ORG Project Details

Award Year 2023

8 Research Projects

PROJECT INDEX

Living Mulch and Grazing Techniques to Improve Soil Health and Weed Control for Farmers Transitioning to Organic Farming Across Climatic Zones

Contract / Grant No.	2023-51106-41077
Grant Year	2023
Investigator(s)	Surendra Singh
Performing Institution	Washington State University

NON-TECHNICAL SUMMARY

Organic agricultureprovides a suite of environmentalbenefits such as improved soil health and nutrient availability,weed control, diseaseand pest control, and reduced carbonemissions.Therefore, organic farming tends toincrease environmentalsustainability compared to conventional farming. The broader scope of this multi-disciplinary and multi-locationproject is to increase sustainable organic production within the three, extremely diverse agro-ecological regions (Pacific Northwest, Southeast, and Northeast)of the United States. This project aims to evaluate and understand the soil and environmental resilience of farms getting converted from conventional to organic integrated crop-livestock systems. The specific objectives of the project are to determinethe impacts of integratinglivestock grazingunder various cropping systems onfarms that are transitioning to organic systems. Additionally, this project also aims to evaluatethe improvement of soil health parametersunder various kinds of cover cropsand livestock grazing practices.Furthermore, this project will determine the impacts of different organic crop rotations and livestock grazing on weed control.Providing researchers, producers, and stakeholders with timely and relevant resources related to regionally specific organic farming practices through hands-on workshops, extension and scientific publications, and curricular resources will be an essential part of this project. Project outcomes will reduce the knowledge gaps, promote sharing of living mulch and grazing techniques amongst organic farmers and enhance the sustainability and productivity of farms transitioning to organic systems. Goals / Objectives The overarching goal of this project is to increase sustainable organic production within the three regions (Pacific Northwest, Southeast, and Northeast) of the U.S. for farms that are currently under transition from conventional to organic farming systems. The specific goalof the project is todevelop novel combinations of living mulch and livestock grazing to achieve better cropyields and profitability by improving weed control, N management, and soil healthduring the transition period. This project proposes to leverage organically certified producer/researcher sites to understand the farm develop economically viable and environmentally sustainable organic production systems in the Pacific Northwest, Southeast, and Northeast regions. Meeting these goals, our ultimate mission is to facilitate American citizens\' access to safe, nutritious, and secure food supply (USDA National IPM goal).Objective 1.Crop and Livestock Performance.Assess the impacts of integrated living mulch and livestock grazing techniques under various cropping systems in farms transitioning to organic farming on crop yield, biomass, livestock performance, and economic benefits.Objective 2.Soil Health and GHG emissions. Evaluate the soil health indices such as soil aggregate stability, water infiltration, carbon sequestration, soil fertility, microbial biomass, enzymes, compaction, and microbial community structure and greenhouse gas emissions under various living mulch and livestock grazing practices.Objective 3.Weed Management. Evaluate the impacts of different organic clover rotations and livestock grazing on weed population, cover, and biomass.Objective 4.Educational and Extension. Provide K-12 teachers, college students, researchers, and producers with timely and relevant resources related to regionally specific organic farming practices through hands-on workshops, extension and scientific publications, and curricular resources. Project Methods Project methods. The methods used to complete the above-mentioned four objectives of this proposal have been mentioned later in this proposal after the description of the study sites.Site 1: This site will be located in the dryland region of Pacific Northwest (hereafter referred as PNW site) where mean annual precipitation is less than 400 mm. This experiment will be conducted at Don Hartley farms in Adams/Pendleton, OR, to evaluate the living mulching/cover crop and livestock grazing techniques on N availability, soil health, weed management, and crop productivity under organic wheat system. Treatments will include:Kura clover (perennial) with grazing/no grazing,Red clover with grazing/no grazing, andCover crop mix \75% legume (pea) + 25% cereal cover crops with grazing/no grazingNo living mulch and no grazing controlThe cover crop mix, which is a common practice for organic systems in the region for N source, will serve as farmer\'s practice for the study at PNW site. Study design will be randomized complete block with split-plot design with four replications. The main plot will be clover/cover crop mix and subplot will be grazing under 2-year alfalfa-winter wheat rotation.Site 2:This site will be located at the Rodale Institute, PA in the Northeast region (hereafter referred as NE site). A four-year trial will be initiated at Rodale Institute\'s agronomic research farm in Kutztown, PA (Northeast region) to assess the effect of perennial clover mulch and intercrop establishment systems on cash crop performance, weed pressure, allelopathic impediment, and soil health during the growing season. The experiment will be designed as Randomized Complete Block in a split-plot arrangement with four replications.The main plots will have two establishment systems:A) concurrent establishment of clover and cash crops in the same year andB) clovers established in year 1 and plant cash crop in the following year.Four different species of perennial clover and control (kura clover, red clover, white clover, Aberlasting clover, and no clover control) will be randomly allocated to subplots with the total number of treatments equal to 10. Two entry points for corn and soybean will make sure that the rotation will be repeated within the planned project period. Corn will go to soybean the next year in one site while in another entry point, soybean will go to corn. The total number of plots including both cash crops will be 80. An on-site weather station will record the meteorological data throughout the study.The experiment will have a grain-clover living mulch system with two intercrop systems. While developing this rotation, we gathered stakeholder input at the 2022 Lebanon Grazing Conference in Pennsylvania. For kura clover + cash crop intercrop, inoculated clover seeds will be planted at a seeding rate of 12 kg ha-1 using a seed drill with row spacings of 19.1-cm in March to allow clover to establish its roots before planting cash crop and the first flush of weeds. Plots will be tilled for the clover establishment, whereas soybean and corn will be planted no-till in the first year. In the second intercrop year, clovers continued to grow during the winter and will be strip-tilled and planted to corn and soybean. A 12-inch-wide rotary hoe will be used to make strips at 76 cm spacing for cash crop planting. Organically produced non-GM corn and soybean seed will be planted using a no-till planter. Organic fertilizer will be applied after considering clovers as a primary source of N. For intercrop, banded application of manure will be carried out to supplement N for corn planting. Irrigation will be as per requirement. Clovers will be mowed as needed during the cash crop growing season using an intra-row mower. Two to three mowing is sufficient for a season to control weeds between the rows. For in-row protected weeds, a Weed Zapper will be used during V3 stage of the soybean. Electrocution will not be an option for corn and after the R3 stage of the soybean.Site 3:This site will be located on the North Carolina State University\'s Cherry Farm Station, Goldsboro, NC (Southeast region), hereafter referred as SE site. An integrated crop and livestock, living mulch - grazing, study will be established on organically certified fields of Center for Environmental Farming Systems, NCSU - Cherry Farm Station. During each of the four years of the project, a corn-wheat-soybean rotation will be established. Treatments will include:Crimson clover + grazing/no grazing,Kura clover + grazing/no grazing,Red clover + grazing/no grazing,White clover (short perennial) + grazing/no grazing, andThe study will be designed as randomized complete block with split-plot designed with four replications. The study will aim to collect soil and plant samples for soil analysis, crop performance, weed cover, weed seedbank quantification and to assess the annual and perennial weed community at peak emergence and peak vegetative growth. Additionally, GHG samples along with moisture and temperature data will also be collected at SE site. Progress 09/01/23 to 08/31/24 Outputs Target Audience:Target Audience: This project\'s target audience included regional producers (conversational, organic, and transitioning to organic), soil conservationists, growers\' associations (commodity boards), researchers, academicians, and various stakeholders. Why These Audiences Were Targeted: Producers transitioning to organic farming were the primary audience, as this group is most directly affected by weed management challenges and nitrogen sources for organic farming. Weed control and nitrogen are particularly difficult in organic farming, and the project\'s focus on living mulch as a weed management solution as well as nitrogen-fixing from legumes holds significant potential to address these issues. In order to cover the cost of living mulch, a grazing component was also included wherever possible. How These Audiences Were Reached: During the reporting period, we developed a robust communication strategy to reach broad audiences. This included the news articles about the funding of the projects from Washington State University (https://news.cahnrs.wsu.edu/article/wsu-researchers-to-study-feasibility-of-organic-inland-northwest-wheat/) and North Carolina State University (https://www.farms.com/news/organic-accelerator-new-study-investigates-grazing-living-mulches-for-soil-health-207371.aspx). Several other regional news agencies with much larger outreach also covered these news articles. The news and concept of this project were also conveyed to the target audience through a podcast recordedby Washington State University (the Podcast has not been published yet). In addition, the audience was also reached through field days. During the reporting period, the project reached approximately 500 producers, soil conservationists, researchers, academicians, and various stakeholders at the Rodale Institute\'s Annual Organic Field Day on July 19th, 2024. This event served as an excellent platform to present the project\'s work on living mulch, weed management, and soil health practices to a broad audience, including organic farmers and other key agricultural stakeholders.The Rodale Institute\'s Organic Field Day served as the primary engagement platform. Participants were introduced to the project\'s experimental plot designs, initial soil health data, and early observations on weed dynamics. The field day included presentations and field tours that facilitated hands-on learning and discussions around the practical implications of living mulch in transitioning to organic systems. The project has successfully reached these critical audiences during this period (will continue to engage the target audience), ensuring that producers and other stakeholders are informed about sustainable practices that can improve both soil health and weed management in organic farming systems. The project has successfully reached these critical audiences during this period, ensuring that producers and other stakeholders are informed about sustainable practices that can improve both soil health and weed management in organic farming systems. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?During the reporting period, the project provided multiple training and professional development opportunities to students, postdocs, and research technicians at all the study sites in the pacific northwest, southeast, and northwest sites. This is the project\'s first year, during which data has been collected and will be analyzed to inform subsequent research activities. Preliminary findings will be presented at upcoming conferences and meetings, such as the ASA-CSSA-SSSA Tri-Society Meeting, to engage with the broader scientific community along with regional stakeholders. The project has provided significant training and professional development opportunities for the team. At Washington State University, two master\'s students will be focusing partial thesis from this project providing them with first-hand experience of organic farming. Both theses will focus on various aspects of the project including weeds, soil fertility, soil health, and soil microbial dynamics.Research Technician at Rodale Institute, Carolyn Garrity, has gained hands-on experience in managing various aspects of the project, including living mulch systems, weed management strategies, and soil health assessments. This has enabled her to develop a deeper understanding of these critical areas. Additionally, Carolyn has been participating in the Advanced Soil Health International Certificate Training Course offered by Cornell University. This training has allowed her to further enhance her expertise in soil health, complementing the practical knowledge gained through the project\'s fieldwork. The combination of in-field training and formal coursework has positioned her well for contributing to the project\'s future phases and sharing insights with stakeholders. At North Carolina State University, PIshave been mentoring technicians, postdocs, and students as part of this grant. Two temporary employees, a post-doc, a field technician, a PhD student, and station personnel (\~4 people) contributed to establishing this study and taking care of the related work. Dr. Ozlu supervised these personnel within person (hands-on) training. Overall, these training and professional development activities have helped build technical capacity within the project team and supported the dissemination of findings to the broader scientific and agricultural community. How have the results been disseminated to communities of interest?This is the first year of the data collection and no results have been disseminated among the target audience yet. What do you plan to do during the next reporting period to accomplish the goals? Continue the field trial and data collection: All study sites will continue and replant the trials at all three study sites and continue the data collection from those trials as discussed below: Post-Harvest Soil Sampling: Collect soil samples from all experimental plots following harvest to assess the impact of treatments on soil properties. Soil Health and Microbial Analysis: Analyze collected soil samples for key soil health indicators, including organic matter content, and nutrient levels. Conduct microbial community analysis using PLFA to evaluate changes in microbial diversity and functional groups in response to different clover treatments. Weed Density and Distribution Assessment: Quantify weed density and map the distribution of weed species across the plots. Evaluate the influence of clover treatments on weed suppression effectiveness compared to control plots. Evaluate the allelochemical activity in the clover treatment plots. Data Analysis and Statistical Evaluation: Perform statistical analysis to determine relationships among soil health parameters, microbial communities, and weed dynamics. Assess the impact of clover treatments on soil health and weed management to identify significant trends and interactions. Addressing Challenges and Unmet Goals: Address any issues encountered during the initial year, such as variability in weed emergence and challenges in sample processing timelines and planting windows. Revisit and refine sampling protocols or experimental designs as needed to ensure the accurate measurement of key variables.6. Personnel Hiring for the Project: At North Carolina State University, PIsaim to hire a student for this project. Develop data from the experiment. We also aim to join more conferences, commodity events, field days, and extension talks to provide deliverables for this project. We also aim to get in touch with 4K education and look for opportunities to deliver to those clientele. We may try to develop some other publications indicating short term impacts of this study. All PIs Annual Meeting 2024: In order to meet and discuss the progress and path forward for the project, PIs will meet in-person at the ASA-CSSA-SSSA annual meetings 2024 in San Antonio, TX on Nov. 11, 2024. This meeting will be attended by PIs and/or representatives from all study sites. Impacts What was accomplished under these goals? Problem Addressed: The key challenge addressed by this project is the development of sustainable weed and nitrogen management strategies and improved soil health for farmers transitioning to organic farming systems. Weed management and nitrogen sources arepersistent issues in organic farming, especially for farmers seeking to maintain soil health and productivity without the use of synthetic herbicides and fertilizers. The project aims to evaluate the effectiveness of integrated legume-based living mulch and grazing techniques to tackle these issues across different cropping systems. Who is Helped and How: The most immediate beneficiaries of this work are organic farmers and producers who are transitioning from conventional to organic farming systems. By providing research-backed strategies for weed control and soil health improvement, the project directly supports the economic viability and sustainability of these farming operations.

The outcomes will also inform researchers, extension agents, and educators engaged in promoting organic farming practices. Accomplishments Under Each Objective: Objectives 1 & 2: Crop and Livestock Performance & Soil Health Major Activities: The project established three fieldexperimental sites with various clover and grazing treatments in the Pacific Northwest, Southeast, and Northeast regions to assess the impact of legume-basedliving mulch on crop yields, nitrogen dynamics, and weed population density and dynamics. Pacific Northwest site: Field trials were established in Adams, OR with treatments: Aberlasting clover (with and without grazing), Red clover (with and without grazing), and cover crop mix. Northeast site:The project established 80 experimental plots with various clover treatments and concurrent cash crop planting systems. Southeast site:Four different clovers, crimson clover, white clover, red clover, and kura clover, were planted in a mixture with rye grass (2.5:1 ratio) with considering animal health conditions. Each plot size was 15-9 meters (\~0.3 acres).In the spring of 2024, study area was grazed by using same size and hunger level animals. Data Collected: Initial soil health baseline data were collected from different soil depthsincluding pH, organic matter, carbon, and fertility. Currently, the data collection is in the process of the first year of the trials. Objective 3: Weed Management Major Activities: Weed density and distribution data collection have begun across the experimental plots. Data Collected: Early weed classification and density data were collected, with ongoing analysis expected to provide insights into the effectiveness of clover treatments in weed suppression. Key Outcome: Preliminary data suggest that clover-based living mulch systems could offer a viable solution for weed suppression in organic farming. Objective 4: Educational and Extension Activities Major Activities:The target audience was reached using various methods such as news articles about the project, field day events, poster presentations, and podcast (not published yet). The project was featured at the Rodale Institute\'s Annual Organic Field Day, engaging over 500 producers and stakeholders. Key Outcome: These activities provided awareness about organic farming, direct knowledge transfer to producers, and showcased the practical benefits of living mulch and grazingtechniques for organic farming. Impact: The project has provided critical insights into sustainable weed and nitrogen management strategies and soil health improvement, directly benefiting organic producers and informing broader agricultural practices. Publications

↑ Return to Index

Characterizing the Microbial Contribution to Integrated Fertility Management in Organic Dryland Cropping Systems

Contract / Grant No.	2023-51106-40966
Grant Year	2023
Investigator(s)	Jed Eberly
Performing Institution	Montana State University

NON-TECHNICAL SUMMARY

The world\'s population is expected to reach 10 billion by 2050, and farmers will need to increase food production on agricultural lands that will also face increased demand for other uses. This puts direct pressure on farmers to simultaneously increase production and reduce the ecological impacts of agriculture on an increasingly precious land base. Incorporating cover crops, applying organic soil amendments, and enhancing the diversity and function of soil microorganisms are practices that can increase soil health and overall sustainability, but at the same time have proven challenging to implement in dryland agricultural systems. Our project seeks to evaluate crop rotations and organic amendments and to document the effects of these organic practices on soil health and fertility. Our research addresses the rising interest in sustainable practices among producers and consumers alike, by focusing on the specifics of meeting crop nutrition needs with sustainable inputs. The objectives of the proposed work are to measure crop productivity and plant uptake of nutrients from organic sources in response to different crop rotations and organic nutrient inputs. Our multidisciplinary research team will utilize field and greenhouse studies in conjunction with molecular methods to measure nutrient partitioning and describe the soil microbial community to measure crop productivity in response to integration of multiple organic nutrient sources and management practices. These results will help organic growers optimize nutrient management sustainably while improving productivity and soil health. Goals / Objectives Thelong-term goalof this research is to enhance the productivity of organic crop farming in the northern Great Plains (NGP) by evaluating the integration of multiple nutrient management strategies, which will include crop rotations that contain cover crops and perennials, and addition of organic amendments and inoculants.The overall goal of this work is to understand the linkages between key soil processes involved in nutrient cycling and crop response to integration of multiple nutrient management practices which will include crop rotations that integrate cover crops, organic amendments, and inoculants. This work will also assess the soil health effects of these inputs and management practices.Specific objectives to accomplish these goals are:Evaluate agronomic performance of crop sequences supplemented with organic N amendments and inoculants.Evaluate soil health effects of crop sequences supplemented with organic amendments and inoculants.Measure N partitioning in plants, soil, and the microbial community in response to organic amendments and inoculants.Share knowledge with organic farming stakeholders on the efficacy of integrated nutrient management practices on crop productivity and soil health. Project Methods Field studies will be performed to evaluate the combined effects of crop sequence, organic amendments, and inoculants on crop productivity. The field studies will compare crop yield components, soil physical and chemical characteristics, and microbial community response in both annual and perennial crops. Studies will be established at the MSU Central Ag Research Center (CARC) and on a portion of Quinn Farm & Ranch which will soon be under the direction of the non-profit Quinn Organic Regenerative Research Institute (QORRI), Big Sandy, MT. A split plot design will be used with the crop sequence as the main plot and organic amendments and inoculant will be randomly assigned in the split. Amendments will be applied to the wheat, flax, and safflower phases of the crop sequence. Main plots will measure 6m x 5m with split plots measuring 1.5m x 5m within the main plots. All phases of the crop sequences will be represented each year of the study. Cover crops were selected based on input from organic growers and members of the Montana Organic Association (MOA). Cover crops will consist of a 9-species cool season polyculture with barley, emmer, oats, pea, lentil, red clover, yellow mustard, radish, and turnip. Cover crops will be grazed with sheep and terminated in the fall by disking.To determine the efficacy of different organic amendments and the contribution of microbial nutrient cycling to nutrient use efficiency, greenhouse studies will be established with different ratios of fertilizer and organic amendments. Studies will be performed with a conventional control (urea fertilizer) and a variety of organic nutrient sources. All treatments are approved for use in organic agriculture and were selected based on input from organic growers in the region. A preliminary experiment will be performed with 4 reps and additional product rates along with 3 rates of RP fertilizer and plant biomass will be measured at 6 weeks. The purpose of

this preliminary experiment is to ensure that the selected product rates and experimental timeframe produce sufficient crop biomass.Subsequentgreenhouse studieswill be performed with a subset of treatments used in year 1. Stable isotope probing will be used to track N from organic amendments and quantify the N pool in the soil, plant roots, plant above ground biomass, and microbial community. Treatments will consist of 10 atom %15N labeled urea (conventional fertilizer control), 10 atom %15N labeled algal amino acids, and a15N green manure. Labeled green manure will be prepared by growing field pea, sweet clover, and forage barley in sand culture with a modified Hogland nutrient solution. Once plants are established, labeling will be performed by addition of 98 atom %15N labeled ammonium nitrate, calcium nitrate, and potassium nitrate in a modified Hoagland solution. Samples of the15N enriched biomass will be submitted to the UC Davis Stable Isotope Facility to quantify the label concentration and the dried biomass will be stored at -20°C until application. Field pea, sweet clover, and forage barley biomass will be applied in subsequent greenhouse experiments at equal mass ratios at a rate equivalent to 2.5 tons/acre. Due to the expense of the15N reagents, an identical trial experiment will be performed with unlabeled substrate to validate the experimental design prior to performing the labeling experiment.To ensure that project goals are met according to the goals and timeline, project evaluations will be conducted through monthly meetings. These meetings will address questions related to the project progress. What challenges were encountered? How were they addressed? Were the activities developed according to the project\'s schedule? Were activities implemented with fidelity? Summative evaluation will focus on assessing the extent to which, and under what conditions, the project achieved its outcomes and addressed NIFA priorities. Annual meetings with the Montana Organic Advisory and Education Council (OEAC) and CARC advisory board will assess questions related to project outcomes. The purpose of these evaluations is to provide ongoing feedback on project implementation and measure the extent to which objectives are achieved. Did the project outcomes impact organic agricultural practices, and Extension education? Did the project outcomes contribute to potential economic benefits of organic agricultural production? Progress 09/01/23 to 08/31/24 Outputs Target Audience:The target audience is organic producers across the norther Great Plains. Farm organizations such as Montana Grain Gorwers and the Montana Organic Association are also part of the target audience that outreach efforts will focus on reacing through field days and extension events. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?One graduate student has been recruited for the project. This student is currently being trained in agronomic principles and practices related to the field trials that have been established. How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals?To address Objectives 1 and 2, field studies will be harvested and agronomic data analyzed. The second year field trials will also be established. Initial greenhouse studies will be established as described in Objective 3 to evaluate crop response microbial inoculants and organic amendments. Impacts What was accomplished under these goals? Crop sequence trials have been established at the Central Agricultural Research Center, Moccasin, MT and the Quinn Institute, Big Sandy, MT to address Objectives 1 and 2. Since this is the first year of the field study, data has not yet been collected and there are no results or outcomes to report. Publications

↑ Return to Index

Revolutionizing Organic Fire Blight Management: Harnessing the Power of Novel Biocontrol Bacterium Pseudomonas Soli T307

Contract / Grant No.	2023-51106-40960
Grant Year	2023
Investigator(s)	Ching-Hong Yang
Performing Institution	University of Wisconsin

NON-TECHNICAL SUMMARY

Our project is set to tackle a major problem affecting agriculture, specifically the disease known as Apple fire blight, caused by the bacterium E. amylovora. We have identified a potential solution, a bacterial strain of Pseudomonas soli T307 (T307), which can counteract the harmful effects of fire blight. The T307 strain produces a unique natural compound, RejuAgro A (RAA), which has proven effective in combatting E. amylovora. Initial testing in controlled environments and on the field showed promise; however, RAA production can fluctuate depending on the temperature and field conditions.To overcome this, we found that natural chemical inducers can be introduced to consistently boost RAA production. The pivotal part of our approach hinges on blending these RAA inducers with our biocontrol agent, to ensure their effective application in the field. Further to this, we are exploring how to enhance the immunity of the host plants, in combination with the application of P. soli T307.The ultimate goal of our project is to develop an integrated management system to protect crops, especially apples and pears, from fire blight for organic farmers, helping to improve crop yields and farm productivity.Our work aligns with the overarching aims of the ORG project, particularly in protecting plant health, expanding markets for emerging technologies, and providing alternatives to clinical antibiotics for disease control in agriculture. In essence, we\'re focused on pushing forward sustainable agricultural practices, ensuring healthier crops and a better future for farmers and the larger community. Goals / Objectives The overarching goal of this project is to contribute to sustainable agriculture and the promotion of organic farming practices, in alignment with the objectives set forth by the ORG.Our primary objectives are twofold:Safeguard Plant and Animal Health: The project aims to reduce the impact of major diseases, pests, and wildlife conflicts. Our focus is on the development of sustainable and effective methods for fire blight control, a serious threat to plant health, particularly for apple and pear crops.Foster Market Expansion for Sustainable Solutions: We strive to support the growth of markets for sustainable products and innovative technologies. By creating an effective alternative to traditional antibiotics used for fire blight control, we are promoting eco-friendly and organic approaches in agriculture. This not only aligns with USDA National Organic Standards Board Materials Subcommittee Research Priorities Proposal but also fosters market growth for these alternatives.Through achieving these objectives, our project anticipates making a significant contribution to sustainable agricultural practices and the growth of organic farming, with the aim of creating a healthier and more sustainable world. Project Methods The project is divided into three stages.Stage 1.1 involves searching for chemical inducers that stimulate RAA production in P. soli T307. These inducers are selected based on their capacity to promote RAA production in bacteria and are tested on P. soli T307 cultures in laboratory conditions. The concentration of RAA is measured using HPLC assay, and inducers that stimulate the highest RAA production are selected for further testing.Stage 1.2 is a greenhouse experiment designed to evaluate the suppression of E. amylovora growth by P. soli T307 treated with selected inducers. The experiment is performed on potted crab apple trees, with flowering induced for year-round data collection. E. amylovora population on the flowers is quantified post-inoculation, and any phytotoxic effects are documented. Data analysis is conducted using Fisher\'s LSD test and ANOVA in R.Stage 1.3 is a multi-year-multi-location field experiment to evaluate the effectiveness of P. soli T307 and inducers in suppressing fire blight disease under field conditions. The rate of fire blight infection post-inoculation is evaluated, and data analysis is performed similar to the greenhouse experiment.The second part of the project involves assessing the compatibility of P. soli T307 with two organic certified products, Regalia and Blossom Protect, and evaluating the efficacy of these combinations in field conditions.Compatibility is evaluated by observing if Regalia inhibits bacterial growth or RAA production in P. soli T307 cultures, and by performing a bioassay to assess the antagonistic effects between P. soli T307 and Aureobasidium pullulans, the active ingredient in Blossom Protect.Following compatibility determination, a two-year field experiment is carried out to evaluate the effectiveness of combined P. soli T307, Regalia, and Blossom Protect in controlling fire blight. Fire blight infections are rated post-inoculation, and the results are statistically analyzed using ANOVA and Fisher\'s LSD test in R.This project also involves dissemination of the findings to the farming community through multiple channels, including cooperative extension activities, direct communication with farmers, presentations at extension events, publications, and online resources. Experienced organic apple farmers, Rami Aburomia and Deirdre Birmingham, are involved in the project to provide practical guidance.The project\'s impact is evaluated by conducting post-project grower surveys and assessing the number of growers transitioning to organic practices. The data generated from this project aims to improve knowledge and influence actions concerning organic control of fire blight, ultimately improving apple tree health and reducing fire blight incidence. Progress 09/01/23 to 08/31/24 Outputs Target Audience:During this reporting period, our outreach efforts primarily targeted the farming community, specifically growers and industry professionals engaged in crop production. This focus is vital as it aligns with our objective to facilitate the practical adoption of research findings related to sustainable crop disease management, particularly the use of antibiotic alternatives. 1. Farmers and Growers We engaged directly with local farmers, such as Deirdre Birmingham of The Cider Farm and Rami Aburomia of Atoms to Apples. These interactions fostered in-depth discussions about fire blight management, emphasizing the efficacy of antibiotic alternatives developed from our research. This grassroots engagement allows us to tailor our findings to the specific needs of the farming community, ensuring that the solutions we propose are practical and implementable. 2. Industry Professionals Our participation in the Wisconsin Fresh Fruit and Vegetable Conference allowed us to engage a diverse audience of growers, agricultural consultants, and industry professionals committed to advancing sustainable practices in crop protection. Dr. Yang\'s presentation on innovative, non-antibiotic strategies for managing apple fire blight, particularly focusing on Pseudomonas soli T307, strongly resonated with attendees. With fire blight posing a persistent challenge in apple production and increasing concerns about the sustainability of antibiotic use in agriculture, the audience showed great interest in biocontrol solutions. The session highlighted the need for sustainable alternatives that align with both regulatory trends and consumer demand for reduced chemical inputs in agriculture. This conference provided an excellent platform for knowledge exchange and networking, leading to discussions on integrating our research into existing crop disease management programs. These conversations opened doors for potential collaboration on field trials and product development, particularly regarding P. soli T307\'s commercial potential. Many attendees expressed a keen interest in how biocontrol agents could help reduce reliance on antibiotics while maintaining crop yield and quality. Additionally, Dr. Yang attended the Annual Biocontrol Industry Meeting (ABIM) Conference in Basel, Switzerland. ABIM is a premier global event for professionals in the biocontrol industry, where Dr. Yang connected with biocontrol companies, regulators, and fellow researchers. At ABIM, discussions centered on the commercialization of biocontrol solutions like P. soli T307, focusing on navigating regulatory frameworks and market trends in the global agricultural sector. This engagement provided valuable insights into ensuring our biocontrol agents meet both regulatory standards and market expectations. Dr. Yang also served as an Invited Speaker at the 12th International Congress of Plant Pathology in Lyon, France, presenting \"T3SS inhibitors as antibiotic alternatives in fire blight management.\" This invitation further expanded our outreach to a global audience of plant pathology experts, showcasing our research on innovative approaches to sustainable crop disease management. 3. Collaborators in Product Development Our collaboration with Dunham Trimmer, LLC, has been instrumental in targeting stakeholders involved in product development, registration, and technology licensing within the crop protection industry. This partnership facilitates our engagement with market trends and consumer preferences, crucial for aligning our strategies with industry standards and expectations. Their expertise provides valuable insights into the commercialization process of our natural metabolite RAA, enhancing our ability to reach farmers effectively. 4. Academic and Research Institutions Dr. Yang\'s presentations at Academia Sinica and various universities, including National Chung Hsing University, the Taiwan Agricultural Research Institute, and the Agricultural Chemical Research Institute, targeted academics and researchers in the field of agriculture. These seminars focused on the transition of natural metabolites from research to commercial products and explored innovative strategies in crop disease management. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project provided multiple opportunities for training and professional development for both the research team and the farming community, fostering advanced technical skills and knowledge dissemination. Hands-on Training and Grassroots Engagement: A key aspect of our training efforts involved direct interaction with local farmers, such as Deirdre Birmingham of The Cider Farm and Rami Aburomia of Atoms to Apples. These interactions allowed us to have in-depth discussions about fire blight management, particularly focusing on the antibiotic alternatives developed in our research. Through these grassroots engagements, we were able to tailor our training and solutions to the specific needs of the farming community, ensuring that our recommendations are practical and easily implementable. Farmers gained knowledge on how to adopt sustainable, non-antibiotic treatments, such as Pseudomonas soli T307, into their operations. Mentorship and Skill Development for Researchers: Members of the research team, particularly graduate students, benefited from one-on-one mentorship provided by Dr. Yang. This included practical training in field trial management, data collection, and statistical analysis, along with guidance in biocontrol application techniques. These training activities enabled the team to develop a strong skill set in sustainable agriculture practices and advanced research methodologies. Professional Development through Conferences and

Networking: Dr. Yang participated in two key conferences that provided opportunities for professional development and networking. Dr. Yang attended the Annual Biocontrol Industry Meeting (ABIM) in Basel, Switzerland, where the latest research in biocontrol, including our findings, was discussed with industry professionals. Additionally, Dr. Yang served as an Invited Speaker at the 12th International Congress of Plant Pathology in Lyon, France, where he shared our research with a global audience. These events allowed Dr. Yang to gain valuable insights into global trends in biocontrol and sustainable agriculture, build professional networks, and engage with key stakeholders in the field. How have the results been disseminated to communities of interest?Our dissemination strategy during this reporting period focused on key target audiences such as local growers, biocontrol industry professionals, and the international scientific community, ensuring that our research findings were shared with those most likely to benefit. Engagement with Local Farmers: We engaged directly with local farmers like Deirdre Birmingham of The Cider Farm and Rami Aburomia of Atoms to Apples. These grassroots interactions fostered in-depth discussions about fire blight management, with a particular emphasis on the efficacy of the antibiotic alternatives we developed, such as Pseudomonas soli T307. This personalized outreach enabled us to tailor our findings to the specific needs of the farming community, making sure that the solutions we propose are not only effective but also practical and easily adoptable by farmers. Dissemination to Industry Professionals: Results were shared with industry stakeholders during the Annual Biocontrol Industry Meeting (ABIM) in Basel, Switzerland. This event allowed us to reach biocontrol companies, regulatory professionals, and product developers, facilitating discussions on the commercialization of Pseudomonas soli T307. By engaging directly with industry professionals, we ensured that our findings could influence the development of sustainable, market-ready biocontrol products. Additionally, our collaboration with Dunham Trimmer, LLC has played a critical role in disseminating our research to stakeholders involved in product development, registration, and technology licensing within the crop protection industry. Dunham Trimmer\'s expertise in aligning product development with market trends and regulatory standards has enhanced our ability to target a broader audience, including those responsible for bringing biocontrol products like Pseudomonas soli T307 to market. Their support has also helped ensure that our research findings are aligned with industry expectations, making it easier to reach farmers with effective, commercially viable solutions. Outreach to the Scientific Community: Dr. Yang\'s presentation at the 12th International Congress of Plant Pathology in Lyon, France, provided an additional platform to share our research with a global network of scientists and researchers. By focusing on antibiotic alternatives in fire blight management, we disseminated our findings to those working in sustainable crop disease management, fostering further advancements and collaborations in this field. Through these targeted efforts, we ensured that the research outcomes were communicated effectively to those who can directly benefit from or contribute to further developments in sustainable fire blight management and biocontrol technologies. What do you plan to do during the next reporting period to accomplish the goals? Further Field Trials: Building on this year\'s results, we plan to conduct additional field trials to confirm the efficacy of P. soli T307 with L-methionine and L-glutathione on a larger scale. We will explore different apple cultivars and environmental conditions to ensure the robustness of the treatment. Refinement of Treatment Combinations: We will test additional concentrations of L-methionine and L-glutathione to fine-tune the treatment for optimal fire blight suppression. Expansion of Outreach Efforts: We plan to broaden our outreach efforts to include more apple growers and expand our participation in industry conferences. Additionally, we aim to disseminate knowledge to a broader farming community. Commercial Development: Further collaboration with industry partners will be prioritized to facilitate the commercialization of P. soli T307 as a sustainable, non-antibiotic alternative for fire blight management. We will focus on addressing regulatory requirements and market demands to bring the product to market. Impacts What was accomplished under these goals? The primary issue our project seeks to address is the control of fire blight, a devastating bacterial disease caused by Erwinia amylovora, particularly in apple orchards. Fire blight poses a significant threat to commercial fruit production, resulting in substantial economic losses. The use of antibiotic-based treatments, such as streptomycin, is increasingly scrutinized due to concerns about antibiotic resistance and sustainability. Therefore, this project aims to develop effective, sustainable, and non-antibiotic alternatives for managing fire blight, utilizing the biocontrol strain Pseudomonas soli T307 with amino acid enhancers. Audience Impacted: The audience most immediately helped by this work includes apple farmers and growers, particularly those in regions prone to fire blight outbreaks. Additionally, industry professionals in crop protection and agricultural researchers have benefited from the knowledge dissemination. The results of this project provide these stakeholders with viable alternatives to antibiotic treatments, promoting sustainable agricultural practices. Major Activities, Data Collected, and Results: During this reporting period, we focused on field trials conducted on 8-year-old \'Pink Lady\' apple trees at the Lockwood Farm of the Connecticut Agricultural Experiment Station. The trials evaluated the efficacy of Pseudomonas soli T307, both with and without the addition of L-methionine and L-glutathione, in controlling blossom blight caused by Erwinia amylovora. The treatments were arranged in a randomized, complete block design with three replicates. Streptomycin (FireWall 17) served as the antibiotic standard, and a water-treated control was used as the negative control. Seven different treatments were tested, each spray-inoculated at 80% and 90% bloom. All trees were inoculated with Erwinia amylovora on May 3rd, 2024. Disease severity was assessed by calculating the percentage of infected flower clusters on May 28th, 2024. Statistical analysis revealed that P. soli T307 alone reduced blossom blight infection from 92% (control) to 65%. The addition of L-methionine (0.12%) and L-glutathione (0.06%) further reduced infection rates to 25%, indicating that this combination has the most significant impact on disease suppression. However, higher concentrations of L-methionine (0.24%) and L-glutathione (0.06%) did not yield further improvements. Key Outcomes and Accomplishments: The key outcome of this reporting period is the identification of an optimal combination of P. soli T307 with L-methionine (0.12%) and L-glutathione (0.06%), which significantly reduced fire blight infection in apple orchards. This finding presents a promising alternative to traditional antibiotic treatments, offering farmers a more sustainable option for disease management. The project\'s broader impact lies in its contribution to the ongoing efforts to reduce antibiotic use in agriculture, addressing both environmental and health-related concerns. This solution supports sustainable farming practices while safeguarding apple yields, ultimately benefiting farmers and consumers. Publications

↑ Return to Index

Empowering Indiana`s Organic Farmers: Assessing Regional and Farm Scale Soil Health with a Farmer Network

Contract / Grant No.	2023-51106-40947
Grant Year	2023
Investigator(s)	Yichao Rui
Performing Institution	Purdue University

NON-TECHNICAL SUMMARY

Soil health is the foundation of successful organic production and many services that organic agriculture provides. Indiana is ranked fifth in the U.S. in agricultural production, but its organic industry is lagging behind neighboring states. Although a new wave of organic transitions in Indiana is happening, a lack of support network for organic growers and insufficient knowledge about the complete soil health benefits of organic agriculture and how to effectively evaluate and maintain soil health are hindering farmers\' ability to build more productive organic production systems. The project aims to address these barriers by (1) establishing an Indiana Organic Network (ION) to facilitate on-farm research, peer learning, and communications among existing and transitioning organic farmers; (2) working with ION farmers to conduct a statewide soil health census of organic farms as well as in-depth soil health assessments on selected organic grain, pastured livestock, and vegetable farms to understand the impacts of organic management on soil health, especially at depth; (3) developing biological soil microbial activity kits to measure biological soil health in-situ; (4) developing geospatial models to support soil health benchmarking at farm scale; and (5) developing a web platform to serve as an information hub to guide farmers for effective organic soil health management. With the partnership between Purdue University, conservation groups, organic industry, and other stakeholders, the multidisciplinary team will conduct research and extension that will provide vital assistance to organic and transitioning farmers in Indiana to facilitate smooth transitions and promote successful organic production in the state. Goals / Objectives The long-term goal of this project is to support the transition and enhancement of organic farming in Indiana, by working directly with the ION farmers, to comprehensively assess soil health and evaluate the impact of various organic management at regional and farm scale. Specific objectives include: 1. Establish the Indiana Organic Network (ION) to facilitate communication, peer-learning, and information exchange among farmers, researchers, conservation groups, and agricultural professionals; 2.Perform state-wide assessments of soil health of Indiana organic farms to identify the key drivers of soil health variation across scales and characterize the impacts of different organic management practices at deeper soil depths; 3.Develop and validate farm-scale geospatial models to improve soil health benchmarking using remote sensing, soil survey, and soil data, to provide guidelines for soil sampling locations and monitoring strategies; 4.Develop new methods for on-farm measurement of soil biological processes, targeting rates of carbon (C) and nitrogen (N) cycling; and 5. Produce an ION website as an information hub to provide organic farmers with regionally-specific knowledge and resources for effective soil health management. Project Methods One primary objective of our proposal is to foster collaboration and engagement among farmers who are interested in organic agriculture and quantifying the benefits of soil health in Indiana. To achieve this goal, we will establish the Indiana Organic Network (ION) to connect diverse stakeholders, including farmers, researchers, soil conservation groups, and industry partners. ION will serve organic farmers throughout the state by building community, facilitating peer-learning and resource sharing, and enabling on-farm research.The aim of Obj. 2 is to characterize the state of soil health on organic farms in Indiana and assess the effects of various management practices on soil health. This objective will be divided into two parts: a state-wide census of surface soil health of organic and transitioning farms in Year 1 (Obj. 2.1), and in-depth soil health measurement on selected organic grain, pastured livestock, and vegetable farms in Year 2 and 3 (Obj. 2.2).Obj. 2.1: State-wide soil health census of organic farms. We propose to conduct the first state-wide census of soil health on organic and transitioning farms in Indiana in Year 1. Our aim is to provide free soil health testing to \~100 farmers, and correlate variation in soil health with geographic, soil, and management characteristics.Obj. 2.2 In-depth soil health assessments at selected organic grain, pastured livestock, and vegetable farms. In Year 2 and 3, based on data collected for the soil health census in Obj. 2.1, we will conduct more in-depth soil health measurements on selected organic grain, pastured livestock, and vegetable farms to quantify the full soil health benefits of organic practices, including those at deeper depths. In Y2, we will target 15-20 organic grain farms and 5-10 pastured livestock farms, and in Y3, we will target 15-20 organic vegetable farms. We will select farms that demonstrate significant differences in

their management practices in response to the most asked questions by the farmers (Table 1). For instance, we aim to select organic grain farms that have varying degrees of tillage intensity, from full tillage, reduced tillage, to no-till, and farms with limited cover crop growth to full-season cover crops.We propose to develop innovative tools for soil health benchmarking using geospatial approaches that will predict farm-scale soil health variation. The aim is to integrate different environmental and management variables to: optimize sampling intensity and sampling locations for modeling soil properties (Obj. 3.1) and develop digital soil mapping models for a comprehensive farm-scale characterization of organic farms identified in Obj. 2.2 which possess a high degree of diversity in soil and management factors (Obj. 3.2).Accurate measurements of organic mineralization rates in soils are valuable to organic farmers who rely on natural processes to supply mineral nutrition to crops, and serve as an indicator of soil health. However, measures of soil bioactivity are typically conducted ex situ in controlled laboratory conditions which bias estimates (Wienhold, 2007). Our project aims to develop two in situ approaches to improve the measurement of biological process rates in soils. In Obj. 4.1, we will adapt the \'buried bag\' method into a \'do-it-yourself\' kit for measuring N mineralization. In Obj. 4.2, we will design, fabricate, and test a \'biological sensor of soil health\' (bioSSH) to resolve rates of C and N mineralization at high sensitivity.We will produce a soil health \'information hub\' to provide general guidance and targeted information as a feature of the ION website. The information hub will provide an interactive recommendation webtool of customized resources for the current or transitioning organic farmers, and conventional farmers considering transitioning (Obj. 5.1). We will also build a prototype of a map-based webtool to guide soil health benchmarking by recommending sampling location, sample number, etc. for future deployment on the information hub (Obj. 5.2). Progress 09/01/23 to 08/31/24 Outputs Target Audience:Since the commencement of the project, the project team has made a concerted and sustained effort to engage with organic growers and stakeholders throughout Indiana. A key scientific component of the project, and one of the major milestones achieved in the first year, has been the initiation of a comprehensive statewide soil health census of organic farms. Recognizing the importance of reaching as many organic farmers as possible, the team employed a variety of outreach strategies and leveraged multiple communication channels. These included an active presence on social media to recruit growers, as well as presentations at significant events such as the Indiana Organic Grain Farmer Meeting, the Indiana Small Farm Conference, and the Indiana Grazing Schools in spring of 2024. Through these diverse efforts, the team successfully connected with a broad network of organic farmers, many of whom expressed interest in participating in soil health research on their farms. As a result of these collaborative efforts, the project was able to collect soil samples from 46 organic farms across the state, marking a substantial step forward in advancing soil health research in Indiana\'s organic farming community.This project has generated significant excitement for soil health and organic research in Indiana. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project has provided several opportunities for training and professional development based on its progress thus far. First, Annie Benson, an MSc student, was recruited to lead the statewide soil health census, offering her valuable hands-on experience in coordinating large-scale data collection and engaging with organic farmers. This role allows her to develop expertise in soil health monitoring and organic farming systems. Additionally, Arsen Yerlan, a PhD student who joined the project in August 2024, will be conducting in-depth soil health assessments and developing in-situ soil health kits. This provides him with an opportunity to build advanced research skills in soil science and contribute to the development of practical tools for farmers. These roles foster a strong learning environment for both graduate students and researchers, enhancing their scientific and leadership skills within the context of organic farming and soil health. How have the results been disseminated to communities of interest?The results of the project have been disseminated to communities of interest through several key avenues. The project team utilized various platforms to engage with Indiana\'s organic farming community and other stakeholders. A website for the Indiana Organic Network (ION) has been developed (http://purdue.ag/ion) and is set to be launched in February 2024, serving as a central hub for sharing project progress, findings, and resources. Additionally, social media platforms, including X (formerly Twitter) and Facebook, were created to facilitate broader outreach and communication with the organic farming community. The project team took advantage of major events such as the Indiana Organic Grain Farmer Conference (February 28, 2024), where the official introduction of the ION and the project was presented to organic farmers across the state. This conference, along with other farmer-focused gatherings, provided an opportunity to share the project\'s objectives, progress, and preliminary findings with a wide audience. Farmer recruitment efforts through these platforms and events have sparked significant interest and enthusiasm, allowing the project team to directly connect with organic farmers who are eager to participate in soil health research. By engaging with these communities through a combination of online platforms and in-person events, the project ensures that its results and ongoing efforts are widely shared and accessible to those who can benefit the most. What do you plan to do during the next reporting period to accomplish the goals?1. Completing the data analysis and dissemination of the 1st year\'s statewide soil health census. 2. Host a webinar in 2025 to report the results back to growers. 3. Host an in-person Advisory Committee meeting in February 2025. 4. Host two field days/workshops on farmers\' fields (grain and vegetable focused) in the summer. 5. Start in-depth soil health analysis on selected farms. Impacts What was accomplished under these goals? The long-term goal of this project is to support the transition and enhancement of organic farming in Indiana, by formalizing an \"Indiana Organic Network (ION)\" and work with the ION farmers, to holistically evaluate soil health under various organic management systems at regional and farm scale.Since the beginning of the NIFA funded project in September, 2023, a website for ION (http://purdue.ag/ion) has been created and will be launched in February 2024. The project team usedthe Indiana Organic Grain Farmer Conference (February 28, 2024) to make an official introduction of the ION and the project to Indiana\'s organic farmers. Social media platforms on X, Facebook account,and Facebook group werecreated. A statewide soil health census of organic farms across Indiana is underway. Soil samples were collected from 46 organic farms across the state. Farmer recruitment using different platforms generate lots of interest and enthusiasm. Annie Benson, MSc student, was recruited to lead this statewide soil health census work. Arsen Yerlan,PhD student started in August 2024 and will beconducting in-depth soil health assessment and develop in-situ soil health kits in Year 2-4 of the project. The search for a postdoctoral researcher to develop geospatial models of soil health characterization of organic farms has completed. Publications

↑ Return to Index

Comparing Soil Health and Weed Suppression Within Organic Annual and Perennial Rotations

Contract / Grant No.	2023-51106-40920
Grant Year	2023
Investigator(s)	Jason Kaye
Performing Institution	Pennsylvania State University

NON-TECHNICAL SUMMARY

One of the challenges facing farmers is how to balance the goals of managing weeds and improving soil health. Tillage is a common tool for controlling weeds, especially in organic systems, yet it also disturbs the soil, degrading its long-term fertility. Rotating perennial hay crops with annual cash crops may offer an opportunity to suppress weeds and improve soil health. Planting perennial crops (which are cut for hay multiple times over two years or more) can interrupt weed life cycles and draw down weed seeds in the soil. The lack of disturbance under perennials provides an opportunity for microorganisms to build organic matter and soil fertility.A key question that we aim to answer through this research is whether combining multiple species of perennials in a field improves weed suppression and soil health. We will compare single species and mixtures of perennials (up to six species) in terms of weed growth and several metrics to assess soil physical and biological health. Also, we will compare two rotations in terms of their corn yields and profitability: corn preceded by two years of perennials versus corn preceded by two years of annual cash crops (soybeans and wheat) with cover crops.Throughout the project, we will have regular meetings with farmers, providing opportunities to share research results and discuss experiences with weed management, selecting perennial species and designing rotations. Our goal is to provide farmers with information about a variety of perennials and their impacts on soil health and weed suppression. Outreach events and materials developed through this project will guide farmers in selecting perennial species and rotations that suppress weeds, build soil health, and also are profitable. Goals / Objectives One of the challenges faced by farmers how to control weeds and also build soil health. Tillage remains a key tool for controlling weeds, especially in organic systems, yet it disrupts soil aggregates and oxidizes soil organic matter, thereby having detrimental effects on soil health. This project addresses two key questions relevant to organic farmers:1) Does a rotation with both annual and perennial crops improve soil health and weed suppression compared to an annual-only rotation with cover crops?2) Does the species diversity of perennials and annual cover crops influence soil health and weed suppression?Our long-term goal is to improve our understanding as to how perennial phases of organic crop rotations can be improved to maximize soil health and weed suppression benefits, as well as overall farm profitability. To meet this goal, we plan to address the following objectives. Objective 1: Evaluate the forage yield and quality of a diverse set of perennial species grown within an organic farming system. The perennial rotation will be phased into our Penn State research station site beginning in the spring after growing corn followed by a cereal rye cover crop. Monocultures of six perennial species will be planted (two legumes, two grasses, and two forbs) along with mixtures of those species, with the most diverse mix including all six species. The perennial species will be harvested for hay for two years and be followed by corn. The perennial diversity gradient distinguishes this proposal from most prior research, and the establishment, yield and quality of these forage species and mixtures will provide material for outreach meetings and extension articles. In addition, the establishment of the diverse perennial rotation at the research station will provide the foundation for accomplishing Objectives 2-4.Objective 2: Evaluate the potential for perennial forage crops to improve soil health as a function of species diversity and length of establishment. At the research station, we will compare soil health within corn-perennial (including simple and diverse perennial stands) and corn-soybean-wheat rotations (with simple and diverse cover crops). We will measure soil carbon levels (partitioned into particulate and mineral-associated organic carbon), soil physical properties (wet aggregate stability and infiltration rates) and soil biological health (microbial biomass and daily respiration rates). Baseline metrics will be collected at the beginning of the project and repeated two years after perennials are established. These data will allow us to evaluate the short-term impacts of diverse perennial forage crops on soil health.At the on-farm sites, we will make the same soil health measurement in established perennials. On-farm sites will be selected for their long history of rotational perennial use, to assess the long-term impactof perennials on soil health. The research station and on-farm soil health datadata will support farm tour and grower meeting discussions about relationships between perennial species, rotations and soil health as well as the development of a webinar about perennial forage crops and soil health.Objective 3: Compare weed suppression by annual cover crops and perennial forage crops across a plant diversity gradient. A diverse group of winter cover crops including six species (two legumes, two grasses and two brassicas) are grown in monoculture and mixtures (2-6 species) between wheat and corn at the Penn State research station. Establishing perennial treatments with a similar diversity gradient (both in number and types of species) will allow us to make a series of comparisons of weed suppression by annual and perennial species. We will sample weed biomass in the annual cover crops and perennial crops in both fall and spring. At these times, we will measure both counts and biomass of Canada thistle, a perennial weed that is problematic at this site and particularly difficult to control in organically managed systems. We will also measure weed biomass in corn following the annual cover crops and the perennial forage crops. Finally, we will assess the weed seedbank in the annual and perennial rotations both in the field and through greenhouse soil seedbank studies. The data generated by the research in this objective will detail the weed suppression benefits of constructing more diverse crop rotations that include perennials, which will be disseminated to farmers at outreach events and through extension publications.Objective 4: Quantify corn yields and overall profitability of a perennial-annual rotation compared to an annual rotation with cover crops across a plant diversity gradient. We will use structural equation modeling to compare how these rotations and embedded cover crop and perennial plant diversity gradients affect corn yields either directly or indirectly through their influence on soil health metrics and weeds. In addition to comparing corn yields, the overall profitability of these two rotations at the research station will be assessed using partial budget analyses. These analyses will help farmers decide whether and how to incorporate perennials into annual cash-crop rotations. Also, they will guide farmers who are considering planting different perennial species or changing their rotation. The yields and profitability analyses will be published in an extension article and incorporated into outreach presentations. Project Methods Objective 1: Perennial forage yield and quality-The Penn State research station has an established organic annual rotation of corn, soybeans and wheat, with a diverse set of cover crops grown between wheat and corn. We will transition to a split-plot design to begin a second rotation, where the soybeans and wheat are replaced by two years of perennials. Following the termination of both perennial and winter cover crop treatments, both rotations (full-sized plots) will planted in corn.We will plant a diverse set of perennial species, corresponding to the types and numbers of species of cover crops grown in the adjacent half-plot remaining in the annual rotation. For example, plots that have a history of a grass-legume cover crop mixture will be planted in a grass-legume perennial mixture on the perennial side of the plot. In the plots with a history of brassica cover crops, we will plant forb species on the perennial side, since most brassicas are annuals.The perennial species will be harvested for hay with 1-3 cuts for the first year and 4 cuts in the second year. Before each harvest, we will quantify forage biomass by species in three 0.5 m ×0.5 m quadrats in each plot. We will measure forage yield using a 1 m wide small plot forage harvester to a length of 10 m, with a cutting height of 7.6 cm. For the first cut each year, we will assess forage quality by compositing and grinding the hand-clipped samples and sending to a certified commercial lab for analysis.Objective 2: Perennials and soil health-At the research station, we will collect all soil health metrics prior to planting the perennial treatments (baseline) and repeat the measurements two years later in both rotations. All measurements will be collected in spring under the following plant species: cereal rye (baseline at the research station), winter cover crops (annual rotation at the research station) or mature perennials (established for at least two years) at the research station and on-farm sites. At the on-farm sites, we will collect the same soil health metrics in established perennials, along with information about length of establishment and rotation in each field. Soil health metrics will include:a) Soil organic matter, divided by wet sieving into the particulate fraction (\>53 µm) and mineral-associated fraction (\<53 µm), with each fraction analyzed for carbon and nitrogen content.b) Wet aggregate stabilitywill be assessed by placing the 1-4mm size fraction in a dunking apparatus for five minutes to collect the unstable aggregates. The percentage of water stable aggregates will be calculated correcting for the water content and sand fraction. c) Soil infiltration rates will be assessed on a subset of treatments at the research station (legume, grass and brassica/forb monocultures and grass-legume, grass-legume-brassica and 6-species mixtures) due to the time required for each measurement.Infiltration rates will be measured with a double-ring infiltrometer (15 cm diameter inner ring, 30 cm diameter outer ring, 10 cm tall, and inserted to a depth of 5 cm) until steady-state is reached.d) Microbial biomass will be estimated using phospholipid fatty acid analysis, which is a low-cost method for determining total microbial biomass and the fungal to bacterial ratio.e) Daily respiration rates will be estimated by measuring carbon dioxide concentrations four times during a 7-day incubation fresh soils.The soil health metrics for the perennial and annual treatments will be compared in two ways: overall (annual vs. perennial) and by treatment (side-by-side comparisons of perennial and annual species that are matched by species type and diversity). For both comparisons we will use a metric of percent change in soil health compared to baseline conditions. The first comparison will combine all treatments into two groups (annuals and perennials) while the second will be a series of treatment comparisons (i.e., grass perennial and grass cover crop), controlling for any effects of species diversity.Objective 3: Perennials and weed suppression-We will perform three types of assessments to compare weed suppression by perennial and annual species.a) Germinable seedbank assays will be based on six soil cores per plot (3 cm diameter X 7 cm depth). Soil cores will be collected in each year of the perennial phase of the rotation which includes: 1) t0, the March preceding the planting of perennial forage treatments; 2) t+1, the following March, after one year of the perennials; and 3) t+2, the March after the second year of perennial treatments. The field soil will be spread over a 2.54 cm layer of potting soil in plastic trays in the greenhouse and watered as needed. We will identify all weeds to species, and count and pull all weed seedlings each week until germination ceases, after which the soil-potting media mixture will be dried, stirred, and the assay will be repeated until all weed seedling germination ceases. As with the soil health metrics, we will compare the geminable weed seed counts overall and by treatment. We will include transformations to decrease the influence of abundant species and perform an indicator species analysis to determine which species are driving any differences between treatments.b) Canada thistle abundance will be assessed throughout the perennial phase of the rotation based on 6m x 6m thistle study areas established in each plot. Within each thistle study area, we will measure counts and heights of Canada thistle shoots. During the corn phase of the rotation, we will repeat the thistle counts as also quantify thistle biomass in these same study areas.c) Weed biomass will be quantified within all rows used for measuring corn yield based on hand-clipped biomass from 0.5m x 0.5m quadrats. These measurements will assess the legacy of perennials vs. cover crops on weed suppression in the following corn crop. Again, these comparisons will be done overall and by treatment. Additionally, across the annual cash crop and perennial forage rotation treatments, we will quantify to what extent the weed communities in the subsequent corn crop result in yield loss. To do this, we will designate a 3 m X 3 m area within the corn crop that will be weeded weekly for the first four weeks after planting, and then every other week after that to create an essentially weed-free condition. We will measure corn yields within the weed-free area and in a similarly sized adjacent (weedy) area.Objective 4: Corn yields and profitability-Consistent with the existing experiment, forage and cover crop species will be terminated by mowing in early May, following perennial forage and cover crop biomass sampling. The remaining plant biomass in both rotations will be incorporated, poultry manure applied (based on soil fertility tests) and corn will be planted in late May. Corn will be harvested for grain each half plot (two central yield rows, 27 m long) to compare yields following the perennial and annual rotations.The interactions between soil health, weeds and corn yield will be analyzed with structural equation modeling (SEM), which is a technique to assess the structure of multivariate relationships. We will analyze how species diversity (both in annual cover crops and perennials) relate to soil health, weed suppression and corn yields. Corn yield data will be utilized for enterprise and partial budget analyses. We will consider costs and revenues associated with both the forage and corn production, assessing the overall profitability of the perennial and annual rotations. Analyses will include seed costs, manure prices, commodity prices, and costs of all field operations and yield variation. These data will be used to calculate the differences in costs and revenues of the two rotations and will include any impacts of the perennial treatments on the following corn yields. This economic component will form a key bridge across all four objectives. Progress 09/01/23 to 08/31/24 Outputs Target Audience:In our first year our target audience was students that we are recruiting as well as scientists, farmers, NGOs, and state agency employees that may beinterested in collaborating. We do not yet have results that would be appropriate to disseminate to farmers. Changes/Problems:Originally, we planned to divide the Penn State Research Station site into equal areas for the perennial and annual rotations. Instead, we decided to utilize one-quarter of the site for the perennial rotation (20-foot strips) and leave the remaining three-quarters of the site in the established annual rotation (60-foot strips). Over the last 12 years, we have built collaborations with several other research groups who are continuing their projects the annual rotation. This will allow sufficient space for all these research activities that are in progress without compromising the objectives for the new perennials project reported on here. A PI on this project (Arrington) accepted a job that was not \"soft money\" grant funded. We decided to replace them with a PhD student, which we successfully recruited. That PhD student will start in January 2025 and we don\'t anticipate any major changes to our objectives. What opportunities for training and professional development has the project provided?Five undergraduate students gained research experience part-time during the 2023-24 school year, and three interns gained training on this project via in Summer 2024. Undergraduate students contributed to this project by testing the method to separate the particulate organic matter fraction from soil samples (a new method in the laboratory), testing seed germination, preparing seed packets, planting perennial forages, and collecting soil infiltration measurements. In addition, they participated in weekly lab group planning meetings where they had opportunities to learn about other projects and provide feedback on draft manuscripts and presentations. We have recruitedone MS student to start Fall 2025 and one PhD student to start in January 2025. Two technicians learned about forage management through this project. One of them, Brosi Bradley, attended PSU extension organic learning circle that included some discussion of various crop rotations including perennials vs annual cover crops. How have the results been disseminated to communities of interest?There are not results to share with communities of interest yet. However, several groups have toured the site to observe the new perennial part of the rotation. Caroyn Lowry took AGRO 28 (Principles of Crop Management Class) and Jason Kaye used the research site as a field trip tour for SOILS 502 (The Nature and Properties of Soils). We also were part of the Penn State Organic Cropping Systems Research Tour on August 14, 2024. Attendees toured the perennials and annual comparison during tour. Approximately 20 people attending as members of the state wide Organic Ag Working Group,consisting mainly of NGOs working in this sector (PCO, PASA, Rodale) and various officials in the Pennsylvania Department of Agriculture. The perennial establishment and annual comparisons were discussed during a field tour of PSU organic crop sites on September 4th, 2024, at the RELARC Cover Crop Cocktails sitethat was for organic growers and certifiers from Argentina. The organizer was Pedro Landa from OIA, Argentina. Discussion included similarities between organic grower challenges of weed and nutrient management and the benefits (or even necessity) of a perennial component of a crop rotation. What do you plan to do during the next reporting period to accomplish the goals?Entry 1: planted 2024: We will complete the 2nd year forage harvests and measurements of forage yield, quality, as well as species composition at 2 time points over the summer. For the annual comparison plots, we will measure wheat yield and harvest, then establish annual cover crop treatments in late August. We will manage soil fertility by analyzing soil samples for nutrient levels and pH, and adding manure after first harvest cut at suitable and consistent rate across all treatments (both perennial and annual). Entry 2: to be planted spring 2025: We will complete baseline soil sampling (0-20 cm depth) prior to perennial forage planting, then analyzesoil for particulate fraction of the soil organic matter as well as aggregate stability, as well as complete infiltration measurements on a subset on plots using the double ring infiltrometer. We will establish the perennial treatments as proposed then measure stand counts for establishment, maintain weed control through mowing, or forage harvest as applicable, and sample biomass in the fall to quantify establishment and growth. We will characterize the baseline soil weed seedbank community in the second perennial forage entry. The annual crop comparison plots will have soybean planted, cultivated, yield measured, then harvested and winter wheat drilled in the fall of 2025. Entry 3: to be planted spring 2026: We will survey the Canada thistle populations in the final perennial forage entry and take soil samples to analyze for fertility, pH to adjust as needed for perennial establishment. We will also meet with farmer advisors, select on-farm research sites, finalize protocols for on-farm sampling and begin measurements on-farm sites. Impacts What was accomplished under these goals? The experiments are being conducted at our Penn State Research Station, which has an organically managed field with an established annual rotation of corn-soybeans-wheat with cover crops. A diverse set of cover crops are grown between wheat and corn, including six cover crop monocultures and five mixtures (2 to 6 species).Cereal rye is grown on all plots (except for a fallow control) between corn and soybeans. The site is divided into three entries, with each entry in a different phase of the rotation, so that all three cash crops are grown each year in different sections of the field. In the first year of the project, we began the establishment of perennial forages during the cereal rye phase of the rotation in one entry of the field. Objective 1: Evaluating Forage Yield and Quality We selected the following varieties for the six perennial species: Alfalfa (44 Mag organic), Birdsfoot trefoil (conventional raw seed, variety not stated), Tall fescue (Lipalma organic), Orchardgrass (Lipalma organic), Forage Chicory (Forb Feast Chicory, untreated), and Small burnet (Delar, conventional raw seed). Conventional untreated seed was used when organic seed was not available from three or more suppliers. For the legumes, species-specific inoculants were used to ensure the presence of correct species of rhizobial bacteria. The alfalfa inoculant was in a seed coating, while a separate inoculant was used for the birdsfoot trefoil. Perennial varieties were selected based on characteristics such as maturity timing, fall dormancy and winter survival with a goal of all species being ready for hay cutting at similar times throughout the growing season. Perennial species seeding rates were selected based on Penn State and NRCS recommendations, with the following rates (pounds per acre) for monocultures: Birdsfoot trefoil (8), Alfalfa (15), Tall fescue (12), Orchardgrass (12), Forage chicory (4) and Small burnet (20). For the mixtures, we combined 2 to 6 perennial species to match the number of species and functional groups (legumes, grasses and brassicas) in the cover crop mixtures. Since brassicas are not typically grown as forages, we selected perennial forb species (forage chicory and small burnet) to correspond with the cover crop brassica species. In the perennial mixtures, equal fractions were multiplied by the monoculture seeding rates for each species, i.e. the 2-species mixture was 50% of the alfalfa monoculture rate plus 50% of the orchardgrass monoculture rate. When preparing seed packets for planting, seeding rates were adjusted based on germination rates measured in our lab for each species, which ranged from 71 to 95%. In the first entry where perennial forages would be planted, corn was harvested for grain in mid-October 2023. After chisel plowing, disking and cultimulching, cereal rye was drill planted in late-October. In March 2024, we initiated the split between the annual and perennial rotation by mowing 20 feet of cereal rye in each strip. The remaining cereal rye in each strip (60 feet) would continue in the annual rotation. After moldboard plowing, disking, s-tine cultivating and cultimulching, the perennial forages were planted in late April. Each perennial monoculture or mixture was planted in a plot which corresponded in both the number of species and plant functional groups to the history of cover crop planting between wheat and corn. For example, the legume-grass perennial mixture (alfalfa-orchardgrass) was planted in plots that have a history of legume-grass cover crops. The established annual rotation at this site includes control plots that have been fallow in winter for two out of three years of the annual rotation: between wheat and corn and between corn and soybeans. (While fallow, these plots have been cultivated for weed control except for a small area used for weed assessments.) Since the perennial forages will be grown for two years before corn, we decided to use an alternative control to prevent areas of the field from being fallow for two years. The plots with a winter fallow history were divided into eight subplots, which was the smallest subdivision we could create with our planting equipment. In these subplots, we planted a subset of the

11 perennial treatments: 5 monocultures (all species except small burnet) and 3 mixtures (all that do not include small burnet). This subset will allow us to test if there is a legacy of cover crops by comparing soil health and weed metrics for each species with and without a history of cover crops in the annual rotation. In the entry where the perennial forages were planted, the operations for the annual rotation management were consistent with previous years. Cereal rye was mowed in mid-May and these strips were moldboard plowed, disked s-tine cultivated, and soybeans were planted in mid-June. Right after planting, soybeans were tine-weeded and then cultivated weekly until mid-July to control weeds. Perennials planted in April 2024 were mowed twice over the summer to control annual weeds. We measured stand counts \~ 3 weeks after planting, and fall biomass growth of all perennial treatments, separated by species and weeds. The annual crop for the split plot comparison for Entry 1 was soybeans, which were planted in spring 2024, then cultivated for weed control, and finally harvested with yield records by plot. Following the harvest, the soil was prepared for planting (chisel plow and following operations), then planted to winter wheat ?Objective 2: Soil Health In March, baseline soil samples (0 to 20 cm soil depth) were collected prior to field operations to begin the division between the perennial and annual rotations. These samples have been analyzed soil for particulate organic matter fraction as well as wet aggregate stability as proposed. In May, we collected baseline soil infiltration measurements in plots that had a history of winter fallow and those that had a history of a 4-species cover crop mixture planted before corn (three randomly selected locations per plot). In the plots with the winter cover crop history, cereal rye was clipped from a 0.25m2 quadrat to clear an area for the infiltration measurements and to estimate cereal rye biomass. Infiltration rates were measured with a double-ring infiltrometer, with a 15 cm diameter inner ring and a 30 cm diameter outer ring, 10 cm tall, inserted to a depth of 5 cm. For each infiltrometer, measurements were recorded until steady state was reached, which was defined as three or more measurements varying by less than 10%. Objective 3: Weed Suppression In Entry 1, which was planted to perennials in April 2024, we sampled the soil seedbank to evaluate the baseline seedbank community prior to the perennial forages being planted. We placed soil in flats in the greenhouse for 6 months and periodically disturbed and homogenized the soil until germination of all weed seedlings was completely exhausted. Entry 2, which will be planted with perennials in April 2025, we surveyed the baseline Canada thistle population to evaluate whether the perennial forage treatments affect Canada thistle density. Object 4: Corn yields and profitability We have been collecting corn yields following the diverse set of winter cover crops (11 treatments with a fallow control) as part of previous projects using the annual rotation. The fourth round of the three-year annual rotation will be completed with corn yield measurements collected in Fall 2024. The historical yield data will document the corn yield-variability at this site. The analyses comparing the corn yields and profitability for the perennial and annual rotations will occur after the first corn harvest following two years of perennial forages. Publications

↑ Return to Index

Integration of Frontier Technologies to Promote Adoption of Organic Tomato Production

Contract / Grant No.	2023-51106-40946
Grant Year	2023
Investigator(s)	Christian Nansen
Performing Institution	University of California, Davis

NON-TECHNICAL SUMMARY

We are unaware of any research collaborations, in which the three frontier technologies in this project (optical sensing, cold plasma, and advanced lighting) are being integrated synergistically. Each frontier technology is associated with a strong track record of being relevant to improved organic crop production, and preliminary data included in this proposal demonstrate our experience with each of them. Additionally, the transferability of project results into commercial crop production operations is considered very high as each frontier technology is commercialized by different companies. As examples, the following are some of the commercial companies, which offer cold plasma solutions to the agricultural sector: Plasma waters (https://plasmawaters.com/) and Vital fluid (https://vitalfluid.com/). On their website, Vital fluid describes several on-going projects with organic growers, in which PAW is used as a fertilizer, particularly as a source of nitrogen for plants and in different pest management applications (mainly of fungal pathogens). Vital fluid and another commercial producer of cold plasma systems (www.plasmatreat.com) have both provided strong letters of support to this proposal. Greenhouse lighting technologies are widely available and electric installations are often in place as supplemental lighting is a frequent practice in organic tomato production. As an example, Co-PD Mattson is co-lead of the Greenhouse Lighting and Systems Engineering (GLASE) consortium (https://glase.org/), in which research and testing of lighting systems is a major priority and is being conducted in close collaboration with manufacturers of lighting systems. We will develop and deliver technology-based solutions, in which three frontier technologies will be integrated and applied in several ways to organic tomato production. Goals / Objectives This new application of a 3-year integrated project brings together a multi-institution and multi-state community of needed participants to address some of the most important challenges faced by organic specialty crop transplant producers. This project aims to test and promote three frontier technologies to: 1) significantly increase adoption of organic tomato production, and 2) increase productivity of existing organic tomato production systems. The overarching project hypothesis is that integration of three frontier technologies (optical sensing, atmospheric cold plasma, and advanced lighting) can markedly increase seed germination, seedling growth and vigor, nutritional quality, and pest management in organic tomato production. We will develop and deliver technology-based solutions, in which three frontier technologies will be integrated and applied in several ways to organic tomato production. Project Methods Objective 1. Project management.Activity 1.1: Project management of activities (years 1-3).Activity 1.2: Project meetings with advisory board (years 1-3). PD Nansen will organize two annual virtual (zoom) project meetings with the advisory board, in PDs and other project team members will update on project status and receive feedback on planned activities.Activity 1.3: Project data management (years 1-3). PD Nansen and postdocs in his lab will be responsible for successful execution of a data management plan attached.Activity 1.4: Project management - reporting and budget (years 1-3). PD Nansen will be responsible for annual reporting to NIFA.Activity 1.5: Project evaluation (years 1 and 3). Mr. Zach Bagley from the California Tomato Research Institute is on the project advisory board and has also agreed to serve as External evaluator.Objective 2. Optimization of plasma activated water (PAW). Co-PD Annor has the overall coordination responsibility and will be assisted by Dr. Trimukhe.Activity 2.1: Experimental production of PAW (Year 1-2). Co-PD Annor and Dr. Trimukhe conduct parallel and complementary experiments and examine PAW characteristics in response to a wide range of experimental conditions.Activity 2.2: Shelf life of PAW (Year 1-2). Water produced by Co-PD Annor and Dr. Trimukhe will be stored in glass containers for about two months and monitored for any changes in their composition.Activity 2.3: Analyses of PAW samples (Year 1-2). Co-PD Annor and Dr. Trimukhe will analyze PAW and non-PAW water samples.Objective 3. Optical sensing as quality control of seeds and seedlings. PD Nansen and Dr Savi will be responsible for successful execution of all activities under this objective. Rationale: inclusion of this frontier technology is supported by a large body of knowledge and preliminary data in this proposal.Activity 3.1: Optical sensing of tomato seeds and seedlings (year 1-3). Existing optical sensing hardware and software in the Nansen lab represent significant in-kind contributions to this

project.Activity 3.2: Optical sensing-based quality control of PAW treatments (years 1-3). A After radiometric filtering, we will develop and optimize classification algorithms. Performance (accuracy and robustness) of different machine learning algorithms will be compared.Objective 4. Use of PAW to optimize seed germination and seedling growth. Inclusion of this frontier technology is supported by a large body of knowledge and preliminary data in this proposal.Activity 4.1: Screening of tomato seed germination (years 1-2). Dr. Savi (UC Davis) and co-PD Mattson and Cornell graduate student will perform screening of tomato seed germination in response to PAW treatments.Activity 4.2: Screening of tomato seedling vigor (years 1-2). Based on results from project activity 4.1, select PAW treatments will be advanced for screening of seedling vigor by Dr. Savi at UC Davis and at Cornell by co-PD Mattson and graduate student.Activity 4.3: Nitrogen benefits of PAW (years 2-3). Under organically certified greenhouse conditions, co-PD Mattson and a graduate student will grow tomato seedlings as described under activity 4.2, except that organically approved N-fertilization.Objective 5. Use of advanced lighting in pest management. Inclusion of this frontier technology is supported by a large body of knowledge and preliminary data in this proposal.Activity 5.1: Light screening to improve pest management (years 1-3). Dr. Savi and PD Nansen will be responsible for performing behavioral studies of phototaxis (response to light) by two-spotted spider mites and western flower thrips.Activity 5.2: Light-based manipulation of spider mites (years 2-3). Dr. Savi and PD Nansen will be responsible for deploying light spectra identified under activity 6.1. to growing tomato transplants under greenhouse conditions.Activity 5.3: Light-based manipulation of western flower thrips (years 2-3). As shown in preliminary data section, Dr. Savi and PD Nansen will be responsible for testing and optimization of light spectra to suppress emergence of western flower thrips from individual tomato leaves.Objective 6. Tomato yields and postharvest quality. This objective is included to characterize and quantify downstream benefits of PAW treatments of organic tomato transplants to harvest.Activity 6.1: Fresh market yield data (years 2-3). Fresh market tomato transplants will be grown by co-PD Mattson and a graduate student.Activity 6.2: Processing tomato yield data (years 2-3). PD Nansen and co-PD Turini will oversee experimental production of processing tomato transplants to be transplanted into organically certified field plots and UC Davis and in demonstration plots at Fresno County Ag Center. Planting is expected to occur in mid-Apr to mid-May in project years 2 and 3.Activity 6.3: Compositional analyses (years 2-3). Co-PD Annor will analyze the quality of tomato fruits harvested from plants that had their seeds treated with PAW to investigate the effects of increased germination rates and vigor on the characteristics of the tomato fruits.Activity 6.4: Arthropod pests in experimental field plots (years 2-3). In microplots described under activity 6.2, Dr Savi and PD Nansen will perform sweep net sampling and visual inspections of tomato plants to obtain quantitative data on arthropod pest population dynamics.Objective 7. Outreach and extension This objective contributes to the successful completion and dissemination of all project outcomes (see logic model).Activity 7.1: Project website (years 1-3). PD Nansen and the two project postdocs will set-up and maintain a website to serve as a clearinghouse for project outreach materials as part of his laboratory website at: http://chrnansen.wix.com/nansen2.Activity 7.2: Demonstrations (years 2-3). As part of in-person demonstrations and presentations, we will conduct presentations, demonstrations, and impact surveys to attendees in three participating states.Activity 7.3: Project videos, presentations, and webinars (years 2-3): Nansen and Annor will produce a series of 5-10 min videos (year 2-3), and links to these will be posted on dedicated project website.Activity 7.4: Trade journal publications (year 2-3).Activity 7.5: Publications and presentations to academic audiences (years 2-3).Activity 7.6: Stakeholder surveys (years 1 & 3).Objective 8. Academic capacity building and education. Using the educational video software, Camtasia (www.camtasia.com), video recordings of: lab experiments, field studies, interactions with growers, and photos and figures of project results will be edited and converted into educational segments to be used in lectures and stakeholder presentations by all PDs.Activity 8.1: Education at UC Davis (year 3). In the Fall of 2023, PD Nansen will start teaching a 3-credit SAS course, entitled \"Urban food and society\". He also teaches a 5-credit course, entitled ENT110 Arthropod pest management, in Fall quarters.Activity 8.2: Education at University of Minnesota (year 3). Educational segments from this project will be integrated into FSCN 4113, FSCN 4112, and FSCN 4131.Activity 8.3: Education at Cornell (year 3). Educational segments from this project will be integrated into an annual course by co-PD Mattson, entitled \"Hydroponic Food Production (4 credits). Progress 09/01/23 to 08/31/24 Outputs Target Audience:This project targets what may be considered the most \"upstream\" agronomic challenge - how to ensure establishment of a healthy seedlings and transplants. The overarching project hypothesis is that integration of three frontier technologies (optical sensing, atmospheric cold plasma, and advanced lighting) can markedly increase seed germination, seedling growth and vigor, nutritional quality, and pest management in organic tomato production. We will develop and deliver technology-based solutions, in which three frontier technologies will be integrated and applied in several ways to organic tomato production. We are unaware of any research collaborations, in which the three frontier technologies in this project (optical sensing, cold plasma, and advanced lighting) are being integrated synergistically. Each frontier technology is associated with a strong track record of being relevant to improved organic crop production, and preliminary data included in this proposal demonstrate our experience with each of them. Additionally, the transferability of project results into commercial crop production operations is considered very high as each frontier technology is commercialized by different companies. Although the proposed integration of three frontier technologies is tailored to organic producers of tomatoes, project outcomes are of high relevance to a diverse range of organic and conventional specialty crops, which are started as transplants. This project aligns with the USDA Strategic Plan Fiscal Year 2022-2026 and specifically addresses the following Strategic Goals: Objective 2.1: Protect Plant and Animal Health by Minimizing Major Diseases, Pests, and Wildlife Conflicts and Objective 2.3: Foster Agricultural Innovation. Of the four Priority Areas for FY 2023, this project addresses two. The project team is making significant efforts to reach and educate relevant stakeholders. Accordingly, virtual meetings and discussions with stakeholders - including representative from commercial companies - are made publicly available and also recorded: https://youtu.be/BCJ4FRZCqzE https://youtu.be/zJjyTEdNqxU Changes/Problems:So far, we have not encountered any real problems. We have made some minor personnel changes, but the project outline remains and progress is according to schedule. What opportunities for training and professional development has the project provided?The project team is making significant efforts to reach and educate relevant stakeholders. Accordingly, virtual meetings and discussions with stakeholders - including representative from commercial companies - are made publicly available and also recorded: https://youtu.be/BCJ4FRZCqzE https://youtu.be/zJjyTEdNqxU In addition, seven educational newsletters are publicly available on the project website. How have the results been disseminated to communities of interest?The project team is making significant efforts to reach and educate relevant stakeholders. Accordingly, virtual meetings and discussions with stakeholders - including representative from commercial companies - are made publicly available and also recorded: https://youtu.be/BCJ4FRZCqzE https://youtu.be/zJjyTEdNqxU In addition, seven educational newsletters are publicly available on the project website. What do you plan to do during the next reporting period to accomplish the goals?This project has a strong and comprehensive outreach component. We will deliver extension presentations, produce educational videos, and we will continue to engage with stakeholders, who are invited to attend meetings and discussions. Impacts What was accomplished under these goals? This is the first project report, so we have not yet had many opportunities to produce outputs with direct benefits to our target audience. However, applied research results, meeting recordings, newsletters and other resources on use of atmospheric cold plasma are shared on a publicly available website (https://chrnansen.wixsite.com/nansen2/cold-plasma-1). This website is updated on a regular basis and as new results and recommendations become available. This project focuses on producers of organic processing tomato transplants. However, such producers typically also producing other transplants (vegetables and ornamentals). Secondly, many producers of organic processing tomato transplants also produce conventional transplants. So, in many ways - outcomes from this project will benefit specialty crop production beyond organic tomatoes. Below, a list of presentations given to different audiences in which the three frontier technologies were highlighted: Nansen C. The Use of drones in cut flower production. Virtual presentation at the 2024 Grow Pro Series (https://endowment.org/growpro/). American Floral Endowment. June 18th, 2024. Nansen C, Savi P, Mantri A. Outdoor hands-on presentations to rotating groups at Oakville Grape Day about drone-based releases of natural enemies. In person at Oakville Experimental Vineyard, 1380 Oakville Grade Rd (https://wineserver.ucdavis.edu/events/oakville-grape-day). June 5, 2025. Nansen C, Savi P, Khodaverdi H, Hammond M, Mantri A. Use of plasma activated water (PAW) and optical sensing in greenhouse crop production. Presentation to the Plant California Alliance Research Committee. Feb 28th, 2024. Nansen C, Layfield B, Kong Z, Ma N, Teske A, Mantri A. Reducing pesticide risk by using drones to enhance performance of biological control. Presentation to the Pest Management Advisory Committee (PMAC) under the Department of Pesticide Regulation. Nov 9th, 2023. Nansen C. Optical (remote) sensing of crop stress. Guest lecture in Agricultural & Environmental Technologies, TAE 10, intro to technology. Biological and Agricultural Engineering Department, Oct 18th, 2023. Nansen C. Smart Spray and optimized spraying of pesticides. BSE Senior Design Project Proposals. Delivered to senior students at UC Davis Biological and Agricultural Engineering Department, Oct 4th, 2023. Publications Type: Websites Status: Published Year Published: 2024 Citation: https://chrnansen.wixsite.com/nansen2/cold-plasma-1 Type: Journal Articles Status: Published Year Published: 2024 Citation: Savi PJ, Mantri A, Khodaverdi H, Zou Y, Moraes GJ, Nansen C. 2024. Indirect effects of plasma-activated water irrigation on Tetranychus urticae populations (Acari: Tetranychidae). Journal of Pest Science. https://doi.org/10.1007/s10340-024-01791-0.

↑ Return to Index

Leveraging Concentrated Organic Byproduct Materials for Higher Nutrient Use Efficiency and Anaerobic Soil Disinfestation in Organic Vegetable Production

Contract / Grant No.	2023-51106-40850
Grant Year	2023
Investigator(s)	Bhupinder Jatana
Performing Institution	Clemson University

NON-TECHNICAL SUMMARY

Managing soil fertility, crop nutrition, and weed and soil-borne diseases are some of the biggest challenges that organic vegetable growers face. One of the difficulties in managing plant nutrition in organic production systems occurs due to a mismatch between the nutrient release rate of organic fertilizers and peak plant nutrient demand. For organic vegetable growers, this mismatch means nutrient release from organic fertilizers that often cannot supply enough nutrients to support periods of rapid crop growth, resulting in the loss of yield or decreased crop quality. Further, the aggressive nature of weeds and diseases and limited means for their management in organic systems, results in substantial loss of marketable crop yield worldwide up to 45-95% and 21.5% yield losses to weeds and diseases, respectively. All these factors make organic vegetable systems less productive and highly variable from one growing season to another. The proposed project aims to improve the yield and profitability of organic vegetable production by developing organic fertilizer formulations using new organic materials from manure processing and rendered materials, with higher nutrient use efficiency and for weed and soil-borne disease management. The proposed project will develop new fertilizer formulations using new manured-based organic products and rendered materials as a base matrix and will employ various natural amendments to increase the retention of mineralized nutrients in the soil for crop uptake for a longer duration, thus facilitating higher nutrient use efficiency. Further, the project team will pair the new fertilizer formulations with novel plasticulture to utilize the carbon in the standardized organic fertilizers for controlling the weeds and soil-borne diseases in organic vegetable crops through anaerobic soil disinfestation (soil disinfestation by creating anaerobic conditions with organic carbon amendments and irrigation under plastic mulch). The project team proposes to produce a pelletized material of standardized fertilizer formulations and evaluate the impact of new fertilizer formulations + novel plastic mulch on crop nutrient use efficiency, soil health, nitrogen losses, weed and soil-borne disease management, and economic feasibility of using new fertilizer formulations and novel plasticulture. The project team will further promote the adoption of new fertilizer formulations and management practices by communicating the research results and guidelines to stakeholders, scientists, and industry professionals in the southeastern and other regions of the US, through extensive education, extension, and outreach program. Goals / Objectives Organic vegetable farming is a holistic production/management system that promotes and enhances agroecosystem health, including biodiversity, biological cycles, and soil biological activity. Major challenges that plague organic vegetable production include a lack of knowledge and limited means to manage soil fertility, weed pressure, and pest outbreaks, which contribute to lower crop yields in organic production systems compared to conventional production systems. Despite scrupulous attempts to improve crop nutrition (through organic amendments), weed (through manual, mechanical, and cultural weeding), and disease (crop rotation, etc.) management, these areas remain among the biggest reasons for low yields in organic production systems. The proposed project aims to utilize the various natural amendments to tailor the nutrient release rate from new organic materials created through manure processing and rendered materials to match the nutrient release rate of organic materials to that of crop nutrient uptake rate and for anaerobic soil disinfestation. Thelong-term goalof the proposed project is to improve the productivity and profitability of organic vegetable crops by developing organic fertilizer formulations from manure products and rendered materials, for higher nutrient use efficiency and anaerobic soil disinfestation for weed and soil-borne disease management. Our integrated research and extension (outreach) activities will lead to effective management strategies to increase domestic organic vegetable production and profitability.The specific objectives of the proposed project are:Prepare and evaluatethe new organic materials-based and rendered materials-based fertilizer formulations for higher retention of net mineralized nutrients in soils for a longer duration by combining them with various natural agricultural amendments and horticultural oils.Fine-tuningthe regulated new organic materials-based and rendered materials-based fertilizer formulations:For maximizing the anaerobic soil disinfestation by combining with novel plasticulture materials.For nutrient release rate under plastic mulch and in the presence of plants.Evaluatethe impact of standardized organic materials-based fertilizer formulations (and their application rate) + novel plastic mulch cover:On crop N and P use efficiency, soil health, and environmental loss of nutrients.For anaerobic soil disinfestation, for its ability to reduce the incidence and population density of weeds and severity of soil-borne disease in organic vegetables grown under plastic mulch.Conducta cost-return analysis of new fertilizer formulations in combination with novel plastic mulch as compared to currently used farmer management practices.Promotingthe adoption of new fertilizer formulations and management practices by communicating research results and guidelines to stakeholders, scientists, and industry professionals in the southeastern and other regions of the US, through extensive education, extension, and outreach program. Project Methods We will conduct laboratory, greenhouse, field and on-farm experiments to prepare, standardize and evaluate new manure product-based and rendered material-based organic fertilizer formulations. The lab incubation studies will be conducted to prepare and evaluate the new manure product-based and rendered material-based fertilizer formulations for higher retention of net mineralized nutrients in soils for a longer duration by combining them with various natural agricultural amendments and horticultural oils.Lab incubationswill be conducted in plastic cups using Barnwell loamy sand and Yonges loamy fine sand, soils collected from the certified organic fields of Clemson University, SC. The experiment will be structured as a completely randomized design with five replications. For the mineralization studies, 250 g of dried soil will be amended with 0, 11.5, and 23 mg of nitrogen, through new manure-based materials and rendered materials. This equates to 0, 100, and 200 kg of nitrogen/ha, which is sufficient to meet the nutrient demand of most vegetable crops. We will mix different naturalamendments at different rates (0, 3, and 5% of nitrogen application rate) with each rate of new manure-based materials and rendered materials in a factorial design. Five replicates per treatment will be harvested at weekly intervals for up to 84 days, days and used to quantify the carbon, nitrogen, and phosphorus mineralization patterns, potential ammonification and nitrification, and soil microbiological health. All data will be subjected to analysis of variance using JMP software. Means will be separated according to Tukey\'s HSD test (α= 0.05). Thegreenhouse studieswill be conducted to maximize the anaerobic soil disinfestation potential of standardized new manure product-based and rendered material-based formulations (from lab studies) by pairing with novel plastic mulch cover (black, bio-degradable, and UV reactive) and capturing the influence of novel plastic mulch and plants on mineralization of nutrients. For the greenhouse studies, we will test the 100% recommended rates of nitrogen application (in conventional production systems). For anaerobic soil disinfestation, native soil weed seed bank of the certified organic field soils will be considered and fusarium wilt culture will be applied to soils in pots. After the organic formulations and fusarium wilt culture mixing in the soil and plastic mulch application, the soil will be water-saturated, and pots will be kept in the greenhouse (mimicking the regional spring weather) for 6 weeks prior to watermelon transplanting. Two watermelon plants will be transplanted in 5-gallon containers. The soil moisture content in the pots will be monitored continuously using TDR probes and will be maintained between 60-70% water holding capacity. The containers prepared as above, but without the plants, will be used to elucidate the effect of plants on nutrient mineralization. All data will be subjected to analysis of variance using JMP. Means will be separated according to Tukey\'s HSD test (α= 0.05). The different observations on nutrient mineralization rates, plant nutrient uptake, weed management, and fusarium wilt disease severity index in watermelon will be collected. Thefield experimentswill be conducted to evaluate the impact of standardized manure product-basedand rendered materials-basedformulations + novel plastic mulch cover: on nitrogen and phosphorus use efficiency of watermelon crop, soil health, and environmental loss of nutrients;for anaerobic soil disinfestation, for its ability to reduce the incidence and population density of weeds and severity of soil-borne disease in organic vegetables grown under plastic mulch. The field studies will be conducted at Edisto Research and Education Center, Blackville, SC, and also at the United States Vegetable Laboratory, Charleston, SC on certified organic fields and grower fields. We plan to test 10-15 promising treatments in split plot design with a combination of standardized organic fertilizer formulations + plastic mulch \main plot: standard farmer practices, manure product-based fertilizer formulation + novel plastic mulch (1), rendered materials-based + novel plastic mulch (1)\ and their application rates as sub-plots, replicated four times on a plot size of 24×30 ft2(3 rows with 10 plants in each row). The field experiments will be conducted for evaluating the dual purpose of the standardized organic fertilizer formulations, novel plasticulture, and their application rates for nutrient management and anaerobic soil disinfestation- for weed and soil-borne disease management. The watermelon nursery will be planted with the cultivarValor. The impact of different treatments on watermelon fruit yield, fruit quality, nutrient use efficiency, soil microbial diversity and abundance, nutrient leaching losses, weed management, and fusarium wilt disease severity index will be evaluated. To evaluate the economic feasibility of new fertilizer formulations and novel plasticulture,partial budget analysisand change in production profits will be calculated. Partial budget analysis is a widely used analytical method practiced by farm owners and managers to estimate the net economic effects of changes in production systems. It is a standard method to compare the financial impacts of changes in various production practices, such as nutrient management, weed management, soil anaerobic disinfestation, and planting methods. The analysis will reveal how profits are expected to change with the adoption of alternative farming practices. Labor, cost, and time savings will also be included in the partial analysis, as appropriate. For example: additional cost of- new fertilizer formulations, natural amendments, novel plasticulture logistic costs; additional income of higher quantity, size & quality (grades), and price, will be taken into consideration while calculating the partial budget. Additional data related to standard production costs, quality, prices, and market will also be cited from USDA, National Agricultural Statistical Service for South Carolina. If needed, to collect any supplementary economic data, we will plan an online survey of major producers in South Carolina in consultation with the Clemson Cooperative Extension. Progress 09/01/23 to 08/31/24 Outputs Target Audience:The target audience for the proposed research is vegetable growers, stakeholders, crop advisors, students, and the scientific community. The presentations/demonstrations were given at the Clemson graduate student research forum, Clemson graduate student research symposium, and will be presented at the upcoming ASA-CSSA-SSSA annual meeting in San Antonio, Texas (Nov. 2024). Further, initial results from the ongoing experiments were shared with specialty crop growers in South Carolina at the Edisto Research and Education Center\'s Watermelon field day. Project initiation was shared with growers, and stakeholders through social media and through a Clemson article. Further a manuscript was submitted to a scientific journal for publication. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Project provided/providing interdisciplinary training to two PhD students. One student is getting trainedon the nutrient management, soil health and weed management aspect of the project involving fertilizer formulation, conducting lab incubation studies and measurement of nitrogen and phosphorus flux changes in soil. A second student is getting trained on soil borne disease management in specialty crops in the project. How have the results been disseminated to communities of interest?The project is utilizing the DAF solids produced by growers, Sedron solids produced by Sedron technologies (Sedro-Woolley, Washington) and rendering materials produced by Darling Ingredients Inc. (Irving, Texas). Further, project is utilizing the neem and karanja oil produced by Ahimsa Organics. The objective and the potential outcome of the project were communicated with the industry stakeholders through informal/formal talks. The results of the ongoing studies were presented to students and scientific audience at the Clemson graduate student research forum, Clemson graduate student research symposium, and will be presented at the upcoming ASA-CSSA-SSSA annual meeting in San Antonio, Texas (Nov. 2024). Further, initial results from ongoing experiments were communicated to the vegetable growers in South Carolina at the Edisto Research and Education Center\'s Watermelon field day. What do you plan to do during the next reporting period to accomplish the goals?From the initial laboratory experiments four best performing manure product-based (two) and rendered animal product-based (two) fertilizer formulations were selected for further studies. During the next reporting year, we will evaluate the selected best performing fertilizer formulations along with different plastic mulch types for anaerobic soil disinfestation (ASD) in greenhouse studies. Four different organic fertilizer formulations that are selected includes MBM, DAF, MBM with sulfur (25% of N) and DAF with neem oil (10% of N). We are evaluating three different plastic mulches including Via flex barrier (designed for bio-fumigation), black solar shrink (UV reactive), and conventional black mulch. The effect of treatments on soil fertility, soil health, plant growth and weed management will be evaluated. Further, first year field trails will be implemented in Spring 2025 using the selected fertilizer formulations and plastic mulch types at two locations in South Carolina. Impacts What was accomplished under these goals? Organic materials such as meat and bone meal (MBM; rendering product) and treated manure products \dissolved air flotation (DAF) solids\ can be an excellent fertilizer due to balanced availability of nutrients. Rendered animal materials and treated manure products have significant amount of essential plant nutrients and carbon. Since organic fertilizer materials have significant amount of carbon, thesecan beutilized for anaerobic soil disinfestation (ASD), which is a technique to manage the aerobic weeds and soil borne pests by creating anaerobic conditions in soil. However, during ASD, rapid nitrogen (N) mineralization from carbon based organic nutrient materials could lead to significant nutrient losses, necessitating measures to modify the N mineralization rate for their dual-purpose use.To regulate the N mineralization, form organic fertilizer materials, three lab incubation studies and one lysimeter (leachate collection) study were conducted. We tested different natural amendments (sulfur) including horticultural oils (neem oil and karanja oil) for their ability to regulate the N mineralization form MBM and DAF solids. Three laboratory incubation studies were conducted under controlled conditions and impact of different natural amendments (NAs) was evaluated on ammonification, nitrification, and net N mineralization form MBM and DAF. The MBM-N mineralized (ammonium + nitrate) at a faster rate than N mineralization from DAF solids. The MBM amended with sulfur at 6% of N significantly increased the soil NH_4^+-N content at 7, 14 and 21 days after incubation and decreased the soil NO_3^- -N content. In DAF solids, application of neem oil at 10% of N, significantly lowered the soil NO_3^- content at 7, 14 and 21 days after incubation than other treatments. The MBM without NAs exhibited the highest net N mineralization (38.11 %), whereas MBM amended with sulfur (at 10% of N) exhibited 27.03% and neem oil (at 10% of N) recorded lowest net N mineralization (15.57%) within first 14 days. Similarly, DAF solids without NAs had the highest (9.07%) net N mineralization rate, on the other hand, DAF with neem oil (at 6% of N) showed the lowest (5.95%) net N mineralization within first 56 days of incubation. DAF solids amended with different NAs had the highest net N mineralized within 56 to 77 days after incubation which was 25.67% as compared to 14.76% in DAF solids without NAs. The DAF solids amended with neem oil (at 10% of N) significantly decreased the net N mineralization (by 12.97%) within first 21 days of incubation. In order to evaluate the form, amount, and the rate at which N is leached below plant root zone, a column leachate study was conducted. The soil in columns was fertilized with different organic fertilizer formulations selected from initial lab incubation studies. A total of 8 treatments were evaluated in leachate study with MBM, DAF, MBM and DAF amended with sulfur and neem oil, ammonium nitrate fertilizer (a positive control) and no fertilizer (negative control) in the column study. Leachate was collected at 7 days interval starting from day 1 after applying the treatments, by leaching with 500 ml of DI water every time. We observed that 1.98 mg and 1.11 mg NH4+ -N was leached from MBM amended with sulfur which was significantly higher than the treatment of MBM alone (1.38 mg and 0.45 mg) at day 7 and day 14, respectively. MBM with sulfur gave the highest NH4+ -N concentration (1.49 mg) in the leachate at day 28 than MBM alone treatment. On the other hand, significantly lower NO3- -N was leached from MBM with sulfur (10.92 mg and 24.42 mg) as compared to MBM alone (17.73 mg and 37.45 mg) at day 7 and day 14, respectively. Similarly, DAF with neem oil (10% of N) had less NO3- -N (13.29 mg) leached than DAF alone (20.44 mg) at day 21. More than 98% of the total N leached was in NO3- form of N with only 1-2 % of total N leached was in NH4+ form of N from different treatments. The leachate was collected up to 56 days after adding the treatments into columns. Ammonium nitrate fertilizer had the highest amount of NO3- -N in the leachate (73.61 mg, 104.45 mg, 127.71 mg, 125.68 mg and 129.56 mg) at day 21, 28, 35, 42 and 56 days after treatment application, respectively. Within first 56 days, only 3.98% and 2.35% of cumulative N (of the total applied N) was lost in the leachate from MBM and DAF, respectively, which was significantly lower than inorganic fertilizer (ammonium nitrate: 26.87% of total N was lost via leaching within first 56 days). The soil from leachate columns (at 56 days after treatment application) was split into three different depths (0-15, 15-30 and 30-45 cm) and analyzed for soil exchangeable ammonium and nitrate content. The MBM amended with S retained significantly more mineralized N in ammoniacal and nitrate form in 0-15, 15-30 and 30-45 cm soil profile in leachate column, as compared MBM alone. Similarly, DAF solids amended with neem oil retained higher soil ammonium N in top 0-15 soil profile as compared DAF alone. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Singh, D., Sanders, T., Jatana, B.S. (2024) Mineralization pattern of different organic nutrient sources as impacted by different natural amendments. 7th Annual Clemson Student Research Forum, Clemson University, Clemson, South Carolina; April 5. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Singh, D., Sanders, T., Jatana, B.S. (2024) Optimizing mineralization pattern of organic nutrient sources through natural amendments. College of Agriculture, Forestry and Life Sciences annual Graduate Student Symposium. Piedmont Research and Education Center, Clemson University; Aug. 19-20. Type: Other Status: Published Year Published: 2024 Citation: Jatana, B.S. (2024) Indoor talk: Organic watermelon research at Edisto Research and Education Center. Watermelon field day at Edisto Research and Education Center, Clemson University; July 11, 2024. Type: Conference Papers and Presentations Status: Accepted Year Published: 2024 Citation: Jatana, B.S., Sanders, T. (2024) Effect of different natural amendments on mineralization dynamics of different organic nutrient sources. Agronomy Society of America- Soil Science Society of America-Crop Science Society of America Annual meeting, San-Antonio, Texas; Nov. 10-13. Type: Journal Articles Status: Submitted Year Published: 2024 Citation: Jatana, B.S. (20XX) Short term mineralization dynamics of meat and bone meal as impacted by different natural amendments. Soil Science and Plant Nutrition; Submitted on June 12, 2024.

↑ Return to Index

Sod: Solutions for Organic Farm Diseases: Suppressing Soilborne Pathogens in Vegetable High Tunnels

Contract / Grant No.	2023-51106-41111
Grant Amount	$490493
Grant Year	2023
Investigator(s)	Sharifa Crandell
Performing Institution	Pennsylvania State University

NON-TECHNICAL SUMMARY

Crop pathogens that disperse through the soil are a significant problem for organic farmers, especially when theyinfect vegetables during high tunnel production in the Northeastern and Midwestern United States. Steaming the soil to high temperatures and Anaerobic Soil Disinfestation (ASD) are two disease management methods that have the potential to kill problematic plant pathogens without using synthetic fungicides or fertilizers. This project will 1) compare the efficacy of soil steaming and ASD for suppressing soilborne diseases of vegetables including a focus on high tunnel tomatoes, 2) determine soil microbial community recovery (composition/diversity) after steaming and/or ASD and impacts on plant health, and 3) understand the factors that affect farmers\' willingness to adopt sustainable soilborne disease management practices. We aim to share best practices with organic growersfrom these two promising, innovative organic farming practices. Results will be disseminated 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.

OBJECTIVES

Crop diseases are a significant problem for organic vegetable farmers in the US with up to 75% yield loss due to soilborne plant pathogens. Steaming the soil and Anaerobic Soil Disinfestation (ASD) are two promising management approaches that can help organic growers suppress pathogens without using synthetic fungicides or fertilizers. However, there is little science-based research on the efficacy of soil steaming and ASD methods or data on the recovery of the microbiome and nutrients post-steaming and ASD treatments. In order for these pathogen management approaches to be effective, it is paramount to understand the underlying biological mechanisms behind these approaches and to capture the willingness of farmers to adopt such technologies. Our goal is toconduct management trials and in-person/online surveys to help organic and transitioning to organic farmers reduce high tunnel soilborne diseases.Objective 1. What Works? To compare the efficacy of ASD and soil steaming for suppressing soilborne diseases of vegetables with a focus on high tunnel tomatoes (Research).Objective 2. Who Survives? To determine soil microbial community recovery (composition/diversity) after steaming and/or ASD and impacts on plant and soil health.Objective 3. Why Adopt These Methods? Is it Worth it? To understand the factors that affect farmers\' willingness to adopt sustainable soilborne disease management practices and educate growers on the management practices.Plans/Milestones: We will conduct controlled high tunnel experiments at an USDA-ARS research station in Ohio, efficacy trials on organic farms in Pennsylvania and Ohio over the duration of the grant, and address farmers\' needs for adoption with interviews, surveys and conduct a cost benefit analysis.Relevance to Program Goals: Two research priorities of the National Organic Standards board are addressed in this proposal: \"Development of systems-based plant disease management strategies are needed to address existing and emerging plant disease threats,\" and \"More research is needed to fully understand the relationship between on-farm biodiversity and pathogen presence and abundance.\"

APPROACH

Objective 1. What Works? To compare the efficacy of ASD and soil steaming for suppressing soilborne diseases of vegetables with a focus on high tunnel tomatoes.At total of 7 experiments will be conducted in vegetable high tunnels located on the USDA-ARS research station in Wooster, OH in order to assess the timing of application and efficacy of steaming and ASD to suppress target pathogens under organic vegetable management conditions. These trials will be carried out in a controlled setting where pathogens can be easily manipulated. High tunnel soils on station will be uniformly inoculated with vermiculite inoculum of the common of the target soilborne pathogens of tomato: Pseudopyrenochaeta lycopersici, C. coccodes, V. dahliae, Fusarium oxysporium f. sp. lycopersici, Phytophthora spp. and eggs of the nematode M. hapla. Soil samples cores \~ 15cm in depth will be collected an analyzed for nutrient analyses and qPCR will be conducted to detect pathogen levels in the soil for each treatment. Tomato \'Red Deuce\' will be planted according to organic farming standards and will be measured for nutrient uptake, root rot severity, and root-knot nematode galling.Evaluation of Outputs: Because the efficacy trials are located on-station at ARS, we will be able to monitor and evaluate their progress closely using data loggers for soil and ambient temperature, moisture etc.The most effective timings for ASD, steaming, and combination treatments will be recorded by hand in spread sheets and with data loggers; these results will be analyzed and communicated to stakeholders. Specifically, trial results will be incorporated into scientific journals which are peer-reviewed, posters,extension factsheets, and we will monitor the number of factsheet downloads.Objective 2. Who Survives? To determine soil microbial community recovery (composition/diversity) after steaming and/or ASD and impacts on plant and soil health.We will conduct on-farm trials where the goal will be to research soilborne pathogens microbial communities in the soil and the effect of treatments on tomato health in organic systems.We will sample soil from 4 treatments: (1) pre-post soil steaming, (2) pre-post ASD, (3) a combined treatment (steaming + ASD) and (4) a control (no treatment). The rationale for conducting these trials is that we can assess the environmental and management variability found in organic farms as opposed to conditions in aresearch station high tunnel (Objective 1). We will screen soils for the presence ofpathogens that already exist in the high tunnel systems, soil and plant beneficial microbes, and we will measure the recovery of the soil over time to examine changes in the soil health (nutrients, soil texture, etc.) and tomato plant health (macronutrients such as nitrogen). We use a novel mixed-methods approach to understand the efficacy of our organic management approaches by using: soil microbiome analyses, soil and plant nutrient analyses,plant health data such as chlorophyll content, root rot severity, soil pathogen populations within roots, RKN damage, photosynthetic efficiency, and fruit yield and biomass at tomato harvest.Evaluation of Outputs: Because these efficacy trials are located on-farm with collaborating farmers, we will monitor and evaluate our trial progress at each visit during the growing season during years 2 and 3 (Post-docs and Graduate Student). Trial results will be incorporated into a peer-reviewed articles, posters, and factsheets and will be presented at grower meetings and conferences.Objective 3. Why Adopt These Methods? Is it Worth it? To understand the factors that affect farmers\' willingness to adopt sustainable soilborne disease management practices and educate growers on the management practices.Our approach will be to (1) research conceptual models related to the theory of Adoption of Innovation, (2) determine the factors affecting the adoption of sustainable soilborne disease management practices, and (3) identify opportunities for organic farmers to use steaming and ASD for disease suppression. We will review existing literature that points to models and outcomes from other agroecosystemsfor the willingness of farmers to adopt new production methods. Next, we will assess farmers\' perceptions about the proposed new management practices in relation to the existing ones, factors affecting adopting new management practices, and incentives for farmers that will influence their attitudes toward the new management practices. A mixture of farmer surveys, interviews, and a cost-benefit analysis will help us gauge how and why organic farmers are or would be willing to adopt soil steaming disinfection and ASD into their high tunnel management practices.Evaluation of Outputs: Through various milestones, we will evaluate our outputs. Specifically, we will recruit a graduate student in year 1. This student will develop socio-economic research methodologies for their thesis and will form a committee of faculty who will evaluate their progress through the gradudate program at Penn State. After gaining IRB approval, the student will conduct in-depth farmer interviews, collect qualitative data (years 2), and complete data analysis of qualitative data and survey instruments (year 3). PSU and ARS extension products will be created such as articles and research presentations to disseminate results to stakeholders.

PROGRESS

Target Audience: Nothing Reported Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

What was accomplished under these goals? The team met regularly to start planning for the field season to ensure smooth execution of obj 1. The PD and Co-PDs helped the graduate student (ARS)get situated in their graduate program and met with themto teach them how to start making pathogen inoculum for the on-station efficacy trials (obj 1). We also worked closely with the Post-doctoral scholars (2 total so far, one left for another position) to startbioinformatic pipeline creation for determining soil microbial communities in anticipation of the summer field data collection in year 1 (obj 2). Finally, recruited an MS student (PSU) who will work on the socio-economic dimensions of this project (obj 3). We did not conduct field work (field season is during the growing season)which, in the revised plan and budget, which will occur in thesummer of 2024. Therefore, there wasn\'t a signifcant amount to reportreport.

PUBLICATIONS

Living mulch and grazing techniques to improve soil health and weed control for farmers transitioning to organic farming across climatic zones Surendra Singh, Washington State University

↑ Return to Index