2020 Annual Report: NCERA 137

Scientist(s): Gary Bergstrom, Kaitlyn Bissonnette, Carl Bradley, Emmanuel Byamukama, Shawn Conley, Martin Chilvers, Tom Creswell, Anne Dorrance, Travis Faske, Tamra Jackson-Ziems, Mehdi Kabbage, Yuba Kandel, Heather Kelly, Nathan Kleczewski, Alyssa Koehler, Marie Langham, Leonor Leandro, Chris Little, Ann MacGuidwin, Dean Malvick, Sam Markell, Febina Mathew, Daren Mueller, Rodrigo, Onofre, Trey Price, Alison Robertson, Alejandro Rojas, John Rupe, Edward Sikora, Damon Smith, Terry Spurlock, Jennifer Starr, Connie Strunk, Connie Tande, Darcy Telenko, Xiaohong Wang

State: AL, AR, DE/MD, IA, IL, IN, KY, LA, MI, ND, NY, OH, SD, and WI

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Project Title: Soybean Disease Committee

Objective 1: *Foster collaborative research and information exchange on new and emerging soybean diseases among scientists in the North Central Region including soybean breeders and entomologists that will lead to improved disease screening protocols, additional sources of disease resistance genes and ultimately, improved host plant resistance.*

A multi-state collaborative effort helped to name and characterize *Xylaria necrophora*, the causal agent of taproot decline, a newly identified disease of increasing importance in the southern US. This disease was identified in six additional counties in Alabama bringing the total number of counties reporting the disease in the state to 29 (out of 67). The northern bounds of pathogen distribution are currently unknown. Information exchange with the North Central Region regarding disease signs, symptoms, and diagnosis will allow us to eventually determine the complete pathogen distribution. We conducted a specialized variety trial during 2020 where we inoculated OVT entries with the taproot decline pathogen, rated multiple times, and released information to stakeholders during the Fall.

We are working to improve the germplasm to manage several important diseases. For example, in Michigan, germplasm was screened for resistance to *Phytophthora sojae*, *P. sansomeana*, *Pythium*, white mold, and sudden death in collaboration with private and public soybean breeders within and outside of the state. In Wisconsin, an improved screening method for resistance to white mold in soybean was developed. The screening method was published here: https://doi.org/10.1094/PDIS-10-20-2193-RE. In addition, multistate, collaborative efforts have resulted in identification of soybean germplasm, advanced lines, and commercial cultivars with resistance to Cercospora leaf blight (CLB), soybean rust, target spot, frogeye leaf spot, and several seed quality diseases (Diaporthe seed decay, purple seed stain, and soybean mosaic virus).

Our understanding the diversity of fungi that cause Diaporthe (Phomopsis) seed decay continues to expand. Research was undertaken to identify *Diaporthe* species in eight U.S. states. Ten species were identified (three being novel) and a publication of this was research was accepted

by Plant Disease. Soybean disease surveys were also conducted to further elucidate the distribution of *Diaporthe* spp. following the discovery of a new species in Delaware.

Collaborations across north central states also occurred to evaluation fungicides products on the severity of sudden death syndrome, white mold, and frogeye in field experiments.

Objective 2: *Compare findings on the impacts of changing production practices such as earlier planting dates, new sources of host plant resistance, increased use of fungicide seed treatments and foliar fungicides, and other new or improved crop production technologies on soybean diseases that could be adopted for other production areas in the region.*

Fungicide resistance for the pathogens causing foliar diseases

New counties continue to be identified within Indiana, Kentucky and Nebraska that have QoI fungicide-resistant strains of either *Cercospora sojina* and/or *Septoria glycines*. QoI fungicide-resistant strains of *C. sojina* were identified in North Dakota and Wisconsin for the first time. *Cercospora* spp. isolates obtained from AL, AR, MO, MS, TN, and TX have been tested for QoI resistance via PCR-RFLP. Preliminary results indicate that resistance exists in these locations. Further, a LAMP assay has been developed that will detect QoI resistance in the Cercospora leaf blight (CLB) pathogens. SDHI and newer generation DMI fungicides have been consistently efficacious on CLB over the past few seasons.

Foliar fungicides were evaluated in many states. Data are used to contribute to the NCERA-137 fungicide efficacy tables, which are reported through Crop Protection Network.

Stem diseases

Potential seed treatment and furrow-applied fungicide options for taproot decline management. More data is needed to refine fungicide options. Crop rotation, tillage, and commercially available resistant varieties remain as options for management. A multi-site year study investigating the integrated management of white mold on soybean in the North Central region was completed. A regional study to compare SDS seed treatments in fields with different risk levels for SDS was initiated. There were 66 locations across the U.S. and Canada. Preliminary data has been shared with the contributors to be included in extension talks, as appropriate.

Nematodes

Seed treatment trials were conducted to assess efficacy for SCN and impacts of earlier planting dates. Foliar fungicide trials were conducted to assess product efficacy in full season beans. Several field trails were conducted to evaluate soybean susceptibility and field efficacy of several seed-applied nematicides to the southern root-knot nematode.

Seed treatments

We conduct annual seed treatment trials to assess the impact on disease management and profitability of production practices. We also have projects assessing agronomic factors such as planting populations, fertility and host plant resistance. Fungicide seed treatments were evaluated in many states. Data are used to contribute to the NCERA-137 fungicide efficacy tables, which are reported on Crop Protection Network.

Objective 3: *Compare data from studies of the ecology and epidemiology of soybean diseases important in the North Central Region.*

Stem diseases

The origin of the taproot decline pathogen remains unclear. However, Teddy Garcia-Aroca's graduate work indicates that the fungus may pre-date significant soybean production in the southern U.S. Herbaria samples from Florida, Louisiana, and St. Martinique indicated the presence of the organism on/in sugarcane nearly 100 years ago. The full extent of the distribution of the pathogen remains to be defined, and mechanisms of pathogenicity remain a mystery. Further work is ongoing concerning a suspected phytotoxin associated with foliar symptoms as well as routes of infection.

We continue to work on improving our understanding of the epidemiology of white mold on soybean. This information is being used to improve the disease prediction tool Sporecaster. Our current efforts focus on understanding the interaction of genetics and susceptibility to white mold and the fungicide action thresholds set in Sporecaster. Facilitated cooperation of New York extension educators/producers with white mold forecasting researchers at University of Wisconsin and Penn State University.

Foliar diseases

The CLB life cycle remains incomplete. There are at least three species associated with this disease. Efforts are underway to complete Koch's postulates during soybean reproductive stages in the greenhouse. Characterization of the pathogen complex continues. Alternative hosts will continue to be defined as well as pathogen distribution and composition. Severe losses from soybean rust were noted in south and central Alabama with a 41% yield loss recorded in one controlled study in Brewton, Alabama and a 25% yield loss in a large-scale fungicide trial in Tallassee, Alabama.

Mapping

We continue to map the pathogen/disease movement, specifically, soybean cyst nematode (SCN), sudden death syndrome (SDS) and frogeye leaf spot.

Objective 4: *Improve knowledge transfer about soybean diseases and their management in the North Central Region to researchers, Extension faculty, producers and the agribusiness community through the use of web sites, podcasts, social media (Twitter and Facebook) and other new technologies as they are developed.*

Information on soybean diseases and management gained from interaction with NCERA-137 colleagues is shared widely with soybean producers, extension, and consultants in all states via listservs, social media, field days, and extension presentations. Ratings on efficacy of foliar and seed fungicides are particularly valued by clientele. With restrictions on travel, information on soybean diseases across the U.S. was shared with colleagues via monthly Land Grant Field Crop Pathologists Zoom calls in 2020. Some highlights include:

Crop Protection Network

Several members of NCERA137 are active participants in the Crop Protection Network outreach activities. This organization provides information on disease management practices at affect farmers and consultants across the cotton, soybean, and corn belts. The Crop Protection Network has expanded the number of soybean diseases in the "Encyclopedia" section and "Research Reviews".

SCN Coalition

A multi-state Extension project on soybean cyst nematode as part of the SCN Coalition involves coordination of information that farmers can utilize to become more aware of the yield losses caused by soybean cyst nematode and the best management practices for mitigation of these losses. The SCN Coalition uses social and traditional media to transfer knowledge. In addition to Twitter, Facebook, website and press releases, the SCN Coalition developed the program 'Let's Talk Todes', a campaign that created 23 videos which generated 913,070 views and 1.7M impression within the agricultural media in a six week period from October 1 – November 15th, 2020.

Social media, Blogs/Newsletters, Websites, Videos, Other

Many methods of communication are used to reach stakeholders. Many of the traditional in-person conferences or field days were converted to virtual in 2020, but remained an important way to communicate with stakeholders (e.g., CropsTV, Delaware Ag Week, Mid-Atlantic Crop School). Soybean disease information was shared through social media platforms including Facebook Instagram and Twitter. State blogs or newsletters were also used (e.g., BadgerCropDoc.com, Pest&Crop Newsletter, Louisiana Crops Newsletter, Agronomy Team Newsletter, Alabama Crops e-Newsletter, Iowa States ICM News). Newsletter articles are often resent from educators/dealers across states. Videos continue to be an important way to communicate about soybean diseases. For example, short recorded #NField observations videos; Farming Friday videos focused on white mold timing and control, soybean diseases to watch for, and fungicide timings were produced and posted on Facebook. Also, several online talks were recorded and posted on YouTube (e.g., Ag Dialogue presentation on fungicide timing and white mold, several research field days). Other communication methods include the Louisiana Delta Crop Podcast (https://podcasts.apple.com/us/podcast/louisiana-delta-crop-report-podcast/id1456654699); recurring radio spots focused on soybean diseases, management, and fungicide timings, and the Louisiana text communication (Remind application).

Objective 5: *Continue to monitor and share information for any new or reemerging pathogens of soybean in the North Central Region and develop appropriate responses to their emergence as they occur.*

We continued to monitor for new and reemerging diseases. Of note is improved understanding of the etiology of seedling diseases (i.e. oomycetes responsible for seed and root rot), sudden death syndrome (i.e. finding of additional *Fusarium* species responsible for SDS), and distribution of frogeye leaf spot QoI fungicide resistance.

Bugwood and regional surveys

- Soybean rust was monitored and shared via the IPM PIPE system (Bugwood). The disease was detected in 64 of the 67 counties in Alabama, and incidence and severity in individual

fields were uncommonly high. Soybean rust was also identified in several other states, including as far north as Kentucky.
- Work with Mid-South group on monitoring the occurrence of Taproot decline in our respective states.

State surveys
- Continued a statewide survey in Indiana to collect *Cercospora sojina* isolates to monitor for QoI fungicide resistant strains.
- Nematode soil samples were collected in 40 fields in Delaware to continue raising awareness of the presence of SCN in the area. SCN was present in over half of the samples and continues to be a reemerging pathogen as host resistance is overcome.
- We continued to monitor for new occurrences of target spot in Kentucky and monitor for diseases not yet detected in Kentucky, such as taproot decline and red crown rot. In addition, we initiated a survey for non-soybean cyst nematode plant parasitic nematodes in Kentucky soybean fields in 2020.
- Monitored for new and emerging pathogens, including SCN, frogeye leaf spot, SDS, charcoal rot and other soybean diseases in North Dakota.

First reports
- First report of *Phytophthora sansomeana* in soybeans was reported in South Dakota and published in Plant Disease.
- Ten species of Diaporthe (three being novel) were identified as the causal agents of Diaporthe seed decay of soybean and this research was published in Plant Disease.
- First report of frogeye leaf spot in North Dakota.

Impact Statements:

Our programs conduct seed treatment and foliar fungicide efficacy trials as well as seed treatment/in-furrow nematicide trials to determine which products are economically viable forming the basis of recommendations for producers. Official variety trials are rated annually for naturally occurring diseases and weathering capability with results promptly provided to stakeholders. We are working with breeders to develop disease resistant varieties adapted to the southern U. S. We continue to monitor fungicide QoI resistance in foliar pathogens (*Cercospora* spp.; *Rhizoctonia solani*) and suspect that other populations (*Corynespora cassiicola*; *Septoria glycines*) also have developed resistance. Fungicides containing SDHI and/or newer generation DMIs appear to be maintaining efficacy. As opportunities arise, we are excited to conduct research and demonstration on farms helping to generate needed information or confirm research station findings. Early in the season, southern blight and taproot decline were prevalent causing significant losses in some cases. Foliar diseases were not much of an issue until mid-season. Aerial blight, soybean rust, target spot, and Cercospora leaf blight were the major diseases impacting soybean in Louisiana. Hurricanes Laura and Delta provided conditions throughout the state that promoted disease development. Many texts, phone calls, and farm visits indicated that Cercospora leaf blight was particularly bad across the state, and in some cases played a role in preventing fields from being harvested. Green stem syndrome (influenced by variety, planting date, stinkbug pressure, disease pressure, and environmental stresses) was prevalent on some farms resulting in severe losses. Timely application of fungicides helped suppress diseases and

preserved yield in some cases. Rains during the harvest season have caused seed quality issues in some cases. Yields averaged 55.0 bu/A across 1,000,000 acres.

The Alabama Cooperative Extension System began sending out Soybean rust (SBR) alerts in May to regional agents, agribusiness clientele and farmers through direct emails, the Alabama Crops Newsletter, ACES blogs, Twitter and Facebook. notifying growers of the developing SBR epidemic brewing in the state. We estimate approximate 20% more soybean acres of the 265,000 planted in 2020 was treated with a fungicide as a result of our monitoring program. This would have protected yield of about 8 bushels per acre from SBR over 53,000 acres at an estimated cost of $795,000 fungicide application cost (1 application =$15). By alerting growers to making a fungicide application for SBR, we estimate the program saved growers $2,685,000 ($8/bu soybeans) in potential yield loss from the disease taking into account the application cost for the fungicide. Since many growers, especially in south and central Alabama, already are aware of the threat of SBR each year due to our IPM educational programs, we suspect the savings of the program is significantly higher, especially in years where SBR is a problem.

The Purdue Field Crop Pathology Extension program provided up-to-date information on field crop diseases and their management. Over 13 Extension presentations on soybean disease management were given to over 924 people in 2020. These included Diagnostic Training Center (DTC) events that addressed participants about field crop disease and awareness about SCN and management.

Soybean Cyst and Root Knot nematodes remain perennial threats to soybean yield potential in DE and MD. Wet seasons have also favored widespread fungal diseases, such as Diaporthe pod and stem blight. Research and extension efforts in the University of Delaware field crops plant pathology lab are improving understanding of pathogen abundance and distribution in the Mid-Atlantic to help soybean farmers improve management approaches. In 2020, field surveys were conducted to better understand nematode distributions and to generate isolate collections of fungi that were characterized to species using molecular tools. The fungus Diaporthe dominated the isolate collection and to date three species have been identified in DE, with D. longicolla most frequently observed. Research is underway to characterize the relative aggressiveness of each of these species and update management recommendations. Diseases caused by Diaporthe species are frequently misidentified as other fungal diseases. A diagnostic handout was created for distribution in a Delaware Weekly Crop Update and other web notifications. To improve nematode management recommendations, seed treatment trials were initiated in a field with known elevated populations. Survey and seed treatment research was conducted in conjunction with foliar fungicide efficacy and planting date trials to update regional recommendations for disease management. Survey findings and management recommendations were shared through multiple regional meetings, virtual training events, and extension publications.

Outreach and extension activities were carried out to inform growers, crop consultants and agronomists on soybean diseases and their management (see extension publications). Awareness and free SCN testing was offered for growers in South Dakota. A grant was secured from the South Dakota Soybean Research and Promotion Council to pay for the SCN testing. SDSU Extension produced a weekly crop and pest newsletter throughout the growing season and produces a monthly newsletter the remainder of the year which provides timely and up-to-date

information on diseases to watch for or seen in the state and their management. Farming Friday videos were created to share information about disease identification and management. Research field days were held virtual which allowed all producers the change to attend from anywhere within the state. An agronomy booth with an emphasis on soybean disease management was available during the Sioux Falls Farm Show.

The Bradley Lab conducted field research trials focused on improved soybean disease management by evaluating fungicide and nematicide seed treatments, foliar fungicides, and disease-resistant soybean cultivars in field trials across Kentucky. We also continue to document and monitor the presence of fungicide-resistant strains of the Septoria brown spot and frogeye leaf spot pathogens in Kentucky. We use the information gleaned from these research trials to provide Kentucky farmers and other stakeholders with information they can use to improve their profitability and sustainability.

Extension education on the expanded range of Soybean Cyst Nematode has generated much interest among soybean producers in SCN soil testing, purchasing SCN-resistant varieties, and using anti-SCN seed treatments. NCERA-137 tables of soybean foliar and seed fungicide efficacy are incorporated into extension soybean management guides and educational programs for producers, and are widely valued.

Protecting soybeans from new and emerging diseases helps protect the nation’s food supply, keeps more money in hands of North Dakota growers and strengthens our local economy. Early detection and proactive management of emerging soybean diseases is critical to protecting soybeans from new and emerging diseases. Extension plant pathology led a statewide effort to detect SCN and deliver management information to soybean growers in the state of North Dakota. Proactive management of SCN is likely to prevent millions of dollars of economic loss to the states’ economy, and help keep North Dakotas farmers financially solvent. In additional, Extension plant pathology detected Frogeye Leaf Spot for the first time and confirmed Sudden Death Syndrome in a second North Dakota county. In all cases, management information was developed and delivered to growers immediately, though traditional and social media, through our public and private partners in (and beyond the state), and via the robust network of Extension specialists and agents.

In late 2019 frogeye leaf spot samples were collected from soybean fields in 10 Nebraska counties. Samples from all 10 counties tested positive for QoI fungicide resistance, documented for the first time in NE. I've initiated winter Extension programming to focus on this emerging issue to help growers better manage the disease in 2020 and beyond and to expand our survey efforts to determine how widespread this problem may be. Cumulatively, all of the corn and soybean disease programs helped Nebraska producers increase income and avoid losses of up to 178 million bushels for a potential value of more than $672 million.

MSU conducted research to improve understanding and management of soybean diseases with emphasis on sudden death syndrome, seedling diseases (Pythium, Phytophthora, Fusarium and Rhizoctonia), white mold, charcoal rot, frogeye leaf spot, Septoria brown spot, and cyst nematode. Results of research findings and management recommendations were distributed through presentations, MSU and CPN publications and social media.

Information on the susceptibility of commonly grown soybean cultivars to the southern root-knot nematode is limited to unavailable. Each year we evaluate several commercially available soybean cultivars for their field performance in a southern root-knot nematode field. Reports of these trials are extended to farmers that use them to select cultivars in nematode infested fields. Recently, one farmer reported a 20% increase in grain yield with utilizing soybean cultivars from these reports.

My laboratory served the stakeholders of Arkansas by providing disease screening of soybean varieties and completed fungicide trials that will be presented at county extension meetings and published on Twitter, the Arkansas Row Crops Blog, and posted on our website. I served as co-editor of the updated 2020 MP154 Arkansas Plant Disease Control products Guide and reviewed/updated the soybean disease section of the Delta Agricultural Digest for 2020. I posted up to date disease progress notifications for Asian soybean rust on the IPMPIPE at https://www.ipmpipe.org/, Arkansas Row Crops Blog, and Twitter to notify growers of disease progress. I also posted Twitter alerts and guidance for other important diseases of soybean. I spent numerous hours traveling the state for field scouting and field calls to identify disease issues, make recommendations, and stay abreast of current field/disease conditions so that I could inform growers and county agents of potential disease issues in crop year 2020. Overall, the extension activities of my laboratory provided or disseminated valuable information that saved real dollars on farms throughout Arkansas either though recommendation of scouting, inputs, or by limiting unnecessary inputs.

Identifying and characterizing loci as well as the genes that contribute to the expression of resistance is critical to develop marker-based breeding programs. In this past year, two genome wide analysis studies were accepted for publication which identify loci for quantitative disease resistance (QDRL) and Rps-gene mediated resistance. There were 75 Rps loci identified as well as 48 markers across 16 chromosomes for QDRL. Auxin and changes in expression of auxin transport genes have been implicated in susceptibility. In our studies, the levels of auxin catabolite IAA-Ala were higher in the moderately susceptible compared to resistant soybean roots following inoculation. And measurable changes in gene expression of PIN proteins which transport auxin, were identified in a time course assay following inoculation with P. sojae. These results suggest that resistant cultivars can manage the accumulation of auxin following infection by P. sojae. Interestingly, in the QDR response, jasmonic acid was higher in inoculated roots in the time course and may play a role in later states of infection.

Identified that ethaboxam combined with metalaxyl or mefenoxam increased both early plant population and yield for soybeans when they were planted in high disease environments. This provides another watermold treatment to those fields where metalaxyl alone does not provide protection.

Publications: (since last report)

Journal Articles:

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