**Issues and Justifications:**

The United States stands as the leading producer and exporter of soybeans, producing nearly 4.3 billion bushels ($45.7 billion) from almost 87.2 million acres planted in 2022 (United States Department of Agriculture National Agricultural Statistics Service [[USDA NASS](https://www.nass.usda.gov/)] 2023). Processed soybeans serve as the primary protein feed and the second-largest source of vegetable oil worldwide. As new markets for green energy and industrial applications utilizing soybean oil emerge, there is a growing demand for improved yield and quality. The U.S. soybean production has grown due to changes in management systems, genetic advancements, and expanded acreage. Although soybean yields have averaged 50.0 bu/A from 2018 to 2022, the prevalence and spread of soybean diseases have hindered the realization of greater yield potential. For example, between 2015 and 2019, soybean diseases inflicted an estimated average economic loss exceeding $44 per acre annually across the United States and Ontario, Canada, with a projected total yield loss of nearly 2.2 billion bushels ([Bradley et al. 2021](https://doi.org/10.1094/PHP-01-21-0013-RS)).

The mission of NCERA-137, the Soybean Disease Committee, is to actively monitor the development of soybean diseases, facilitate research coordination, and provide science-based information to stakeholders including farmers, soybean breeders, agricultural companies, and agencies in the North Central region and other U.S. soybean production areas. The NCERA-137 committee members belong to institutions in 20+ U.S. soybean producing states, with research and/or Extension appointments at their respective institutions. The committee operates as a robust system for the rapid exchange of information on soybean diseases, aiming to minimize yield losses and support cost savings for farmers and companies. Specifically, the members work collaboratively through multi-state projects on established and emerging soybean diseases related to disease diagnosis, pathogen biology and epidemiology, disease forecasting, fungicide sensitivity monitoring, host resistance, and host-pathogen interactions, which ultimately allows for successful adoption of best management practices by farmers. Through its coordinated, multistate research and information-sharing network, NCERA-137 assists soybean breeders, seed companies, and fungicide/biologicals manufacturers in the development of improved germplasm lines, cultivars, and integrated pest management programs. In addition, NCERA-137 members maintain strong partnerships with state, regional and national soybean commodity organizations, ensuring close collaboration and information exchange. They actively engage in technology transfer and improve accessibility to soybean disease research and management information through various channels, including traditional publications, electronic media, the SCN Coalition, and the Crop Protection Network (CPN).

**Related, Current and Previous Work:**

The overall goal of the NCERA-137 committee is to enhance the profitability of soybean production while upholding environmental protection and the sustainability of soybean cultivation. This renewal proposal for NCERA-137 (2024-2029) describes research and Extension activities that will expand and supplement information available on soybean diseases and disease management. All accomplishments of the committee are listed under the previous yearly reports submitted by the group members. Few select accomplishments include:

* NCERA-137 received the 2023 National Excellence in Multistate Research Award, which is a testament to the collaborative and combined efforts of this committee.
* Detection and identification of soybean pathogens has improved. For example, scientists in Delaware, Iowa, Louisiana, Michigan, Mississippi, North Dakota, Tennessee, and Wisconsin worked together to identify three novel species of *Diaporthe* that cause Phomopsis seed decay.A multi-state effort (with researchers in Kentucky as the lead) was established that identified fungicide-resistant strains of *Cercospora sojina*, which causes frogeye leaf spot, in 22 U.S. states.
* Specific farming practices were identified that can reduce the severity of soybean diseases. For researchers in Michigan and Wisconsin demonstrated that row spacing can dramatically reduce white mold severity.Four varieties with resistance to *Sclerotinia sclerotiorum* (which causes white mold) will be released in 2024.
* Soybean Cyst Nematode (SCN) Coalition (with researchers in North Dakota as the lead nearly two dozen other states contributing) was launched. The SCN Coalition efforts increased active management among soybean growers nationally, saving them an estimated $100 million+ from SCN.
* Fungicide seed treatments and foliar fungicides efficacy tables developed by the NCERA-137 group reach about 100,000 users in 20+ states each year.
* Ongoing multi-state regional efforts, such as the Crop Protection Network (CPN), serve as a centralized hub, benefiting farmers, consultants, and researchers in the soybean community by providing comprehensive resources.
* Between 2015 and 2023, the NCERA-137 committee produced 700+ peer reviewed publications, proceedings, abstracts, and technical reports; 20 books or book chapters; and 500+ newsletters, videos, webinars, podcasts, news articles, and other Extension products.

**Previous work**

NCERA-137 exceled in its ability to facilitate discussions and responses to new and reemerging diseases within the soybean production area across the United States. For instance, the committee played a key role when soybean rust was first discovered near Baton Rouge, Louisiana, in 2004. The committee members were at the forefront of the national response even before the establishment of the NCERA-208 Soybean Rust Committee. While soybean rust has not caused the catastrophic national losses initially feared, its unpredictable spread presents ongoing challenges for soybean production in the central and southern US and in assessing its long-term impact. NCERA-137 members participated in soybean rust monitoring through the IPM PIPE website (http://sbr.ipmpipe.org). Although this site was originally focused on soybean rust, additional diseases were monitored and reported through this site.

**Related and current work**

NCERA-137 continues to serve as a platform to establish research and Extension priorities related to soybean diseases, as well as co-ordinate collaborations with other organizations interested in soybean health and productivity (e.g., NC committees, Southern Soybean Disease Workers, and soybean breeders’ groups). Collaboration within NCERA-137 and with other organizations serves as the foundation for numerous regional research projects and multistate grant proposals supported by organizations like the United Soybean Board (USB), North Central IPM Center, the North Central Soybean Research Program (NCSRP), and USDA-AFRI. Recent coordinated regional projects have addressed various diseases, including Sclerotinia stem rot, Phytophthora root rot, charcoal rot, sudden death syndrome, *Diaporthe*-caused diseases, soybean cyst nematode, frogeye leaf spot, and seedling diseases. A regional disease loss survey, conducted by researchers and Extension specialists affiliated with NCERA-137, provides annual estimates of yield losses caused by plant diseases in the north central region. This comprehensive assessment, undertaken in collaboration with the USB and NCERA-137 membership, plays a critical role in determining the relative importance of soybean diseases. The information obtained from this survey guides research prioritization and breeding efforts in the field of soybean disease management.

The introduction of soybean rust, coupled with other factors including soybean market prices, has led to a significant rise in fungicide usage, even in non-rust areas. Data from USDA-NASS indicates minimal fungicide usage on soybeans before 2006. However, fungicide applications surged to over 362,000 pounds in 2006, surpassing 1 million pounds in 2012, and nearly reaching 2 million pounds in 2017. Several questions regarding the effective use of foliar fungicides, including plant health claims, remain unanswered. Heightened fungicide usage raises concerns of increased risk of the selection of fungicide-resistant soybean pathogens. In 2010, the loss of disease control and the emergence of resistance to QoI fungicides were documented in *Cercospora sojina*, the causal agent of frogeye leaf spot. QoI-resistant pathogens that cause Cercospora leaf blight, aerial blight, Septoria brown spot, and target spot have subsequently been identified. Monitoring fungicide resistance and undertaking educational efforts will be necessary to minimize or prevent the loss of disease control for these and other soybean diseases.

Despite substantial research and Extension efforts to manage soybean cyst nematode (SCN), caused by *Heterodera glycines*, populations of the nematode with the ability to feed and reproduce on soybeans with the PI88788 source of resistance continue to increase.). This highlights the ongoing need for the development of soybean cultivars that utilize alternative sources of resistance and for research evaluating additional methods to manage SCN, such as nematicide seed protectants. Additionally, Extension and outreach activities to educate stakeholders about the importance of SCN, field sampling to determine SCN egg densities, and active management of SCN will continue to be necessary. Thus, in collaboration with the NC1197 committee (Practical Management of Nematodes on Corn, Soybeans and Other Crops of Regional Importance), agrochemical companies, agricultural media partners and the soybean checkoff organizations, the NCERA-137 members are promoting education on SCN and nematode management among farmers and other stakeholders through the SCN Coalition.

Plant pathologists, breeders, and industry experts actively collaborate to develop effective strategies (e.g., fungicides, host resistance) for managing root and stem diseases. The prevalence of root and stem diseases such as Sclerotinia stem rot (caused by *Sclerotinia sclerotiorum*), and sudden death syndrome (caused by *Fusarium virguliforme*) has increased due to changing climatic trends, including wetter field conditions, as well as altered management practices such as no-till and reduced tillage. In addition, the prevalence of historically southern diseases, such as charcoal rot (caused by *Macrophomina phaseolina*), frogeye leaf spot, *Diaporthe*-caused diseases, and red crown rot (caused by *Calonectria ilicicola*), has expanded and negatively impacted soybean production in the north central region. Additionally, new diseases such as tap root decline (caused by *Xylaria necrophora*) are of increasing concern.

To ensure continued success, NCERA-137 places great importance on actively training the next generation of researchers, teachers, and Extension workers. Since 2020, the soybean disease research community has seen an influx of new researchers and Extension specialists. The participation of these new faculty members in NCERA-137 is crucial for fostering collaborations and facilitating effective communication of research outcomes. With a successful history, NCERA-137 annual meetings have consistently achieved near-perfect attendance from member states. The committee also maintains an international presence with participation from Ontario, Canada. The high value placed on interpersonal exchanges is evident in the attendance rate and the lively and productive discussions during these meetings. Despite challenges in obtaining funding for graduate students, postdoctoral associates, and technicians, the committee remains committed to seeking new opportunities to support these individuals in studying soybean diseases and actively participating in NCERA-137 activities.

**Objectives:**

1. Coordinate yield loss estimates and economic impact associated with soybean diseases across the U.S. and Canada (Ontario) soybean producing region.
2. Evaluate, refine, and integrate management strategies for soybean diseases in the North Central region and other U.S. soybean production areas to increase grower profitability.
3. Develop appropriate responses to the emerging or re-emerging threats to soybeans in the North Central Region, such as fungicide resistance and disease forecasting.
4. Foster collaborative research and information exchange on soybean diseases among scientists with different expertise and resources in the North Central region and other U.S. soybean production areas.
5. Improve share of knowledge and expand resources about soybean diseases and their management with soybean growers and agribusinesses.

**Procedures and Activities:**

Members of the NCERA-137 committee are focused on objectives and sub-objectives, which allow for sustained and combined efforts to best address the needs of stakeholders and with groups such as NC1197 committee, Southern Soybean Disease Workers (SSDW), and soybean breeders’ groups.

1. Coordinate yield loss estimates and economic impact associated with soybean diseases across the U.S. and Canada (Ontario) soybean producing region.

The estimates of yield loss associated with important soybean diseases are provided by the NCERA-137 members, SSDW, as well as other Extension personnel, following each growing season. A list of at least 20 foliar, stem and root, nematode, and seed and grain diseases are sent annually to plant pathologists in 29 U.S. states and the Canadian province of Ontario. The methods used for soybean yield losses estimates may vary among states, but the data is derived from survey within a given state or province, submissions of diseased plant samples to a diagnostic laboratory, evaluations of fungicide and cultivar performance trials, feedback from university Extension specialists, industry personnel, and farmer representatives, and/or additional methods.

1. Evaluate, refine, and integrate management strategies for soybean diseases in the North Central region and other U.S. soybean production areas to increase grower profitability.

2.a. Fungicide efficacy trials for soybean diseases.

NCERA-137 members establish field trials to evaluate foliar fungicide and seed treatment products for their efficacy and application timings in their respective states to manage soybean diseases and produce a profitable crop. There have been efforts with funding from the North Central Soybean Research Program and the United Soybean Board to conduct coordinated trials for Sclerotinia stem rot (*Sclerotinia sclerotiorum*), and sudden death syndrome (*Fusarium virguliforme*), and the members continue to evaluate products for their effectiveness against frogeye leaf spot (*Cercospora sojina*), Phytophthora root and stem rot (*Phytophthora sojae*) and seedling pathogens (*Fusarium*, *Rhizoctonia*). Data from these research trials are compiled into an annual update on fungicide efficacy as well as helps the EPA with the information needed for emergency registration of products (Section 18).

2.b. Screening soybean accessions for resistance to economically important pathogens

Members of the NCERA-137 screen accessions in the genus *Glycine* that belong to the USDA soybean germplasm, or from the public (USDA-ARS) and industry breeding programs using standard inoculation methods established for soybean pathogens under lab, growth chamber, greenhouse and/or field conditions. These projects are made possible with funding from the state commodity boards, North Central Soybean Research Program and the United Soybean Board. In addition, the members evaluate Uniform Regional Nurseries, and soybean variety performance trials in their individual states to characterize resistance to economically important pathogens in advanced breeding lines. Data obtained from the screening experiments are shared with breeders and other scientists to develop commercial cultivars with disease resistance for farmers, and other genetic studies (e.g., identification of candidate resistance genes). This sub-objective has the benefit of integrating with the sub-objectives (2.a.) and (2.c.) for developing best management practices for soybean diseases.

2.c. Development of strategies besides fungicides and host resistance to manage soybean diseases

NCERA-137 members evaluate the use of cover crops, biologicals, and other alternative practices (i.e., besides fungicides and host resistance) against seedling pathogens, and other diseases using standard inoculation methods established for soybean pathogens under lab, growth chamber, greenhouse and/or field conditions. These projects are made possible with funding from the state commodity boards, NCSRP and USB. This sub-objective has the benefit of integrating with the sub-objectives (2.a.) and (2.b.) for developing best management practices for soybean diseases.

1. Develop appropriate responses to the emerging or re-emerging threats to soybeans in the North Central Region, such as fungicide resistance and disease forecasting models.

These projects are made possible with funding from the state commodity boards, NCSRP and USB. Members of the NCERA-137 have collaborated on the development of disease forecasting models for Sclerotinia stem rot, frogeye leaf spot and other diseases. These models provide the current risk of disease development and provide management recommendations (e.g., foliar fungicide applications) where appropriate. The members are continuing to refine the models and develop smart phone applications that will enable soybean growers to access disease risk information in their field. Research is underway by the group to link the fungicide efficacy trials (Sub-objective 2.a.) with the disease-forecasting models to allow real-time validation and improved accuracy. As for fungicide resistance studies, Quinone outside Inhibitor (QoI) fungicides have been used for managing soybean foliar diseases, but these chemicals have a high risk of several fungi (>30) developing resistance to them (Fungicide Resistance Action Committee 2011). Thus, a QoI fungicide resistance monitoring program has been established by the NCERA-137 members to monitor shifts in sensitivity for fungal pathogens such as *Cercospora sojina*, *Diaporthe* spp., *Septoria* spp., among others.

1. Foster collaborative research and information exchange on soybean diseases among scientists with different expertise and resources in the North Central region and other U.S. soybean production areas.

NCERA-137 members have a documented history to promote the exchange of research information, pathogen inoculation techniques, fungicide efficacy results, soybean germplasm and advanced breeding lines, and pathogen cultures to collaborate and coordinate research and Extension efforts. Knowledge sharing and information exchange among researchers is made possible through the annual meetings, virtual meetings (Field Crop Pathology Extension) as well as through national, regional, and state plant pathology meetings. Furthermore, we maintain coordinated email discussions, including the NCERA-137 Soybean Diseases Basecamp (https://3.basecamp.com/3209262/projects/20354587), SSDW Basecamp (https://3.basecamp.com/3209262/projects/30767361) and Field Crop Pathology Extension Specialists (https://3.basecamp.com/3209262/projects/25121917). In addition, the committee will continue to meet with other organizations such as NC1197 committee, SSDW, and soybean breeders’ groups when possible. Also, the members work with social media, such as Twitter, and with the CPN for dissemination of outputs to broad audiences, which expands the reach and impact of the group.

1. Improve share of knowledge and expand resources about soybean diseases and their management with soybean growers and agribusinesses.

Members of the NCERA-137 work collaboratively to produce and disseminate updated and timely Extension materials for use by soybean growers and agribusinesses. Resources are made available through the Extension service of land-grant institutions, CPN, The SCN Coalition and other social and traditional media outputs, such as Fungicide Efficacy for Control of Soybean Foliar Diseases, Fungicide Efficacy for Control of Soybean Seedling Diseases, A Farmer's Guide to Soybean Diseases and Compendium of Soybean Diseases and Pests published by the American Phytopathological Society (APS) and Grow: Plant Health Exchange. The members will continue to refine fungicide efficacy tables and disease factsheets, which are distributed nationally.

**Expected Outcomes and Impacts:**

**Outputs:**

* Updated information on soybean yield loss estimates as well as soybean diseases and disease management made available through the CPN, APS, and other sources (e.g., Twitter, www.thescncoalition.com).
* Coordinated research and Extension efforts to evaluate best management practices for the management of soybean diseases (e.g., multi-state projects to establish replicated trials to evaluate the efficacy of fungicides).
* Standardized methods and techniques for accurate identification of soybean pathogens and to screen soybean accessions for disease resistance.
* Refined disease forecasting models to accurately estimate the risk of disease development and provide management recommendations (e.g., fungicides)
* Availability of soybean germplasm lines and release of cultivars with resistance to disease-causing pathogens of importance in the north-central and other U.S. soybean production regions.
* Availability of fungicide efficacy tables and other disease management guidelines for use by soybean growers, Extension agents, crop consultants and industry personnel (see Literature Cited section for examples from 2017-2022).

**Projected Impacts:**

* Increased reach to, and engagement with, soybean growers and stakeholders through NCERA-137 outputs and NCERA-137 partnerships.
* Increased farmer awareness of soybean diseases and disease management strategies.
* Improved efficiency in the identification of soybean pathogens as determined by plant disease diagnosticians and other specialists.
* Increase in active management tools and/or strategies for soybean diseases among soybean farmers.
* Increased number of germplasm lines for breeders and cultivar options for growers with resistance to soybean pathogens of economic importance.
* Increased prevention and/or mitigation of losses to diseases among soybean growers.

**Projected Participation**

View Appendix E: Participation

**Educational Plan**

Objectives 4 and 5 directly address the educational plan and we will continue to tailor our Extension and outreach activities depending on the audience. Our audience includes soybean growers, soybean commodity groups, chemical manufacturers and seed industry, regulatory agencies, and researchers in industry, government, or academia. Currently, the information generated from the NCERA-137 committee is made available through annual meetings, University Extension activities, weekly newsletters, mailing lists (e.g., listservs), grower meetings, social media (e.g., Twitter, YouTube), and publications. In addition, the CPN (<https://cropprotectionnetwork.org/>), Grow: Plant Health Exchange (<https://www.planthealthexchange.org/soybean/Pages/default.aspx>), and The SCN Coalition ([www.thescncoalition.com](file:///C%3A%5CUsers%5CFebina%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CINetCache%5CContent.Outlook%5C9XHL63X9%5Cwww.thescncoalition.com)) continue to be outlets for NCERA-137 members to report information on soybean diseases and disease management. Also, the members collaborate and discuss real-time issues in identifying diseases or other observations in the soybean production areas through the NCERA-137 Basecamp and other mailing lists (SSDW and Field Crop Extension Plant Pathologists). Also, information is disseminated through refereed research journals such as *Plant Disease*, *Plant Health Progress*, and other scientific publications. For many of our activities, the members are funded by NCSRP, USB, USDA-NIFA, industry funds, etc. so that disease management information is promptly and effectively disseminated to producers and others in the soybean community.

**Organization/Governance**

There will be two officers (one secretary and one chair) for NCERA-137. A secretary will be elected at each annual meeting. The secretary records and distributes the minutes of the annual meeting, submits the annual report, and then becomes chair of the committee for the following year. The chair directs the activities of the committee, serves as the liaison between the committee and the administrative advisor, and assists with or directs arrangements for the next annual meeting. The chair and secretary will be nominated and elected by committee members for a one-year term.