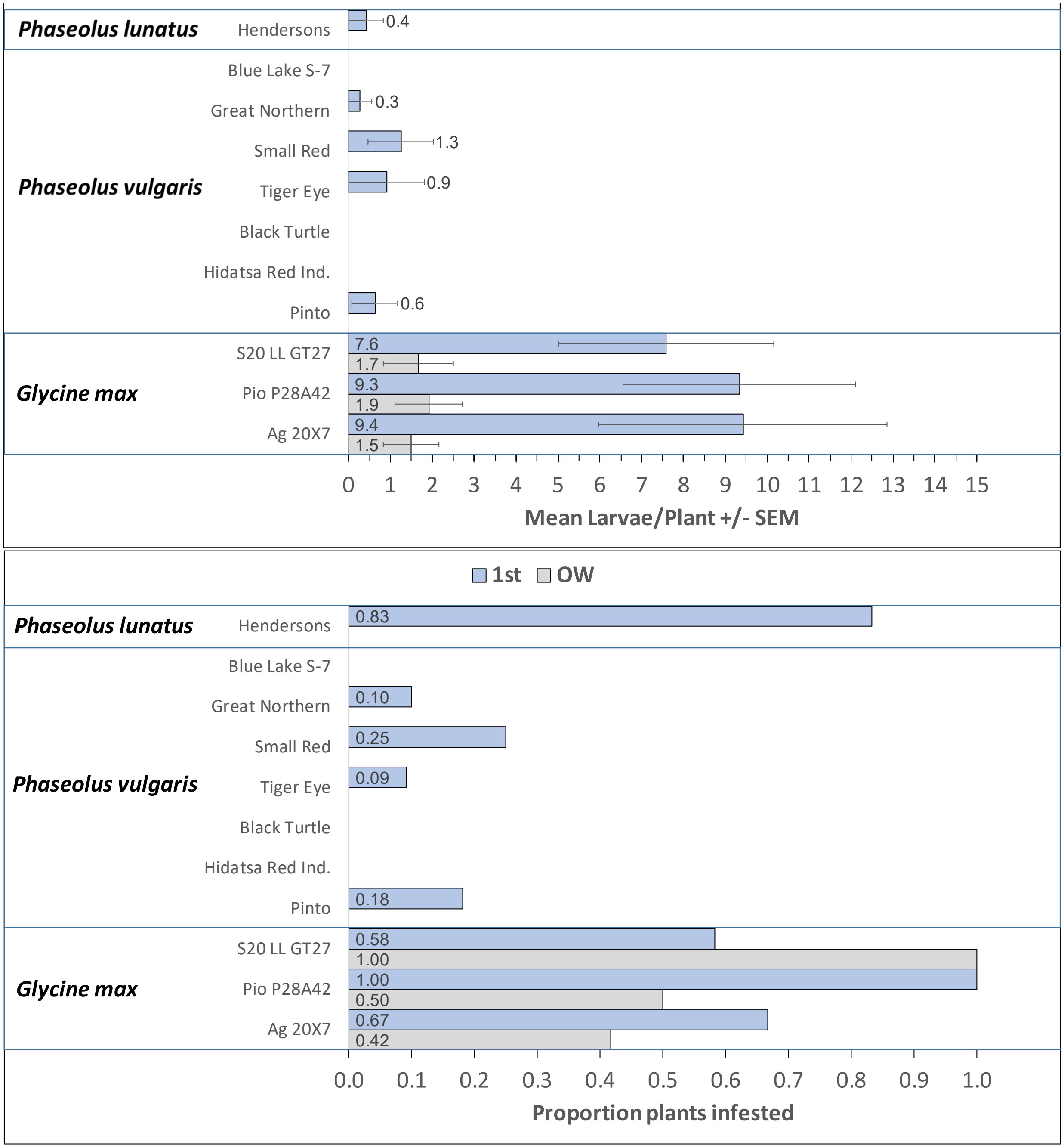

Fig. 2. *Overwintering (OW) and 1st generation SGM infestation of G. max and Phaseolus sp. sentinels placed in Rock Co., MN, soybean fields in June and July 2022. Other species with no recovery of larvae are not shown.*

Results from the studies in this project were presented through several venues including:

Extension articles
Potter, B., R. Koch, G. Melotto, and S. Lisak. 2022. Soybean gall midge – Not just for soybeans anymore. Minnesota Crop News - October 31, 2022. https://blog-crop-news.extension.umn.edu/2022/10/soybean-gall-midge-not-just-for.html

Potter, B., and D. Malvick. 2022. Long-term studies: Do insurance applications of foliar fungicides provide benefits in corn and soybeans? MN Crop News – July 13, 2022.

Potter, B. 2022. The soybean gall midge returns to Minnesota in 2022. MN Crop News – June 28, 2022.

Presentations
2023 Soybean gall midge Research Update. February 27, 2023. https://soybeangallmidge.org/soybean-gall-midge-series-videos. Webinar.

Koch, R. 2023. Soybean insect update. Extension Research Update. Waseca, Oronoco, Lamberton, Morris, Willmar, Crookston, MN. January 1-12.

Koch, R. 2022. Updates on soybean gall midge. Crop Pest Management Short Course. St Paul, MN. December 8.

Potter, B., R. Koch, T. Vollmer, G. Melotto, and S. Lisak. 2023. Bean and lima bean (*Phaseolus* spp.) as hosts of the soybean gall midge Joint North Central Branch and Southwest Branch Meeting of the Entomological Society of Minnesota. April 16-19, 2023. Oklahoma City, Oklahoma. Display presentation.

Potter, B. 2023. Do economical low-stress insect management strategies exist. Winter Crops Day. Slayton, MN. March 16, 2023.

Potter, B. 2023. Pesticide applicator training: insects. Commercial/ non-commercial pesticide applicator training. Willmar, Faribault, Mankato. January 24 -26. Note: also included in private/commercial/non-commercial presentations by extension educators.

Potter, B. 2023. The soybean gall midge in Minnesota: A look at changing distribution and host preferences. MN Ag Expo. Mankato, MN. January 19. Display presentation.

Potter, B. 2022. What's new? The soybean gall midge and other insect discoveries. South Dakota Ag Business Association Agronomy Conference. December,14. Webinar.

Potter, B. 2022. Do you need an insect risk management program for your farm? 2023 Crop Management Input Seminar. December 13, 2022.

Potter, B and R. Koch. 2023. Soybean gall midge field day. Luverne, MN. July 13, 2022, Field Day presentation.