***S1080: 2021 State Reports***

***S1080 Alabama State Report 2021***

***Scott H. Graham***

**Alabama Overview:**

* Key insect pest activity, observations or general findings
* Overview of major projects or any multi-state collaborations

**Report summary –** In 2021, the Alabama Extension Soybean Entomology Team conducted several research trials and insect monitoring efforts were made to provide recommendations and information to soybean producers and field advisors across Alabama.

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

The annual soybean insect losses report for the 2021 growing season showed that again, insect pests were not a major yield limiting factor for Alabama soybean producers. Historically, and in 2021, stink bugs, soybean loopers and velvetbean caterpillars were among the most injurious insects across the state. Brown marmorated and redbanded stink bugs represented ≈5% and ≈3% of the stink bug population, respectively. Kudzu bug were not widespread (≈35% infested; 15% above ET) in 2021.

*Peer reviewed pubs:*

*Non-peer reviewed*

Musser, F.R., A.L. Catchot, Jr, S.P. Conley, J.A. Davis, C. DiFonzo, S.H. Graham, J.K. Greene, R.L. Koch, D. Owens, D.D. Reisig, P. Roberts, T. Royer, N.J. Seiter, S.D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R.T. Villanueva, and M.O. Way. 2021. 2020 Soybean Insect Losses in the United States. Midsouth Entomologist. [14](https://midsouthentomologist.org.msstate.edu/pdfs/Vol14_1/ME21-001%20final.pdf)*.*

*Professional presentations:*

n/a

*Extension presentations:*

See section 4

*Impact statements:*

The yearly documentation of insect pest infestations and losses allows for historical references to observe trends over time and understand how complexes change over time.

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:*

A soybean looper and bollworm pheromone trapping program was on Alabama Agricultural Experiment Stations and grower fields in north (Limestone Co.), central (Autauga, Elmore Co.) and south (Monroe, Baldwin, Escambia, Henry Co.) Alabama. Trap counts were low overall. The peak soybean looper flight was near the historical average (mid-August).

*Peer reviewed pubs:*

n/a

*Professional presentations:*

n/a

*Extension presentations:*

See section 4

*Impact statements:*

Monitoring moth flights allows for in season reports made to growers and other field advisors for intensifying scouting efforts and observing for economic infestations of pests.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

A study was done in central Alabama (Prattville) to evaluate the threshold recommended by Alabama Extension for the “traditional” stink bug complex (i.e., not redbanded stink bug). Thresholds evaluated were the current (3/25 sweeps), 2x TH (6/25 sweeps) and 3x TH (9/25 sweeps) and a nontreated check. The current threshold required 2 insecticide applications, the 2x threshold required 1 application and the 3x did not reach threshold. The current TH (3/25) resulted in significantly higher yield and ROI, even when considering the extra application costs.

Another study was done to evaluate the impacts of cover crop (cereal rye) burndown timing and insecticide seed treatment on early season soybean health and yield (Prattville, Belle Mina). Burndown timings included 4 and 2 weeks prior to plant and at-plant. The insecticide seed treatment (IST) used was Gaucho (imidacloprid). Main effects of burndown timing and IST significantly affected stand. Higher plant populations were observed were earlier burndown timings and with the IST. No differences in threecornered alfalfa hopper damage plants were observed across either main effect. No difference in yield for IST was observed, but the 4- and 2-week burndown timing resulted in significantly higher yield than the at-plant burndown.

Additionally, 6 insecticide efficacy trials were conducted on soybean insect pests.

*Peer reviewed pubs:*

n/a

*Professional presentations:*

n/a

*Extension presentations:*

See section 4.

*Impact statements:*

Results from these trials support insecticide recommendations, validate our thresholds and provide insight on the impacts of ISTs and burndown behind grass cover crops.

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:*

In 2021, the Alabama Soybean Extension Team gave numerous updates and recommendations to soybean producers and field advisors across Alabama. Additionally, we participated 5 in-service trainings for Alabama Regional Agents and 1 for Florida Ag Agents.

*Peer reviewed pubs:*

*Non-peer reviewed book*

Sisson, A.J., D.S. Mueller, S.P. Conley, C.K Gerber, S.H. Graham, E.W. Hodgson, T.R. Leglieter, P.P. Price, K.J. Schaefer, E.J. Sikora, T.H. Wilkerson and K.L. Wise. 2021. Crop Scouting Basics for Corn and Soybean. Crop Protection Network. CPN 4007 Doi.org/10.31274/cpn-20201214-0.

*Professional presentations:*

n/a

*Extension presentations:*

**Graham, S.H.** 2021. Cotton, Soybean and Peanut IPM in 2022. Alabama Crop Management Association, Winter Training. Auburn, AL.

**Graham, S.H.** 2021. Managing Pests in Cover Crops. National Cover Crop Summit: Fall Edition. Virtual. (*Invited*).

**Graham, S.H.** 2021. Insect Issues in Cotton, Peanut and Soybean. Alabama Crop Management Association, Summer Training. Orange Beach, AL. (*Invited*).

**Graham, S.H.** 2021. 2021 Insect Pest Management in SW Alabama. SW Alabama Virtual Producer Meeting.

**Graham, S.H.** 2021. Row Crop Insect Pest Management Update. Virtual Florida Ag Agents In-Service Training. (*Invited).*

* 10 Regional/County meetings (146 attendees, 35 counties)
* Weekly Alabama Crops Report Newsletter contributions
* 4 Pest Patrol Hotline Updates
* 2 Soybean Insect Scouting Videos
* 4 Cotton and Soybean Insect Scouting Schools (135 attendees)
* Various updates in trade journals such as AgFax

*Impact statements:*

Extension updates, scouting schools and personal contacts help to improve IPM adoption for Alabama soybeans and increase the profitability of the industry statewide.

***S-1080 Delaware State Report 2021***

***David Owens and Michael Crossley***

**Associated Students:** Thabu Mugala (started February 2022)

**Delaware Overview:**

DE soybean were grown on 153,000 acres, with an average yield of 51 bushel per acre. Pest pressure was lighter in 2021 than in previous years. A couple of early planted soybean fields were negatively impacted by seedcorn maggot and were replanted. Slugs caused scattered damage to April and early May planted soybean, primarily in the northern part of the state. Dry weather in the southern part of the state reduced slug activity.

Mid-season defoliator populations were low to moderate. Stink bug activity was a little higher than in previous years. Several calls came in August and September regarding stink bug pressure in R6 beans. Corn earworm pressure was light and widely scattered in southern DE double crop fields. Dectes lodging was noted in a few fields at harvest time.

**Report Summary**

1. Document changing soybean pest and beneficial arthropod assemblages.

*Short Summary:*

Southern green stink bug was identified in Bishopville, MD which is very close to Delaware. Seedcorn maggot damage was higher in 2021, slug damage was less prevalent. Earworm pressure and mid-season defoliator pressure was lighter in 2021. Stink bugs and Dectes stem borer caused more damage in 2021.

*Peer Reviewed Pubs:*

Musser, F. R., A. L. Catchot, Jr., S. P. Conley, J. A. Davis, C. DiFonzo, S. H. Graham, J. K. Greene, R. L. Koch, D. Owens, D. D. Reisig, P. Roberts, T. Royer, N. J. Seiter, S. D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R. T. Villanueva, and M. O. Way. 2021. 2020 Soybean Insect Losses in the United States. Midsouth Entomologist 14: 1-25.

*Extension presentations:* see below.

*Professional presentations*: NA

*Impact Statements*:

Two SCM-impacted fields and one slug-impacted field were visited in 2021. Eight fields were scouted regularly during the main season. Two fields were scouted for Dectes Stem Borer. Scouting updates were shared via the Delaware Weekly Crop Update and one Pest Patrol text alert. Consultants were regularly contacted via text message. Extension meetings reached more than 200 producers and consultants and in-season updates reached more than 700 distinct email addresses.

1. Characterize soybean insect biology and ecology

*Short summary:*

A collaborative effort with Virginia Tech (Sally Taylor) was initiated sampling fields for slug egg hatch and slug-infesting nematodes. Work was funded through the Northeast IPM Center as well as the Delaware Soybean Board. 14 fields were sampled throughout the spring. Data is still being analyzed, but slug pressure in Delaware was lower than previous years. Gray garden slug eggs seem to begin hatching at fairly defined times, but marsh slug life cycles do not appear to be time of the year dependent.

A collaborative effort with University of Missouri (Kevin Rice), University of Kentucky (Raul Villanueva), and Nebraska (Bob Wright) continued, sampling Dectes stem borer in fields partially bordered by sunflower. Three fields were visited during the season; one of which consisted solely of pre-planting Dectes presence sampling at the request of a farmer. Dectes populations peaked mid-July. Once sunflowers began senescing, Dectes left for adjacent soybean. At one site, a single application of lambda cyhalothrin to sunflower resulted in impressive Dectes kill.

Two spray trials were conducted on cooperator farmer fields, one for stink bug and one for corn earworm. Corn earworm adult vial tests were conducted in June, July, and August documenting levels of potential earworm pyrethroid resistance in 2021.

A Delaware Soybean Board funded project was initiated with the goal of studying cover crop impact to slug populations over the next two seasons. Cover crop plots (60x100’) were installed on 3 cooperator field sites. This is the beginning of a 2 year project.

*Peer Reviewed Pubs:* NA

*Professional presentations:*

Owens, D., J. Deidesheimer, C. Stubbs, S. Cotten, I. Hiltpold. 2021. Difficult pests of Delmarva. 2021 Eastern Branch of the Entomological Society of America Annual Meeting. Virtual.

*Extension presentations:* see below

*Impact Statements:*

Observations from slug and Dectes sampling have been shared at producer meetings and used to inform management recommendations. A Soybean Board article was published describing slug sampling efforts, with the key takeaway that gray garden slug eggs begin hatching in early April; baits applied before then will not be effective. At least one producer has expressed concern for refining Dectes management practices on his farm. A Dectes fact sheet was updated and is in the peer review process to be jointly published with University of Maryland (Kelly Hamby and Alan Leslie).

3. Develop coordinated best management practices (BMPs).

*Short summary:*

Strip trials were installed in 7 fields to be treated or not with lambda cyhalothrin upon vegetative stage herbicide application. Pest pressure was monitored during the season and yield data collected from each strip. Sampling showed minor reductions in defoliator worms, at no point did pest populations in untreated strips exceed economic thresholds and there were no significant yield differences.

*Peer reviewed pubs:* NA

*Professional presentations:* NA

*Extension presentations:* See below

*Impact Statements:*

Farmers continue to be discouraged from prophylactically tank mixing insecticide with pre-reproductive stage input applications.

4. Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods.

*Short Summary:*

The primary education outreach conducted by the UD soybean entomology group is through field visits, informal but regular communication with consultants, a weekly blog, voice text alerts, and extension meetings which, in 2021, were fewer and were virtual.

We contributed towards content development and promotion of the MyIPM app for soybean.

*Peer reviewed pubs:* NA

*Professional presentations:* NA

*Extension presentations:*

Owens, D. and J. Deidesheimer. 17 March 2021. Soybean 2020 Pest Observations for 2021. Kent County Soybean School.

Owens, D. and J. Deidesheimer. 2021. Is Hindsight 2020 for Soybean Insect Pest Management? Delaware Agriculture Week. Virtual.

Owens, D. 10 June 2021. NCC Entomology Update. New Castle County Extension Meeting. Virtual.

Owens, D. 19 July 2021. Soybean Insect Identification. Virtual.

Owens, D. and J. Deidesheimer. 11 January 2021. Cover Crop Selection and Termination Implications for Slugs. Delaware Soybean Board Proposal presentation. Virtual.

*Impact Statements:* [From Objective 1] Two SCM-impacted fields and one slug-impacted field were visited in 2021. Eight fields were scouted regularly during the main season. Two fields were scouted for Dectes Stem Borer. Scouting updates were shared via the Delaware Weekly Crop Update and one Pest Patrol text alert. Consultants were regularly contacted via text message. Extension meetings reached more than 200 producers and consultants and in-season updates reached more than 700 distinct email addresses.

A soybean insect pest identification review was held virtually in July, but was lightly attended.

***S-1080 Florida State Report 2021***

**Silvana Paula-Moraes**

**Major goals of the project**

1. Document and characterize the spatial and temporal occurrence and population dynamics of arthropod pests in several field crops in the agricultural landscape of the Florida Panhandle. The long-term contribution will be to improve pest management decision-making and efficiency in the agriculture of the region.

What was accomplished in the period?

1. For the first time in the U.S., the seasonal flight of soybean looper using year-round trapping was documented, including a complete inventory of Plusiinae species cross-attracted to the commercial pheromone lure (Shaw et al., 2021).
2. Collaborative work with researchers from U.S. documented the current distribution (Huseth et al., 2021) and information for correct identification of pests associated with soybean supporting management decisions (Hodgson et al., 2021), in addition to the estimation of economic thresholds for management decision (Justus et al., 2022).

Products:

Shaw, T.J., Paula-Moraes, S.V., Hahn, P.G., Specht, A. 2021. Seasonal Flight Patterns of Chrysodeixis includens (Lepidoptera: Noctuidae) in the Florida Panhandle and Inventory of Plusiine species cross-attracted to synthetic pheromone. J. Econ. Entomol., 114:2315-2325. <https://doi.org/10.1093/jee/toab179>.

Fleming, D.E., Davis, J.A., Musser, F., Paula-Moraes, S.V., Stephenson, R.C. 2021. Trapping soybean looper, Chrysodeixis includens (Lepidoptera: Noctuidae), in the southeastern USA and implications for pheromone-based research and management. In: 2021 ESA Annual Meeting, October 31-November 3.

Talton, H., Hodges, A.C., Paula-Moraes, S.V., Gilligan, T.M. 2021. Monitoring and surveillance of Helicoverpa spp. in agronomic fields in Florida. In: 2021 ESA Annual Meeting, October 31-November 3.

Hodgson, E.W., Koch, R.L., Davis, J.A., Reisig, D. and Paula-Moraes, S.V. 2021. Identification and Biology of Common Caterpillars in US Soybean. J. of Integr. Pest Manag., 12: 13. <https://doi.org/10.1093/jipm/pmab006>.

***S1080 Illinois State Report 2021***

***Nick Seiter, University of Illinois Dept. of Crop Sciences |*** [***nseiter@illinois.edu***](mailto:nseiter@illinois.edu)

***Joe Spencer, Illinois Natural History Survey |*** [***spencer1@illinois.edu***](mailto:spencer1@illinois.edu)

**Associated Post-Docs:** none during report period

**Associated Students:** L. Brodie Dunn (M.Sc. 2022)

**Illinois Overview:**

* During the early season, seedcorn maggot caused an unusually high number of damage reports and full or partial replants in soybean.
* Overall levels of defoliation were relatively low throughout most of the season; the large fall armyworm outbreak late in the season affected some late double-crop fields, though the greatest impacts were in pastures/forages.
* Bean leaf beetles were at higher than average populations in R6-R7 in parts of northeastern Illinois, though not to the same extent as in 2020.
* Soybean aphid remained mostly a non-issue in Illinois; difficult to even find individual aphid colonies in most of the state, including Champaign-Urbana.
* There were a few reports of lodging due to dectes stem borer in southern Illinois, partly a result of harvest delays during a very wet October.
* The annual Statewide Insect Survey turned up no evidence of soybean gall midge activity; this insect still has not been found in Illinois.

**Report summary – Please emphasize collaborations with other states/members of the group when possible and relevant. Add a short summary to this section as related to the below objectives.**

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

M.S. student Brodie Dunn finished an assessment of the pest and beneficial insect assemblage in soybean fields that use a rye cover crop; Brodie recently defended his thesis, and will produce a peer-reviewed manuscript shortly based on this work. A new project funded by Illinois Soybean Association supported work to document dectes stem borer incidence in southern Illinois. A recently completed study of soybean defoliation by insects (funded by NCSRP) documented low overall levels of insect defoliation in the North Central region of the U.S. Annual Statewide Insect Surveys and previous/future NCSRP-funded multi-state efforts have supported surveys for the potentially invasive soybean gall midge, which has not been found in Illinois. Assessments of western corn rootworm adults in soybean indicate a reduced impact of the crop rotation-resistant variant in east-central Illinois over the last several years (see research report at end of document).

*Peer reviewed pubs:*

Calresso Aita, R., D. T. Pezzini, E. C. Burkness, C. D. DiFonzo, D. L. Finke, T. E. Hunt, J. J. Knodel, C. H. Krupke, L. Marchi-Werle, B. McCornack, A. P. Michel, C. R. Phillips, N. J. Seiter, A. J. Varenhorst, R. J. Wright, W. D. Hutchison, and R. L. Koch. 2021. Presence-absence sampling plans for stink bugs (Hemiptera: Pentatomidae) in the Midwest region of the United States. Journal of Economic Entomology 114(3): 1362-1372. <https://doi.org/10.1093/jee/toab076>

*Impact statements:*

Sharing information about low WCR populations may offer some reassurance to growers who have not monitored WCR in their E. and C. Illinois fields. Sharing WCR abundance monitoring trends and discussing them in the context of justifying management decisions is IPM messaging at its most basic: “If you are not monitoring, you are not doing IPM”.

Cover crops are a key component of the Illinois Nutrient Loss Reduction Strategy, and have potential benefits for soil health, erosion reduction, and weed control. However, these systems have the potential to favor both pest and beneficial insects. We sought to characterize the pest and beneficial insect populations residing in cereal rye cover crops planted before soybean, and to assess the risk of insect pest pressure based on cover crop usage. Out of 72 fields (half with a cereal rye cover crop and half without), none reached an economic threshold for insect pests. One field was replanted in part due to slug infestations. The overall additional risk of insect pest pressure from a cereal rye cover crop in Illinois was found to be low. This information will help farmers to better understand the risks of adoption of cereal rye cover crops.

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

This was the final year of a three-year multi-state experiment (coordinated by Justin McMechan, UNL) to document the impacts of cover crop termination timing on soybean pest management. This study found an overall low risk of insect damage to soybean following a cover crop regardless of termination timing.

In addition to surveying levels of insect defoliation in the region, our multi-year soybean defoliation project (7 states) will result in updated guidance on monitoring and managing insect defoliatiors in the North Central region. A half-page scouting guide on card stock will be made available shortly to disseminate these recommendations to farmers.

*Impact statements:*

Defoliating insects, including the Japanese beetle, green cloverworm, and bean leaf beetle, represent the most common insect pests of soybean. While soybean is highly tolerant of defoliation, the damage is conspicuous and its impact is often over-estimated, resulting in unnecessary insecticide applications. Methods of assessing this damage that are accurate, repeatable, and efficient would better equip producers and crop consultants to make informed control decisions for defoliating pests. As part of a regional project funded by soybean producers through the North Central Soybean Research Program, we conducted a 3-year project to develop such a system for Illinois and the North Central region (participation from 7 states). The long-term impact goal for this project is to reduce the number of unnecessary insecticide sprays in soybean.

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:*

We continue to deliver digital and in-person Extension content to our farmer and crop-advisor stakeholders to meet their evolving informational needs. In 2021, we presented 5 webinars and 3 in-person Extension talks related to soybean insect management to an audience of 762. Internal Extension efforts included an update to the Insect Management chapter of the Illinois Agronomy Handbook, designed to provide comprehensive insect management recommendations for corn and soybean production in Illinois. An annual report of applied research, including routine evaluations of soybean insecticides for pest control, was published by Illinois Extension to provide our clientele with up-to-date information on control performance and insect pest distributions in Illinois. A scouting aid produced by Chris Difonzo at Michigan State was distributed to all Illinois Soybean Association members at the beginning of the summer to increase awareness of this potential invasive pest.

*Extension presentations:*

Seiter, N. (presenter). Bean leaf beetle biology and management. February 01, 2021. CropFlix Virtual Crop Management Conference. Audience: farmers and crop consultants. Impact: provided management recommendations for bean leaf beetle in soybean. Contact: Chelsea Harbach. Total participation (live + archive): 78

Seiter, N. (presenter). Dectes stem borer management. February 01, 2021. CropFlix Virtual Crop Management Conference. Audience: farmers and crop consultants. Impact: provided management recommendations for dectes stem borer in soybeanContact: Chelsea Harbach. Total participation (live + archive): 82

Seiter, N. (presenter). Cover crops and insect management. February 01, 2021. CropFlix Virtual Crop Management Conference. Audience: farmers and crop consultants. Impact: provided management recommendations for insect pests following a cover crop. Contact: Chelsea Harbach. Total participation (live + archive): 91

Seiter, N. (presenter). Insect management: what did we learn in 2020?. February 17, 2021. ILSoyAdvisor Soybean Summit. Audience: farmers and crop consultants. Impact: provided management recommendations for bean leaf beetle and dectes stem borer, and an applied research update in soybean. Contact: Todd Steinacher. Total participation (live + archive): 109

Seiter, N. (presenter/organizer). Regional impact and management of fall armyworm. December 02, 2021. Crop Protection Network Webinar Series. Audience: farmers and crop consultants. Impact: trained crop advisors and scouts on fall armyworm biology and identification. Contact: Daren Mueller . Total participation (live + archive): 271

Seiter, N. (Presenter). Insect management in cover crops. June 10, 2021. Cover Crop Field Day. Audience: Farmers. Impact: discussed insect management following a cover crop with farmers. Contact: Jean Brokish. Attendance: 15. State focus area: Food and Environment.

Seiter, N. (Presenter). Insect management in corn and soybean. July 22, 2021. Ewing Field Day. Audience: Farmers, Crop Advisors. Impact: instructed farmers and crop consultants how to identify soybean insects and make appropriate management decisions. Contact: Talon Becker. Attendance: 81. State focus area: Food and Environment.

Seiter, N. (Presenter). Dectes Stem Borer Biology and Management. December 20, 2021. Bayer Southern IL Academic Roundtable. Audience: Industry personnel, Extension personnel. Impact: discussed dectes stem borer biology and its use in management with Bayer and Extension personnel in southern IL. Contact: Talon Becker. Attendance: 35. State focus area: Food and Environment.

**Research Report**

**A. Rotation-resistant western corn rootworm abundance patterns in East-central Illinois soybean fields.**

J.L. Spencer

Overall crop rotation-resistant western corn rootworm beetle (WCR) abundance per sweep in 2021 soybean (0.041 ± 0.005 WCR/sweep ± SEM) peaked in August (0.061 ± 0.007 WCR/sweep ± SEM) and was higher than that the overall mean from 2020 (0.008 ± 0.003 WCR/sweep ± SEM). The August WCR collection rate was significantly greater than that for July (0.026 ± 0.004). A total of 158 WCR beetles were collected in 4,000 sweeps. This was far below Champaign Co. collection rates from 2005-2006 (0.73 beetles per sweep) and the >1.5 WCR per sweep in 2004, but is consistent with modest populations that have been the rule since 2015 (see **Figure**). Despite the increase in WCR soybean field abundance since 2020, this pest is still at very low abundance compared to historical trends. The threat from rotation-resistant WCR remains low in East-central Illinois (this is likely true across much of Illinois). These data are consistent with county level samples for WCR in soybean from E. Illinois that were collected for a statewide sampling program. WCR populations do not present an economic threat locally. Higher, economically damaging populations are present in N. Illinois based on statewide surveys. Other potentially damaging pests like bean leaf beetle (BLB) and Japanese beetle (JB) were also in relatively low abundance (0.247 ± 0.102 BLB/sweep and 0.031 ± 0.005 JB/sweep, respectively) as they were in 2020 (0.085 ± 0.011 BLB/sweep and 0.003 ± 0.001 JB/sweep, respectively). Insect pest pressure at this location (on the University of Illinois South Farms) is well managed.

Chart

Description automatically generated

**2021 Dectes stem borer survey – larvae and stem tunneling**

Nicholas Seiter1 and Ashley Decker2, University of Illinois Department of Crop Sciences

1Research Assistant Professor, Field Crop Entomology | [nseiter@illinois.edu](mailto:nseiter@illinois.edu) | (812) 593-4317 2Research Specialist in Entomology

**Objective**: Determine the distribution and severity of dectes stem borer larvae in southern IL.

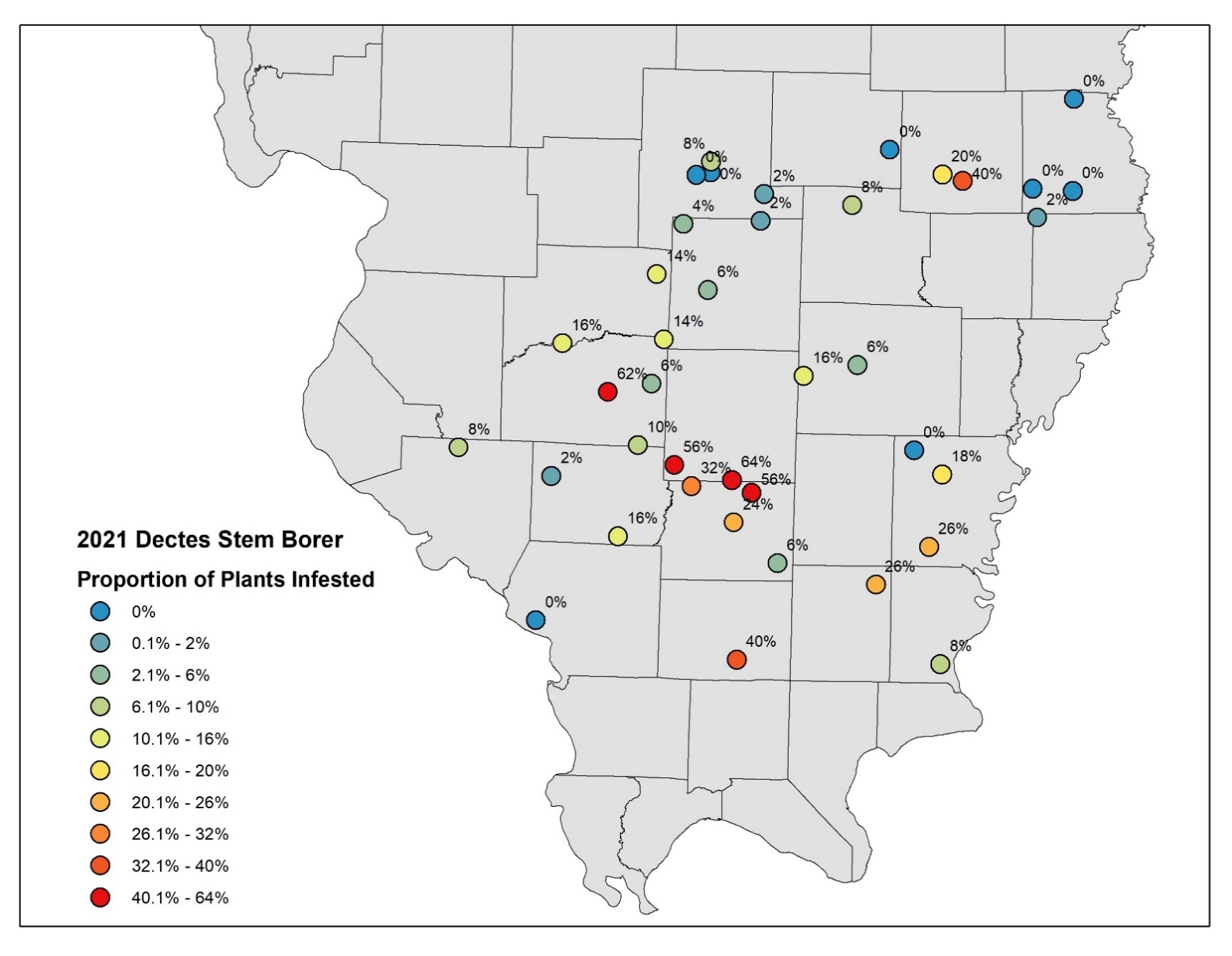
**Materials and Methods**: Soybean fields in southern IL were sampled beginning in September 2021 (growth stages R6-R8). The main stems of 25 or 50 soybean plants per field were split open, and the presence or absence of dectes stem borer larvae and/or their tunnels was recorded. These values were then used to determine the percent of plants infested for each field.

**Summary**: The level of infestation ranged from 0-64% of plants infested with either tunnels or larvae (see map on following page). This is the first year of a planned multi-year survey to observe the distribution and spread of this insect. If you are interested in participating in future surveys, please email [nseiter@illinois.edu](mailto:nseiter@illinois.edu) with the subject line “Illinois dectes survey.”

**Funding**: The Illinois Soybean Association provided funding for this effort.

**Acknowledgements**: We thank Mike Wurglitz (Corteva), Chad Guyer (Guyer Seed Sales), Talon Becker (University of Illinois Extension), and Jennifer Jones (University of Illinois Extension) for their help identifying and/or surveying fields.

Dectes stem borer larva and tunnel in a soybean stem



Proportion of sampled plants infested by dectes stem borer larvae (tunnels, larvae, or both present).

Map created by Dennis Bowman, University of Illinois Extension.

***S1080 Kansas State Report 2021***

***Brian McCornack and Jeff Whitworth***

**Kansas Overview:**

* Corn earworm continues to dominate the pest complex across much of the soybean in south central Kansas. Dectes stem borer continues to expand its range across much of the state and severity within the north central Kansas continues to increase where soybean acreage has increased. The Nebraska and Kansas border was extensively sampled this past summer for soybean gall midge infestations, but no populations were identified. Isolated populations of green clover worm continue to infest and substantially defoliate double crop soybean, and treatments have been warranted but only when yield potentials are high due to adequate rainfall
* Kansas has two major projects with the Kansas Soybean commission. The first is a research project aimed to create soybean plants resistant to soybean stem borer by inserting borer RNA into soybean plants to interfere (RNAi) with genes necessary for borer survival and increasing insecticide efficacy by using host plant and other environmental cues or conditions to adjust timing and placement of application. The second project focuses on the expansion of existing Research Experiences for Teachers (RET) program to other elementary schools in Kansas. Kansas also contributes to the North Central Soybean Research Program grant led by Kelley Tilmon.

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:* Along with collaborators in other Midwest states, we evaluated the adult activity period for soybean gall midge adults as part of a NCSRP funded effort. We also monitored the expansion of Dectes stem borer in historically under-reported counties across south eastern Kansas. Populations of this native pest continue to expand in severity in central Kansas, likely due to the increased acreage in soybean, including the increase in continuous soybean planting practices.

*Impact statements*: Documented phenology and expanded range and severity of Dectes texanus.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:* Kansas contributed to a binomial (decision-making) sampling plan that was developed by Koch in Minnesota for estimating stink bugs in Midwest soybean as part of a multistate effort. We also participated in the final year of a mult-year soybean defoliation validation study. PI165673 antibiosis resistance is polygenic and reduces D. texanus egg oviposition, larval density and could affect development of first-instar larvae. However, surviving larvae can tunnel into PI165673 stems, develop until the sixth-instar stage, and potentially cause girdling damage. Therefore, PI165673 resistance needs to be reinforced with other sources of soybean resistance or biotechnological techniques before releasing seed material to farmers. Future screening and evaluation of resistance to D. texanus should include records of larval size, weight, and developmental rate to detect soybean genotypes that impair or slow larval development inside the petioles and stems. Combining a high antibiosis ratio with larval development impairment in a cultivar could provide durable and long-term D. texanus resistance.

*Peer reviewed pubs:*

Aita, R.C., D.T. Pezzini, E.C. Burkness, C.D. DiFonzo, D.L. Finke, T.E. Hunt, J.J. Knodel, C.H. Krupke, L.Marchi-Werle, B. McCornack, A.P. Michel, C.R. Philips, N.J. Seiter, A.J. Varenhorst, R.J. Wright, W.D. Hutchison and R.L. Koch. 2021. Presence-absence sampling plans for stink bugs (Hemiptera: Pentatomidae) in the Midwest Region of the U.S. Journal of Economic Entomology 114(3): 1362–1372 <https://doi.org/10.1093/jee/toab076>

Aguirre-Rojas, Lina M., Lawrent L. Buschman, Brian McCornack, William T. Schapaugh, Erin D. Scully, Kun Y. Zhu, Harold N. Trick, and Charles M. Smith. 2021. "Inheritance of Antibiosis Resistance to the Dectes Stem Borer, Dectes texanus, in Soybean PI165673" Agronomy 11, no. 4: 738. https://doi.org/10.3390/agronomy11040738

*Impact statements:*Provided growers and consultants with sampling tools for estimating stink bug populations in commercial soybean.

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:* We have successfully extended our Research Experience for K-12 teacher program to Kansas teachers. In total, 58 elementary schools in 25 districts have incorporated “systems thinking” or inquiry approach using the soybean as the focus organism in their classrooms since the fall of 2012. The impact of this initial project resulted in thousands of children from these schools engaged in the study of science using soybean. A total of 115 teachers have been involved in the institute since 2012, which directly impacts over a thousand kids in a given school year through science curricula that uses soybean as the model system. This is a highly interactive process that started with the teachers engaging in science during a 3-week Institute at K-State.

***S1080 Kentucky State Report 2021***

***Raul T. Villanuevat, Armando Falcon, and Zenaida Viloria***

**Associated Students: Josey Tolley (molluks)**

**Kentucky Overview:**

* An outbreak of spider mites (a rare event in western Kentucky); was reported in soybeans in Union and Ballard counties by mid-July; the last episode tof this pest in W-KY was in 2021.
* Seedcorn maggots in corn and soybeans were reported in several counties of KY in 2021, abundant decaying matter and weather might had cause this epidode in May 2021.
* At the beginning of July until mid-August in 2021 there were reports of FAW outbreaks. Many forages, sorghum, and double crop soybeans were seriously affectedacroos several areas of KY.Although corn is affected, this outbreak did not cause damages to this crop.
* Slugs were also a severe problem in soybeans, many full season fields were replanted, and some farmers replanted at least four times.
* The brown marmorated stink bug continue its geographic expantion in KY. In 20120 were first reported in several soybean fields, in 2020 they are the second most abundant species after the green stink bug and displacing the brown sstink bug complex to a third place.

**(1) Using sunflowers as trap crop to reduce the soybean stem borer in western Kentucky**

This is a study, that is part of a multistate project with the university of Missouri (K. Rice), University of BEbraska (R. Whright) and University of Delaware (D. Owens). Here, I a reporting only the KY section.

The stalk borer *Dectes texanus* LeConte (Coleoptera: Cerambycidae) is an endemic long horned beetle that feeds on soybeans. This species can cause losses to soybean production across many soybeans grown areas of North America. The larvae feed on the pith of soybean stems during its development. This damage debilitates the plant and can cause lodging, which can be most likely on windy events or rain. Previous works have proposed the use of sunflower as a trap crop to reduce the attacks of the soybean stem borer in Kansas (Michaud & Grant 2005, Michaud et al., 2007). In those studies, they found that sunflower attract Dectes and soybeans in rows closer to sunflowers had higher Dectes populations than distant plants from sunflower plants. The objective of this study was to evaluate if sunflowers can be a trap crop in soybeans in Kentucky.

The numbers of *D. texanus* in soybean stalks and branches decreased as the distance to sunflower increased; the lowest incidence of D. texanus on soybean stalks was found at 200 m away from the sunflowers (Fig. 1). Within the sunflowers, the red cocklebur weevil, *Rhodobaenus quinquepunctatus* (Coleoptera: Curculionidae) was found colonizing the stalks (Fig. 2). Larvae of *R. quinquepunctatus* colonized the sunflowers earlier than *D. texanus* (Fig. 2a). T *Rhodobaenus quinquepunctatus* fed on most of the pith of sunflower in the lower half of the plant (Fig. 2b).

Chart, scatter chart

Description automatically generated

**Figure 1. Total counts of *Dectes texanus* larvae found in soybean stems at different distances from sunflower field edge .**

Weevil pupation occurred at the root and then adults chewed their way out of the plants (Fig. 2c).This beetle feeds on many weed species and on soybeans. *Rhodobaenus quinquepunctatus* was found in larger proportions (86%) than *D. texanus* in sunflower plants (Fig. 3).



**Figure 2. *Rhodobaenus quinquepunctatus* within sunflower stalks; a) immature larva, b) two larvae and their damage to the pith system of the plant; c) adult. Photos: Armando Falcon-Brindis.**

Chart, bar chart

Description automatically generated

**Figure 3. Percentage of infested plants by the cocklebur weevil (only sunflower) or Dectes at different distances from sunflower edge plot.**

**(2)** **Rapid colonization of western Kentucky by the brown marmorated stink bug in 2020-2021.**

Villanueva (unpublished) did not find the BMSB in many commercial soybean fields of western Kentucky from 2016 to 2019, and Gonzalez (2020) conducting a very intensive scouting for stink bugs in six western Kentucky counties had similar results in 2018 and 2019. Comparing 2020 and 2021, we noticed that BMSB dispersed rapidly. The path of this movement is unknown, it might be from east to west or north to south. The BMSB has been present in Kentucky since 2010; however, in the western region of the state and prior to 2020, findings were sporadic, and in most cases, they were hitchhikers –a well-known behavior of this species. Moreover, we confirmed the presence of the BMSB in five new counties in the western region (Carlisle, Ballard, McCracken, and Livingston) and one central (Hancock) Kentucky county. In terms of the the geographic spread of BMSB, its proportion is rapidly increasing when compared with 2020 (Figure 4).

Chart, sunburst chart

Description automatically generated

**Figure 4. Changes in the proportion of common stink bugs during 2020 and 2021 in western and central Kentucky. N = total stink bugs collected.**

**(3).** **Fall Armyworms Affected Double-Crop Soybeans in Many Counties of Kentucky in 2021**

The FAW is a native pest of the New World. In the continental USA, it overwinters in south Florida or in the southernmost region of Texas (The Rio Grande Valley). Adults are strong fliers and move northward during the summer months. In double-crop soybeans, fall armyworms can be devastating defoliators affecting plants from the seedling to V4 stages. During mid July, 2021, there were reports of FAW outbreaks that affected double-crop soybeans in Central and Western Kentucky from La Center (Ballard Co.) to Bowling Green (Warren Co). The pheromone-based trap in Princeton recorded 152, 280, 340 and 23 FAW moths through the last 4 weeks (July 9 to August 6), indicating that moth flight peaked by the end of July, however, egg masses were found up until mid-December.

At the UKREC at Princeton a double-crop soybean field adjacent to an alfalfa field was sprayed with a double mode of action insecticide containing λ-cyhalothrin + chlorantraniliprole (Besiege®) at 10 fl. oz./A. Tallies of caterpillar larvae were conducted 1 and 20 days after the spray in the inner (>60 ft from edge) and border (5 ft from field edge) areas of the field in soybeans, and field in the alfalfa within the 30 ft from the edge. Tallies were conducted in 6 to 10 sites in the border or inner parts of the field with 20 net sweeps in each site. In addition, an unsprayed double crop soybean field distant approximately 0.8 miles from the alfalfa field was tallied using the procedure described above. In all fields, tallies of caterpillars included FAW, alfalfa cloverworms, velvetbean caterpillar, and soybean loopers.

In this study the Besiege® was effective killing different stages of the FAW larvae and controlling soybean caterpillars. Even 20 days after the application only a single velvetbean caterpillar was found in the Besiege® sprayed field, whereas no FAW was detected (Figure 5). A similar situation was observed in a commercial field in Hardin County, KY, where caterpillars were not found 4 weeks after a Besiege® spray.

Chart

Description automatically generated

**Figure 5. Mean numbers (±SEM) of caterpillars in soybean and alfalfa fields with a single spray of Besiege® (20 fl.oz./ acre); and on a distant unsprayed soybean field (0.8 miles from the alfalfa field) at 1 and 20 days after the application. Live FAW were not found on any of these dates**

**(4) Evaluating Molluscicides for the Mananagement of Slugs in Soybeans**.

Slugs outbreaks were common in soybeans in in KY in 2021, many full season fields were replanted, some were replanted at least four times. Two molluscicides were applied in a field each at two different rates: iron phosphate at 20 and 40 Lbs/A, and metaldehyde at 5 and 10 Lbs/A.

Results of field application of molluscicides showed that the recommended rate of iron phosphate (44 lbs) was the most effective in decreasing the slug population (Figure 6). This treatment had the highest number of slugs in the plot after the molluscicide application, but then the number of slugs declined and by the end of the study, slugs were not found in any of these treated plots. The high number of slugs in the plot immediately after the molluscicide application could be due to attraction of the molluscicide baits. Baits might had attracted slugs to the application area and then did their job by killing the slugs after the molluscicide was ingested. The control might have a lower number of slugs at the beginning of the study because the slugs were attracted to baits and moved from these plots. However, by the end of the study the control had the greatest number of slugs. This al- so showed that molluscicide baits were effective because the slug populations in treated plots were lower than the control at the end of the experiment in all molluscicide treatments.

Chart, line chart

Description automatically generated

**Figure 6. Mean (±SEM) slug numbers/4ft row lengths after molluscicide application (arrow indicates the time of the molluscicide application).**

**(5). The Importance of Carabids in the Predation of Slugs in Soybeans**.

All these studies were were completed in the laboratory using 3cm in diameter Petri-dishes. Slug eggs, immatures and adults were used as prey. Slug eggs that were oviposited in the laboratory from a slug colony were used in the study. For the slug eggs, 10 eggs were placed in 1 Petri-dish. A black beetle on a white surface

Description automatically generated with medium confidenceFor immature slugs, 7 immatures were in 1 Petri-dish. Finally, there was 1 adult slug per Petri-dish. One ground beetle per Petri-dish was the standard for all 3 of these studies. An identification number was applied to each ground beetle so that data could be collected and added to their predation history for posterior identification of the carabid species.

All stages of slugs were preyed by most carabid beetles as shown in Figure 7

**Figure 7. Ground beetle feeding on immature slug. Photo: Josey Tolley**

Chart, bar chart

Description automatically generatedFigure 8 shows the predation of eggs, immature and adult slugs by individual carabid beetles. Most slug eggs were consumed in less than 72 h, most imatures were consumed in less than 24 h, and single slugs were consumed in less than 48 h (Figure 8)

Regarding the predatory behavior of ground beetles, the beetles used in this study are in process to determine their species. Some species of the ground beetles portrayed cannibalistic behaviors in the laboratory colony, that is the reason only 1 beetle was in each Petri dish. A couple of questions that arise from the ground beetle study are: how can we increase the population of predatory ground beetles in fields, would higher populations of ground beetles be enough to lower the population of slugs? And how insecticides affect these carabid beetles.

**Figure 8. Mean (±SEM) of different stages of slugs (10 eggs, 7 immature slugs, and 1 adult slug per petri-dish) preyed on by ground beetles (n =10 per each slug stage). (1 adult slug per Petri dish)**

*Professional presentations:*

* Expansion of the brown marmorated stink bug to western Kentucky soybean fields. Raul T. Villanueva and Zenaida Viloria

*Extension presentations:*

* Seedcorn Maggot Seen in Abundant Numbers in Corn and Soybeans. Raul Villanueva.
* Increased Mollusk Activity in Corn and Soybeans Observed in the spring of 2021. Raul Villanueva.
* Fall armyworms affected double-crop soybeans in many counties of Kentucky in 2021. Raul Villanueva.
* Soybean Gall Midge, the “new pest” of soybeans in the Midwest, still not detected in Kentucky
* Outbreaks of fall armyworm soybeans in western Kentucky
* Speculations on the Causes of Fall Armyworm Outbreaks in 2021 and its Management in Soybeans in Kentucky
* Effects of Various Rates of Potash and Molluscicides in the Management of Slugs: Laboratory and Field Studies. Josey Tolley, , Raul T. Villanueva, Entomology Extension Specialist, and Edwin Ritchey.
* Blister Beetles in Soybeans in Kentucky
* Description of the rapid colonization of western Kentucky by the brown marmorated stink bug 2020-2021. Armando Falcon-Brindis, Zenaida Viloria, and Raul T. Villanueva
* The Ragweed Weevil, a Harmless Visitor of Soybean Fields in Kentucky
* Evaluating sunflower as a trap crop for Dectes stem borer in western Kentucky.
* Evaluating Molluscicides and Carabid Predation of Slugs in Soybeans. Josey Tolley and Raul T. Villanueva
* Brown Marmorated Stink Bug Increases its Numbers in Western KY Soybeans in 2021 Raul Villanueva and Armando Falcon-Brindis

*Impact statements:*

* Sunflowers can potentially be used as trap crops to control Dectes. In addition, a native weevil, *R quinquepunctatus* competes with dectes for the same host plant and interferes with the movement of dectes larva from the stem to the root, a location where dectes overwinters.
* The brown marmorated stink bug is now well-spread in all Kentucky. Before 2020, BMSB reported in the western part of KY might be only “hitchikers”, in 2020 and 2021 BMSB are ubiquitous; and in 2021 it was the second most abundant species after the green stink bug.
* Slugs are becoming a frequent problem in soybeans, growers are deciding to pay for a molluscicide bait application (~$20/A) rather replanting soybeans.
* Laboratory studies in KY showed that carabid ground beetles play an important role reducing slug populations, however identification of these species are necessary as well as studies to increase carabid populations in fields and evalauting the effects of insecticide seed treatments

***S1080 Louisiana State Report 2021***

***Jeffrey A. Davis***

**Associated Post-Docs:** none

**Associated Students:** Scott T. Lee (PhD), Colin Bonser (PhD), Tyler Musgrove (MS)

**Louisiana Overview:**

In June of 2021, we confirmed a reproducing population of brown marmorated stink bug at a property in Iberville Parish. The Louisiana Soybean and Grain Research and Promotion Board has funded a project to determine brown marmorated stink bug pest distribution and densities in fields and surrounding landscapes in south central Louisiana. In general, pest populations were normal with redbanded stink bug still being the dominant soybean pest. Other hemipteran pests include threecornered alfalfa hopper, Southern green stink bug, green stink bug, and brown stink bug. Of lepidopterans, soybean looper is the most widespread followed by velvetbean caterpillar and green cloverworm. Like much of the Midsouth, we had an unexpected fall armyworm issue in soybean and pastures. Unlike previous years, pyrethroids were not effective in controlling them.

**Report summary**

(1) Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

The insects that utilize soybean as a food source have changed drastically over the last 20 yr. Much of the extension literature summarizing pest species distribution and abundance is out of date. We created a new article that provides profiles for five common soybean caterpillars, including description, life cycle, and injury to plant.

The distribution of lepidopteran pests in soybean is a current knowledge gap limiting accurate prioritization of Integrated Pest Management (IPM) research. Regional characterizations of lepidopteran distribution in soybean are now more than 25 yr old. The goal of this study was to generate a contemporary assessment of the distribution and population persistence of lepidopteran soybean pests. To understand which species are currently infesting soybean and their persistence, we conducted a survey of soybean entomologists with responsibility for approximately 33.6 million hectares of production in 31 U.S. states. We focused this survey on five lepidopteran pests: corn earworm (*Helicoverpa zea* Boddie) (Lepidoptera: Noctuidae), green cloverworm (*Hypena scabra* Fabricius) (Lepidoptera: Erebidae), painted lady (*Vanessa cardui* L.) (Lepidoptera: Nymphalidae), soybean looper (*Chrysodeixis includens* Walker) (Lepidoptera: Noctuidae), and velvetbean caterpillar (*Anticarsia gemmatalis* Hübner) (Lepidoptera: Erebidae). Results of this survey highlight dissimilar geographic distribution and relative persistence of lepidopteran pests in soybean. Clear differences in occurrence and abundance among species provide important contemporary distributions and persistence estimates. Assessments of scouting practices demonstrate a need to improve IPM adoption in some states. Estimated insect management costs and losses due to insects in soybean during the 2020 growing season were collected and compiled from 18 states to provide a record of insect pressure and management practices for the year. Participating states represented 48% of soybean acreage grown in the United States, with near 100% participation in southern states. Overall, the stink bug complex was the costliest insect pest in soybean followed by corn earworm. Total insect management costs were $15.80 per acre, with estimated crop losses to insects at $13.85 per acre, making the 2020 total costs plus losses $29.65 per acre.

*Peer reviewed pubs:*

Fleming, D. E., J. A. Davis, F. R. Musser, S. V. Paula-Moraes, R. C. Stephenson, C. A. Wheeler, E. Ringpis, T. S. Crum, J. K. Tran. 2021. Trapping soybean looper (Lepidoptera: Noctuidae) in the southeastern USA and implications for pheromone-based research and management. Florida Entomol. 104: 186-194.

Britt, K. E., T. P. Kuhar, W. Cranshaw, C. T. McCullough, S. V. Taylor, B. R Arends, H. Burrack, M. Pulkoski, D. Owens, T. A .Tolosa, S. Zebelo, K. A. Kesheimer, O. S. Ajayi, M. Samuel-Foo, J. A. Davis, N. Arey, H. Doughty, J. Jones, M. Bolt, B. J. Fritz, J. F. Grant, J. Cosner, and M. Schreiner. 2021. Pest management needs and limitations for corn earworm (Lepidoptera: Noctuidae), an emergent key pest of hemp in the United States. J. Integr. Pest Manag. 12, 34.

Huseth, A. S., R. L. Koch, D. D. Reisig, J. A. Davis, S. V. Paula-Moraes, and E. W. Hodgson. 2021. Current distribution and population persistence of five lepidopteran pests in U.S. soybean. J. Integr. Pest Manag. 11, <https://doi.org/10.1093/jipm/pmab004>.

Musser, F. R., A. L. Catchot, Jr., S. P. Conley, J. A. Davis, C. DiFonzo, S. H. Graham, J. Greene, R. L. Koch, D. Owens, D. D. Reisig, P. Roberts, T. Royer, N. J. Seiter, S. D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R. T. Villanueva, and M. O. Way. 2021. 2020 Soybean insect losses in the United States. Midsouth Entomol. 13: 1-25.

*Professional presentations:*

Fleming, D. E., J. A. Davis, F. Musser, F. R. Musser, S. V. Paula-Moraes, R. C. Stephenson, T. Galvan, and C. A. Wheeler. Trapping soybean looper, *Chrysodeixis includens* (Lepidoptera: Noctuidae), in the southeastern USA and implications for pheromone-based research and management. 2021 Annual Meeting of the Entomological Society of America, Denver, CO. November 2, 2021.

Lee, S. T., and J. A. Davis. Composition and temporal abundance of resident arthropod predators in Louisiana soybean. 2021 Annual Meeting of the Entomological Society of America, Denver, CO. November 1, 2021.

Lee, S. T., and J. A. Davis. Composition and temporal abundance of resident arthropod predators in Louisiana soybean. 11th Annual LSU Entomology Department Graduate Student Symposium, Baton Rouge, LA. October 22, 2021.

*Extension presentations:*

None

*Impact statements:*

Growers, researchers, and industry now know which pests are the most important in soybean and how they are distributed across the soybean growing regions of the U.S. Use of different trapping methods and the pheromones used have been tested.

(2) Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:*

Aphids are plant virus vectors whose vector efficiency can be altered by plant defenses. To determine if systemic induction influences aphid feeding behaviors related to virus transmission, three soybean varieties, Davis, Lyon, and Progeny 4906RR, were induced by subjecting plants to soybean looper (SBL) herbivory, or exogenous applications of either jasmonic acid (JA) or salicylic acid (SA). Green peach aphid (GPA) apterae feeding behavior was recorded on induced and control plants using the Electrical Penetration Graph (EPG) technique. SBL growth bioassays were used to assess systemic induction. Previous SBL herbivory reduced SBL larval weights when fed Progeny 4906RR. JA reduced larval weights on Progeny 4906RR and Davis. SA increased SBL larval weights on Lyon. SBL herbivory decreased behaviors associated with nonpersistent virus transmission in Davis and Progeny 4906RR. JA altered behaviors associated with virus transmission in Davis and increased behaviors associated with virus acquisition in Progeny 4906RR. SA delayed probing in Davis, but increased behaviors associated with virus transmission in Progeny 4906RR and Lyon. Inducing host plant resistance with JA may reduce herbivore performance and increase nonpersistent virus transmission. Previous chewing herbivory may decrease nonpersistent virus transmission by aphids but is variety dependent.

We investigated the effect of biodegradable polymeric lignin-based nanoparticles (LNPs) and zein nanoparticles (ZNP) on soybean plant health. Soybeans were grown hydroponically and treated with 0.02, 0.2, and 2 mg/ml of LNPs or ZNPs at 28 days after germination. Plants were harvested after 1, 3, 7 and 14 days of particle exposure and analyzed for root and stem length, chlorophyll concentration, dry biomass of roots and stem, nutrient uptake and plant ROS. Root and stem length, chlorophyll and stem biomass did not differ significantly between treatments and controls for LNPs-treated plants at all concentrations, and at low doses of ZNPs. At 2 mg/ml ZNPs, the highest concentration tested, after 7 days of treatment chlorophyll levels and root biomass increased and stem length was reduced in comparison to the control. Nutrient uptake was largely unaffected at 0.02 and 0.2 mg/ml NPs. A concentration-dependent increase in the oxidative stresses was detected, especially in the ZNP treated plants. Overall, LNPs and ZNPs had a minimum impact on soybean health especially at low and medium doses.

The current study investigated the relationship between constitutive and inducible resistance in vegetative-stage soybeans (V5-V6) against larvae of the generalist defoliator, *Spodoptera frugiperda*. Eighteen soybean genotypes differing in their constitutive resistance to coleopteran or lepidopteran defoliators were used over four experiments. Exogenous jasmonic acid (JA, 2 mM) was used to induce plants. Larval weight gains before JA treatments revealed genotypic variability in constitutive resistance. Overall, reductions in weight gain (28.7% to 76.7%), foliar consumption (3.7% - 65%) and conversion efficiency (10.9% -42.2%) were found in JA treatments. Significant (P < 0.05) or marginally significant (P < 0.10) negative correlations between constitutive resistance (larval weight gains on non-induced plants) and induced resistance (differences in weight gains before and after induction) were found in all four experiments, suggesting tradeoff between the two modes of resistance does exist in soybean for this herbivore. Additional evidence for tradeoffs between constitutive and inducible resistance was also found in the analysis of consumption data. Comparisons of consumption and conversion efficiencies suggest that similar antibiotic and antixenotic factors are involved in constitutive and inducible resistance to fall armyworm in soybean.

*Peer reviewed pubs:*

Salinas, F., C. E. Astete, J. H. Waldvogel, S. Navarro, J. C. White, W. Elmer, C. Tamez, J. A. Davis, and C. M. Sabliov. 2021. Effects of engineered lignin-graft-PLGA and zein-based nanoparticles on soybean health. NanoImpact, 23, 100329.

Hodgson, E. W., R. L. Koch, J. A. Davis, D. Reisig, S. V. Paula-Moraes. 2021. Identification and biology of common caterpillars in U.S. soybean.  J. Integr. Pest Manag. 12. <https://doi.org/10.1093/jipm/pmab006>

Lanka, S. K., B. D. Elderd, J. A. Davis, and M. J. Stout. 2021. Jasmonic acid-induced resistance to fall armyworm in soybeans: Variation among genotypes and tradeoffs with constitutive resistance. Basic Appl. Ecol. 56: 97-109.

Dryburgh, J., and J. A. Davis. 2021. Effect of soybean variety and systemic induction on herbivore feeding guilds. Arthropod-Plant Interactions 15: 171–181.

*Professional presentations:*

Arey, N., and J. A. Davis. Life table analysis of known noctuid pests of hemp, *Cannabis sativa* (L.). 11th Annual LSU Entomology Department Graduate Student Symposium, Baton Rouge, LA. October 22, 2021.

Arey, N., and J. A. Davis. Life table analysis of known noctuid pests of hemp, *Cannabis sativa* (L.). 2021 Annual Meeting of the Entomological Society of America Annual Meeting, Denver, CO. November 1, 2021.

Bonser, C. A. R., C. E. Astete, C. M. Sabliov, and J. A. Davis. Life history of *Chrysodeixis includens* (Lepidoptera: Noctuidae) on zein nanoparticles. 11th Annual LSU Entomology Department Graduate Student Symposium, Baton Rouge, LA. October 22, 2021. (infographic)

Bonser, C. A. R., C. E. Astete, C. M. Sabliov, and J. A. Davis. Developmental effects of biopolymeric nanoparticles on *Chrysodeixis includens* (Walker). 2021 Annual Meeting of the Entomological Society of America, Denver, CO. November 1, 2021.

Musgrove, T., and J. A. Davis. The effects of neonicotinoid seed treatments on threecornered alfalfa hopper, *Spissistilus festinus* (Say), in Louisiana soybean, *Glycine max* (L) Merr. 11th Annual LSU Entomology Department Graduate Student Symposium, Baton Rouge, LA. October 22, 2021

Musgrove, T., and J.A. Davis. The effects of neonicotinoid seed treatments on threecornered alfalfa hopper, *Spissistilus festinus* (Say), in Louisiana soybean, *Glycine max* (L) Merr. 2021 Annual Meeting of the Entomological Society of America, Denver, CO. November 1, 2021.

O’Hara, F. M., D. R. Swale, and J. A. Davis. Testing the effect of commercialized aphicides on the feeding behavior of the cotton aphid, *Aphis gossypii*. 2021 Annual Meeting of the Entomological Society of America, Denver, CO. November 1, 2021.

O'Hara, F. M. J. A. Davis, and D. R. Swale. Toxicity and changes to feeding behavior of *Aphis gossypii* after exposure to commercial insecticides. 2021 Fall Meeting of the American Chemical Society, Virtual Conference. August 22 - 26, 2021.

*Extension presentations:*

None

*Impact statements:*

Biodegradable nanoparticles will not impact soybean yield. Constitutive and inducible resistances vary by soybean variety and will need to be assessed each time a variety is released. Pheromone mating disruption may have a place in large row crops, but much work is needed to refine its use.

***S1080 MICHIGAN State Report 2021***

***Chris DiFonzo MSU Field Crops Entomologist***

Overview:

There were few pest issues in the season. A push for early planting resulted in some fields in SW Michigan with stand loss from seedcorn maggot. This was predictable and avoidable, if the interval between killing weeds & cover crops and planting had been longer. Seed treatments did not seem to make much difference. In the middle of the season, there were some fields that had high popualtions of soybean aphid in the Thumb of Michigan. These fields were sporadic, and populations crashed in fields that were not sprayed. It was abnormally warm well into the fall. In forages, fall armyworm was an issue in some fields. I had no reports of FAW in Michigan soybean, athough they were found in soybeans in neighboring states.

(1) Document changing soybean pest and beneficial arthropod assemblages.

Short Summary: Contributed yield loss estimates for 2021 to the soybean insect loss survey, run by F. Musser at Mississippi State. The publication below relates to losses in 2020.

Peer reviewed pubs:

Musser, F.R., A.L. Catchot, S. Conley, J. A. Davis, C. DiFonzo, S. Graham, J. Greene, R. Koch, D. Owens, D.D. Reisig, P. Roberts, T. Royer, N. Seiter, S.D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R.T. Villanueva, and M.O. Way. 2021. 2020 Soybean Insect Losses in the United States. Midsouth Entomologist 14 (1): 1-25.

(3) Develop coordinated best management practices (BMPs). As soybean insect pest

Short Summary: A multistate team has been sampling stink bugs in soybean for several years, in an attempt to document changes in populations, streamline sampling and better-predict damaging popualtions. Michigan has been part of that effort for several years, reflected in the publication below. A new sampling project is planned for 2022.

Peer reviewed pubs:

Aita, C.R., D.T. Pezzini, E.C. Burkness, C.D. DiFonzo, D.L. Finke, T.E. Hunt, J. J. Knodel, C.H. Krupke, L. Marchi-Werle, B. McCornack, A.P Michel, C.R. Philips, N.J. Seiter, A.J. Varenhorst, R.J. Wright, , W.D. Hutchison, and R.L. Koch. 2021. Presence–absence sampling plans for stink bugs (Hemiptera: Pentatomidae) in the Midwest region of the United States. J. Econ. Ent. 114(3): 1362–1372. doi: 10.1093/jee/toab076. [Impact factor 2.4]

Professional presentations:

Ribeiro, A.V., R.C. Aita, D.T. Pezzini, C.D. DiFonzo, T.E. Hunt, J. Knodel, C. Krupke, L. Marchi-Werle, A. Michel, N. Seiter, R. Wright, W. Hutchison, and R. Koch. 2021. Optimizing sample unit size for sampling stink bugs in Midwest soybean. ESA National Meeting, Denver, CO.

4) Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods.

Extension bulletins

DiFonzo (MSU) and Tilmon (OSU): Soybean gall midge ‘truck-ready’ identification post cards \* 75,000 printed. Cards mailed to every soybean farmer in Illinois; remainder distributed to cooperating entomologists in all states in the Midwest



DiFonzo, C. and K. Tilmon MSU-OSU Field Crops Insect Pest Management Guide (2021)

Chapter on soybean IPM

* Calendar
* damage checklist
* biology information
* scouting & thresholds
* non-chemical management
* insecticides

Extension presentations (n= 13 related to soybean)

• MSUE Integrated Crop & Pest Management Update, Dec 20. Insect Update

• Soybean Field Day, MSU Campus. 26 Aug. Insect update)

• MSU Field Crops Virtual Breakfast. 5 Aug. Insect update

• B&M Grower Field Day, Coldwater. 27 July. AGB & insect update

• ‘Ag Ideas to Grow With’ program, 19 Feb, Vertebrate damage in field crops

• AGB summit for OH and MI. 4 Feb. Update from Michigan

• Michigan Agribusiness Assoc. 3 Feb. MiCENT training in field crops entomology.

• Field Crops IPM Meeting, SW Michigan. 29 Jan. Neonic profitability

• Field Crops IPM Meeting, SE Michigan. 26 Jan. Neonic profitability

• SW Ag Conference Tek Talk, Ontario. 19 Jan. Q&A about insects and IPM

• Field Crops IPM Meeting, Thumb area. 13 Jan. Neonics & soil insects

• Field Crops IPM Meeting, Central area. 7 Jan. Insect open mic

• SW Ontario Ag Conference. 6 Jan. IPM Mythbusters

January 2021 “The Art of Scouting”. Recorded for the ‘In the Weeds’ podcast at <https://open.spotify.com/episode/5kMVPN8J4TM3Q7uas4WHDq?si=4smtnP7sQpKETbk93pUy-w>

Interview with DTN / Progressive Farmer, 13 July 2021. “Treated Seed Troubles. Seed Treatment Overload: The Unintended Consequences of a Popular Practice” by Emily Unglesbee

https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/07/13/seed-treatment-overload-unintended

Interview with DTN / Progressive Farmer r. 1 July 2021. “Aphids Versus Predators” by Emily Unglesbee

https://www.dtnpf.com/agriculture/web/ag/crops/article/2021/07/01/got-soybean-aphids-forget-look

OTHER - serving on five grad student committees related to soybean

Table

Description automatically generated

***S1080 Minnesota State Report 2021***

***Robert Koch and Bruce Potter***

**Associated Post-Docs:** Arthur Vieira

**Associated Students:** James Menger, Tina Lozano, Gloria Melotto

**Minnesota Overview:**

* Key insect pest activity, observations, or general findings
  + The 2022 drought conditions across much of Minnesota impacted soybean arthropod pests in the state. Soybean aphid is generally the most significant insect pest of soybean in Minnesota; however, the abundance of soybean aphid was very low across the state in 2022. This continues a downward population trend over the past few years. In contrast, two-spotted spider mites were quite abundant, with considerable acreage requiring insecticide treatments. Grasshoppers and bean leaf beetle were also abundant in parts of western Minnesota with insecticide treatments for the former mostly limited to borders to borders and the latter to the 1st generation. Finally, the known geographic range of soybean gall midge in Minnesota now includes 29 counties across southwest Minnesota.
* Overview of major projects or any multi-state collaborations
  + Multistate efforts, supported largely by the North Central Soybean Research Program (NCSRP), focused on sampling to determine the geographic range and phenology of soybean gall midge, and to assess fitness costs of pyrethroid resistance in soybean aphid. Another multistate project supported by NCSRP relates to stink bug sampling in Midwest soybean. Additional projects related to other aspects of insecticide resistance in soybean aphid, remote sensing for soybean aphid and Japanese beetle, sampling for stink bugs, host plant resistance for soybean aphid, biological control for and host range of soybean gall midge, and insecticide efficacy testing for soybean pests.

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

We made the first documentation of the hog peanut leafminer feeding on soybean, which may represent a host range expansion for this native insect.

*Peer reviewed pubs:*

Koch, R.L., J. Moisan-De Serres and A.V. Ribeiro. 2021. First reports of *Macrosaccus morrisella* (Lepidoptera: Gracillariidae) feeding on soybean, *Glycine max* (Fabales: Fabaceae). Journal of Integrated Pest Management 12(1): 1-4 <https://doi.org/10.1093/jipm/pmab038>

First documentation of the hog peanut leafminer feeding on soybean

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:*

Along with collaborators in other Midwest states, we evaluated the adult activity period for soybean gall midge adults as part of a NCSRP funded effort. As part of this funding, we also continued to document the range of the soybean gall midge in Minnesota soybean. Although economic damage from the soybean gall midge is currently limited to a few SW Minnesota fields, the range of this insect within the state is much wider. Additional Minnesota Soybean Research and Promotion Council funding began to expand this effort to evaluate potential native hosts and to dry bean.

Our remote sensing work with soybean aphid has expanded to address the Japanse beetle which is an emerging soybean pest in the state. We also documented the variability within and among soybean fields in target site mutations associated with pyrethroid resistance of soybean aphid, and separately for phenotypic variability of virulence to host plant resistance of soybean aphid.

*Peer reviewed pubs:*

Lozano, R., D.P. Paula, D.A. Andow and R.L. Koch. 2022. Validation of reference genes across populations of Aphis glycines (Hemiptera: Aphididae) for RT-qPCR analysis of gene expression related to pyrethroid detoxification. Journal of Entomological Science 57(2): xx-xx

Paula, D.P., R. Lozano, J. Menger, D.A. Andow and R.L. Koch. 2021. Identification of point mutations related to pyrethroid resistance in voltage-gated sodium channel genes in Aphis glycines. Entomologia Generalis 41(3): 243-255 DOI: 10.1127/entomologia/2021/1226

Bhusal, S.J., R.L. Koch and A.J. Lorenz. 2021. Variation in soybean aphid biotypes within fields. Journal of Economic Entomology 114(3): 1336-1344 https://doi.org/10.1093/jee/toab058

McMechan, A.J., E.W. Hodgson, A.. 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. Volume 12, Issue 1, 2021, 8, <https://doi.org/10.1093/jipm/pmab001> J

*Professional presentations:*

Ribeiro, A.V., T. Cira, R. Miller, L. Benhken, I.V. MacRae and R.L. Koch. 2021, October. Impacts of soybean aphid and Japanese beetle or artificial defoliation on spectral reflectance of soybean canopies. 10-minute presentation. Meeting of the Entomological Society of America. Denver, CO.

Menger, J., A.V. Ribeiro and R.L. Koch. 2021, October. Lack of evidence for fitness tradeoffs in soybean aphid (Hemiptera: Aphididae) with resistance to pyrethroid insecticides in the Upper Midwestern United States .10-minute presentation. Meeting of the Entomological Society of America. Denver, CO.

Ribeiro, A.V., R.C. Aita, D. Pezzini, C.D. DiFonzo, T.E. Hunt, J.J. Knodel, C.H. Krupke, L.Marchi-Werle, A.P. Michel, N.J. Seiter, R.J. Wright, W.D. Hutchison and R.L. Koch. 2021, October. Optimizing sample unit size for sampling stink bugs in Midwest soybean. Poster presentation. Meeting of the Entomological Society of America. Denver, CO.

# McMechan, A., E. W. Hodson, B. Potter, A. Varenhorst, T. Hunt, and B. Wright. 2021. Soybean gall midge: Understanding a new and emerging pest of soybean. 2021 Annual meeting of the Entomological Society of America. Oct. 31- Nov. 3. Symposium presentation.

*Extension presentations:*

Ribeiro, A., R.L. Koch and B Potter. 2021, December. Soybean insect research update. Prairie Grains Conference. Grand Forks, ND

Koch, R.L. 2021, February. Pest management in soybean: There's more than just aphids out there. Advanced Crop Advisors Workshop.

Koch, R.L., K. Ostlie and B. Potter. 2021, August. Late season insect and mite issues. Strategic Farming: Field Notes. August 4, 2021. University of Minnesota Extension

Potter, B. and R.L. Koch. 2021, January. Avoiding soybean gall midge misidentification. Midwest Soybean Gall Midge Discussion Series

Koch, R.L. and A. Hanson. 2021, July. Identification and scouting for insects and diseases. Field School for Agricultural Professionals. Institute for Agricultural Professionals, University of Minnesota Extension. St. Paul, MN

Koch, R.L. 2021, February. Managing soybean aphid and insecticide resistance. County Crops Day on the Radio (KDHL), University of Minnesota Extension Rice and Steele Counties

Koch, R.L. 2021, January. Soybean aphid management: Insecticide resistance and treatment decisions. Wisconsin Ag Business Classic. (25-minute presentation with 305 attendees)

Koch, R.L. 2021, January. Remote sensing for soybean aphid. Minnesota Ag Expo.

Koch, R.L. 2021, January. Advancing remote sensing for soybean aphid. Research Updates for Agricultural Professionals, Institute for Agricultural Professionals, University of Minnesota Extension.

Potter, B.D. 2021. Some Insect and disease issues for 2021. Virtual Meeting. February 26, 2021.

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

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

Potter, B.D. 2021. Understanding, detecting, and managing sporadic crop pest problems. 2021 Crop pest management short course. December 8. 2021. Minneapolis, MN.

Potter, B.D. 2021. Sometimes you need a hammer instead of pliers. Corn rootworm management. 2022 Crop management seminar. December 10, 2021. (Note: The presentation included a section on soybean gall midge distribution, scouting, and host plants.)

Potter, B.D. 2021. "Invertebrates in your cover crops" - 2021 Soil health management summit. Dec. 14, 2021. Mankato, MN.

*Impact statements:*

Advanced remote sensing capabilities for soybean aphid. Improved understanding of insecticide resistance in soybean aphid. Documented phenology and geographic range of soybean gall midge.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

A binomial (decision-making) sampling plan was developed for stink bugs in Midwest soybean as part of a multistate effort. We participated in the final year of a multi-state NCSRP-funded study on effects of cover crop termination on insects in soybean

*Peer reviewed pubs:*

Aita, R.C., D.T. Pezzini, E.C. Burkness, C.D. DiFonzo, D.L. Finke, T.E. Hunt, J.J. Knodel, C.H. Krupke, L.Marchi-Werle, B. McCornack, A.P. Michel, C.R. Philips, N.J. Seiter, A.J. Varenhorst, R.J. Wright, W.D. Hutchison and R.L. Koch. 2021. Presence-absence sampling plans for stink bugs (Hemiptera: Pentatomidae) in the Midwest Region of the U.S. Journal of Economic Entomology 114(3): 1362–1372 <https://doi.org/10.1093/jee/toab076>

*Extension presentations:*

Potter, B.D. 2021. "Invertebrates in your cover crops" - 2021 Soil health management summit. Dec. 14, 2021. Mankato, MN.

*Impact statements:*

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:*

Covid impacted in-person meetings and field day activities. Users of soybean pest management information were still reached via extension newsletters, radio and webinars.

With the spider mite outbreak, extension materials were produced to provide guidance on insecticide/miticide selection for this pest ( <https://blog-crop-news.extension.umn.edu/2021/08/environmental-protection-agencys.html> and

<https://blog-crop-news.extension.umn.edu/2021/07/two-spotted-spider-mites-in-2021.html> )

We also wrote a series of articles related to caterpillar pests in soybean.

*Peer reviewed pubs:*

Huseth, A.S., R.L. Koch, D. Reisig, J.A. Davis, S. Paula-Moraes and E.W. Hodgson. 2021. Current distribution and population persistence of five lepidopteran pests in U.S. soybean. Journal of Integrated Pest Management 12(1): 1-10 https://doi.org/10.1093/jipm/pmab004

Hodgson, E.W., R.L. Koch, J.A. Davis, D. Reisig and S. Paula-Moraes. 2021. Identification and biology of common caterpillars in U.S. soybean. Journal of Integrated Pest Management 12(1): 1-8 https://doi.org/10.1093/jipm/pmab006

# McMechan, A., E. W. Hodson, B. Potter, A. Varenhorst, T. Hunt, and B. Wright. 2021. Soybean gall midge: Understanding a new and emerging pest of soybean. 2021 Annual meeting of the Entomological Society of America. Oct. 31- Nov. 3. Symposium presentation.

*Impact statements:*

Peer-reviewed Extension-focused articles (JIPM) were published on caterpillars and soybean gall midge in soybean.

***S1080 Mississippi State Report 2021***

***Fred Musser, Angus Catchot, Don Cook, Whitney Crow, Jeff Gore***

**Associated Post-Docs:**

**Associated Students:** Jacob Smith, Gene Merkl, Judge Fortenberry, Sena Isbilir, Tom Paul

**Mississippi Overview:**

* The primary insect pests in Mississippi during 2021 were stink bugs, corn earworm and soybean looper as has been reported every year since insect losses were first estimated in 2004. As such, most of our research and extension efforts were focused on these three pests during 2021. This includes documenting population dynamics of soybean looper using pheromone traps (Obj. 1), compiling estimated insect losses in soybean for the nation (Obj. 1), studying the genetic and physiological bases of insecticide resistance in soybean looper (Obj. 2), studying the overwintering behavior of redbanded stink bug (Obj. 2), studying the interaction of agronomic factors and defoliation (Obj. 3), and studying the efficacy and residual of insecticides and insecticidal seed treatments (Obj. 3). In addition to presenting and publishing these data in professional forums, numerous presentations and publications targeted growers and consultants (Obj. 4).

**Report summary –** In total, we published 5 refereed and 26 other articles, presented 9 papers at professional meetings and gave 19 extension presentations. These publications and presentations spanned all 4 objectives of the S1080 project. Several were multi-state efforts, but the majority were done entirely within Mississippi. The number of Arthropod Management Test reports was large this year as there was an effort to publish data from all insecticide efficacy trials completed over the last 5 years.

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

Soybean insect losses are compiled annually. The report covering 2020 includes data from 18 states representing 48% of U.S. soybean acreage. Over time, the changes in infestation and injury reported can provide an indication of the spread or contraction of insect populations with changes in weather and production practices.

*Peer reviewed publications:*

Fleming, D. E., J. A. Davis, F. R. Musser, S. V. Paula-Moraes, R. C. Stephenson, C. A. Wheeler, E. Ringpis, T. S. Crum, and J. K. Tran. 2021. Trapping soybean looper (Lepidoptera: Noctuidae) in the Southeastern USA and implications for pheromone-based research and management. Flor. Entomol. 104(3): 186-194. <https://doi.org/10.1653/024.104.0307>

*Other publications:*

Musser, F. R., A. L. Catchot, Jr., S. P. Conley, J. A. Davis, C. DiFonzo, S. H. Graham, J. K. Greene, D. Owens, D. D. Reisig, P. Roberts, T. Royer, N. J. Seiter, R. Smith, S. D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R. T. Villanueva, and M. O. Way. 2021. 2020 soybean insect losses in the United States. Midsouth Entomol. 14: 1-25. <http://midsouthentomologist.org.msstate.edu/>.

*Professional presentations:*

Fleming, D., J. Davis, F. Musser, S. Paula-Moraes, R. Stephenson, T. Galvan, and C. Wheeler. Trapping soybean looper, *Chrysodeixis includens* (Lepidoptera: Noctuidae) in the southeastern USA and implications for pheromone-based research and management. Entomol. Soc. Amer. annual meeting, Denver, CO, Nov. 2, 2021.

*Extension presentations:*

D. Cook, W.D. Crow, J. Gore, and A.L. Catchot. 2021. Unusual Pests Impacting Soybean. Row Crop Short Course, Starkville, MS, December 2021.

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:*

Two graduate students, Tom Paul and Sena Isbilir, are conducting studies on stink bug overwintering and recolonization, and the mechanisms of insecticide resistance in soybean looper, respectively.

*Peer reviewed publications:*

Reisig, D. D., D. Cook, J. Greene, M. Caprio, J. Gore, F. Musser, and F. Reay-Jones. 2021. Vertical and temporal distribution of *Helicoverpa zea* (Lepidoptera: Noctuidae) larvae in determinate and indeterminate soybean. Bull. Entomol. Res. 111(3): 282-288 <https://doi.org/10.1017/S0007485320000619>.

*Professional presentations:*

Isbilir, S., F. Musser, and S. Ahn. Molecular cloning of a ryanodine receptor, a target of diamide insecticide, in the soybean looper. MS Entomol. Assn. annual meeting, Mississippi State, MS, Nov. 8, 2021.

Isbilir, S., F. Musser, and S. Ahn. Molecular cloning of a ryanodine receptor, a target of diamide insecticide, in the soybean looper, *Chrysodeixis includens*. MS Academy Sci. annual meeting, Biloxi, MS, Aug. 5, 2021

Paul, T., A. Catchot, F. Musser, P. Basu, and S. Ward. Assessing overwintering survival and range dynamics of redbanded stink bug. Poster at Entomol. Soc. Amer. annual meeting, Denver, CO, Nov. 3, 2021.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

Two former graduate students, Ben Thrash and Adam Whalen, had papers published that evaluated the interaction of agronomic variables and defoliation, and neonicotinoid degradation over time, respectively. Two current graduate students, Jacob Smith and Judge Fortenberry, are conducting research on residual activity of insecticides, and optimizing the use of nuclear polyhedrosis viruses (NPV) for insect control in soybean, respectively. In addition, the results of many insecticide efficacy trials on the common pests found on Mississippi soybeans were published in Arthopod Management Tests.

*Peer reviewed publications:*

Thrash, B., A. Catchot, J. Gore, D. Cook, F. Musser, T. Irby, and J. Krutz. 2021. Effects of soybean plant population on yield loss from defoliation. J. Econ. Entomol. 114(2): 702-709. <https://doi.org/10.1093/jee/toaa279>

Thrash, B., A. Catchot, J. Gore, D. Cook, F. Musser, T. Irby, J. Krutz, and G. Lorenz. 2021. Effects of soybean planting date on yield loss from defoliation. J. Econ. Entomol. 114(2): 993-997. <https://doi.org/10.1093/jee/toaa280>

Whalen, D. A., A. L. Catchot, Jr., J. Gore, S. D. Stewart, G. M. Lorenz, D. R. Cook, F. R. Musser, J. W. Harris, and N. Krishnan. 2021. Temporal profile of neonicotinoid concentrations in cotton, corn and soybean resulting from insecticidal seed treatments. Agronomy 11(6): 1200. <https://doi.org/10.3390/agronomy11061200>

*Other publications:*

Bateman, N.R., A.L. Catchot, D. Bao, and W.D. Crow. 2021. Residual efficacy of selected insecticides for control of soybean loopers in soybeans, 2013 (Test 2). Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab001>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Efficacy of selected insecticide against stink bugs in soybean 1, 2020. Arthropod Management Tests. 46(1). <https://doi.org/.1093/amt/tsab018>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Efficacy of selected insecticides against stink bugs in soybean 2, 2020. Arthropod Management Tests. 46(1). <https://doi.org/10.1093/amt/tsab024>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Efficacy of selected insecticides against stink bugs in soybean 3, 2020. Arthropod Management Tests. 46(1). <https://doi.org/10.1093/amt/tsab025>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Efficacy of selected insecticides against stink bugs in soybean 4, 2020. Arthropod Management Tests. 46(1). <https://doi.org/10.1093/amt/tsab026>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Efficacy of selected insecticides against stink bugs in soybean 5, 2020. Arthropod Management Tests 46(1). <https://doi.org/10.1093/amt/tsab106>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Impact of selected insecticide seed treatments on soybean stand establishment and yield 1, 2019. Arthropod Management Tests. 46(1). <https://doi.org/.1093/amt/tsab021>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Impact of selected insecticide seed treatment on soybean stand and establishment and yield 2, 2019. Arthropod Management Tests. 46(1). <https://doi.org/10.1093/amt/tsab109>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Impact of early season insecticide applications on soybean stand establishment, 2020. Arthropod Management Tests. 46(1). <https://doi.org/.1093/amt/tsab017>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Impact of selected insecticide seed treatments on soybean stand establishment and yield, 2020. Arthropod Management Test. 46(1). <https://doi.org/10.1093/amt/tsab086>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Performance of selected insecticides against corn earworm infesting soybean, 2020. Arthropod Management Tests. 46(1). <https://doi.org/.1093/amt/tsab019>

Cook, D. R., W. Crow, J. Gore, and M. Threet. 2021. Performance of selected insecticides against soybean looper in soybean, 2020. Arthropod Management Tests. 46(1). <https://doi.org/.1093/amt/tsab020>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides on kudzu bug in soybean, 2015. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab033>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides for control of Lepidoptera pests in soybean, 2016. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab034>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides for control of Lepidoptera pests in soybean, 2016 (Test 2). Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab035>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides for control of Lepidoptera pests in soybean, 2017. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab154>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides for control of redbanded stink bug in soybean, 2017. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab153>

Crow, W.D., A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticides for control of soybean insect pests, 2016. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab132>

Smith, J.H, W.D. Crow,, A.L. Catchot, D. Bao. 2021. Efficacy of selected insecticide for soybean looper control in soybean, 2020. Arthropod Manag. 46(1). <https://doi.org/10.1093/amt/tsab145>

*Professional presentations:*

Smith, J., W.D. Crow, A.L Catchot, J. Gore, and D.R. Cook., November 2021. Determining residual activity of commonly used insecticides in midsouthern soybean production systems. Entomological Society of America Annual Meeting, Entomological Society of America, Denver, CO.

Smith, J., W.D. Crow, A.L Catchot, J. Gore, and D.R. Cook. November 2021. Determining residual and systemic activity of chlorantraniliprole in soybean. Mississippi Entomological Association Meeting, Mississippi Entomological Association, Starkville, MS.

Fortenberry, J., D.R. Cook, A.L. Catchot, W.D. Crow and, J. Gore. November 2021. Novel use strategies of NPVs in midsouthern cropping systems." Oral Presentation. Entomological Society of America

Fortenberry, J., D.R. Cook, A.L. Catchot, W.D. Crow and, J. Gore. November 2021. Novel use strategies of NPV's in midsouthern cropping systems. Mississippi Entomological Association Meeting, Mississippi Entomological Association, Starkville, MS.

Musser, F. Insecticide resistance monitoring: 2018-2020. S1080 annual meeting, Virtual, Mar. 25, 2021.

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:*

The Mississippi Crop Situation blog is a resource of pest management information widely used by farmers and consultants in Mississippi and the surrounding region for all agronomic crops, including soybean. Therefore we have published several articles on pest management in the blog. In addition, overall soybean insect management was a topic at many winter producer meetings during 2021.

*Extension publications:*

Catchot, A. L., W.D. Crow, J. Gore, D.R. Cook. 2021. Insecticide seed treatments in MS soybeans: Do they pay? MS Crop Situation blog. April 19, 2021 <https://www.mississippi-crops.com/2021/04/19/insecticide-seed-treatments-in-ms-soybeans-do-they-pay/>

Catchot, A., J. Gore, W. Crow, and D. Cook. Cool and wet conditions increase slug concerns in Mississippi. MS Crop Situation blog. May 11, 2021. <https://www.mississippi-crops.com/2021/05/11/cool-and-wet-conditions-increase-slug-concerns-in-mississippi/>

Catchot, A., W. Crow, D. Cook and J. Gore. RBSB distchbank survey: Week of 5/3/21. MS Crop Situation blog. May 7, 2021. <https://www.mississippi-crops.com/2021/05/07/rbsb-ditchbank-survey-week-of-5-3-21/>

Crow, W., J. Bond, T. Allen, D. Cook and J. Gore. Insect and disease in lultra-late soybean (Podcast). MS Crop Situation blog. Aug 3, 2021. <http://extension.msstate.edu/content/insects-and-diseases-ultra-late-soybean>

Crow, W.D. A.L. Catchot, J. Gore, D. Cook, B. Layton, F. Musser, B. Pieralisi, E. Larson, and T. Irby. 2021. 2021 Insect Control Guide for Agronomic Crops. Mississippi State University Extension. P2471

Gore, J., A. Catchot, W. Crow and D. Cook. Alert: Poor control of fall armyworm across the state. MS Crop Situation blog. June 26, 2021. <https://www.mississippi-crops.com/2021/06/26/alert-poor-control-of-fall-armyworm-across-the-state-soybean-and-rice/>

*Extension presentations:*

Catchot, A. Soybean management strategies for 2021 (18 producer meetings in 2021, various counties)

***S1080 North Carolina State Report 2021***

***Dominic Reisig***

**Associated Students:** Taynara Possebom, Kevin Orta

Accomplishments under the major goals of the project:

1. Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

* The non-peer reviewed article authored by Musser et al. (2021) in this reporting period documented soybean insect pest incidence and damage across 39% of the US soybean acreage. I contributed estimates from North Carolina. Yearly reporting from North Carolina has revealed that corn earworm is consistently the top pest. Stink bugs and soybean loopers are usually the second and third most important pests.

1. Characterize soybean insect biology and ecology. The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures.

* The peer-reviewed articles reported during this period revealed that determinate and

indeterminate soybean growth habit did not impact *Helicoverpa zea* larval preference for different soybean tissue types or vertical positions on soybeans plants. Our studies suggest *H. zea* larvae prefer specific tissue types, but also provide evidence that experimental design can influence the results. Furthermore, our studies also lend support to the hypothesis that *H. zea* larval movement and location within soybean canopies may not result entirely from oviposition location and nutritional requirements.

1. Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

* Nothing to report

1. Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

* Three soybean management webinars were given, attended by 272 total individuals.
* Soybean insect management recommendations were presented at 16 county-based North Carolina grower meetings, reaching 814 total individuals.
* Three in-person county agent trainings were performed across North Carolina, reaching nearly all agents with soybean responsibilities (~70).
* Three invited presentations were given at the Southwest Agricultural Conference in Ridgetown, ON on 7 January, 2020. This is an Extension conference attended by growers and 300 attendees were reached here.
* As reported above, YouTube and the web was used to reach growers. In addition, articles (n= 6) were posted on soybeans.ces.ncsu.edu

Peer-reviewed articles

* Reisig, D. R., D. Cook, J. Greene, M. Caprio, J. Gore, F. Musser, and F. Reay-Jones. 2020. Vertical and temporal distribution of *Helicoverpa zea* (Lepidoptera: Noctuidae) larvae in determinate and indeterminate soybean. Bull. Entomol. Res. doi: 10.1017/S0007485320000619
* Reisig, D. R., D. Cook, J. Greene, M. Caprio, J. Gore, F. Musser, and F. Reay-Jones. 2020. Location of *Helicoverpa zea* (Lepidoptera: Noctuidae) larvae on different plant parts of determinate and indeterminate soybean. Bull. Entomol. Res. 110: 725-731. doi: 10.1017/S0007485320000280

Non-peer reviewed articles

* Musser, F. R., A. L. Catchot, Jr., S. P. Conley, J. A. Davis, C. DiFonzo, J. Greene, G. M. Lorenz, D. Owens, D. D. Reisig, P. Roberts, T. Royer, N. J. Seiter, S. D. Stewart, S. Taylor, K. Tilmon, R. T. Villanueva, and M. O. Way. 2020. 2019 soybean insect losses in the United States. Midsouth Entomol. 13: 1-23.

YouTube videos

- Stink bug management in soybeans. 2020. <https://www.youtube.com/watch?v=TKTxSfwiFIE&feature=emb_logo>

-     Mid-season soybean insect scouting. 2020. <https://www.youtube.com/watch?v=5YvQEo1lWv8>

-     Corn earworm in soybeans. 2020. <https://www.youtube.com/watch?v=1rVwz4z19qg&feature=youtu.be>

Webpages

Management of Soybean Insect Pests in North Carolina

* Armyworm complex
  + https://content.ces.ncsu.edu/armyworm-complex
* Bean leaf beetle
  + https://content.ces.ncsu.edu/bean-leaf-beetle-in-soybean
* Blister beetle
  + https://content.ces.ncsu.edu/bilster-beetle-in-soybean
* Corn earworm
  + https://content.ces.ncsu.edu/corn-earworm-in-soybean
* Cutworm
  + https://content.ces.ncsu.edu/black-cutworm-in-soybean
* Dectes stem borer
  + https://content.ces.ncsu.edu/dectes-stem-borer-in-soybean
* Grape colaspis
  + https://content.ces.ncsu.edu/grape-colaspis-in-soybean
* Grasshoppers and Crickets
  + https://content.ces.ncsu.edu/grasshoppers-and-crickets-in-soybean
* Green Cloverworm
  + https://content.ces.ncsu.edu/green-cloverworm-in-soybean
* Kudzu bug
  + https://content.ces.ncsu.edu/kudzu-bug
* Lesser cornstalk borer
  + https://content.ces.ncsu.edu/lesser-cornstalk-borer-in-soybean
* Mexican bean beetle
  + https://content.ces.ncsu.edu/mexican-bean-beetle-in-soybean
* Slugs
  + https://content.ces.ncsu.edu/slugs-in-soybean
* Soybean aphid
  + https://content.ces.ncsu.edu/soybean-aphid-in-soybean
* Soybean looper
  + https://content.ces.ncsu.edu/soybean-looper-in-soybean
* Spider mite
  + https://content.ces.ncsu.edu/spider-mites-in-soybean
* Stink bug
  + https://content.ces.ncsu.edu/stink-bug-in-soybean
* Threecornered alfalfa hopper
  + https://content.ces.ncsu.edu/three-cornered-alfalfa-hopper-in-soybean
* Thrips
  + https://content.ces.ncsu.edu/thrips-in-soybean
* Velvetbean caterpillar
  + <https://content.ces.ncsu.edu/velvetbean-caterpillar-in-soybean>

Impacts: We found evidence that *Helicoverpa* zea larvae, largely prefer soybean leaves and are distributed evenly throughout the canopy. Documentation of losses provides a historical context to track pest importance over time.

Outputs:

* Three soybean management webinars were given, attended by 272 total individuals.
* Soybean insect management recommendations were presented at 16 county-based North Carolina grower meetings, reaching 814 total individuals.
* Three in-person county agent trainings were performed across North Carolina, reaching nearly all agents with soybean responsibilities (~70).
* Three invited presentations were given at the Southwest Agricultural Conference in Ridgetown, ON on 7 January, 2020. This is an Extension conference attended by growers and 300 attendees were reached here.
* As reported above, YouTube and the web was used to reach growers. In addition, articles (n= 6) were posted on soybeans.ces.ncsu.edu

***S1080 North Dakota State Report 2021***

***Janet Knodel***

**Post-Doc: Dr. Veronica Calles Torrez**

State Overview:

* The key insect pests that we scout for are soybean aphids, spider mites, grasshoppers and bean leaf beetles. North Dakota was in a severe to extreme drought in 2021, and grasshoppers were the most common insect pest problem. Spider mites were not as common as expected with the drought. Soybean aphid continues to be low since 2018. Bean leaf beetles is increasing, but not economic yet in southeastern North Dakota.
* We collaborate in the multistate project *Regional Response to Insecticide-Resistant Soybean Aphids* lead by Dr. Koch of University of Minnesota for the NCSRP. In addition, we are active surveying for the soybean gall midge in North Dakota. The IPM Crop Survey Program survey for economic insect pests of soybean through trained IPM scouts throughout the state.

North Dakota is participating in these two objectives:

Objective 1. Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

Objective 2. Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

**OBJECTIVE 1: Document changing soybean pest and beneficial arthropod assemblages.**

* **NCSRP Multistate Project - Regional Response to Insecticide-Resistant Soybean Aphids**

o Participating in this objective to compare results of glass-vial bioassay of susceptibility of soybean aphid to pyrethroid insecticides with results from pyrethroid performance in field efficacy trials (Project Leader Robert Koch & James Menger-Anderson, University of Minnesota)

* **Research supported by the *North Dakota Soybean Council***

**Objective 1: Screening populations of soybean aphids for insecticide resistance.**

**Soybean aphids** were not an economic pest problem in 2021. This suggests that some soybean aphid populations in North Dakota may be susceptible to pyrethroid insecticides. Since soybean aphids are mobile, pyrethroid resistant soybean aphid populations could migrated yearly into North Dakota from other resistant areas, such as south-central Minnesota where the resistance

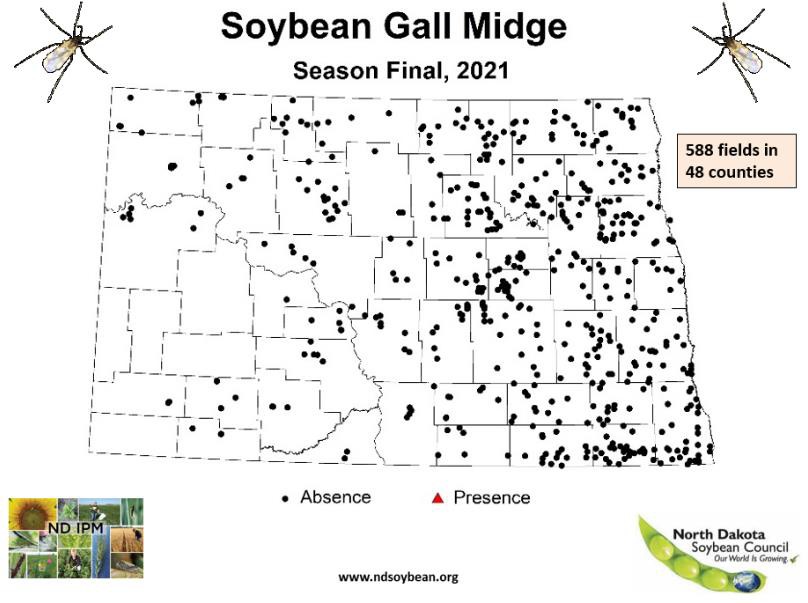
first occurred in 2015. Since pyrethroid resistant soybean aphids can vary by year and locations, screening more populations of soybean aphids in ND is key to determine their presence or absence, and their resistance status. These findings will be essential for soybean growers, so they can wisely decide which insecticide to use when soybean aphid populations are above the E.T. level.

**Objective 2: To survey for the invasive soybean gall midge in North Dakota**

Soybean gall midge, *Resseliella maxima*, continues to be an economic new pest of soybeans and has increased its presence in Iowa, Minnesota, Nebraska, South Dakota and Missouri from a total of 67 counties in 2018 to 114 counties in 2020 to 140 counties in 2021 (Source: J. McMechan, University of Nebraska).

A total of 588 soybean fields was surveyed to detect soybean gall midge larvae in 48 counties of North Dakota during 2021. A more intense survey was focus in the eastern part of the state (Figure 1). Soybean fields were sampled from June to mid-August. Soybean crop stages were between the VE (cotyledons emergence) and R6 (full seed set formation).

Field observations from soybean gall midge-infested states indicate that this insect is commonly found near field edges and on soybean plants adjacent to dense vegetation such as shelterbelts or uncut grass. Therefore, at each field site, a line-transect was walked near the field edge, and 10 consecutive plants were examined for the presence of soybean gall midge or symptomatic plants at 10 sampling sites per field. A total of 100 plants per field was examined. Sampling sites were separated by 60 ft. If darkened areas were present at the base of stems, the outer epidermis of the stem was



**Figure 1.**

peeled back to see if white - orange larvae were present. At each field site, the GPS location and crop stage were recorded.

Fortunately, our results from the 2021 soybean gall midge survey were negative for all soybean fields surveyed in North Dakota for a second year in a row (Fig. 1). Good news for ND soybean farmers!

Data were mapped using ArcMap to show its absence.

Maps were posted on the IPM website under soybean.

**Peer-reviewed research publications:**

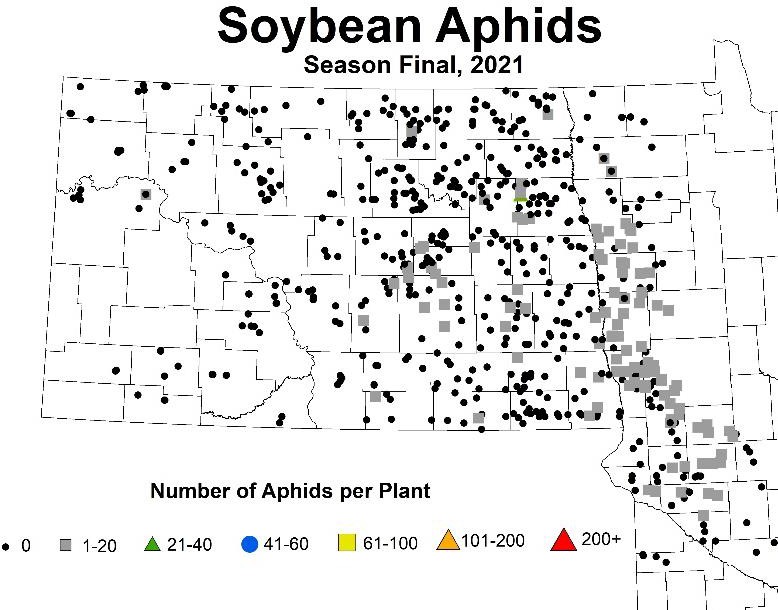
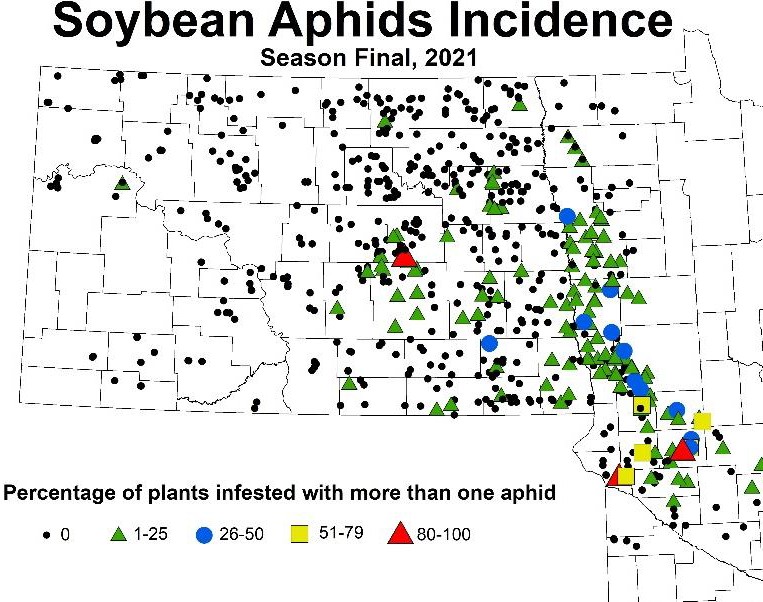
Rafael Carlesso Aita, Daniela T. Pezzini, Eric C. Burkness, Christina D. DiFonzo, Deborah L. Finke, Thomas E. Hunt, Janet J. Knodel, Christian H. Krupke, Lia Marchi-Werle, Brian McCornack, Andrew P. Michel, Christopher R. Philips, Nicholas J. Seiter, Adam J. Varenhorst, Robert J. Wright, William D. Hutchison, and Robert L. Koch. 2021. Presence–Absence Sampling Plans for Stink Bugs (Hemiptera: Pentatomidae) in the Midwest Region of the United States. J. Econ.

Entomol. 114(3):1362-1372.

**OBJECTIVE 4:** Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods.

**EXTENSION OUTREACH** (meetings, publications) increase knowledge on the importance of Integrated Pest Management strategies for control of soybean aphids and other soybean insect pests. Some examples are field scouting, economic thresholds, insecticide recommendations, development of insecticide resistance, role of biological control agents and host plant resistance.

* **Trade magazine:**
  + Knodel, J.J. 2021. Spider mites come with drought. The North Dakota Soybean Grower Magazine. 10(4): 27 (August 2021).
* **Peer-reviewed Extension Publications with soybean insect information:**
  + **Knodel, J.J.**, P. Beauzay, and K. Hoppe. 2021. Blister Beetle Management in Forages and Field Crops E1002 (revised). NDSU Ext., Fargo, ND.
  + Calles-Torrez, V., P. Beauzay, T.J. Prochaska and **J.J. Knodel**. 2021. Common Natural Enemies of Insect Pests E2013. NDSU Ext., Fargo, ND.
  + **Knodel, J.J.**, P. Beauzay, M.A. Boetel, T.J. Prochaska and A. Chirumamilla. 2020. 2021 North Dakota Field Crop Insect Management Guide E1143 (revised). NDSU Ext., Fargo, ND. [https://www.ndsu.edu/agriculture/ag-hub/publications/north-dakota-field-crop-insect-](https://www.ndsu.edu/agriculture/ag-hub/publications/north-dakota-field-crop-insect-management-guide) [management-guide](https://www.ndsu.edu/agriculture/ag-hub/publications/north-dakota-field-crop-insect-management-guide)
* **Extension Newsletter – NDSU Extension *Crop & Pest Report*: (soybean insect articles only)**
  + Knodel, J.J., Beauzay, P.B., Friskop, A., and Markell, S. 2021. IPM crop survey starts in ND and MN. NDSU Extension *Crop and Pest Report* #6 (June 3, 2021).
  + Knodel, J.J. 2021. Grasshopper update. NDSU Extension *Crop and Pest Report* #7 (June 10, 2021).
  + Knodel, J.J. 2021. Soybean aphids and spider mites starting. NDSU Extension *Crop and Pest Report* #8 (June 17, 2021).
  + Calles-Torrez, V., and Knodel, J.J. 2021. Soybean gall midge update in North Dakota. NDSU Extension *Crop and Pest Report* #9 (June 24, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #11 (July 8, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #12 (July 15, 2021).
  + Beauzay, P.B., and Knodel, J.J. 2021. Which insecticide is best for grasshopper control? NDSU Extension *Crop and Pest Report* #12 (July 15, 2021).
  + Beauzay, P.B., and Knodel, J.J. 2021. Red-headed flea beetle in soybeans and corn. NDSU Extension *Crop and Pest Report* #12 (July 15, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #13 (July 22, 2021).
  + Beauzay, P.B., and Knodel, J.J. 2021. Scout for spider mites in soybeans, dry beans and corn. NDSU Extension *Crop and Pest Report* #13 (July 22, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #14 (July 29, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #15 (August 5, 2021).
  + Knodel, J.J. 2021. IPM crop survey - insect update. NDSU Extension *Crop and Pest Report* #16 (August 12, 2021).



* + Knodel, J.J., Friskop, A., Beauzay, P., and Markell, S. 2021 IPM survey - soybean and sunflower. NDSU Extension *Crop and Pest Report* #19 (September 23, 2021).
* **NDSU Extension's Integrated Pest Management Survey**

*Supported by the USDA NIFA CPPM-EIP [grant no. 2014-70006-22562]*

Six NDSU IPM scouts surveyed a total of 539 soybean fields in North Dakota during 2021. The survey was initiated in early June and continued through August 13. Crops were surveyed from the 2-leaf stage through R5 growth stage in soybeans. Some of the pest highlights for soybean are summarized below. IPM survey data/maps provide near real-time pest information to North Dakota producers and others in agriculture to assist with scouting and pest management decision making. Pest maps from the 2021 IPM Survey in North Dakota were uploaded weekly onto the [NDSU IPM website](https://www.ag.ndsu.edu/ndipm/) (<http://www.ag.ndsu.edu/ndipm>).

Some of the insect pest highlights for soybean are summarized below.

**Soybean aphids** - No soybean aphids were observed in 91% of the soybean fields surveyed for the third year in a row! There were no soybean aphids observed in 96% of the soybean fields in 2020 and 93% in 2019. The percent of plants infested with soybean aphids in fields was low with an average of 11% of plants infested and ranged from 2 to 94% of plants infested. The average number of aphids per plant was only 2 aphids per plant and ranged from 1 to 32 aphids per plant. Most of the positive fields were located in the eastern half of North Dakota. Soybean aphids never reached the economic threshold (E.T.) level (average of 250 aphids per plant, 80% of plants infested with one or more aphids and increasing population levels) in any of the soybean fields surveyed.

Diagram

Description automatically generated**Bean leaf beetles** were detected in sweep net samples and is becoming a more common insect pest of soybean in North Dakota. It was most prevalent in south eastern North Dakota, but also was found in north central and east central North Dakota. Bean leaf beetle was not present at economic levels in soybean fields in 2021.

Although it was a hot, dry year, **spider mites** were observed in only 7% of the soybean fields scouted. Most scouting was completed when spider mites started to increase in severe drought areas, and were mainly a problem on field edges.

* **Extension Presentations: (**All are invited talks about soybean insects by Dr. Knodel.)
  + Virtual Getting It Right Soybean Production, Virtual due to COVID. Feb. 17, 2021. Total audience

= 184 people.

* + Virtual Centrol Roundtable meeting, Virtual due to COVID. March 4, 2021. Total audience = 49 people.
  + 2021 Western Crop and Pest Management School, Virtual due to COVID. March 10, 2021. Total audience = 61 people.
  + Good Bugs Webinar Series, Virtual due to COVID. June 23, 2021. Total audience = 61 people.
  + SHARE Farm Mooreton Field Day, August 25, 2021, In person + Virtual, 300 people.

NDSU / UM Commercial Pesticide Applicator Training, Dec. 1, 2021. Total audience = 1

***S1080 Nebraska State Report 2021***

***Justin McMechan, Thomas Hunt, Robert Wright, and Ana Velez***

**Associated Post-Docs:**

**Associated Students:**

Ademokoya, Blessing. PhD graduated 2021. (Advisors: Tom Hunt and Robert Wright)

PhD Sandwich Student Program (term at UNL): Muriel Soares (2021, Brazil). (Advised by:Tom Hunt and Justin McMechan

Vilma Montenegro, M.S. Student. (Advisor: Justin McMechan)

Ravneet Kaur, M.S. Student (Advisors: Ana Velez and Justin McMechan)

Natasha Umezu, M.S. Student (Advisor: Justin McMechan)

Mikaelison da Silva Lima, M.S. Student (Advisor: Justin McMechan)

Pragya Gupta, M.S. Student (Advisor: Justin McMechan)

Joana Schroeder de Souza, Undergraduate Research Scholar (Advisor: Justin McMechan)

Earl Agpawa, Undergraduate Senior Thesis (Advisor: Justin McMechan)

**Nebraska Overview:**

Pest pressure on soybean was relatively normal with the exception of a greater presence of bean leaf beetle in east-central Nebraska in the spring of 2021. Soybean gall midge presence and plant injury was noticeable in several counties in east-central and northeast Nebraska, although pressure was generally considered to be less than what was observed in 2020.

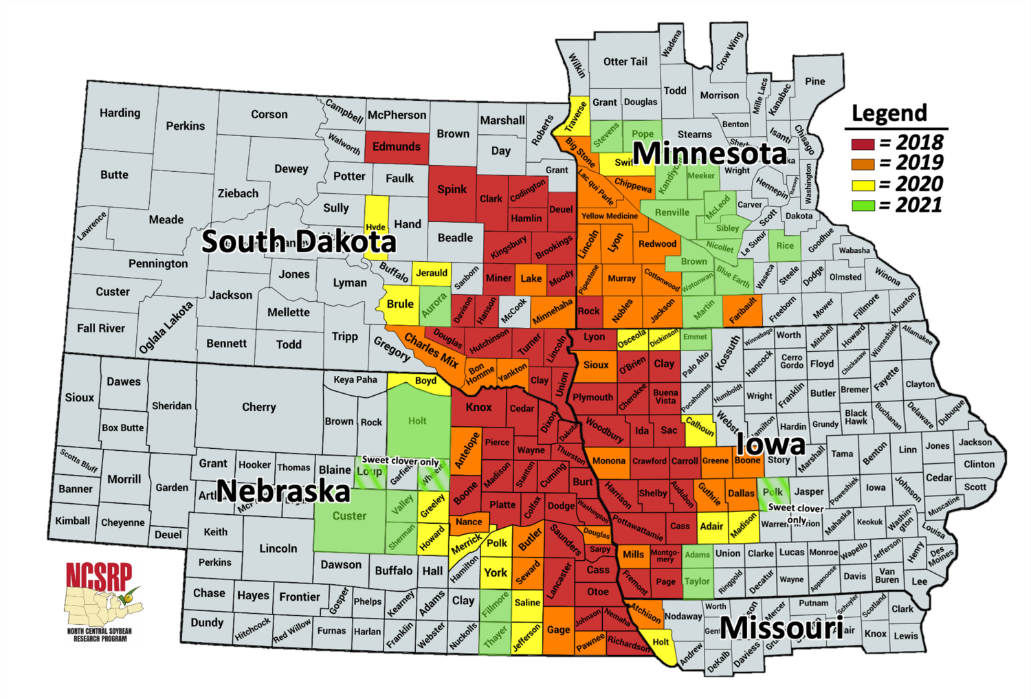
**Report summary**

A multi-state North Central Soybean Research Program (NCSRP) funded survey of fields (NE, IA, SD, and MN) for soybean gall midge found that 56% of the 245 total fields surveyed in Nebraska had larval presence. Counties with a historical record of soybean gall midge were 74% positive for the presence of larvae from a total of 156 fields surveyed. Additional multi-state soybean gall midge studies were conducted on the timing of adult emergence from 32 sites across NE, IA, SD, and MN with over 5,000 adults collected. A second study to identify a source of resistance to soybean gall midge through screen 716 accession lines from the US Germplasm resulted in several potential sources of resistance

A second multi-state NCSRP collaboration on arthropod activity and pest potential in a cereal rye to soybean was conducted across six state (NE, SD, MN, OH, IL, and MO). Significant arthropod activity from pitfall traps was detected at all sites regardless of the presence of a cover crop. In some cases the presence of the cover crop increased arthropod activity in pitfall traps placed at the V2-V4 stage. No significant defoliation was observed at any of the sites. Soybean yield was only significantly reduced at one site where cover crop biomass greatly exceed the typical amount when terminated.

(1)Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

Field surveys of soybean gall midge showed that the insect is present in a significant portion of the state where soybean is grown. A total of 254 fields were sampled across 54 counties in eastern Nebraska. Of the fields sampled, 56% were found to have larval presence. Historically infested counties were 74% positive for larvae for the 156 fields that were surved in the those counties. Efforts were coordinated across multiple states to track and document the presence of soybean gall midge update the soybeangallmidge.org website. An additional 26 counties were identified across four states with eight new counties in Nebraska.

*Peer reviewed pubs:*

Baldin, E. L., Ongarotto, S., Hunt, T. E., Montezano, D., Robinson, E. 2021. Using a video tracking system to assess intraguild interaction between *Anticarsia gemmatalis* (Lepidoptera: Erebidae) and *Chrysodeixis includens* (Lepidoptera: Noctuidae) in soybean. 2021 Entomology Society of America Annual Conference, Entomology Society of America, Denver, CO, November 3, 2021.

McMechan, A. J.,E. Hodgson, A. J. Varenhorst, T. Hunt, R. Wright, and B. Potter. 2021. First report of a new species, *Resseliella maxima* (Diptera: Cecidomyiidae), causing injury to soybean in the United States. Journal of Integrated Pest Management. 12(1): 8, 1-4.

*Professional presentations:*

Ademokoya, B. F., Hunt, T. E., Wright, R. J.. 2021. Parasitism of stink bugs by native parasitoids in Nebraska. 2021 Entomology Society of America Annual Conference, Entomology Society of America, Denver, CO, November 3, 2021.

Baldin, E. L., Ongarotto, S., Hunt, T. E., Montezano, D., Robinson, E. 2021. Using a video tracking system to assess intraguild interaction between *Anticarsia gemmatalis* (Lepidoptera: Erebidae) and *Chrysodeixis includens* (Lepidoptera: Noctuidae) in soybean. 2021 Entomology Society of America Annual Conference, Entomology Society of America, Denver, CO, November 3, 2021.

Schroeder de Souza, G. Carmona, and **A.J. McMechan**. Soybean gall midge: estimating spatial severity of plant injury and yield loss. Annual Entomological Society of America Meeting. Poster. 1 November 2021.

Apawa, E. and **A.J. Mcmechan**. Soybean gall midge: understanding adult emergence through artificial rainfall and physical barriers. Annual Entomological Society of America Meeting. Poster. 3 November 2021.

Montenegro, V., Robinson, E. and **A.J. McMechan.** Soybean gall midge: understanding seasonal larval abundance. North Central Branch Entomological Society Meeting. [Poster Online] 21 June 2021.

Kaur R., A. Velez and **A.J. McMechan.** Soybean Gall Midge: Characterizing the population structure of newly emerged pest across its geographic range and host plants. North Central Branch Entomological Society Meeting. [Poster Online] 21 June 2021.

**McMechan, A. J.**, T. Hunt, R. Wright, E. W. Hodgson, B. Koch, and B. Potter. Soybean gall midge: Understanding a new and emerging pest of soybean. Annual Entomological Society of America Meeting.[38 people] 2 November 2021.

Kaur, R., A. Velez, and **A.J. McMechan.**Soybean gall midge: characterizing the geographic and host plant range distribution. Annual Entomological Society of America Meeting [35 people] 1 November 2021.

*Extension presentations:*

**McMechan, A. J.**, T. Hunt, R. Wright. E. W. Hodgson, B. Koch, and B. Potter. Soybean gall midge: Understanding Risk and Management Options. Nebraska Soybean Day and Machine Expo, Wahoo, NE. [55 people} 16 December 2021.

**McMechan, A.J.** Soybean Gall Midge: An overview of a new pest in soybean. Nebraska Department of Ag, Lincoln, NE. [12 people]. 28 April 2021.

**McMechan, A.J.** Soybean Insect Pests. AGRO 308: Management of Crop Insects Class. UNL, Lincoln, NE. [12 people]. 6 April 2021.

**McMechan, A.J.** Soybean gall midge: understanding a new threat to the midwest. NW Missouri CCA Conference. [124 participants] 19 January 2021.

**McMechan, A.J.** Understanding a new pest in the midwest. Wisconsin Agribusiness Classic. Online [230 participants] 13 January 2021

**McMechan, A. J.,** T. Hunt and R. Wright. Soybean gall midge: battling a new pest of soybean. UNL Crop Production Clinics Online. [225 participants] 7 January 2021, 14 January 2021, 21 January 2021.

**McMechan, A J**., T. Hunt, E. W. Hodgson, B. Koch, and B. Potter. Soybean gall midge biology,

distribution, sampling tips, and look-alikes. Soybean gall midge discussion series, Virtual Delivery.

[195 views live; 98 on-demand views] 5 January 2021

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Short Summary:*

Several studies were conducted in Nebraska in conjuction with IA, SD, MN on soybean gall midge adult emergence. A total of 32 sites were tracked for overwintering emergence with several sites tracking season long adult emergence. In Nebraska approximately 4,700 adults were collected throughout the season. The data from the study clearly demonstrated a long duration of emergence with an average of 35 days of emergence from overwintering sites. The continued increase in duration of adult emergence observed over the past three years will pose a significant challenge for management. Additional studies were conducted soybean gall midge to understand its seasonal larval abudance, temporal abundance of cocoons in the soil, the spatial distribution of cocoons, and larval movement from infested plants.

*Peer reviewed pubs:*

Ademokoya, B. 2021. Stink bug (Hemiptera: Heteroptera: Pentatomidae) ecology in Nebraska agroecosystems. PhD Dissertation, University of Nebraska-Lincoln, Lincoln NE.

*Professional presentations:*

da Silva Lima, M. and **A.J. McMechan**. Larval distribution of soybean gall midge from infested soybean plants. Annual Entomological Society of America Meeting. Poster. 1 November 2021.

**McMechan, A. J.**, T. Hunt, R. Wright. E. W. Hodgson, B. Koch, and B. Potter. Soybean gall midge: observations and challenges from the 2020 season. North Central Branch Entomological Society Meeting. [Online] 21 June 2021.

*Extension presentations:*

**McMechan A. J.**, T. Hunt, and R. Wright. Soybean gall midge: An update from the 2021 season. Midwest Soybean Production Clinic, UNL. [32 people] 26 August 2021.

**McMechan, A.J.** Soybean gall midge: Hail interactions and the biology of a new pest of soybean. CITI Rain and Hail Training [263 participants online]. 24 March 2021.

**McMechan, A.J.** Soybean gall midge: Insights on a new pest of soybean. Syngenta Western and Eastern Iowa Sales Team Training. Online [26 participants online]. 8 March 2021.

**McMechan, A,J.** Soybean gall midge: A new pest in the midwest. NeABA Mid-Winter Conference. Online [40 people] 2 March 2021.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

Several chemical, cultural, and host plant resistance studies were conducted on soybean gall midge. Some of which was coordinated with IA, MN, and SD. Chemical control studies found that results were not consistent in controlling soybean gall midge with the exception of Thimet which showed more consistent control but was impacted by planting date. Screening of resistant varieties was very successful with significant infestation (98%) across the 713 accession lines from the U.S. germplasm.

*Peer reviewed pubs:*

Ongaratto, S. E.\*, C. M. Silveira, M. C. Santos, J. E. R. Gorri, M. M. P. Sartori, T. E. Hunt, A. L. Lourenção, E. L. L. Baldin. 2021 Resistance of soybean genotypes to *Anticarsia gemmatalis* (Lepidoptera: Erebidae): antixenosis and antibiosis characterization. J. Econ. Entomol. 114(6): 2571-2580, <https://doi.org/10.1093/jee/toab197>

Aita, R.C., D.T. Pezzini, E.C. Burkness, C.D. DiFonzo, D.L. Finke, T.E. Hunt, J.J. Knodel, C.H. Krupke, L. Marchi-Werle, B. McCornack, A.P. Michel, C.R. Philips, N.J. Seiter, A.J. Varenhorst, R.J. Wright, W.D. Hutchison, and R. L. Koch. 2021. Presence-absence Sampling Plans for Stink Bugs (Hemiptera: Pentatomidae) in the Midwest region of the United States. J. Econ. Entomol. 114(3), 1362–1372, <https://doi.org/10.1093/jee/toab076>

Bueno, A.F., A.R. Panizzi, T.E. Hunt, P.M. Dourado, R.M. Pitta, J. Gonçalves. 2021. Challenges for Adoption of Integrated Pest Management (IPM): The Soybean Example. Neotropical Entomology 50:5-20. <https://doi.org/10.1007/s13744-020-00792-9>

McMechan, A. J. 2021. Evaluation of at-plant soil treatment thimet against soybean gall midge, 2020. Arthropod Management Tests. 46(1): 1-2.

*Professional presentations:*

Ribeiro, A. V., Aita, R. C., Pezzini, D. T., DiFonzo, C., Hunt, T. E., Knodel, J. J., Krupke, C., Marchi-Werle, L., Michel, A., Seitler, N. J., Wright, R. J., Hutchison, W. D., Koch, R. 2021. Optimizing sample unit size for sampling stink bugs in Midwest soybean. 2021 Entomology Society of America Annual Conference, Entomology Society of America, Denver, CO, November 3, 2021.

Umezu, N. and **A.J. McMechan**. Soybean gall midge: evaluating planting date and seed treatment as a management strategy. Annual Entomological Society of America Meeting. Poster. 1 November 2021.

Kolbe, B., **A.J. McMechan**, and **E. W. Hodgson.** Tillage effects on soybean gall midge overwintering populations. Annual Entomological Society of America Meeting. Poster. 1 November 2021.

Montenegro V. and **A.J. McMechan**. Soybean gall midge: evaluating the efficacy of insecticide timing relative to adult emergence. Annual Entomological Society of America Meeting. [22 people] 1 November 2021.

*Extension presentations:*

**McMechan A. J.**, T. Hunt, and R. Wright. Soybean gall midge: An update from the 2021 season. Midwest Soybean Production Clinic, UNL. [32 people] 26 August 2021.

**McMechan A. J.** T. Hunt, and R. Wright. Strategies for Managing Soybean Gall Midge and Insect Management in Cover Crops. Soybean Management Field Days, Arlington, NE. [81 people] 13 August 2021.

**McMechan A. J.** T. Hunt, and R. Wright. Strategies for Managing Soybean Gall Midge and Insect Management in Cover Crops. Soybean Management Field Days, Rising City, NE. [73 people] 12 August 2021.

McMechan A. J. **T. Hunt**, and R. Wright. Strategies for Managing Soybean Gall Midge and Insect Management in Cover Crops. Soybean Management Field Days, Elgin, NE. [73 people] 11 August 2021.

**McMechan, A.J.** Soybean Insect Pests. Crop Scout Clinic. Eastern Nebraska Research and Extension Center, Mead, NE. [23 people]. 21 April 2021.

**McMechan, A.J.** Soybean gall midge: Managing and understanding a new pest of soybean. AMVAC Product Meeting. Dordt University. Sioux City, IA. [32 people] 31 March 2021.

**McMechan, A.J.** Soybean gall midge: scouting, biology, and management of a new pest in the Midwest. Great Plains Diagnostic Network [18 participants online]. 17 March 2021.

**McMechan, A,J.** Key Pests in Corn, Wheat and Soybean. WinField United Agronomy Conference. Online [272 people] 23 February 2021.

**McMechan, A.J.** Soybean gall midge: an uphill road to management. GrowMark Agronomy Virtual Agronomy Monthly. Online [28 people] 16 February 2021.

Montengro V., A. J. McMechan, and E. W. Hodgson. Soybean gall midge ecology and plant injury. Soybean gall midge discussion series, Virtual Delivery. [216 live views; 157 on-demand views] 12 January 2021

**McMechan, A.J.,** E. W. Hodgson, T. Hunt,. B. Potter, R. Wright and A. Varenhorst. Soybean gall midge management. Soybean gall midge discussion series, Virtual Delivery. [216 live views; 157 on-demand views] 19 January 2021

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

*Short Summary:*

**Map

Description automatically generated**The dissemination of research-based information on a newly discovered pest, the soybean gall midge (SGM) enhanced through a dedicated website, alert system, and regional webinar series. Website metrics expanded significantly in 2021 with over 4,688 unique visitors and 10,369 pageviews from participants in 44 states (Fig. 1) within the U.S.A as well as 48 countries. The website provided real-time updates on the distribution of the soybean gall midge and adult emergence from overwintering and the current years soybean field which is updated daily during the early half of the growing season. Rapid communication on SGM emergence and management with clientele during the season through an alert system on blackboard connect. The system is capable of delivering an automated phone call, text message, and email to a total of 452 clientele across eight states and Canada. Participation in the alert network grew by 40% this past year.

A multi-state soybean gall midge webinar series consisted of three-parts with over 380 registered with 625 live views and an additional 432 views of the recordings. Robust discussions occurred with clientele even in an online platform with questions extending 30-45 minutes beyond the presentations, allowing us to gain critical insights on the concerns, needs, and observations of participants that will serve as the framework for future SGM research. Presentations in 2021 on SGM were given to 3,581 clientele from NE, IA, WI, KS, CO, and MN.

*Peer reviewed pubs:*

Casey, Mary Anne, Kevin B. Rice, Thomas E. Hunt. 2021. Farmers Needs Related to Soybean Insect Pests: Focus Group Interviews with Soybean Growers & Crop Consultants. (pp. 42). North Central Soybean Research Program.

McMechan, A.J., T. Hunt and R. Wright. Soybean Gall Midge in Nebraska. NebGuide G2331. University of Nebraska-Lincoln. April 2021.

***S1080 Ohio State Report 2021***

***Kelley Tilmon and Andy Michel***

**Ohio Overview:**

* Key insect pest activity, observations or general findings
  + We saw perhaps higher than average stink bug activity in soybean, but not dramatically so.
  + Soybean aphids were all but absent.
  + No unusual defoliation activity this year
* Overview of major projects or any multi-state collaborations
  + We had a collaboration with OSU agricultural engineer Dr. Sami Khanal to use drone-mounted remote imaging to diagnose soybean defoliation. The technology works at high enough defoliation levels, which are relatively rare in Ohio.
  + A collaboration with Dr. Kevin Rice at University of Missouri to use pheromone baits developed for orchard monitoring to monitor stink bugs in soybean. This project is ongoing and starting in 2022 it will be a multistate collaboration involving six North Central states.
  + Developed a new method for sampling slugs in field crops including soybean
  + Have developed capacity in 3D pringing to generate models of soybean pests including stink bugs, stink bug eggs, soybean gall midge larvae, and leaf feeding defoliation levels, for use in extension training programs

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

*Short Summary:*

* Contributed to multistate pest survey conducted by Dr. Fred Musser

*Peer reviewed pubs:*

Raudenbush, A.L., A.J. Pekarcik, V.R. Haden, and K.J. **Tilmon**. 2021. Evaluation of slug refuge traps in a soybean no-till cover crop system. Insects 12: htps://doi.org/10.3390/insects12010062

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

*Peer reviewed pubs:*

**Tilmon**, K. J., A. **Michel** and M. E. O’Neal. 2021. Aphid resistance is the future for soybean production, and has been since 2004: Efforts towards a wider use of host plant resistance in soybean. Current Opinion in Insect Science. 45:53-58 https://doi.org/10.1016/j.cois.2021.01.003.

Esquivel, C. J., L. A. Canas, K. **Tilmon** and A. P. **Michel**. 2021. Evaluating the role of insecticidal seed treatment and refuge for managing soybean aphid virulence. Pest Management Science. https://doi.org/10.1002/ps.6328

**Extension pubs**

Welty, C., J. Jasinski, and **K. Tilmon**. 2021. Brown marmorated stink bug. Ohio State University Extension, https://ohioline.osu.edu/factsheet/ent-90

Raudenbush, A. and **K. J. Tilmon.** 2021. Soybean gall midge alert card.

Newsletter Articles

Young, C. and **K. Tilmon**. “Soybean Defoliation: It Takes a lot to Really Matter!” CORN Newsletter: 22-2021. July 13-19, 2021. <https://agcrops.osu.edu/newsletter/corn-newsletter/22-2021/soybean-defoliation-it-takes-lot-really-matter>

Michel, A., and **K. Tilmon**. “Remember soybean aphids? They might be in your fields” CORN Newsletter: 27-2021. Aug. 17-23, 2021. <https://agcrops.osu.edu/newsletter/corn-newsletter/2021-27/remember-soybean-aphids-they-might-be-your-fields>

**Tilmon, K.** “Check out the new Michigan State/Ohio State Field Crops Insect Pest Management Guide” CORN Newsletter: 28-2021. Aug. 24-30, 2021. <https://agcrops.osu.edu/newsletter/corn-newsletter/2021-28/check-out-new-michigan-stateohio-state-field-crops-insect-pest>

**Tilmon, K.,** C. Young, A. Michel. “Late-Season Pod Feeding by Bean Leaf Beetle, Grasshopper, and Stink Bugs.” CORN Newsletter: 30-2021. Sept. 7-13, 2021. <https://agcrops.osu.edu/newsletter/corn-newsletter/2021-30/late-season-pod-feeding-bean-leaf-beetle-grasshopper-and-stink>

Lindsey, L., **K. Tilmon,** A. Michel. “Are You Seeing Brown Pods and Green Stems?” CORN Newsletter: 34-2021. Oct. 5-11, 2021. <https://agcrops.osu.edu/newsletter/corn-newsletter/2021-34/are-you-seeing-brown-pods-and-green-stems>

*Professional presentations:*

**Tilmon, K. J.** 2021. *Harmonia axyridis* immigration and oviposition in response to variable aphid density. Oklahoma State University Seminar Series.

Zhang, Z., S. Khanal, C. Stewart, A. Raudenbush and **K. Tilmon**. 2021. UAV based monitoring of soybean leaf defoliation from insects. American Society of Agricultural and Biological Engineers Annual Meeting.

*Extension presentations:*

|  |  |  |
| --- | --- | --- |
| 4/2021 | Slug pest management in field crops | Michigan State University Field Crops Virtual Breakfast Series |

|  |  |  |
| --- | --- | --- |
| 3/2021 | Insecticidal seed treatments – back to basics | OSU Conservation Tillage and Technology Conference [virtual] |
| 3/2021 | Pest management panel discussion | OSU Conservation Tillage and Technology Conference [virtual] |
| 2/2021 | Insecticidal seed treatments – back to basics | TMK Bakersville Winter Learning Series [virtual] |
| 2/2021 | Soybean insect management | OSU Virtual Corn College and Soybean School [virtual] |

***S1080 Oklahoma State Report 2021***

***Tom Royer***

(1)

Document changing soybean pest and beneficial arthropod assemblages. Soybean is injured by a diverse guild of insect pests feeding on leaves, stems, roots, nodules, and pods. The major insect pests in these guilds have markedly changed in the last two decades due to the introduction and range expansion of invasive insects and the adaptation of native pests.

* We conducted two insecticide efficacy trials targeting stinkbug and defoliating caterpillars. Stinkbug populations did not materialize as expected, and foliar caterpillar populations were not at ecomonic levels. Therefore, the trials were not completed.

(2)

Characterize soybean insect biology and ecology The range expansion of invasive pests, coupled with the adaptation of native pests, necessitate further research into how insects cope with new selection pressures

* Nothing to report. Needs include documenting the yield impact of stinkbugs to soybean statewide, and communicating that to our stakeholders.

(3)

Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

* We have updated our factsheets: CR 7167: "Soybean insect survey and control in Oklahoma" to reflect updated managment information for soybean pests

(4)

Educate farmers, industry, colleagues, general public, and agricultural professionals using traditional tools and innovative methods. Our Working Group works extensively with stakeholders at all levels. For our clientele, we represent one of the only unbiased sources of information for decision-making of IPM strategies.

**Peer reviewed pubs:**

• Musser, F., A. Catchot, S. Conley, J. A. Davis, C. Difonzo, J. Greene, G. Lorenz, D.Owens, D. Reisig, P. Roberts, T. Royer, N. Seiter, R. Smith, S. Stewart, S. Taylor, K. Tilmon, R. Villanueva, and M. Way. 2020. 2019 soybean insect losses in the United States. Midsouth Entomologist 13: 1-23.**Professional presentations:**

**Extension presentations:**

* Nothing to report

**Impacts statements:**

* Nothing to report

***S1080 South Carolina State Report 2021***

***Jeremy Greene***

***Cooperating Scientists: Francis Reay-Jones and Michael Plumblee***

**Associated Post-Docs:** none

**Associated Students:** Anthony Daniel Greene, Kyle Smith

**South Carolina Overview:**

* Key insect pests included stem feeders, such as kudzu bug and threecornered alfalfa hopper, defoliators, such as soybean looper, green cloverworm, and velvetbean caterpillar, and seed feeders, such as podworm and stink bugs (brown stink bug, green stink bug, southern green stink bug, brown marmorated stink bug, redbanded stink bug, etc. – we observed reproducing populations of all in the Coastal Plain region of SC during 2021).
* Major projects included publishing research on spatial distributions of insects in soybeans, analyses of data from experiments addressing the effects of planting date and maturity group on important arthropods in soybeans, continued evaluations of Bt soybeans for lepidopterans, simulated rainfall timings after insecticide application, and insecticide efficacy trials.

**Report summary –** In soybeans in South Carolina, existing species, such as podworm, velvetbean caterpillar, soybean looper, and stink bugs, provide challenges for producers annually. Relatively new species, such as the brown marmorated and redbanded stink bugs, provide additional obstacles for farmers in producing a profitable crop. Continuous changes in production environments, such as availability of new technologies, loss of efficacious pesticides, and introduction of new species require research programs to be responsive and as predictive as possible. Research published on spatial distribution of insects in soybeans indicated some associations with in-field variables (calendar week, crop phenology, plant height, and NDVI) potentially useful for site-specific management of key pests in the crop. New research in South Carolina that focused on simulated rainfall timings after insecticide application showed that the pyrethroid insecticide bifenthrin provided good control of stink bugs (predominantly southern green stink bug) regardless of wash-off timing (<1 to 24 hr), indicating that only initial contact with the target species was needed to preserve product efficacy. This finding will save producers money by demonstrating that re-treatment after a rain event is not as critical as previously thought, at least with bifenthrin and southern green stink bug. Other accomplishments were related to insecticide efficacy on other pestiferous insects in soybeans. The efficacy and fit of Bt technologies for control of lepidopterans in soybeans were also evaluated.

*Peer reviewed pubs:*

Greene, A. D., F. P. F. Reay-Jones, K. R. Kirk, B. K. Peoples, and J. K. Greene. 2021. Spatial associations of key lepidopteran pests with defoliation, NDVI, and plant height in soybean. Environ. Entomol. 50(6): 1378-1392. <https://doi.org/10.1093/ee/nvab098>

Arends, B., D. D. Reisig, S. Gundry, A. S. Huseth, F. P. F. Reay-Jones, J. K. Greene, and G. G. Kennedy. 2021. Effectiveness of the natural resistance management refuge for Bt-cotton is dominated by local abundance of soybean and maize. Scientific Reports 11, 17601 (2021) <https://doi.org/10.1038/s41598-021-97123-8>

Greene, A. D., F. P. F. Reay-Jones, K. R. Kirk, B. K. Peoples, and J. K. Greene. 2021. Associating site characteristics with distributions of pestiferous and predaceous arthropods in soybean. Environ. Entomol. 50(2): 477-488. <https://doi.org/10.1093/ee/nvaa173>

*Extension pubs:*

Greene, J. K. 2021. Cotton/Soybean Insect Newsletter (Vol. 16, 20 Issues). Distributed weekly to various clientele (county agents, consultants, producers, etc.). Spring-Summer. <https://www.clemson.edu//extension/agronomy/cotton1/newsletters.html>

Plumblee, M. T., B. S. Farmaha, J. K. Greene, M. W. Marshall, S. Mickey, J. D. Mueller, N. B. Smith, and A. P. Turner. 2021. South Carolina Soybean Production Guide (2021). Clemson Cooperative Extension Service. <https://clemson.app.box.com/s/a27svxqckn50ew65hc502vl3i29x8vbz>

Greene, J. K. 2021. Soybean Insect Control, pp. 265-275. In South Carolina Pest Management Handbook. <http://www.clemson.edu/extension/agronomy/pest%20management%20handbook.html>

Musser, F. R., A. L. Catchot, S. P. Conley, J. A. Davis, C. DiFonzo, S. Graham, J. K. Greene, R. Koch, D. Owens, D. D. Reisig, P. Roberts, T. Royer, N. J. Seiter, S. D. Stewart, S. Taylor, B. Thrash, K. Tilmon, R. T. Villanueva, and M. O. Way. 2021. 2020 soybean insect losses in the United States. Midsouth Entomologist. 13: 1-25.

*Extension presentations:*

February 2021. Management of insects in soybeans during 2020. Corn and soybean virtual production meeting. Online Zoom meeting (23 February).

February 2021. Management of insects in soybeans during 2020. Corn and soybean virtual production meeting. Online Zoom meeting (17 February).

***S1080 USDA-ARS, South Dakota State Report 2021***

***Louis Hesler***

**Overview:** **USDA-ARS, South Dakota**

**Report summary – USDA-ARS, South Dakota participated in several soybean pest projects.**

a) Evaluations of aphid-resistant soybean in the field and laboratory. Participants: Louis Hesler (USDA-ARS, South Dakota), Earl Taliercio (USDA-ARS, Raleigh, NC).

b) Cover crops: pest and beneficial insects in cereal rye to soybean transition systems. Participants: Justin McMecha (leader, University of Nebraska), Shawn Conley (University of Wisconsin), Louis Hesler and Shannon Osborne (USDA ARS South Dakota), Thomas Hunt (University of Nebraska), Bruce Potter (University of Minnesota), Kevin Rice (University of Missouri), Nick Seiter (University of Illinois); Kelley Tilmon (Ohio State University), and Robert Wright (University of Nebraska).

c) Advancing aphid resistant soybeans through a public-private partnership. Participants: Matt O’Neal\* (Iowa State University), Andy Michel\* (Ohio State University), Mauricio Urrutia\* (Corteva), David Onstad\* (Corteva), Kelley Tilmon (Ohio State University), Thomas Hunt (University of Nebraska), Deirdre Prischmann (North Dakota State University), Adam Varenhorst (South Dakota State University), Louis Hesler (USDA ARS South Dakota). \*Project leaders

(3) Develop coordinated best management practices (BMPs). As soybean insect pest assemblages change, there is a need to update pest management strategies.

*Short Summary:*

a) Evaluations of aphid-resistant soybean in the field and laboratory.

Field plots. ARS scientists in Brookings, South Dakota, conducted a field study to test the effectiveness of insecticide seed treatment, foliar insecticide spray, and an aphid-resistant soybean cultivar as tactics against soybean aphid. While each tactic independently reduced the population densities of soybean aphids, it was discovered that the use of the resistant cultivar produced the greatest impacts on aphids and reduced their populations by 28- to 150-fold per year.

Laboratory. Wild soybean enhances the arsenal of aphid resistance genes that can be bred into modern soybean cultivars. A study by ARS researchers in Brookings, South Dakota, and Raleigh, North Carolina, evaluated 76 selected soja accessions and 14 soybean accessions for resistance against two virulentcolonies of soybean aphid in experiment growth chambers. The two colonies included a new soybean aphid biotype known as ‘Accrue,’ which has a novel virulence pattern against known aphid-resistance genes, and another highly virulent biotype, known as ‘Volga16.’ Soja line PI 507624 showed strong resistance against the Accrue colony, whereas PI 597458 C showed strong resistance to Volga16. Based on results from these tests, follow-up studies are warranted to determine the genetic basis of aphid resistance in these two soja lines in order to inform breeding programs that are developing aphid-resistant soybean cultivars.

b) Cover crops: pest and beneficial insects in cereal rye to soybean transition systems.

No significant defoliation of soybean was observed at any of the sites, regardless of the presence or absence of a cover crop. In general, soybean yields were not impacted by the presence of the cover crop. Soybean biomass was measured at a few sites during the V2 stage and in some situations the presence of cover crop significantly reduced total soybean biomass, however, it did not impact final yield.

c) Advancing aphid resistant soybeans through a public-private partnership

The work will help predict how long aphid-resistant soybeans will remain durable, and also lead to strategies that can delay the increase in virulence (aphids overcoming resistant varieties). Dr. Onstad (Corteva) has developed and fine-tuned a mathematical model to explore the durability of aphid resistanceThe model is in the final stages of development, with a manuscript to be submitted in spring or summer of 2022. Other data generated included a new assay to identify virulent aphids, which will be further validated in the new NCSRP project.

*Peer reviewed pubs:*

**Hesler, L.S.** and E. Taliercio. 2021. Resistance among selected wild soybean and associated soybean accessions against two virulent colonies of *Aphis glycines* (Hemiptera: Aphididae). Phytoparasitica 49:243-251. <https://doi.org/10.1007/s12600-020-00845-0>.

**Hesler, L.S.** and E.A. Beckendorf. 2021. Soybean aphid infestation and crop yield in relation to cultivar, foliar insecticide, and insecticidal seed treatment in South Dakota. Phytoparasitica 49:971-981. <https://doi.org/10.1007/s12600-021-00914-y>.

**Hesler, L.S.**, K.J. Tilmon, A.J. Varenhorst, *S.R. Conzemius*,E. Taliercio and E.A. Beckendorf. 2022. Challenges and prospects of wild soybean as a resistance source against soybean aphid. Ann. Entomol. Soc. Am. 115:25-38. <https://doi.org/10.1093/aesa/saab033>.

*Extension presentations:*

Field Day (virtual), Seed Treatment, Foliar Insecticide and a Resistant Cultivar for Managing Soybean Aphid, Eastern South Dakota Soil & Water Research Farm, Mar. 1, 2021.

*Impact statement:* Managing soybean aphid with a resistant cultivar is highly effective, based on a three- year field study from 2015 thru 2017 in South Dakota that evaluated insecticide seed treatment, foliar insecticide spray, and use of an aphid-resistant soybean cultivar containing aphid-resistance genes. Each of the three management tactics independently reduced soybean aphid population densities. By far, the resistant cultivar had the greatest impact on soybean aphid populations, reducing them by 28- to 150-fold per year, whereas insecticide seed treatment reduced aphid populations 1.7- to 3.5-fold per year, and foliar insecticide spray reduced it from 2.0- to 5.6-fold per year. The results demonstrated the viability of a soybean cultivar with two aphid-resistance genes as an alternative to the common strategy of using insecticides to manage soybean aphid.