**2019 Annual Report: NCERA 137**

**Scientist(s):** Tom Allen, Prakash Arelli, Soledad Bentiz-Ponce, Gary Bergstrom, Kaitlyn Bissonnette, Carl Bradley, Emmanuel Byamukama, Senyu Chen, Shawn Conley, Tom Creswell, Jaime Cummings, Brian Diers, Anne Dorrance, Travis Faske, Glen Hartman, Brian Hudelson, Tamra Jackson-Ziems, Yuba Kandel, Heather Kelly, Nathan Kleczewski, Alyssa Koehler, James Kurle, Marie Langham, Leonor Leandro, Chris Little, Ann MacGuidwin, Dean Malvick, Sam Markell, Shin-Yi Marzano, Febina Mathew, Angela McClure, Alemu Mengistu, Santiago Mideros, Daren Mueller, Boyd Padgett, Trey Price, Feng Qu, Alison Robertson, Alejandro Rojas, John Rupe, Bill Schapaugh, Nathan Schroeder, Edward Sikora, Damon Smith, Terry Spurlock, Jennifer Starr, Scott Stewart, Connie Strunk, Connie Tande, Chris Taylor, Darcy Telenko, Tim Todd, Greg Tylka

**State(s):** Alabama, Arkansas, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Minnesota, Missouri, Mississippi, Nebraska, New York, North Dakota, Ohio, South Dakota, Tennessee, Wisconsin

**Date:**  April 1, 2020

**Project Title:** Soybean Diseases

**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.

*Impact statement:*

**Taproot Decline**

Taproot decline is a new and emerging root and stem disease of soybean that has been reported in major soybean-producing states in the southern United States. Researchers have observed yield losses as great as 30% in some research trials. To determine effective ways to control taproot decline, researchers at land-grant Universities are evaluating different soybean varieties, seed treatments and fungicides. To date, commercially available soybean varieties do not appear to be resistant to the fungus. In addition, seed treatments do not appear to provide control or benefit yield. However, in-furrow fungicides appear more promising. This information will help farmer make cost-effective choices when trying to manage taproot decline and prevent yield losses. In the future, our research will focus on incorporating these findings into a comprehensive and effective set of integrated management practices for taproot decline.

*Individual state contributions:*

Alabama: Collaborating with plant pathologists and plant breeders in the mid-south region to develop soybeans lines resistant to Cercospora leaf blight. We conduct one variety trial in Alabama annually as part of the program. Continue collection of isolates of *Xylella* spp, causal agent of taproot decline to help determine distribution of the disease and genetic variability in populations in the southeast.

Delaware/Maryland: Soybean disease surveys were conducted to continue to better understand the distribution of Diaporthe spp. following the discovery of a new species associated with Diaporthe (Phomopsis) Seed Decay in DE that will be published in 2020.

Illinois: Illinois has been exceptionally involved in national and international extension research, with Diers and Hartman working closely with producers in economically challenged countries in Africa and Kleczewski working closely with producers in Illinois, surrounding states, and Canada. Diers and Kleczewski currently are working on collaborative, multi state projects pertaining to soybean resistance, disease management, and disease identification through multiple funding agencies.

Indiana: The Telenko lab collaborated with plant pathologists in the north-central region to evaluate fungicides products on the severity of sudden death syndrome, white mold, and frogeye in field experiments. Indiana was surveyed for soybean diseases during 2020 to gain a better understanding of disease distribution.

Iowa: The effect of fungicide products on severity of sudden death syndrome (SDS), plant establishment, and soybean yield has been evaluated in field experiments in Illinois, Indiana, Iowa, Michigan, South Dakota, Wisconsin, and Ontario, Canada since 2013. We conducted field experiments to determine how fungicide and nematicide seed treatments affected SDS and soybean cyst nematode (SCN). Preliminary data showed that SCN seed treatments alone did not affect SDS but when combined with ILEVO they provided the better disease and yield response than ILEVO alone. A second study evaluated the influence of cultivar and two rates of ILEVO on root rot and foliar symptoms of SDS. Results showed that ILEVO reduced root rot and foliar SDS severity and increased yield compared to the base treatment. Yield was negatively correlated with root rot and foliar symptoms suggesting both phases play an important role in SDS development and should be managed accordingly. In another study, we complied data on ILEVO for SDS management and yield response using a meta-analysis approach. A 35% reduction in SDS and 4.4 bu/ac (7.6%) increase in yield were estimated for ILEVO-amended seed treatment relative to base seed treatments.

Louisiana: Our programs have shared information regarding the novel taproot decline (TRD) pathogen and are collaborating on various research projects to develop integrated disease management strategies for TRD. Additionally, a collaborative effort is ongoing to develop soybean varieties resistant to Cercospora leaf blight (CLB) and other significant diseases.

Minnesota:

* D. Malvick is conducting studies on improvement of evaluation protocols and has been working to identify tolerance or partial resistance to Rhizoctonia root rot caused by *R. solani*.
* J. Kurle and D. Malvick participated in a collaborative research project on *Phytophthora* pathogens affecting soybean across the North Central U.S., with the goal of improving durability of resistance in soybean.
* D. Malvick is working on improving methods for evaluating resistance to brown stem rot.

Mississippi: I continue to evaluate the entries contained in the Mississippi State University Official Variety Trial program to the foliar diseases that occur across the locations where the plots are planted in addition to providing information cooperators on the response of breeder’s entries on major soybean diseases such as Cercospora leaf blight. In addition, I aid in several regional projects to address the disease loss estimates associated with plant diseases (USB funded), provide a location to conduct research associated with the losses that occur as a result of Cercospora leaf blight and how varieties respond to the disease throughout the season (USB and Mid-south soybean board funded), and also conduct research to address important local plant diseases (funded by the Mississippi Soybean Promotion Board).

New York: We have updated scientists in other states on new and changing diseases in New York, particularly the expansion from one to seven counties now infested by Soybean Cyst Nematode.

North Dakota: The SCN Coalition, which includes many members of the NCERA137, drafted and released the National Soybean Nematode Strategic Plan. This was done with close coordination of the United Soybean Board and the North Central Soybean Research Program.

The National Soybean Nematode Strategic Plan was released via a national news release distributed in conjunction with the press conference during Commodity Classic. Ten media articles were published generating 673,090 potential impressions about the Strategic Plan. These impressions alert agriculture professionals to both the impact of checkoff research and the future direction of research efforts. Additionally, the strategic plan was distributed broadly to scientists in the U.S., which should function to align research priorities, foster collaboration and ultimately improve plant disease management.

Ohio: Initiated and led a multi-state proposal, which engaged many soybean researchers across the North Central Region for a coordinated response to emerging pathogens. (not funded, but encouraged to reapply). Presented two invited talks in 2019 at the Soybean Breeders Workshop related to the latest developments in i) population genetics of *Phytophthora sojae* and our improved understanding of quantitative disease resistance and ii) identification and mapping of quantitative resistance towards *Pythium* spp.

South Dakota: (Mathew) Research was undertaken to characterize the species of *Diaporthe* causing Phomopsis seed decay of soybean in the U.S. In addition, studies on isolate by genotype interaction among isolates of *D. caulivora*, *D. longicolla* and *D. aspalathi* from multiple states (22 U.S. states) was also performed. Publications on the two research projects will be submitted to Plant Disease in the coming months. (Marzano) Furthered knowledge on *Sclerotinia sclerotiorum* biology and to combat the disease by RNA silencing.

Tennessee: Presented soybean data from TN research trials at Annual American Phytopathological Society meeting, Southern Division APS meeting, and Southern Soybean Disease Workers meeting.

Wisconsin: The Smith laboratory maintains a small soybean breeding program with the goal to improve resistance to white mold in northern soybean varieties. We have made significant progress over recent years and released our first variety W16-9138 (Dane) as a public, non-GMO, food grade variety in 2019. We will be releasing newer varieties in the next several years as well, with a focus on resistance toward white mold.

**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.

*Impact statement:*

Soybean farmers lose $1.5 billion annually to fungal pathogens that cause foliar diseases. Farmers have traditionally used fungicides to control foliar diseases, but many pathogens have developed fungicide resistance. Fungicide resistance leads to loss in product efficacy and results in wasted and time and money on ineffective products. University researchers across the U.S. have worked together to identify and develop diagnostic tools that can be used to determine fungicide resistance in pathogen populations:

* Frogeye leaf spot resistance to fungicide across 19 states and over 300 counties
* Septoria brown spot resistance to fungicide across 4 states
* Target Spot resistance to fungicide across 2 states

Through collaborative outreach efforts, researchers increased awareness of fungicide resistance. Knowing which diseases have developed resistance to fungicide has led to improved integrated pest management (IPM) practices, which include using resistant varieties, cultural practices, and smarter fungicide selection. These IPM practices have improved foliar disease management in soybean production and save the farmer and industry millions of dollars.

*Individual state contributions:*

Alabama: We continue to conduct fungicide trials focused on soybean rust, frogeye leaf spot, Cercospora leaf blight and target spot in various locations in the state. Products evaluated consists of both labeled and numbered compounds. This type of research is important particularly due to the lack of sufficient information on fungicide efficacy for target spot as well as for the limited locations in the U.S. that can provide adequate data on soybean rust control.

Arkansas: Several field trails were conducted to evaluate soybean susceptibility and field efficacy of several seed-applied nematicides to the southern root-knot nematode.

Delaware/Maryland: Two foliar fungicide trials were conducted to assess product efficacy in full season beans. Two double crop fungicide trials were conducted to compare the effects of plant spacing and fungicide timing on disease levels.

Illinois: Kleczewski is part of a collaborative multi state grant assessing cultivar, planting date, and seed treatment effects on SDS.

Indiana: Continue to evaluate fungicide seed treatment and fungicide foliar applications across Indiana. These include a multi-state project on seed treatment and coordinated efficacy trials.

Kansas: *Evaluation of soybean root diseases and soil pathogen populations in a long-term fertility study in Kansas*: This work tests whether N, P, or K increases soybean sufficiently to reduce SDS. Thus far, results show that P decreases *F. virguliforme* soil populations and in a severe epidemic. Consecutive years have shown the relationship between P and SDS. This is a long-term study (30 yr NPK trial) and the application time of fertilizer P, It is possible that these results are due to soil test P levels that were achieved over time. This suggests that maintaining optimum agronomic levels of soil test P may maintain the overall plant health. Additional studies are required to evaluate the effect of fertilizer P application to the soybean crop and the severity of SDS. This could offer growers another tool to manage the disease and increase productivity.

Kentucky: Over the past two years (2018-19), my research program has evaluated the effect of fungicides and soybean cultivars on southern stem canker of soybean. Our research has shown that fungicides are ineffective in managing southern stem canker when applied anywhere from planting (in-furrow) to the R3 (beginning pod development) growth stage. However, we did find that planting a soybean cultivar with resistance to southern stem canker was a very effective way to manage southern stem canker. This research was funded by the Kentucky Soybean Board.

Louisiana: We have identified varieties resistant to taproot decline along with determining that rotation and tillage are viable management options. Publicly available cultivars and plant introductions have been identified with resistance to Cercospora leaf blight. We have identified QoI and MBC resistance in multiple soybean pathogen populations resulting in lessened use of these modes-of-action. Other compounds with SDHI and newer-generation DMI modes-of-action are showing somewhat consistent efficacy on QoI resistant populations for aerial blight, CLB, and frogeye leaf spot. Additional studies have been conducted to evaluate the impact of planting date and maturity group on disease incidence and severity.

Minnesota: D. Malvick is developing and refining information on the use of foliar fungicides for management of white mold, and continues to contribute to studies of SDS management with seed treatment fungicides and partial resistance. Results from studies conducted in Minnesota have been used in regional and international publications. In addition, D. Malvick collected samples of frogeye leaf spot in Minnesota and worked with Carl Bradley at the University of Kentucky to confirm that resistance to QoI fungicides occurs over a broad area in Minnesota.

Mississippi: Foliar fungicide efficacy trials are conducted at the Delta Research and Extension Center in Stoneville, MS and some additional locations throughout Mississippi on an annual basis. Efficacy plots are conducted to address the current product offerings on managing the important foliar disease component within the Mid-southern soybean production system.

New York: New York has benefitted from information on fungicide efficacy against soybean diseases from researchers in other states.

North Dakota: Approximately two dozen field trials were run to provide growers better information on managing SCN, white mold and root rots.

Ohio: The seed quality of the 2018 seed crop in Ohio was abysmal with germinations well below 50%. We identified that a combination of seed treatment fungicides could rescue this seed and be used to obtain healthy plants. This information was released immediately via Extension Newsletters and a manuscript was submitted. Much of 2019 was spent focusing and providing information on the AgCrisis 2019 in Ohio. With the hashtag - #LeanOnYourLandGrant, resources were developed for the ag community which had regions of the state which were >40% prevented plant. Most of the soybeans were planted in July during 2019 (<https://u.osu.edu/2019farmassistance/home/>)

Tennessee: Screened 86 commercial varieties (maturity groups 3, 4, and 5) at 2 to 3 trial locations in split plot design with fungicide treatment at growth stage R3 – data available to public at search.utcrops.com

Wisconsin: The Smith laboratory is leading a multistate, multisite field experiment to understand the integrated management of white mold on soybean. Trials are being evaluated in numerous north central states to build improved management recommendations for the disease.

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

*Impact statement:*

**White Mold Sporecaster**

Weather-based models for assessing the risk of *Sclerotinia sclerotiorum* apothecial presence in soybean fields were developed from multi-state trials. A Smartphone application called Sporecaster was developed to deliver the models to farmers across the U.S. and Canada. Sporecaster was made available to the public as a free download on the Google Play Store and iPhone app store in May of 2018. Sporecaster was validated at all research locations. As of this report, Sporecaster was downloaded over 3,000 times from the Apple and Android stores. Daily use rates during the major “white mold season” (July and August) averaged 600-800 users per day. Sporecaster was Awarded the 2018 American Society of Agronomy (ASA) Extension Education Community Educational Award in the category of digital decision aids (software, web-based, smartphone and tablet apps). We also developed Sporebuster which is a white mold fungicide return on investment calculator. Sporebuster was Awarded the 2019 American Society of Agronomy (ASA) Extension Education Community Educational Award in the category of digital decision aids (software, web-based, smartphone and tablet apps).

*Individual state contributions:*

Illinois: Kleczewski and Mideros have projects assessing Pythium and Phytophthora status and sensitivity to fungicides in Illinois.

Iowa: The effects of a winter cereal rye and winter camelina cover crop of soybean seedling disease, growth and development and yield were investigated in a 3-year field experiment. Both cover crops before soybean had either a positive or no effect on seedling disease, soybean growth and yield. Pythium clade F populations were greater in soybeans following camelina compared to those following a rye cover crop. Multiple pathogens are frequently recovered together from diseased soybean seedlings, suggesting a seedling disease complex.  We hypothesized that infection with multiple seedling disease pathogens would cause disease symptoms to be more severe than either pathogen alone. A cup assay was used to evaluate the effect of co-inoculation with *Pythium* and *Fusarium* species on soybean seedling disease development. Seedling disease was more severe in cups inoculated with *Pythium* compared with those inoculated with *Fusarium* alone. No difference in disease development was observed for the *Pythium* species tested, but more severe disease occurred on seedlings inoculated with *F. graminearum* compared with those inoculated with *F. oxysporum*. Under the conditions used in these experiments, co-inoculation with *Pythium* and *Fusarium* did not result in more severe seedling disease on soybean.

Kansas: *Metabarcoding pathogenic Fusarium spp. within the soybean seed mycobiome*: The main objective of this work is to use DNA metabarcoding to identify and better understand the frequency distribution of *Fusarium* spp. in asymptomatic soybean seeds. A total of nine soybean seed samples were used in this study. Total DNA was extracted from five individual asymptomatic seeds from each sample. Forward fITS7 and reverse ITS4-barcoded primers were used for the amplification of the fungal ITS2 region. After library construction, amplicons were sequenced using the Illumina-MiSeq platform. Approximately 291,000 high-quality reads were produced from all soybean seed samples analyzed. Knownpathogenic groups such as *F. proliferatum* and *F. thapsinum* were observed in all seed analyzed. Overall, *F. proliferatum* was the most abundantly amplified species followed by *F. thapsinum*, *F. acuminatum*, *F. merismoides*, *F. solani*, *Fusarium* sp., and *F. semitectum*. Accurate information regarding the identity and frequency of the microorganisms that seed lots carry among and within them is crucial for significant improvements in seed and seedling disease management strategies, especially relating to the detection of pathogenic seedborne fungi.

*Brassica juncea pre-season cover crops reduce soybean soil populations and root colonization by Macrophomina phaseolina in Kansas*: Mustard (*Brassica juncea*) was tested as a pre-soybean cover crop biofumigant for control of charcoal rot disease severity, host root colonization, and suppression of pathogen soil populations. The cover crop was compared to a triazole fungicide seed treatment and a combination treatment with both seed treatment and cover crop for three seasons (2015 to 2017) in southeast Kansas. *B. juncea* biofumigation treatment did not significantly increase soybean yield but reduced disease severity in mid- and late-maturing varieties. *B. juncea* in combination with the seed treatment reduced *M. phaseolina* populations in soybean roots at R7-8 (*P* = 0.0007) compared to control. These results indicate the potential for using a natural cover crop for control of charcoal rot disease in soybeans.

Louisiana: The distribution range of taproot decline may extend further than we have defined into north central region states; more research is needed to completely define affected areas. We have determined that there are at least three species of Cercospora associated with CLB, and species composition varies with location.

Minnesota: D. Malvick is cooperating on a *Rhizoctonia zeae* project with Sydney Everhart and Nikita Gambhir at the University of Nebraska and other colleagues from across the North Central Region.

New York: We have begun sharing data and observations of white mold in New York to assess the utility of Sporecaster for predicting white mold across a wider geographic area.

North Dakota: Contribution of data to NC projects related to fungicide efficacy.

Tennessee: Utilized statewide soybean sentinel plots to monitor major foliar diseases (frogeye leaf spot, Septoria brown spot, downy mildew, and target spot) throughout the 2019 season

Wisconsin: (see impact statement)

**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.

*Impact statement:*

Yield losses due to soybean diseases cost millions of dollars to the industry each year and knowing which diseases are impacting soybean yields is a challenge. With help from the NCERA 137 members, the Crop Protection Network, which is a multi-state and international collaboration of specialists, has developed an interactive tool to assist soybean farmers to determine the potential yield losses from disease in their fields. This information can be used to identify changes and assess disease risks over time. For example, the average loss from frogeye leaf spot in Midwestern states has increased 3,000 percent: 1996-2000: losses were ~460,000 bushels/year ($0.04/ac); 2014-2018: losses were ~15.7 million bushels/year ($2.06/ac). This tool will help farmers, scientists, breeders, government, and educators prioritize disease management, research, policy, and educational efforts regarding soybean economically important soybean disease. Visit <https://loss.cropprotectionnetwork.org/> for more information.

*Individual state contributions:*

Alabama: Contribute to the Crop Protection Network publication series. I also share information on soybean disease development and management through Facebook and twitter (alabamaED#)

Arkansas: Interact with Crop Protection Network group as author and committee member. This organization provides information on disease management practices at affect farmers and consultants across the cotton, soybean, and corn belts.

Delaware/Maryland: Disease information, survey results, and fungicide efficacy data were disseminated to stakeholders through face-to-face interaction and meetings that included Delaware Ag Week, Mid-Atlantic Crop School, and other training events. Soybean disease information was also shared through social media platforms including Instagram and Twitter @UDPlantPath.

Illinois: Kleczewski worked closely to deliver in person talks, field days, webinars, and produce extension materials delivered through CPN, USB, UIUC Extension, and PARM.

Indiana: Soybean disease information, disease survey results and fungicide efficacy shared with Indiana stakeholders in multiple ways including field days, Extension meetings, conferences, Extension publications with CPN, articles in the Pest&Crop newsletter, and on-line media such as a website and twitter.

Iowa: Started in 2015, the Crop Protection Network (CPN) now serves as the infrastructure for multi-state field crop Extension outputs across the United States, the majority of which are soybean-focused. This network is composed of individuals in land grant universities and closely related organizations in the United States and Canada. CPN relies on input from over 125 specialists from 34 universities and other institutions either as authors, reviewers, or contributors. We partner with North Central Integrated Pest Management program and other commodity groups to leverage support for CPN. More than 45,000 publications have been downloaded from the CPN website more than 100,000 visits to CPN encyclopedia articles have occurred since 2018.

Kansas: Knowledge and information were disseminated in several formats. 1,293 K-State Crop Diseases Facebook followers; 1,624 @KSU\_CropDoc Twitter followers; >90% of producers are using a seed applied fungicide/insecticide/nematicide/PGR; Late season PRR development continues to be a problem.

Kentucky: We continue to support the Crop Protection Network (CPN) as an outlet to provide soybean disease management information to farmers and the ag industry. This includes providing input on annual revisions of the “Soybean Fungicide Efficacy Guides” that are available on the CPN website (cropprotectionnetwork.org). In February 2020, CPN had a booth at the National Farm Machinery Show in Louisville, KY to help promote the CPN as a resource for soybean disease management information.

Louisiana: We have transferred knowledge by communicating/collaborating with research and/or extension faculty directly or through refereed publications. Many methods of communication are used to reach stakeholders: www.lsuagcenter.com; Twitter (@ppp\_trey); the Louisiana Delta Crop Podcast (https://podcasts.apple.com/us/podcast/louisiana-delta-crop-report-podcast/id1456654699); text communication (Remind application); Louisiana Crops Newsletter (https://www.lsuagcenter.com/portals/communications/publications/newsletters/louisiana-crops); and email.

Minnesota: D. Malvick has contributed to knowledge transfer about soybean diseases and their management via contributions to publications on the Crop Protection Network and via web sites.

Mississippi: I remain active on Twitter (@baldpathologist) and continue to provide information related to the observation of important soybean diseases as well as potential management alternatives to be used throughout the season. In addition, a podcast initiated by several Extension personnel at MSU has continued to provide information as it relates to important topics from the field throughout the season. The podcast can be located at the Mississippi Crop Situation Podcast on Apple Music.

Nebraska: Identification and management of soybean diseases was highlighted in numerous traditional live and multimedia Extension programs, including on television, radio, online print media, and social media.

New York: Bergstrom participates in development and evaluation of soybean disease information for Crop Protection Network.

North Dakota: As the SCN Coalition leadership and membership is comprised largely of members of the NCERA-137, SCN Coalition activities and outputs are related to the actions of the NCERA-137.

Ohio: Yes, I tweeted!

South Dakota: (Mathew, Byamukama) Extension articles were prepared along with other researchers in the North Central Region to disseminate information on soybean diseases through SDSU Extension (Frogeye leaf spot, Sudden Death Syndrome), Crop Protection Network (Sudden Death Syndrome) and Soybean Research and Information Initiative (Seedling diseases).

Tennessee: Multiple newsletter/blog articles posted on news.utcrops.com and disease identification and management resources highlighted at guide.utcrops.com. Hands on training at annual soybean disease field day held at Milan Research and Education Center and multiple in-season soybean scout schools held in farmers’ fields in July

Wisconsin: Wisconsin researchers continue to deliver high-quality research-based information to farmers and practitioners in a variety of ways. Coolbean.info and the Wisconsin Field Crops Pathology website (badgercropdoc.com) are the primary methods of delivery. However, Both Dr. Conley (@badgerbean) and Dr. Smith (@badgercropdoc) maintain active twitter accounts and push all new information in this platform.

**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.

*Impact statement:*

*(See SCN coalition update on separate page)*

*Individual state contributions:*

Alabama: Sharing observations, isolates and data with researchers at LSU and Mississippi State University on *Xylaria* spp., cause of taproot decline, as we continue to learn about this emerging disease of soybeans in the U.S.

Arkansas: Work with Mid-South group on monitoring the occurrence of Taproot decline in our respective states.

Delaware/Maryland: Nematode soil samples were collected in 60 field 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.

Illinois: Kleczewski identified a new disease to the region and published these findings. Kleczewski and Schroeder are monitoring HG types of SCN within the state and working to assess biological control potential on this nematode.

Indiana: Initiated a statewide survey to collect *Cercospora sojina* isolates to monitor for QoI fungicide resistant strains.

Kentucky: Through funding from the United Soybean Board, the Bradley lab at the University of Kentucky helps document new observations of strains of the frogeye leaf spot pathogen (*Cercospora sojina*) with resistance to quinone outside inhibitor (QoI) fungicides in the U.S. In 2019, my lab helped document the presence of QoI-resistant strains of *C. sojina* in Michigan, Minnesota, and Nebraska for the first time. With these findings, QoI-resistant *C. sojina* has now been documented in a total of 19 states.

Louisiana: See objective 1.

Minnesota: D. Malvick has been monitoring the occurrence and distribution of frogeye leaf spot in Minnesota, which is an emerging disease in the state. He is also working with colleagues in North Dakota on the distribution and spread of sudden death syndrome and brown stem rot into areas where it has not been found.

Mississippi: Continued to monitor the soybean crop for the presence of soybean rust throughout the 2019 season. Even though soybean rust has not presented itself as the major threat that was initially considered (ca. 2004), monitoring for the presence of the disease remains important for local soybean farmers as a result of oftentimes continued periods of conducive environmental conditions. All observations of soybean rust have been moved to the mapping project that Joe LaForest from UGA Bugwood has initiated.

Nebraska: In 2019, our laboratory coordinated the collection of soybean leaf samples with frogeye leaf spot from 12 fields in 10 Nebraska counties. Samples were shipped to Dr. Carl Bradley’s laboratory at the University of Kentucky to collect and test the Cercospora sojina fungus for reduced sensitivity to QoI Group 11 fungicides (formerly strobilurin). C. sojina from all 10 Nebraska counties tested positive for resistance to QoI fungicides and is the first documentation of fungicide resistance in this pathogen in Nebraska. Among the fungal isolates that Dr. Bradley’s lab collected, 111 out of 113 (98%) of the Nebraska isolates exhibited reduced sensitivity to QoI fungicides. Results of this preliminary work has been broadly disseminated in Extension outreach programs to Nebraska stakeholders and regional collaborators. Results have also been used as justification for funding requests, submitted in collaboration with Dr. Sydney Everhart (UNL), to support research and Extension efforts to continue and expand related work.

New York: New York information is shared with other states through NCERA-184.

North Dakota: In 2019, a North Dakota monitoring effort for SCN continued. Succinctly, the North Dakota Soybean Council provides funding to cover laboratory costs of SCN samples though a grower-focused program. Growers receive pre-marked and pre-paid soil sample bags from any County Extension office in ND. They submit a sample and receive data in the map. NDSU Extension receives a data point and maps the distribution of the SCN statewide. In 2019, approximately 400 samples were received. This is significantly less than previous years, and a direct reflection of a difficult harvest season and two feet of snow throughout much of the state between October 10 and October 12.

South Dakota: (Byamukama) New species, *Phytophthora sansomeana,* were detected in soybeans. A first report has been submitted for publication.

Tennessee: Documented the second report of taproot decline in Tennessee (first report from Hardeman County in 2017) in research plots at Milan Research and Education Center in Gibson County and at on-farm location in Madison County in 2018. Confirmed by morphology and molecular identification. Soil survey campaign – screening for pathogenic nematodes and charcoal rot pathogen.

Wisconsin: We are leading a research project to investigate the interaction of Soybean vein necrosis virus (SVNV) and Tobacco streak virus (TSV) in soybean, and the impact that this interaction has on seed health. Our research lab has previously worked on describing seed transmission of SVNV and partnered with Iowa State University researchers to show evidence that SVNV and TSV co-occur naturally in soybeans.

**Individual State Impact statements:**

Alabama: Soybean rust (SBR) was the most common disease of soybean in Alabama during 2019. The disease was found in 43 of the 67 counties by September 20th (Figure 1). This compares to only 13 counties reporting the disease at the same point in time during 2018. With soybean plantings delayed in some areas due to wet weather in the spring, and fewer growers spraying fungicides due to the depressed price of soybeans, we feared that SBR could be a significant problem on late maturing soybeans in the state.

Conditions were favorable for SBR activity due to the mild winter that allowed the pathogen to overwinter on kudzu quite readily in Florida, Georgia, Louisiana, and Alabama. The mild winter coupled with wet spring conditions suggested there was good potential for a significant out-break of SBR on late-planted soybeans in the state. Because of this risk, the Alabama Cooperative Extension System (ACES) Crops Team was on high alert as we monitored disease progress throughout the growing season.

Figure 1. Distribution of soybean rust in Alabama during 2019.

By mid-September SBR was found in most counties in the state. Concern grew when we noted a number of commercial fields in North Alabama were still in highly vulnerable, early reproductive growth stages at a time when SBR as at high levels in the immediate area. However, only a few commercial fields appeared to suffer yield loss from SBR, most likely due to farmers making a single fungicide application in response to “SBR Alerts” sent out by the ACES Crops Team due to the high risk of SBR.

A major impact was noted for farmers that utilize center pivot irrigation. Based on research we have conducted recently, we estimate a yield savings of 15% when a fungicide is applied to soybeans grown under irrigation when SBR is a threat to the crop. In 2019 there were 270,000 acres of soybeans grown in Alabama with approximately 8,100 acres irrigated. These growers traditionally follow fungicide recommendations made by the ACES Crops Team. We estimate that growers using center pivot irrigation that followed our disease management program in 2019 saved approximately 6 bushels per acre worth $51 at current prices. Therefore, the ACES Crops team-soybean management program saved growers in the state $413,100 in 2019.

Delaware/Maryland: In recent years, wet conditions have favored fungal diseases in soybeans while Soybean Cyst Nematode and Root Knot Nematode continue to be perennial threats to soybean yield potential in DE and MD. An important factor of pest management is proper identification. In 2019, the University of Delaware field crops plant pathology lab conducted on farm surveys to better understand the distribution of soybean pathogens across Delaware and Maryland. Collected isolates were molecularly characterized to determine the correct species and establish isolate collections for future analysis of fungicide sensitivities. This work was conducted in conjunction with soybean fungicide efficacy field trials to generate regional recommendations for disease management. Survey findings and management recommendations were shared through multiple regional meetings, training events, and extension publications.

Illinois: The Illinois soybean program resulted in several measurable outputs in 2019 including 18 peer reviewed publications with two book chapters, 6 abstracts at meetings, 5 extension articles and 10 extension talks pertaining to soybeans. Extension outputs reached over 6,410 individuals in 76 countries.

Indiana: The Purdue Field Crop Pathology Extension program continues to provided up-to-date information on field crop diseases and their management. Over 22 Extension presentations on soybean disease management were given to over 1,800 people in 2019. These also include awareness about SCN and management.

Iowa: Our programs continue to identify the most problematic soybean diseases in Iowa each year, and provide management options for these diseases.

Kentucky: From 2014 to 2018, soybean diseases were estimated to be responsible for causing an average loss of over 8 million bushels annually in Kentucky. Dr. Carl Bradley’s research/extension program at the University of Kentucky has implemented research trials to improve management of soybean diseases to help mitigate these losses and has implemented outreach efforts to help Kentucky farmers improve their management of these diseases. Examples include:

* Increasing awareness of soybean cyst nematode (SCN) by implementing a free SCN testing program for Kentucky soybean farmers through funding from the Kentucky Soybean Board
* Monitoring for fungicide-resistant strains of the frogeye leaf spot pathogen in Kentucky and the nation through funding from the United Soybean Board
* Identifying the best management practices for southern stem canker of soybean by conducting field research trials in Kentucky

Kentucky farmers can improve their management of soybean diseases and their farm profitability by utilizing the information generated from these research trials and outreach efforts.

Louisiana: 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 US. 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. Diseases/pathogens of note that occurred in Louisiana soybean and that caused significant losses during 2019 included: aerial blight, anthracnose, Cercospora leaf blight, charcoal rot, frogeye leaf spot, Phomopsis seed decay, pod and stem blight, reniform nematode, Septoria brown spot, southern blight, southern RKN, and taproot decline. Harvest conditions were much improved compared to 2018, and yields averaged 48.0 bu/A across 860,000 acres.

Minnesota: Management of soybean SDS with seed treatment fungicides and partial resistance has been studied by D. Malvick and cooperators in universities and industry to improve and optimize management of this spreading disease. Multiple studies were conducted in Minnesota over several years, and the results have been used in extension education programs to improve management of this disease and have been presented at various conferences, and scientific publications. D. Malvick has also conducted studies on white mold management with fungicides and partial resistance in soybean over multiple years, and the results from this work have improved management of white mold.

Missouri: The Field Crop Plant Pathology program impacted the management of soybean diseases in Missouri through topic-focused Extension field days and winter meetings, fungicide and SCN seed treatment efficacy trials, and social/traditional media outreach.

Mississippi: In addition to answering field calls as they relate to plant disease issues in Mississippi, I conduct a large fungicide efficacy program. The fungicide efficacy data provides information for farmers in MS on the specific efficacy of important fungicide products on managing some of the more problematic, local diseases (Cercospora blight, frogeye leaf spot, Septoria brown spot, and target spot). In addition, I continue to evaluate the varieties contained in the Mississippi State University Official Variety Trial program for their response to inoculation with the southern stem canker pathogen as well as evaluate all of the OVT locations for the response of the entries contained in the program to important, naturally occurring plant disease. The information obtained from those programs help encompass the submissions to Plant Disease Management Reports, are used widely in annual Extension-based county meetings, help guide podcast reports, and are also disseminated on the Mississippi Crop Situation Blog. Data from each of those efforts are shared across the region with either collaborators on projects, but are also widely used by farmers across Mississippi to help them reduce the losses associated with plant diseases in the Mississippi soybean production system. Monitoring for important plant diseases such as soybean rust likely saves soybean farmers millions of dollars by reducing the need for fungicide application. In addition, the proper diagnoses of plant diseases greatly benefits soybean farmers by properly addressing the specific diseases that occur throughout the state and helping guide farmers on making important variety decisions as well as whether or not making a fungicide application would be economically beneficial.

Nebraska: I expect increased awareness of fungicide-resistant frogeye leaf spot among stakeholders that will support expanded survey efforts of the disease in Nebraska. In addition, Extension programming has already begun to emphasize the use of IPM principles for disease management. Management strategies, including use of disease-resistant soybean varieties and crop rotation, should be considered first to reduce disease severity. When disease develops, we recommend the use of crop scouting prior to making fungicide application decisions. When fungicide use is necessary to mitigate losses due to disease(s), we promoted the selection of products containing active ingredients representing at least 2 and preferably 3 modes of action to reduce selection pressure and development of more resistance in this and other pathogens.

New York: Information gained through exchange with NCERA137 scientists has benefitted New York soybean producers especially regarding knowledge of the efficacy of fungicides (foliar and seed) for control of soybean diseases. Bergstrom utilizes NCERA 137 information in his outreach to New York producers.

North Dakota: SCN is widely considered the most economically important soybean disease in the United States, and an merging threat in North Dakota. In North Dakota, the state-wide grower-based sampling program for SCN has increased sampling by hundreds of growers annually in the state. Changes in grower conversations and use of management tools have been documents. Additionally, materials developed by the SCN Coalition are used frequently throughout the state.

Ohio: Six separate soybean nested association mapping populations were screened for resistance to three different *Pythium* spp and *P. sojae.* Thirty-three quantitative disease resistance loci were identified, of which only 3 were associated with resistance to more than one pathogen. This suggest that there are very different mechanisms for each of these pathogens associated with resistance.

South Dakota: (Byamukama) 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. (Byamukama) Foliar fungicide application in soybeans continue to show inconsistent yield response. Results from these trials have been shared with producers, crop consultants and agronomists and also posted at the university extension website

Tennessee: Significant activities in 2019 include meeting and developing strong relationships with county agents, Tennessee farmers, extension and research colleagues, consultants, industry and other agricultural professionals, as well as posting news articles on the utcrops.com blog, popular press articles, research articles, and participating in in-service and county meetings - providing disease identification and management information. Specifically, in 2019 soybeans were harvested on more than 1.37 million acres in Tennessee. Final state average yield was 47 bushels/acre (NASS 2019 State Agriculture Overview - Tennessee). Meetings/trainings included: Row-crops training for Extension Agents in Tennessee, 8 county production meetings, 2 consultants meetings, 5 scout schools/field days, 2 guest lecture - at UT Martin and Union Universities. Numerous farm visits, client visits, phone, and email contacts. Evaluation of plant disease management tools and strategies including over 65 experiments including many cooperative, regional projects. Over 3,000 agricultural clients were directly trained in disease management strategies for field crops at various production meetings, including over 100 individuals trained at soybean scout schools and soybean field day. Over 10,000 direct client contacts via individual visits, telephone conversations and email. Indirect contacts resulting for news articles and other publications exceeded 450,000. Over 100 clients viewed test plots and demonstration of IPM control tactics, and results of many experiments were published on the internet for public access. Savings to row crops producers in Tennessee via reduced fungicide costs and yield loss in field crops due to their increased understand of disease management strategies are conservatively estimated at greater than $6,000,000 in 2019.

Wisconsin: Weather-based models for assessing the risk of *Sclerotinia sclerotiorum* apothecial presence in soybean fields were developed from multi-state trials. A Smartphone application called Sporecaster was developed to deliver the models to farmers across the U.S. and Canada. Sporecaster was made available to the public as a free download on the Google Play Store and iPhone app store in May of 2018. Sporecaster was validated at all research locations. As of this report, Sporecaster was downloaded over 3,000 times from the Apple and Android stores. Daily use rates during the major “white mold season” (July and August) averaged 600-800 users per day. Sporecaster was validated at all research locations. Currently, programming adjustments are being made to Sporecaster in preparation for the 2020 field season.

**Publications (since last report)**

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**Job Announcement:**

The NDSU Department of Plant Pathology anticipates advertising for a Dry Edible Bean / Pulse Crop Pathologist. The position will likely be 90% research / 10% teaching and advertised as a tenure-track Assistant Professor. The position is also likely to have a focus on applied research and disease management. While the announcement was tentatively slated for April, the Covid-19 situation could delay the search. Planted acreage of the dry edible bean and pulse crops in North Dakota exceeds 1M acres annually, and crop commodity groups have a long history of supporting the plant pathologist.

**A Public-Private Partnership to Fight Soybean Cyst Nematode**

**Public Value Statement**

Helping producers recognize and manage new and re-emerging diseases supports their profitability, the local economy and helps protect the nation’s food supply.

**The Situation**

Soybean Cyst Nematode (SCN) causes more yield loss to soybeans than any other disease in the United States. SCN continues to spread in North America and is slowly adapting to the genetic resistance used in approximately 95% of the soybean in the US. Simultaneously, the majority of soybean growers are unaware of the erosion of this critical disease management tool. The situation is too large and complex for one organization to address alone. Without intervention, yield losses to SCN will continue to increase and reduce soybean profitability.

**Extension Response**

A public-private partnership called **‘The SCN Coalition’** was launched in 2018, with dozens of partner Universities, companies, and soybean checkoff organizations. Led by University Extension specialists, the SCN Coalition has secured over **$2.5M** in support from the soybean checkoff and private industry partners to raise awareness and improve management of this devastating disease.

**Outputs**

In 2018 and 2019, the SCN Coalition has:

* 429 national article mentions
* 16.4% share of the national ‘SCN’ discussion
* 18.2 M potential impressions
* Embedded itself in the nation’s largest outdoor and indoor farm shows.
* Worked with media partners to deliver a special edition 32-page insert in the Corn+Soybean Digest to 113,000 growers mailboxes.
* Been awarded the Best of NAMA Award for Overall Public Relations Program. NAMA is the largest agri-marketing organization in the US.

**Measuring Impacts**

Baseline research on grower awareness and practices was conducted in 2015. In 2020, market research will be repeated. Impact objectives include:

* Increase the number of growers who agree that SCN is adapting and overcoming resistance from 57% by fall 2020. Target is 8% increase.
* Increase the number of growers scouting/sampling for SCN from 34% by fall 2020. Target is a 5% increase.
* Increase the number of growers who are rotating SCN-resistant varieties from 30% by fall 2020. Target is a 3% increase.

**Resource Links**

[www.theSCNCoalition.com](http://www.theSCNCoalition.com)

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