1. ACCOMPLISHMENTS **(2,500 character limit)**

**S1083 : Ecological and genetic diversity of soilborne pathogens and indigenous microflora**

**Dr. Sharifa Crandall – Penn State**

Soil Ecology and Disinfestation (Crandall Lab). In 2024, we conducted research on a USDA NIFA Organic Transitions research project that is line with two multi-state hatch objectives: (1) evaluate the biology and diversity of soilborne pathogens in Pennsylvania and Ohio, (2) to conduct efficacy trials to assess which combination of steaming disinfection and ASD methods effectively suppress a suite of soilborne pathogens that devastate tomato crops in high tunnel systems. Plant pathogens that disperse through the soil are a significant problem for organic farmers, especially when they infect vegetables during high tunnel production in the Northeastern and Midwestern United States. Organic farmers have few options for managing diseases compared to farmers that use synthetic fungicides. Steaming the soil to high temperatures and Anaerobic Soil Disinfestation (ASD) are two disease management methods that are chemical-free and have the potential to kill problematic soilborne pathogens without (or in rotation) with synthetic fungicides or fertilizers.

In 2024, my Soilborne Disease Ecology lab group at Penn State, in collaboration with the USDA-ARS station in Wooster, OH (Testen Lab), set up for efficacy trials at the research high tunnel at ARS in OH. These trials in subsequent years will compare how well soil steaming and ASD suppresses soilborne diseases of vegetables with a focus on high tunnel tomatoes. Our goals were to determine soil microbial community recovery (composition/diversity) after steaming and/or ASD and impacts on plant health and try to understand the factors that affect farmers' willingness to adopt sustainable soilborne disease management practices by the end of the project. We aim to share best practices with organic growers from these two promising, innovative organic farming practices. We will eventually disseminate results at farmer conferences and meetings, through peer-reviewed publications, extension materials, factsheets, and webinars. The target audiences will include partnering organically certified farmers, those who are interested in or who are in transition to organic production, industry partners, federal and academic scientists, and the public at large.

***Short-term Outcomes:*** We were able to create an extension article that is available online to growers and the public. This research will inform management practices in the short-term for farmers with high tunnels in Ohio and Pennsylvania, especially those that are in transition to organic or those that are currently certified. A cost-benefit analysis will be made available for the adoption of technological practices such as soil steaming disinfection and ASD. Moreover, another short-term outcome will be an increased awareness among growers of phytosanitary methods and their utility for high tunnel agricultural systems. Finally, growers will receive extension educational support and networking opportunities to share best practices at workshops and conferences.

***Outputs:*** In 2024, the post-doc at Penn State found high tunnel farmers to participate in this research through reaching out to our extension network of vegetable farmers in PA. 1 MS graduate student was hired who is mentored jointly by the PD (Crandall) and Co-PD (Windon). Note that in year 3 (2025) onward, we expect an output of at least 2 peer-reviewed research articles and/or least 2 extension factsheets or other form of outreach materials. In 2024, an extension factsheet was published on soil steaming as a viable option for suppressing soilborne pathogens. In year 3, at least 1-2 exhibits per year will be presented at Agricultural Progress Days held in August at Penn State in 2025 to showcase ongoing projects to vegetable growers. Finally, at least 3-4 stakeholder workshops will be given over the duration of the project and/or webinars on suppressing soilborne pathogens through soil steaming and ASD.

***Activities:*** In 2024, we continued to plan and started execution of obj. 1 (see milestones below) which involved initial on-station experimental set-up, and we obtained large equipment for the trials (e.g., field steaming engine). Personnel were trained on how to use this equipment. The MS graduate student began a literature search. They created a draft survey for farmers that will be administered (exempt) anonymously to gain more information about the innovation of these technologies in high tunnels. The PhD student in OH began creating inoculum for the soilborne pathogens in the lab for the experimental trials. Inoculum for on-station experiments and optimization of detection assays were conducted.

***Milestones:*** Milestones for this project are to 1) set up and conduct on-station efficacy trials at the USDA-ARS in year 1-2 (obj.1); 2) measure the diversity of soil fungi post-soilborne pathogen suppression (steaming/ASD) on-station manipulative experiments and on partnering organic farms in years 1-4 (obj.2), and 3) assess the willingness of vegetable high tunnel growers to adopt these innovations and the barriers to do so in years 2-5 (obj. 3). The graduate student at the ARS in 2024 optimized protocols for ASD and steaming on station suppression of soilborne pathogens on tomato. Target pathogens for detection were: *Pseudopyrenochaeta lycopersici, C. coccodes, V. dahliae, Fusarium oxysporium* f. sp. *lycopersici, Phytophthora* spp*.* and the nematode *M. hapla.*

**Dr. Soledad Benitez – Ohio State University**

Research in the Benitez Ponce Laboratory at OSU is focused on understanding the relationships between agricultural production practices, crop health, and the agricultural microbiome. For this project, the emphasis is on soybean production systems, practices that promote soil health through crop diversification, and understanding interactions between microorganisms in agricultural systems. Accomplishments are presented below by Objective (two objectives to report).

**Objective 2**

Short-term outcomes:

- Continued analysis of arbuscular mycorrhizal fungal (AMF) communities in Ohio soils (under soybean production), and their distribution across different regions.

- Curated and organized datasets and pipelines for future analysis.

Outputs:

- Sequence data and taxonomic description of AMF recovered from Ohio soils by region.

Activities:

- During the 2023-2024 period our team worked on revising the bioinformatic pipelines and curating the AMF databases for better taxonomic assignment of recovered sequences. Several databases were evaluated during this period, including Marjaam, SILVA and reference sequences in NCBI. In addition, the data was organized and curated to incorporate not only AM taxonomy based on sequencing reads, but also soil characteristics, biogeographical region and environmental parameters such as average precipitation and temperature. We will apply the revised classification pipelines for the recovered AMF sequences and analyze AMF diversity across the state and generate hypothesis about AMF biogeographical patterns.

Milestones:

- To determine the most accurate classification for AM fungal reads recovered from amplicon metabarcoding analysis of soils.

**Objective 4**

Short-term outcomes:

- Organized, prepared and delivered an amplicon metabarcoding workshop.

- Organized a Session at the National Diversity in Stem Conference (Oct 2023).

- Continued training undergraduate and graduate students, as well as visiting scholar and postdoctoral researchers in aspects of soils, soil microorganisms, soilborne diseases and microbial antagonism.

Outputs:

- One workshop.

Activities:

- During the 2023-2024 period our team organized a workshop in collaboration with members of my of the core molecular biology laboratory. The workshop covered theoretical aspects of experimental design, sampling, sequencing library preparation and sequencing. In addition it covered on-hands work with short-read Illumina sequencing from data retrieval, quality control and trimming, to descriptive statistics, and differential abundance and network analysis. As part of the workshop organization, trainees (advanced graduate students and postdocs) had the opportunity to prepare and deliver workshop material to more junior students and technicians, as well as postdocs new to the topic of amplicon metabarcoding. We also organized a scientific session to be presented as part of the National Diversity in Stem Conference, held in Portland Oregon in October 2023. The session was titled: Understanding and Managing Plant Diseases: Diverse Approaches and Applications, and include three speakers from government, academia and extension.

Milestones:

- To contribute with training in techniques to study the diversity of microorganisms in soils and their relationships with soilborne diseases.

- To contribute with knowledge about plant diseases, their study and management.

**Dr. Richard Baird – Mississippi State University**

Several long-term metagenomic and microbial detection studies in agricultural crop and forest ecosystems were completed in 2023-2024. The initial long-term field research projects list for the last reporting period includes the first year's sampling and results. The research evaluates tip/end rot disease in storage associated with the soilborne fungal pathogen complex, other associated fungi, and bacteria. Harvested field samples were placed within a grower's storage facility in October to simulate real environmental conditions. To date, samples were collected in October and January, with additional dates in May and August 2024. Tissue samples from inner and outer tissues for the first two dates are being processed, obtaining gDNA to examine the microbiome before, during, and after storage using Next Generation Sequencing. Sequence data is available yet. Additional tissue samples from the same hybrid and replicate roots are being used to obtain primary and secondary untargeted metabolic profiles. To determine the association between rot and primarily sweetpotato tissue metabolism variations over time, changes in cellular metabolites are starting to be processed through Nuclear Magnetic Resonance (NMR) and GC-MS platforms. The aim of this research remains the same. That is to gain insights that could help prevent early infections both before and during storage, as well as to better understand storage methods that maximize the nutritional benefits of sweetpotato after storage for consumption.

Results from a four-year wildfire study in the Southern Appalachians (SA) compared temporal metagenomic data, focusing on soil pathogenic and mycorrhizal-forming microbes, coupled with soil chemistry results collected across four sampling dates to assess the ecosystem's recovery potential. These findings were published in 2023, followed by follow-up analyses of soil enzymes about microbiome community assessments, which were published in 2024. To conclude the study and follow natural recovery, soil samples were collected six years after the fire. These samples were processed to analyze microbial profiles and variations in exoenzyme data temporally, as we aimed to correlate vegetation recovery and tree survival using aerial imagery. Interestingly, the last year of sampling indicated a high percentage of trees had died.

White Oak (Oak Decline) Reforestation research was established in October 2024. Oak species, including Red Oak (*Quercus rubra* - RO) and White Oak (Quercus alba—WO), serve as keystone species throughout the eastern United States. Besides their vital roles within ecosystems, these oak species are crucial to the forestry and logging industries. However, due to excessive harvesting, their populations have significantly declined, and reforestation efforts face challenges from various pathogens that kill seedlings at outplanting sites. The proposed project aims to enhance our understanding of sustainable reforestation practices for a keystone forestry species, the WO. Significant soilborne pathogen pressures threaten the survival of WO during its early establishment. Yet, there is limited knowledge regarding how silvicultural management strategies and changing climate conditions will affect this species' artificial and natural regeneration. This research addresses critical gaps in applied and molecular (untargeted metagenomic profiles), provides essential insights to improve management recommendations, and applies translational research toward protecting WO. The first WO study evaluates the long-term survival of nursery outplanted seedling families across multiple locations in the southeastern United States. Untargeted metagenomic profiles are being developed to understand changes in microbial communities and variations in the population of natural forest pathogens, such a*s Phytophthora cinnamomi*. This research aims to determine the genetic variations in the occurrence of these pathogens throughout the region. The process involves yearly soil sampling and baiting samples to obtain isolates for further greenhouse pathogenicity screening. Potential untargeted RNA sequencing will also be conducted to analyze gene expression associated with different WO families being tested. A second study was designed to assess pathogen occurrences in WO and RO acorn seeds to understand the reasons behind seedling mortality during early establishment using traditional isolation methods. Next Generation Sequencing is being used to understand over community variation between oak families within and across geographical locations. This study began in the fall and continues into spring 2025, identifying the endophytic fungi associated with WO and RO acorn seeds sourced from five families in the Southern Region. From the initial research, 35 different unidentified organisms were isolated. During the summer and fall of 2025, these isolates will be further evaluated in greenhouse screenings to determine their association with WO and RO seedlings, specifically looking into their endophytic or pathogenic potential across different genetically distinct oak families. Additionally, molecular sequencing will be conducted to identify the fungal isolates, which will help develop a culture collection for future studies.

Long-term charcoal rot research on soybeans. The research in 2024 continued to evaluate *Rhizoctonia* and *Macrophomina phaseolina* (Mp) isolates from around the country to determine genetic variability in their host specificity and geography, with a specific interest in their pathogenicity and virulence potential, especially for soybeans and sweet potato varieties. The project evaluates these crops under controlled environments, employing environmental stressors such as drought/high temperatures compared to an established control treatment. Three years of data were obtained across three summer greenhouse trials, and a “Proof of Concept” field trial was completed in October 2024, collecting soil and plant tissue samples from two field-grown putative disease-resistant soybean hybrids. The soil-root is currently being prepared to determine Mp occurrences at the rhizosphere level, and plant tissues, untargeted metagenomic and metabolomic profiles are being used as potential biomarkers for disease resistance. The study aims to enable molecular breeding (RNA-seq) to identify potential gene-associated resistance or utilize these compounds as direct biomarkers for variety selection. The final group of completed research projects evaluated the impacts of soil microbial (pathogenic and mycorrhizal) communities over six years on the survival and reestablishment of disease-resistant hybrids of American chestnut in natural forest ecosystems, if SA. Three publications from the reforestation research with Forest Service personnel are presented below. Newly initiated studies in 2022-2023 included research using select soybean hybrids to determine the metagenomic, metabolomic (ROS) factors impacting Mp disease development under global warming factors such as drought, high temperatures, and other CO2 levels. A second sweet potato tip/endrot project has been restarted with new funding this year. Sweet potato soil and plant tissue samples, currently stored at -80C and being inventoried this year, will be evaluated using metagenomic and metabolomic protocols to determine if specific management practices contribute to tip/endrot pathogens establishment. Lastly, three long-term oak reforestation studies were initiated in fall 2022 with baseline soil samples being obtained just before planting in National Forests located in Alabama, Kentucky, and Tennessee. Emphasis for these last studies is to monitor root pathogen and mycorrhizal associations and their population densities, such as *Phytophthora cinnamomi,* *Pythium ultimatum* (spp), and *Fusarium*, which is ubiquitous throughout the southern region. The establishment and reestablishment of WO has been a challenge when planted into forest sites and results from these studies hope to define biotic and abiotic soil factors on tree survival and growth. Following the first-year, soil samples were taken at the plant and at four months in 2023, using traditional baiting approaches, two locations were found to have low levels of the targeted pathogen *P. cinnamomi*. Site locations include Daniel Boone National Forest, Kentucky, and Bankhead National Forest, Alabama, which had confirmed *P. cinnamomi*, and none were found within the Cherokee National Forest, Tennessee, planting site. Yearly long-term monitoring will continue using soil sampling and field disease ratings (analyses) for the pathogen. Metagenomic data analyses from soils from years 1 and 2, with the soils also collected in 2024.

**Dr. Sara Thomas-Sharma – Louisiana State University Agricultural Center**

The Field Crop Pathology lab at LSUAgCenter focuses on diseases of field crops. Of particular relevance for S1083 is research on the management of aerial blight on soybean, caused by a soilborne fungal pathogen *Rhizoctonia solani* AG 1-IA. Presently the focus of the work is screening commercial soybean varieties for resistance to aerial blight, training students and early career researchers on this work, and providing information to stakeholders.

**Objective 3 and 4**

Short-term Outcomes:

Established funding and experimental set-up to conduct yearly evaluation of commercial soybean varieties for resistance to aerial blight to assess availability of host resistance as a management tool for stakeholders. Trained graduate students, student workers, and research associate in resistance screening.

Outputs:

Manuscript describing pathogen diversity and greenhouse resistance screening protocols published.

Grant from local soybean commodity board received to conduct screening of commercial soybean varieties for resistance to aerial blight.

Activities:

Seeds of soybean core block varieties (n=24) were assembled. These varieties would be available for use in the 2025 field season. Two humid chambers were set-up for screening in fall of 2024. A research associate (also a graduate student) will conduct screening.

Milestones:

Generate data to support the use of host resistance as a viable management tool to manage aerial blight on soybean.

**Dr. Shankar Ganapathi – Mississippi State University**

The focus of this project is to study the interactions between soil microorganisms, plant systems and the soil physical-chemical environment using metagenomics and bioinformatics tools to understand how the soil microbial diversity and interactions contribute to specific soil functions. We use traditional metagenomics, and spatial/temporal methodologies to understand microbial community dynamics that determine soil health and plant health on economically important crops in the U.S, including sweet-potato and corn.

***Short-term Outcomes:*** Cover crops are increasingly adopted as a tool for improving N availability and soil health in US agriculture, and growers are demanding cover crops that serve a broader range of cropping systems, and a better understanding of how to deploy them for the greatest soil health benefit. This work is targeted to meet that demand.

***Outputs:*** Submitted following annual and quarterly reports

* Annual Report: Mississippi Corn Promotion board -Jan 2024: “Long-term study on the impact of cover crop on soil microbiome function affecting C and N inputs in Corn production systems.”
* Quarterly report: CEIF (The Center for Environmental Sustainability through Insect Farming)- Feb and August 2024: “Study of frass-associated microbiome on plant growth and their potential use as biofertilizers.”
* Quarterly report- Mississippi soybean promotion board: July 2014: “Unraveling the Microbiome Dynamics in Soil Fertility: A Comparative Study of Fertile and Infertile Soil in Soybean Cultivation and the Implications for Soybean Productivity”.

***Activities:***

1. We determined the changes in microbial functional gene abundances in the total soil metagenome that correlated with multiple soil ecological functions to determine which traits are consistently most predictive of changes in soil N cycling in Cover Crop-sweet potato production system.
2. We also determined how the contrasting cover crops enrich for different sets of microbiomes that have the functional potential to distinctly alter soil health parameters in sweet potato production system, such as soil N cycling, organic carbon sequestration, plant growth promotion and disease suppression.

***Milestones:*** This study will help meet the challenge of matching sustainable yields of sweet potato production systems with soil health by connecting genomic characterization of the soil microbiome.

**Dr. Sean Toporek – South Dakota State University**

A multidisciplinary SARE Research and Education grant has been submitted to study the long-term effects of landscape fabric on soil health in vegetable production systems by examining physical property change, microbiome change, and soilborne pathogen proliferation. After pre-proposal submission, the project was invited for a full submission and submitted on March 27th, 2025 and titled "The long-term effects of landscape fabric use on soil health in vegetable production systems".

**Dr. Alejandro Rojas – Michigan State University**

The Microbial-Plant Interaction and Ecology lab at Michigan State University has been focused on addressing challenges in three main areas: (1) Evaluation of chemical and biological agents for control of soilborne pathogens, (2) soybean seed quality issues and their management, and (3) ecology of soilborne pathogens in horticultural and field crops. Within this framework, the lab has contributed with the following activities and outputs:

Objective 1

**Short-term Outcomes:**

* + Developed a qPCR diagnostic to evaluate soil and plant samples infested with *Xylaria necrophora,* and currently we are processing three year’s worth of samples that represent field trials looking cover crop practices and disease development within a season.
	+ Developed a protocol for the transformation of *Xylaria necrophora* for tagging isolates with fluorescent proteins for microscopy and studying host pathogen interactions.
	+ A new set of 50 isolates of *R. solani* were genotyped in addition to the 145 isolates of *Rhizoctonia solani* AG1-1A from rice (Sheath blight) and soybean (Aerial blight) and these are target for designing PCR markers for QoI resistance.

**Outputs:**

* + Three student presentations at national conference (Plant Health 2024 and MSA 2024)
	+ One student poster presentation at regional conference
	+ Two invited talks at BGSU and Genetics Dept at MSU

**Activities:**

In 2023-2024, we have process two years of samples of a trial. Focus on the epidemiology of Taproot decline caused by *X. necrophora.* The aim is to use the qPCR for quantifying and evaluating the progression of *X. necrophora* under the three cultivars with high susceptibility to tolerant responses. In addition, we successfully transformed *Xylaria* with a GFP plasmid. This will allows us to study pathogen colonization on the tissue of different hosts.

Isolates of *Rhizoctonia solani* have been collected in Arkansas and received from collaborators in the Southern US for genotyping and population genomics analyses.  As part of the development, we are phenotypically characterizing those isolates for growth rates and tolerance to fungicide.

**Milestones:**

* Understand the biology and epidemiology of *X. necrophora* for the development of better management practices
* Characterize the genetic diversity of soilborne pathogens, especially *Rhizoctonia solani* AG1-1A, and the implications on the selection of plant-resistant material
* Implement non-destructive technologies to monitor the effect of soilborne diseases on host physiology and performance

Objective 2

**Short-term Outcomes:**

* Analysis of critical points in a greenhouse production system for vegetable seedlings using HACCP approach.
* Development of a targeted approach for monitoring Fusarium species in crop systems.

**Outputs:**

* + One student poster presentation at regional conference
	+ Train and mentored an REU student from minority serving institution

**Activities:**

* + A research project focusing on monitoring critical points in the production of ceilings in greenhouse environments was conducted. We are using amplicon approaches to profile bacterial, fungal, and oomycete communities at different stages of production, from the use of materials for producing the seedlings, through planting, and the final step that are the seedlings. These seedlings are commercialized and distributed to producers and stores for commercialization. Over 500 samples, including water, soilless substrates, swabs from surfaces, and plant samples, were processed for DNA extraction, and the resulting DNA was used to characterize those communities. This is project is in collaboration with Dr. Johana del Castillo at UC-Davis California.
	+ A preliminary study to monitor *Fusarium* populations in legume fields has been started using nanopore sequences. Samples collected in 2024 were processed and are currently being used for library preparation for sequencing. Preliminary tests showed EF-1 gene fragment as a useful marker to study *Fusarium* communities.

**Milestones:**

* + Establish the use of nanopore sequencing for fungal systematics and community ecology using targeted genes for specific groups of pathogens.
	+ Contribute to the monitoring of pathogens on production systems using culture-independent approaches.

2. IMPACTS

***Activities:***

* (Crandall Lab) We organized and specific functions or duties, such as informal meetings at the Pasa Conference in PA to gauge farmers’ interest in adopting innovative tech.
* (Benitez Lab) Training of one PhD student, one undergraduate researcher and two research associates.
* (Benitez Lab) One workshop development and presentation.
* (Benitez Lab) Organized a Session at the National Diversity in STEM Conference.
* (Baird Lab) Agricultural research focuses on controlling soilborne pathogens, specifically Mp on soybean and the sweet potato microbial complex associated with tip/endrot. For soybean Mp results in millions of dollars in lost income in the US, and any methods to reduce the loss can be substantial to grower income and food supply worldwide. For soybeans, charcoal rot fungus *Macrophomina phaseolina* is an economically crucial soilborne disease of many crops in the US. No practical management approaches or highly resistant varieties are available to manage this disease in soybeans. While the charcoal rot pathogen causes high mortality, asymptomatic soybean plants are frequently present in field disease patches. Preliminary studies revealed apparent differences in endophytic microbial communities and metabolites between asymptomatic and symptomatic plants. Culturally independent and dependent studies identified several bacteria and fungi with strong antifungal activities against Mp. We hypothesize that these antifungal endophytes, and accompanying cellular metabolic fingerprinting, are critical in plant resistance to the disease. In year 3, we propose combining culture-dependent and culture-independent methods to identify and test key endophytes and metabolites commonly residing in disease-resistant plants. Specific objectives of this project are (1) Characterization of endophytic bacterial and fungal communities using culture-dependent methods; (2) Community analysis of endophytes using metagenomics approaches, and metabolomic changes associated with plant disease development; (3) Focus on increases or down regulation of targeted endophytes and metabolites in greenhouse and “Proof of Concept” field sampling evaluation; and (4) Interrogation of mechanisms of targeted endophytic microbes and cellular metabolites on plant growth and disease development. Studies are underway to evaluate endophytic next-generation sequence and metabolomic data between healthy and greenhouse trials using artificially infected disease-assessed plants under drought and high temperature treatments, and in-field sampling from healthy and Mp diseased plants. Results from these studies are preliminary and will be presented in 2024.
* (Baird Lab) The focus of forest research is to support the reforestation of hardwood trees such as white oaks in various southern forest ecosystems, understanding the influences of the forest community due to environmental stress (global warming potential effects). These studies show that the pathogen and symbiotic involvement below and above the group can help determine forest ecosystem health. Diversity in forest tree types (reforestation) must continue to be maintained at the overall forest ecosystem level to support the forest products industry and general global environmental health, affecting overall organismal survival.
* (Thomas-Sharma Lab) Trained one MS student, 1 undergraduate student worker, and a research associate on screening of fungicide resistance.
* (Thomas-Sharma Lab) Received funds from local commodity board to conduct screening of commercial soybean varieties for resistance to aerial blight.
* (Ganapathi Lab) Limited research exists on studying disease suppressive implications of soil microorganisms in cover crop - sweet potato systems. Field study was initiated at Pontotoc Ridge-Flatwoods Branch Experiment Station in Pontotoc, Mississippi to assess the effects of cover crops on nitrogen availability in sweet potato. This study was implemented in a randomized block design following a split block arrangement and replicated four times. Total of three N treatments (0, 50, 100 lb/acre) and three cover crop treatments (no cover crop, winter wheat cover crop, and clover cover crop) were adopted
* (Ganapathi Lab) Two graduate students and 2 student workers were hired to work on these projects and underwent training on soil metagenomics and bioinformatics.
* (Rojas lab) Training of three PhD students, two Master’s students and four undergraduate students. One Masters student defended and graduated.

***Milestones:***

* (Crandall Lab) In 2024, we measured the diversity of soil fungi post-soilborne pathogens and found potential partnering farms that have high tunnels with a) tomatoes and b) problems with tomato wilt and other diseases to participate in soilborne pathogen survey.
* (Benitez Lab) To characterize variability in AM fungal communities recovered from soybean production systems in Ohio
* (Benitez Lab) To train students on techniques to study microbial diversity in soils, soil suppressiveness and soilborne pathogens.
* (Benitez Lab) To share our research with stakeholders including undergraduate students and students from different fields of science.
* (Thomas-Sharma Lab) To conduct annual screening of commercial varieties for resistance to aerial blight
* (Thomas-Sharma Lab)To publish results as peer-reviewed manuscripts and in stakeholder accessible material.
* (Ganapathi Lab) Cover crop treatment showed significantly higher soil PoXC levels than the control treatment. DNA sequencing data revealed a significant difference in microbial alpha diversity among nitrogen treatments. Beta diversity analysis indicated a significant difference in soil microbial community composition influenced by both cover crops and N treatments.
* (Rojas Lab)To characterize variability in fungal communities in corn and soybean production systems
* (Rojas Lab) To explain relationships between different groups of microorganisms in the soil environment
* (Rojas Lab) Develop diagnostic assays and markers to monitor pathogen specific populations during the crop growth season and monitor their effect on plant health

***Indicators:***

* (Crandall Lab) “Red Duce,” a common tomato cultivar in the Mid-west and Mid-Atlantic that is also susceptible to soilborne pathogens was chosen to grow for on-station trials.
* (Benitez Lab) Development of microbial markers as indicators of soil health
* (Benitez Lab) Description of parameters that enrich for specific fungal populations in soils
* (Benitez Lab) Increased enrollment in plant pathology, soil science and microbiology
* (Benitez Lab) Increased engagement of undergraduate students in research
* (Thomas-Sharma Lab) Stakeholders download and use cultivar screening information in planting decisions
* (Thomas-Sharma Lab) Adoption of resistant cultivars, if available, in areas of high disease pressure.
* (Rojas Lab) Webinar on crop protection network accessible to stakeholders about taproot decline and drone data collection.

3. PUBLICATIONS **(NO character limit)**  If none, write “nothing to report”.

Peer-reviewed manuscripts:

Roman-Reyna, V.☨, and Crandall, S.G☨. 2024. Seeing in the dark: a metagenomic approach can illuminate the drivers of plant disease. Frontiers in Plant Science Bioinformatics. 15:1-7. https://doi.org/10.3389/fpls.2024.1405042. (☨ denotes equal contribution).

Harris, J.E., Bledsoe, R.B., Guha, S., Omari, H., Crandall, S.G., Burghardt, L.T., Couradeau, E.M. 2024. The activity of soil microbial taxa in the rhizosphere predicts the success of root colonization. Pre-print: bioRxiv 2024.12.07.627353; https://doi.org/10.1101/2024.12.07.627353

Schill, M. L., Baird, R. E., Brown, S. P., Veach, A. (2024). Wildfire severity alters soil microbial exoenzyme production and fungal abundances in the Southern Appalachian Mountains. *Pedosphere,* 34(4), 15.

Brown, S., Shahrtash, M., Stokes, C. E., Baird, S. M., Baird, R., Lu, S. (2024). Model-based community analyses identify fungal endophytes that may modulate symptom development of charcoal rot disease in soybean. *Phytofrontiers* (Online Publication), 23. https://apsjournals.apsnet.org/doi/10.1094/PHYTOFR-04-23-0052-SC

Blandenjer, Q., Gibson, N., Tice, A., Jones, R., Jones, E., Baird, R., Zurweller, B., Brown, M.

2024 Full 18S metabarcoding of environmental samples of various substrates with Nanopore sequencing. *Protocols.io* Springer, dx.doi.org/10.17504/protocols.io.3byl4qe48vo5/v2 Online publication.

Rodriguez-Herrera, K. D., Vargas, A., Doyle, V. P., Price, P.P., Moseley, D., Thomas-Sharma, S. 2024. Development of a greenhouse assay to screen soybean varieties for resistance to aerial blight caused by Rhizoctonia solani AG1-IA. ‘Key Challenges’ focus issue, Phytopathology 114 (5): 1039-1049 (<https://doi.org/10.1094/PHYTO-10-23-0390-KC>).

Riley D Messman, Rebecca M Swanson, Shankar Ganapathi Shanmugam, Caleb O Lemley, 333 Awardee Talk: Navigating the bovine neonatal microbiome: Insights into inoculation, maternal sources, and immunological influence, Journal of Animal Science, Volume 102, Issue Supplement\_3, September 2024, Pages 58–59, https://doi.org/10.1093/jas/skae234.063

Sinha, N., Rushing, B. R., Acharya, A., & Ganapathi Shanmugam, S. (2024). Effect of Integrated Crop–Livestock Systems on Soil Properties and Microbial Diversity in Soybean Production. Applied Biosciences, 3(4), 484-502. https://doi.org/10.3390/applbiosci3040031

Cato, A. J., McWhirt, A. L., and Rojas, A. 2024. Impact of Soil-Applied Thyme Oil on Strawberry Yield and Disease Abundance. International Journal of Fruit Science. 24:130–141.

Wolf R, Holland R, Rojas JA, Fernandes S, Fernandes I, Rupe JC. Assessing Soybean Cultivar Resistance to Target Spot Using a Detached Leaf Assay. PhytoFrontiers™. 2024 Dec 25;4(4):728-33.

Zaccaron M, Holland R, Gbur E, Thompson K, Rojas JA, Rupe JC. Effect of drought stress during seed development on charcoal rot and yield of soybean. Plant Disease. 2024 Nov 1;108(11):3258-68.

Li, X., Zaia, R., Liu, K., Xu, X., Silva, M.D., Rojas, A., Welbaum, G.E., Zhang, B. and Rideout, S., 2024. Response of the Edamame Germplasm to Early-Season Diseases in the United States. Agronomy, 14(8), p.1660.

Hamilton, R., Jacobs, J.L., McCoy, A.G., Kelly, H.M., Bradley, C.A., Malvick, D.K., Rojas, J.A. and Chilvers, M.I., 2024. Multistate Sensitivity Monitoring of *Fusarium virguliforme* to the SDHI Fungicides Fluopyram and Pydiflumetofen in the United States. *Plant disease*, *108*(6), pp.1602-1611.

Oral presentations:

Benitez Ponce. MS. Plant bacteriology and agricultural microbiomes lab. Department Seminar Spotlight. Department of Plant Pathology, The Ohio State University, Seminar. February 5, 2024.

Banson, I. (Author & Presenter), Jones, R. (Author), Blandenier, Q. (Author), Tice, A. (Author), Baird, R. E., Zurweller, B. (Author), Brown, M. E. (Author), (July 29, 2024). "Soil Protists: Probing the function of the forgotten predators in Agricultural Productivity." Oral Presentation. IPS-ISOP-ISEP Annual Meeting, International Society of Protistologists, University of Washington, Seattle.Scope: International. Refereed: Yes. Invited or accepted: Accepted

Gallegos, A. (Author & Presenter), Smith, J. W. (Author), Baird, R. E. (Author), Brown, S. (Author), (March 20, 2024). "Daily prebiotic consumption of sweet potatoes shifts abundances of key gut microbiota connected to gut health." Poster. 85th Annual Meeting of the Association of Southeastern Biologists, ASB, Chattanooga TN.Scope: Regional. Refereed: Yes. Invited or accepted: Accepted

Brown, S. P. (Author & Presenter), Noui, A. (Author), Baird, R. E. (Author), Schlarbaum, S. E. (Author), Schweitzer, C. (Author), Clark, S. L. (Author), (October 7, 2024). "Pathogen monitoring and host-environment interactions for improving white oak outplanting success. International Oak Symposium." Oral Presentation. International Oak Symposium, USDA/FS and University of Tennessee, Knoxville, TN.Scope: National. Refereed: No.

Brown, S. (Author & Presenter), Baird, R. E. (Author), Williams, R. (Author), Schlarbaum, S. E. (Author), Clark, S. (Author), (June 23, 2024). "More than trees: how fungal community ecology can inform and improve success of Castanea outplanting performance and disease outcomes." Poster. IUFRO World Congress, International Union of Forest Research Organizations, Stockholm Sweden. Scope: International. Refereed: No. Invited or accepted: Accepted

Thomas-Sharma, 2023 Louisiana Soybean and Grain Research and Promotion Board, Baton Rouge, LA. ‘Screening of soybean core block varieties for resistance to aerial blight’ (11/16/2023).

Rojas, A. 2024. Tracing plant-associated fungal pathogens through integrated approaches. Bowling Green State University – Dept. Biological Sciences. October 2024.

Rojas, A. 2024. Tracing plant-associated fungal pathogens through integrated approaches. Genetics and Genome Sciences Program seminar. (March)

Salazar, A., Arias, J., Rojas, A., Del Castillo Múnera, J.  Developing Best Management Practices for Vegetable Transplant Production by Implementing a Hazard Analyses of Critical Control Points (HACCP). *Plant Health 2024*

Souza, M., Rojas, JA. Effects of Fungicide Seed Treatments on Soil Microbiome Across Years. 2024 *Mycological Society of America*.

Extension and outreach presentations:

Windon, S.W. and Adhikari, A. December 25th, 2024. “Applying Adoption Models to Farmer's Decision-Making.” Penn State Extension. <https://extension.psu.edu/applying-adoption-models-to-farmers-decision-making>.

Adams, T. (Author & Presenter), Easley, H., Baird, R. E., (August 2, 2024). "Analysis of ROS Production in Soybean Subjected to Drought and *Macrophomina phaseolina* Challenges." Poster. MSU Undergraduate Research Symposium, Mississippi State University, Mississippi State University.Scope: Local. Refereed: No.

Hill, C. (Author & Presenter), Easley, H. (Author), Baird, R. E. (Author), (August 2, 2024). "Investigating the Impacts of *M. phaseolina* on the Metabolome of Soybean." Other. MSU Undergraduate Research Symposium, Mississippi State University, Mississippi State, MS.Scope: Local. Refereed: No. Invited or accepted: Accepted

Daves, N. (Author & Presenter), Easley, H. (Author), Baird, R. E. (Author), (August 2, 2024). "Temporal Investigation of Insect Populations in a Mississippi Soybean Greenhouse Trial." Poster. MSU Undergraduate Research Symposium, Mississippi State University, Mississippi State, MS. Invited or accepted: Accepted

Adams, T. (Author & Presenter), Easley, H. (Author), Baird, R. E. (Author), (April 12, 2024). "Analysis of ROS Production in Soybean Subjected to Drought and *Macrophomina phaseolina* Challenges." Poster. Biological and Life Sciences to the Spring Undergraduate Research Symposium, Shackouls Honors College, Mississippi State University, Starkville, MS.Scope: Local. Refereed: No.

Phillips, A. (Author & Presenter), Easley, H. (Author), Baird, R. E., (April 12, 2024). "Analysis of Soybean Response to Drought and M. phaseolina Infection." Poster. Biological and Life Sciences to the Spring Undergraduate Research Symposium, Shackouls Honor College, Mississippi State University. Scope: Local. Refereed: No. Invited or accepted: Accepted

Koenig, A. (Author & Presenter), Easley, H., Baird, R. E., (April 12, 2024). "Analysis of Soybean Response to Drought and M. phaseolina Infection." Paper. Biological and Life Sciences to the Spring Undergraduate Research Symposium, Shackouls Honors College, Mississippi State University, Starkville, MS.Scope: Local. Refereed: No. Invited or accepted: Accepted

Briggs, E. (Author & Presenter), Easley, H. (Author), Baird, R. E. (Author), (April 12, 2024). "Shackouls Honors College." Poster. Undergraduate Research Symposium, Biological and Life Sciences, The Importance of Phytophthora cinnamomi in the Oak Decline Disease Complex and White Oak Restoration, Mississippi State University.Scope: Local. Refereed: No. Invited or accepted: Accepted

Related grants:

Zurweller, B. (Principal), Brown, M. W. (Co-Principal), Tice, A. (Co-Principal), Baird, R. E. (Co-Principal), "Soil Protist: Probing the Function of the Forgotten Predators in Agricultural Productivity," Sponsored by Mississippi Agricultural and Forestry Experiment Station, Mississippi State University, $50,000.00. Awarded, Grant. (March 2023 - March 2024).

Mlsna, T. E. (Principal), Mlsna, D. A. (Co-Principal), Baird, R. E. (Co-Principal), Emerson, J. P., Fitzkee, N. C. (Co-Principal), Patrick, A. L. (Co-Principal), Crider, B. P. (Co-Principal), Gude, V. G. (Co-Principal), Zhang, D. (Co-Principal), Street, J. T. (Co-Principal), Montiel Palma, V. (Co-Principal), Schauwecker, T. J. (Co-Principal), "REU Site: Environmental Focus in Food, Energy and Water Security," Sponsored by National Science Foundation, Federal, $405,000.00. Awarded Grant. (September 1, 2022 - August 31, 2025).

Fitzkee, N. C., Baird, R. E., Johnson, C., Vance, C., Montiel Palma, V., Emerson, J. P., Smith, D., Scott, C. N., "MRI: Acquisition of the First 800 MHz NMR with Cryoprobe in the State of Mississippi for Biological and Chemical Research and Teaching," Sponsored by National Science Foundation, Mississippi State University, $3,147,269.00. Awarded, Grant. (August 1, 2022 - July 31, 2025). Equipment grant for used NMR for metabolomic research

Baird, R. E. (Principal) Monitoring Pathogen buildup in White Oak

Outplanted Restoration Sites. Sponsored by USFS, Mississippi State University $15,000. Awarded, Grant (June 2024 -June 2029).

Baird, R. E. (CoPI) Monitoring Pathogen Buildup in White Oak Outplanted Restoration Sites. Sponsored by USFS, Mississippi State University $24,380. Awarded, Grant (March 2023 – July 2025(2028 continuation)

Baird, R. E. (Principal) Impacts of charcoal rot (*Macrophomina phaseolina*) epidemiology on drought-resistant soybean cellular metabolism and accompanying tissue microbiome for identifying alternative breeding targets under increasing environmental stress. Sponsored by Mississippi Soybean Promotion Board, Mississippi State University, $98,972 Awarded (April 2024 – June 2026).

White, S. (Principal), Baird R. E. (CoPI) Evaluation of Sweet Potato Production Practices (Conventional vs Organic) on Nutritional Quality During Long-term Storage. Sponsored by Mississippi Department of Agriculture and Commerce, Mississippi State University, $50,509 Awarded (October 2023 – July 2025). Sweetpotato tip/endrot storage disease research

Mlsna, T. E. (Principal), Elder, A. (Co-Principal), Vicky Montiel-Palma (Co-Principal), Fitzkee, N. (Co-Principal), Stokes, S. (Co-Principal), Emerson, J. (Co-Principal) Patrick, A. (Co-Principal), Rozier, P. (Co-Principal), Baird, R. E. (Co-Principal), Crider, B. P. Schauwecker, T. (Co-Principal), Street, J. (Co-Principal), "REU Site: Environmental Focus in Food, Energy and Water Security," Sponsored by National Science Foundation, Federal, $447,029. Awarded Grant. (September 2025 - August 2028). Students participated in soybean disease research

Baird, R. E. (Principal) RNA-seq-profiling to identify candidate biomarker genes for genetic screening of soybean varieties for charcoal rot disease resistance breeding efforts. Mississippi Soybean Promotion Board, Mississippi State University $97,405 Pending (April 2025 – March 2026).

Collins, G. A. (Principal), Ahn, S. (Supporting), Meyer, F. S. (Supporting), Baird, R. E. (Supporting), Krishnan, N. (Supporting), Liu, C. (Supporting), Lu, S. (Supporting), Wilkerson, T. H. (Supporting), Tseng, T. M. (Supporting), "Applied Biosystems Quantstudio Real-time PCR System”. Sponsored by MAFES, Mississippi State University, $70,262.08. Denied, Other. (2024 - Present).

Baird, R. E. (Principal) Biochemical approach for identifying metabolomic biomarkers for soybean plant resistance to *Macrophomina phaseolina*.

MAFES, Mississippi State University $99,568 Denied (January 2025 – December 2026).

Baird, R. E. (CoPI) Development of sustainable climate-adapted white oak outplanting tools to ensure future timber availability. USDA-AFRI, Mississippi State University, $199,993-Baird portion $59,966, Denied (January 2025 – December 2028).

Easley, Hannah-Student's Home Department : Biochemistry, Molecular Biology, Entomology, & Plant Pathology, Title: Impacts of charcoal rot (*Macrophomina phaseolina*) epidemiology on drought-resistant soybean cellular metabolism and accompanying tissue microbiome for identifying alternative breeding targets under increasing environmental stress, Stage of Completion: In-Process. **Graduate Student Support – Mississippi Soybean Promotion Board (2024-2025) Assistantship.**

Thomas-Sharma, S., and Moseley, D. Screening of soybean core block varieties for resistance to aerial blight. [LSGRPB, submitted, Total funding: $14,919].