OREI Project Details

Award Year 2019

19 Research Projects

PROJECT INDEX

Southeast Organic Agriculture Research and Education Forum

Accession No.	1020722
Project No.	OREI Conf2020
Agency	NIFA AL.X\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30250
Proposal No.	2019-03037
Start Date	01 SEP 2019
Term Date	31 AUG 2020
Grant Amount	$50,000
Grant Year	2019
Investigator(s)	Kpomblekou-A, K.; Bovell-Benjamin, AD, .

NON-TECHNICAL SUMMARY

The United States produced alone in 2016 \$43.1 billion of the world organic market estimated at \$89.7 billion. The number of certified organic farms in the US increased to 14,217 while the acreage of certified farms reached 5.0 million in 2016. Acreages of certified organic farms has increased considerably in ten states in the West (California, Montana, Oregon, Alaska, and Idaho), Midwest (Wisconsin), Southwest (Texas, Colorado), Northeast (New York and Vermont) but increased only slightly in the Southeast. The numbers of organic farmers reached 247, 123, and 83 in North Carolina, Florida, and Georgia, respectively in 2016 with sales accounting for \$145,000 in North Carolina placing the latter the only state in the Southeast among the ten top states in certified organic commodity. A lack of information on organic agriculture practices and progressive legislation agendas constitutes a serious barrier to expansion of organic agriculture in the Southeast. Dissemination of agricultural information from extension personnel to organic growers and from a grower-to-grower played a significant role in development of organic hotspots in California. Thus, the goals of this proposed symposium are two-fold: 1) to disseminate currently available organic farming research information to growers in the Southeast and 2) to promote and strengthen organic farming substructure in the Southeast. The objectives of the symposium are to: 1) Bring researchers, extension personnel, and successful organic growers together to identify research and legislative needs that would remove barriers conducive to development of organic hotspots throughout the Southeast, 2) Disseminate current relevant research information obtained throughout the Southeast to organic growers, and 3) Identify research and legislative priorities that will improve organic farming activities in the Southeast. The symposium will be organized by Tuskegee University in partnership with Organic Farming Research Foundation and selected land-grants institutions across the country in conjunction with the 2020 conference of the Southern Sustainable Agriculture Working Group (SSAWG) in Little Rock, AR. This proposed one-day symposium brings together scientists from the Southeast, the Midwest, the West, non-profit organizations, and successful organic producers around the country to provide current organic farming information to farmers and ranchers in the Southeast. The symposium will provide a unique opportunity for a wider range of stakeholders in the Southeast to express their views on the constraints to expansion of organic agriculture. One of our partners, e-organic will live stream the symposium to enable farmers who could not attend the gathering to interact with symposium participants. Outputs of the symposium will be published in organic farmers\' association bulletins in the Southeastern states (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia). At the symposium end, a survey will be administered to evaluate its effectiveness and the outputs will be made available on-line for public access and used as backbone of future research and extension OREI proposals from the symposium organizers.

OBJECTIVES

Demand for organically grown foods is increasing in the Southeast and this is a market niche that limited-resource farmers have the potential to fill. However, most of the organically grown foods consumed in the Southeast are imported from other states, particularly from California and the upper Midwest. Thus, ourmajor goals are to: 1)increase knowledge and acceptance of organic farming practices in the Southeast and 2) create economic opportunities for limited-resource farmersin support of the USDA\'s new dietary guidelines (USDA, 2010).

APPROACH

Tuskegee University is proposing to hold a one-day forum. This one-day forum will be organized in partnership with the Organic Farming Research Foundation (OFRF) as part of their annual research forum. Other partners include selected land-grant institutions across the country and the Southern Sustainable Agriculture Working Group (SSAWG), who will co-host the forum in conjunction with their 2020 conference in Little Rock, AR. Presenters as well as poster presenters, will be chosen through a Call for Proposals, organized by OFRF. There will be a diversity of topics ranging from horticulture, soil fertility management, food science, consumer science, sociology, crop physiology and post-harvest physiology, agriculture engineering, agriculture economics, biochemistry, food nutrition, weed science, and entomology with research and/or extension appointments that emphasize organic farming systems. The forum will provide a unique opportunity for a wider range of stakeholders in the Southeast to express their views on the constraints to the expansion of organic agriculture in this region. **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:The targeted audienceswere organic growers and consumers in the southeast United States.The forum was held in conjunction with the annual conference of the Southern Sustainable Agriculture Working Group Conference in Little Rock, AR. Several other groups of growers transitioning into organic farming were present as well. The forum was a venue organic growers and consumers in the southeast to interact with researchers. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Participating organic growers from the southeast, students from various schools, and other forum attendantsparticipated in interactivelearning sessions. During the sessions, organic growers, students, and researchers learned from each other. Twelve oral presentations were made on: 1. Strengthening Organic Agriculture through Healthy Soils and Plant Breeding, 2.Organic Management of Pests and Diseases, 3.Impacts of Organic Agriculture on Food Safety and Human Nutrition, and 4.Consumer Preferences, Markets, and Knowledge Transfer in Organic Systems, Ten poster presentations were made on: 1.Organic Crop Production, Soil Health, and Pest Management, 2.Organic Livestock Production, 3.Organic Certification, Organic Transition, and Public Policy, and 4.Forestry, Wildlife Conservation, and Global Change These presentations gave training and professional developmentopportinities to the forum attendants. How have the results been disseminated to communities of interest?Following the forum, we visited with various organic growers in Alabama, Georgia, Mississippi, North Carolina and South Carolina to inform them about major issues discussed at the forum and a way to move forward in preparation of the next OREI proposal. For a large distribution of forum outputs and to reach maximum organic growers, the forum report was posted at OFRF website: https://ofrf.org.reports/ What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **Impacts** What was accomplished under these goals? We were able to bring researchers, extension personnel, and successful organic growers together to identify research and legislative needs that would remove barriers to developing organic hotspots throughout the Southeast and disseminate current research information obtained throughout the Southeast to organic growers. The forum broughttogether scientists from across the country with emphasis from the Southeast, as well as non-profit organizations and successful organic producers to provide science-based guidance to farmers and ranchers interested in organic production. Three presenters, as well as poster presenters, werechosen through a Call for Proposals, organized by OFRF. Priority wasgiven to researchers and organizations who are doing relevant research on production, economic, and social barriers for farmers in the Southeast. Proposals werereviewed and scored by OFRF, Tuskegee University, and SSAWG. The forum committee invited a balance of presentations and with previously confirmed presenters, there werea diversity of topics ranging from horticulture, soil fertility management, food science, consumer science, sociology, crop physiology and post-harvest physiology, agriculture engineering, agriculture economics, biochemistry, food nutrition, weed science, and entomology with research and/or extension appointments that emphasize organic farming systems. **Publications** - Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Kokoasse Kpomblekou-A, Mark Schonbeck, Adelia C. Bovell-Benjamin, Lauren Snyder. 2020 Organic Agriculture Research Forum; Proceedings presented in partnership with the Southern Sustainable Agriculture Working Group, January 23, 2020, Little Rock, Arkansas.

↑ Return to Index

A National Agenda for Organic and Transitioning Research

Accession No.	1020392
Project No.	CALW-2019-03049
Agency	NIFA CALW\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30249
Proposal No.	2019-03049
Start Date	01 SEP 2019
Term Date	31 AUG 2022
Grant Amount	$499,646
Grant Year	2019
Investigator(s)	Tencer, B.; Zystro, JA.; Snyder, LA.; Hubbard, KR.
Performing Institution	ORGANIC FARMING RESEARCH FOUNDATION, 303 POTRERO ST STE 29-203, SANTA CRUZ, CALIFORNIA 950602759

NON-TECHNICAL SUMMARY

The Organic Farming Research Foundation (OFRF) and Organic Seed Alliance (OSA) will combine their national grower survey to identify research priorites for organic and transitioning farmers and ranchers. An open web-based survey will be emailed and postcards with the survey link will be sent to the entire National Organic Producer list. A random sample of 2,000 growers from that list will include email, phone, and mailings. There will also be a minimum of 15 listening sessions to collect additional qualitative data from growers. Data will be analyzed and included in two reports. The National Organic and Research Agenda (NORA) will provide an overview of production and economic research needed in organic and transitioning production, while the State of Organic Seed (SOS) will specifically look at findings related to organic seed supply and plant breeding. Both reports will be used to inform funders, policy makers, researchers, and extension on the most pressing research and education needed to advance organic production.

OBJECTIVES

Both the National Organic Research Agenda (NORA) and State of the Seed (SOS) reports needto be updated to provide a current detailed roadmap for organic research, education, and outreachactivities, with the goal of strategically accelerating the next era of growth for organic agricultureand seed systems. By identifying current research needs, the Organic Farming ResearchFoundation (OFRF) and Organic Seed Alliance (OSA) hope to significantly increase knowledgeand expertise in scientifically based organic practices and principles that help organic farmers besuccessful in meeting the growing demand for organic products. Together, the NORA and SOSreports will provide comprehensive information on the needs of organic and transitioninggrowers with the goal of understanding barriers and challenges that have prevented the growth oforganic production.

APPROACH

There will betwo national surveys. One will target organic farmers and ranchers (Organic Survey), the other will focus onproducers transitioning to organic practices (Transitioning Survey).National Organic Survey. The national organic survey will assess the needs of organic farmersand ranchers for research-based production, economic, and social information. More specifically,the survey will identify the most pressing production and environmental challenges for organicfarmers and ranchers, as well as evaluate the social, economic, and policy barriers to organicproduction.The organic survey will be partitioned into two phases: 1) a mixed mode survey of a randomsample of organic producers (closed distribution survey) followed by; 2) an open distributionconvenience non-probability web survey (open distribution survey). The random sample surveyoffers a statistically sound approach that enables us to capture a representative sample of thelarger organic production community, while the open distribution survey will give us theopportunity to hear from a larger number of respondents.With the closed distribution survey, we will select a random sample of 2,000 organic farmers andranchers from the NOP list with a target goal of a 20% response rate. This phase of the surveywill be implemented as a web-based and paper survey (e.g., mixed mode). The online survey willbe developed by SESRC using their DCWorks software. The closed survey will be initiated withan introductory postal letter to over 14,000 farmers and ranchers on the NOP list that havecontact information available with a weblink to the survey, followed by personalized emailinvitations and reminders. SESRC\'s mail survey unit will track responses and schedulefollow-ups using its electronic tracking system. If a response is not elicited, a paper survey willbe mailed via USPS. OFRF, OSA, and our advisory team and outreach partners will publicize thesurvey to our farmer networks. The closed distribution survey will remain open for six months.Following the closed, random distribution survey, SESRC will implement the same survey via anopen distribution method. OFRF, OSA, and our advisory committee and outreach partners willadvertise the survey through multiple mechanisms: electronic announcements via organizationwebsites, newsletters, social media, and organizational publications. Direct mailings toorganizational lists will announce how to access the online survey. Once the survey is live, allcertified organic producers will be sent an email at their NOP-listed email address. The emailwill introduce and explain the survey, and provide a web link and unique access code for therecipient. Three email reminders will be sent, along with a postcard reminder via USPS.National Transitioning Survey: A separate survey will be sent to farmers and rancherstransitioning to organic production. In addition to containing core questions from the organicsurvey, the transition survey will explore challenges and barriers specific to transitioning farmersand ranchers. For example, questions will address the ability to access land or start-up capital,acquire new agronomic and production knowledge to be successful as an organic practitioner,and overcome social stigmas associated with organic production systems (Moncada et al. 2010).Unlike the NOP list of organic producers, no national list of transitioning producers exists.Therefore, OFRF & OSA will collaborate with partner organizations to identify transitioningproducers. In particular, Oregon Tilth is connected to 20 transition leads (individuals workingdirectly with transitional producers) across the country. This network will allow us to reachtransitional producers directly, as well as connect with other organizations that work withtransitioning farmers and ranchers. Similar to the open distribution national survey, thetransition-specific survey will be advertised by OFRF, OSA, and our Advisory Committee andoutreach partners.Both the organic and transitioning survey will be designed based on the Tailored Design Method(TDM) model of social science survey principles, practices, and protocols (Dillman et al. 2009).TDM protocols guide survey content and design to maximize user comprehension, ensure ease ofnavigability, and accommodate accessibility needs. Question types will be predominantlyclosed-ended, including a mix of dichotomous, rating scale, Likert scale, semantic differential,rank order, and/or multiple choice. We will include several open-ended questions to capturemore detailed feedback. Questions will be included to filter, cross-tabulate, and cross-referenceresponses, including those pertaining to length of time farming, length of time farmingorganically, production system/key product category, size of farm, etc. The organic andtransitioning surveys will be piloted by 20 farmers and ranchers who will provide feedback andrecommendations for final revision regarding content, format, and navigability.Core Listening Sessions: Five core listening sessions will be conducted with a focus groupformat at key organic grower conferences around the country: MOSES, SSAWG, EFA,NOFA-NY, and NFU (see conference outreach partners). The goal of the focus group format isto delve deeper into the broad themes gleaned from the national surveys and to generate a morenuanced perspective of organic farmer and rancher opinions and perceptions. SESRC will workwith OFRF and OSA to develop a focus group protocol and set of questions for the focus groups.The protocol will include stimulus material to promote discussion around the production, environmental, economic, and social issues pertaining to organic production systems.Participants will be asked to respond to the information provided and the moderator will probefor additional detail. Conference outreach partners will advertise the focus groups as aconference workshop and participation will be strictly voluntary. Written consent will beobtained from all participants before data collection. SESRC will coordinate with local courtreporters who will provide verbatim transcripts of the focus group discussions. Transcripts willbe analyzed using RQDA, an R package for qualitative data analysis (Huang 2018), to examinethemes and emergent patterns from the focus groups.Additional Listening Sessions. An additional 10-12 listening sessions will be hosted at farmerand rancher conferences and meetings across the country. OSA will conduct a listening sessionwith seed growers during the 2020 Organic Seed Growers Conference. Other organizationsparticipating in these listening sessions will be chosen through an RFA process. Priority will begiven to organizations that host outreach events attended by socially disadvantaged, beginning,and transitioning farmers. Training and a listening session protocol will be given to selectedorganizations along with a financial stipend once data is received.Listening sessions will expand the project\'s reach to farmers who don\'t participate in the survey,as well as provide additional insights and context for interpreting survey results. Listeningsessions with beginning, transitioning, and socially disadvantaged farmers will contribute anuanced understanding of these stakeholders\' specific needs for information and support. Thepurpose of these sessions is to: 1) compare these populations with the more quantitative onlinesurvey data, and 2) to learn how the survey results can inform learning, implementation, andoutreach to socially disadvantaged and underserved populations. Progress 09/01/19 to 01/31/23 Outputs Target Audience:OFRF reached out to over 14,000 organic producers from the National Organic Producers List and worked with organic certification agencies and NRCS to send to transitional farmers. There were around 1,200 producers who fully completed the survey and just under 2,000 that partially filled out the survey. We also conducted virtual listening sessions with just over 180 organic and transitioning growers from across the country. Since released, the NORA report page has been visited over 7,000 times by farmers, policy makers, partner organizations, consumers, and others interested in viewing the report. Changes/Problems:The pandemic really limited our ability to go to grower conferences and meetings and conduct listening sessions. While we were able to collect input through virtual focus groups, they did not allow us to collect input from as many growers as we had hoped. Many growers didn\'t show up to the virtual meetings (despite particpation gift cards), and it was difficult to have too many people in virtual meetings, so we limited it to 15 participants per focus group. We also feel like COVID may have impacted survey participation. The orginal project manager left the position very early in 2021, so the work was delayed by a couple of months. We were able to hire a new position and use external contractors to help keep us on schedule, and we only ended up being a month behind that year. Due to COVID-19 restrictions and changes in conference meetings to remote, we did less travel that origionally anticipated during our dissemination period. Even though we did not attend conferences in-person, we were still able to present our findings remotely to a diverse audience. What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest?Both reports were shared extensively through various outreach channels, including online dissemination, in-person presentations, industry conferences, virtual meetings/webinars, and mailed print copies. Presentations were done to diverse audiences including USDA ARS, USDA NOP, NOSB, policymakers, researchers, organic sector partners and farmers. The report page on our website has already been visited over 7,000 times and printed hard-copies have been shared with key partners. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Both the National Organic Research Agenda (NORA) and State of the Seed (SOS) reports were updated and published. The Organic Farming Research Foundation (OFRF) and Organic Seed Alliance (OSA) significantly increased knowledge and expertise in scientifically based organic practices and principles that help organic farmers be successful in meeting the growing demand for organic products. Together, the NORA and SOS reports provided comprehensive information on the needs of organic and transitioning growers with the goal of understanding barriers and challenges that have prevented the growth of organic production. Publications Type: Other Status: Published Year Published: 2022 Citation: OFRF.2021.National Organic Research Agenda Type: Other Status: Published Year Published: 2022 Citation: OSA.2022.State of the Seed Progress 09/01/22 to 01/31/23 Outputs Target Audience:During this reporting period, we continued with the outreach and dissemination of our National Organic Research Agenda report. We presented to researchers, farmers, policy makers, and consumers at meeting and events including the American Society of Agronomy conference as well as the National Organic Program. 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?Both reports were shared extensively through various outreach channels, including online dissemination, in-person presentations, industry conferences, virtual meetings/webinars, and mailed print copies. Presentations were done to diverse audiences including USDA ARS, USDA NOP, NOSB, policymakers, researchers, organic sector partners and farmers. The report page on our website has already been visited over 7,000 times and printed hard-copies have been shared with key partners. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Both the National Organic Research Agenda (NORA) and State of the Seed (SOS) reports were updated and published. The Organic Farming ResearchFoundation (OFRF) and Organic Seed Alliance (OSA) significantly increased knowledgeand expertise in scientifically based organic practices and principles that help organic farmers besuccessful in meeting the growing demand for organic products. Together, the NORA and SOSreports provided comprehensive information on the needs of organic and transitioninggrowers with the goal of understanding barriers and challenges that have prevented the growth oforganic production. Publications Type: Other Status: Published Year Published: 2022 Citation: OFRF.2021.National Organic Research Agenda Progress 09/01/21 to 08/31/22 Outputs Target Audience:OFRF reached out to over 14,000 organic producers from the National Organic Producers List and worked with organic certification agencies and NRCS to send to transitional farmers. There were around 1,200 producers who fully completed the survey and just under 2,000 that partially filled out the survey. We also conducted virtual listening sessions with just over 180 organic and transitioning growers from across the country. Since released, the NORA report page has been visited over 6,000 times by farmers, policy makers, partner organizations, consumers, and others interested in viewing the report.

Changes/Problems:Due to COVID-19 restrictions and changes in conference meetings to remote, we did less travel that origionally anticipated during our dissemination period. Even though we did not attend conferences in-person, we were still able to present our findings remotely. What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest?Both reports were shared extensively through various outreach channels, including online dissemination, in-person presentations, industry conferences, virtual meetings/webinars, and mailed print copies. Presentations were done to diverse audiences including USDA ARS, USDA NOP, NOSB, policymakers, researchers, organic sector partners and farmers. The report page on our website has already been visited over 6,000 times and printed hard-copies have been shared with key partners. What do you plan to do during the next reporting period to accomplish the goals?We will continue dissemination efforts and presentations on the National Organic Research Agenda. Impacts What was accomplished under these goals? The 2021 draft report was reviewed by the advisory committee and all revisions were integrated. In 2022, the report was finalized, copy/edited and formatted into a full 230-page report. The Organic Seed Alliance also completed and published their State of the Seed report. OFRF created an extensive outreach and dissemination plan and shared the report to a wide audience. OFRF printed the full report and executive summaries, as well as created presentations and easily accessible factsheets and infographics. Publications Type: Other Status: Published Year Published: 2022 Citation: OFRF.2021.National Organic Research Agenda **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:OFRF reached out to over 14,000 organic producers from the National Organic Producers List and worked with organic certificaiton agencies and NRCS to send to transitional farmers. There were around 1,200 producers who fully completed the survey and just under 2,000 that paritally filled out the survey. We also conducted virtual listening sessions with just over 180 organic and transitioninggrowers from across the country. Changes/Problems:The pandemic really limited our ability to go to grower conferences and meetings and conduct listening sessions. While we were able to collect input through virtual focus groups, they did not allow us to collect input from as many growers as we had hoped. Many growers didn't show up to the virtual meetings (despite particpation gift cards), and it was difficult to have too many people in virtual meetings, so we limited it to 15 participants per focus group. We also feel like COVID may have impacted survey participation. The orginal project manager left the position very early in 2021, so the work was delayed by a couple of months. We were able to hire a new position and use external contractors to help keep us on schedule, and we only ended up being a month behind. 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?We will finish publishing and releasing the 2021 NORA report. We will share results through several conferenes, with agencies, and universities/researchers through an extensive dissemination campaign. **Impacts** What was accomplished under these goals? All the data from random sample and open surveys, as well as 16 focus groups was compiled, coded, and analyzed. OFRF wrote draft of the 2021 National Organic Research Agenda outlining the findings and sent to the advisory comittee for review. OSA analyzed seed data and is currently working on the State of the Seed report. **Publications** - Type: Other Status: Under Review Year Published: 2021 Citation: OFRF.2021. National Organic Research Agenda

↑ Return to Index

Boa: Taking High Plains Organic Farming to the Next Level

Accession No.	1021083
Project No.	COL0-2019-03031
Agency	NIFA COL\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30256
Proposal No.	2019-03031
Start Date	01 SEP 2019
Term Date	31 AUG 2020
Grant Amount	$49,995
Grant Year	2019
Investigator(s)	Yoder, N.; Norton, JA, B.; Uchanski, MA.; Crowe, VI.

NON-TECHNICAL SUMMARY

The goal of this conference grant is to expand the reach of the existing High Plains Organic Conference in Cheyenne, Wyoming, in February, 2020. Producers, researchers, educators, processors, vendors, and other stakeholders have been engaged in this annual organic farming conferece held in February for 6 consecutive years, 2014-2019, in eastern Wyoming and targeting the northern High Plains region. Growing participation each year of the meeting reflects increasing interest in organic production and expanding markets in the Front Range metropolitan area. The northern High Plains region includes southeastern Wyoming, southwestern Nebraska, and northeastern Colorado, and is characterized by low and variable rainfall, low-fertility soils, and combined production of dryland cropping systems based on winter wheat, irrigated production of vegetables and forages, and livestock production dominated by cattle. There is no other regional conference or organization that addresses its unique production challenges. The conference planning committee draws on stakeholders identified during organization of the annual meetings. Specific objectives of the project include:1.Identify Breakthroughs in Organic Agriculture (BOA) to enhance the ability of producer and processors to grow and market high quality organic agricultural products. This includes identifying new partners from unconventional fields to explore potential \"leapfrog\" technologies that are specific to organic agriculture;2.Expand and improve our regional annual organic farming conference through better marketing and outreach and digital representation (better signage and social media presence to attract young producers);3.Educate participants on best practices, state-of-the-art knowledge, and knowledge gaps pertaining to organic production and marketing to assist farmers and ranchers in whole farm planning;4.Identify research, extension, and education needs for organic production and marketing in the High Plains to inform universities, agencies, and NIFA and to create a roadmap of successful organic production in the region;5.Provide networking and problem-solving opportunities for producers, researchers, educators, buyers, processors, vendors, and others;6.Increase conference outputs for continued use throughout the year. This will include digitizing presentations and conference materials to be made available on the conference website and organizing appropriate extension publications related to breakthroughs in organic agriculture.

OBJECTIVES

The northern High Plains is a distinct geographic region with unique production and marketing challenges and opportunities, increasing interest in organic production, and increasing demand in the rapidly growing Colorado Front Range metro area, making it a prime site for agricultural innovation and breakthroughs. Our objectives relate directly to 4 of the 8 OREI goals that were legislatively defined by the Farm Bill because the intent is to facilitate discussion and identify needs pertaining to all the goals. This includes:Goal 1: Facilitating the development and improvement of organic agriculture production, breeding, and processing methods. Networking, facilitated problem-solving discussions, and invited guest speakers from other regions and countries will create ongoing research and education in these areas, creating a regional road map for organic agriculture;Goal 5: Identifying marketing and policy constraints on the expansion of organic agriculture. Involvement by state and US department of agriculture personnel will facilitate identification of constraints and ideas for dealing with them; in response to stakeholder inputs, Dr. Dawn Thilmany (CSU) has agreed to serve as a speaker in 2020 to discuss the consumer aspects of organic food in our region.Goal 6: Conducting advanced on-farm research and development that emphasizes observation of, experimentation with, and innovation for working organic farms, including research relating to production, marketing, food safety, socioeconomic conditions, and farm business management. The meetings and the conference have already facilitated identification of specific needs and implementation of research via networking among researchers, producers, and others. Both OREI 2014-51300-22240 and OREI 2009-01436 were conceived at and a direct result of research and grower networking at the High Plains Organic Farming conference. These and other collaborations will continue to expand moving forward;Goal 7: Examining optimal conservation and environmental outcomes relating to organic certified produced agricultural products. A central objective is to identify specific environmental and conservation challenges in the High Plains region where research is needed to improve sustainability of production systems.

APPROACH

Project objectives will be achieved via four steps: Conference Coordinator (Natalie Yoder) and assisting grad student (Victoria Crowe)assemble conference planning committee made up of researchers, producers and other industry stakeholders; develop conference agenda and approve venue and dates; identify and invite speakers to address topics both innovative and requested from local producers through the previous years\' surveys. Conference coordinator and assisting graduate student begin marketing campaign. Hire graphic designer help to brand the conference\'s digital presence; Compile contact list of certified organic producers, processors, vendors, buyers, consumers, and others in or near the target region who would be interested in attending or sponsoring the conference. This will be accomplished by building upon lists of participants in the first six organic conferences, lists of certified producers and processors provided by the NOP. Email this list;Start social media outreach on Twitter, Instagram and Facebook;Update and promote the HPOFC website;Create press releases and advertise on public radio, though online newsletters, and though all agriculture universities in the area;Use new yard signs to promote the conference ahead of time as well as guide attendees to the appropriate building and parking lot for the conference.Host the 7th annual conference in late February 2020. Invite a keynote speaker who is practicing innovative organic agriculture that will inspire our producers to create breakthroughs in organic agriculture and in their operations. Other speakers will be invited from within the targeted regional area as well as from Montana, Utah, and other areas with relevant research programs to facilitate breakthroughs in critical organic farming topics for High Plains producers (Fig. 2). The conference agenda will include: Programming will include concurrent how-to workshops, discussion panels that incorporate producers, extension specialists, and researchers, as well as session topics on the status of emerging organic farming research from the Land Grant Universities. Following each session, we will engage participants in a discussion to identify research and extension needs facing organic producers in the High Plains. Sessions could include, but are not limited to: Dryland - Economic analysis of organic vs. conventional in wheat or other drylands operations. Cover crops - Cost of cover crops both in dollars and nutrients and moisture. Specialty crops - Saving water in specialty crops and using marketing to improve public acceptance of unique cultivars and heirlooms. Address the integration of hemp production into organic agriculture operations. Livestock - Integrating livestock on fall cover crops as and opportunities for partnership between organic farming and livestock producers. \"Sticky challenges\" in organic farming - Address issues such as; how to deal with excessive erosion, weeds, and weed management; appropriate organic amendments and inputs; best production techniques in organic farming for different scales of operation. Regulatory - Provide a Farm Bill update and how legislation and future decisions will impact organic farmers in the High Plains region. Panel discussions - These combine producer, extension specialist, and researcher panels will increase interactivity and address specific producer questions in current research, and future research needs to fill the gaps for producers in specific areas of production for organic producers. Research and education - Fulfill producer requests to understand the carbon and nitrogen cycles, and how they affect greenhouse gas models to gauge the comparative effects of organic vs. conventional agriculture \-- marketing workshop to emphasize food safety, human health, and ecological benefits of organic food in marketing.\" Meet the Researchers\" poster gallery and vendor/sponsor displays; Facilitated breakout sessions to discuss and define needs; Concluding panel discussion solidifying outcomes and future activities. Follow-up meeting of conference planning committee: Review conference outcomes and evaluations; The conference committee will actively compile regional priorities and facilitate discussion on how the conference can address these priorities;Digitize, curate and edit conference outputs and email to all attendees- conference videos, handouts, and related published articles. Make these materials available to all on the conference webpage.

PROGRESS

2019/09 TO 2020/08 Target Audience:Our target audience is every current and future producer who is currently growing organic or who wishes to grow organic goods within Colorado, Wyoming and Nebraska. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?As a conference, this event was inherently loaded with training and professional development opportunities. Not only did farmers get direct training through lectures, but they connected with researchers and other growers for follow-up training or on-farm collaboration. We hosted a vendor area rich with employers and products useful to organic farmers and we programmed ample time to socialize and visit with the vendor booths as well. How have the results been disseminated to communities of interest?Videos of many of our speakers were made free to the public via YouTube and posted through links on our social media pages and website. Visit www.youtube.comto view the posted videos! What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? Goal 1: Facilitating the development and improvement of organic agriculture production, breeding, and processing methods. 106 attendees and speakers participated in the 2020 conference. Speakers flew in from Texas, Washington, Oregon, Montana, Indiana, and Conneticut. Networking was accomplished through small breakout sessions and diverse concurrent talks with Q & A sessions after each talk. Goal 5: Identifying marketing and policy constraints on the expansion of organic agriculture. Dr. Dawn Thilmany served as a speaker addressing these policy constraints as did speakers during the session \"USDA-NOP oversight and procedures\" with Emily Prisco, Auditor, USDA, National Organic Program and \"Interpretation of NOP guidelines\" with Amy Stafford, Certification specialist, OneCert. Both of these sessions were well attended and gave the attendants a chance to speak with policy makers about the real life constraints they experience daily as producers in this region. Goal 6: Conducting advanced on-farm research and development that emphasizes observation of, experimentation with, and innovation for working organic farms, including research relating to production, marketing, food safety, socioeconomic conditions, and farm business management. The connections between researchers and farmers were further strengthened during this conference. The talks that led to the most direct connection and future collaboration were the \'Hemp Seed, Research, and Product Testing\' Talk that was followed by an interactive panel, as well as the \'Bringing Kernza® Perennial Grain to market: new economic opportunities and agronomic challenges\' talk were many farmers signed up to trial Kernza on their farms following this talk. Goal 7: Examining optimal conservation and environmental outcomes relating to organic certified produced agricultural products. Again, this goal was accomplished by encouraging collaboration across the conference. \'Bringing Kernza® Perennial Grain to market: new economic opportunities and agronomic challenges\' talk led to farmers questioning the local application of a crop that was created outside of their region. It led to not only farmer interest in trialing this crop, but interest on the breeder side of testing their crop for local applicability. This was also accomplished during the talk \"Soil building practices in driest dryland wheat production\" where a professor from Utah State University shared her experience and research with increasing sustainability practices in arid growing environments. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 No publications reported this period.

↑ Return to Index

Assessment to Quantify Current Practices and Research Priorities for Organic Citrus Growers Combating Huanglongbing

Accession No.	1020655
Project No.	FLA-SWF-005863
Agency	NIFA FLA\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30241
Proposal No.	2019-03043
Start Date	01 SEP 2019
Term Date	31 AUG 2020
Grant Amount	$47,299
Grant Year	2019
Investigator(s)	Qureshi, J. A.; Shade, JE.
Performing Institution	UNIVERSITY OF FLORIDA, G022 MCCARTY HALL, GAINESVILLE, FLORIDA 32611

OBJECTIVES

Our long-term goals are to equip organic citrus growers with tools that will 1) allow them to increase the adoption of organic practices and 2) allow organic citrus farming to be more feasible and profitable to promote the success and expansion of the sector. Our overall objectives are to expand communication between the organic citrus growers across the U.S. and the research community, and to determine research and extension priorities to provide organic citrus farmers with tools to face the threat of Huanglongbing.

APPROACH

Activities and methods: A needs assessment is proposed for organic citrus growers combating Huanglongbing. The study will quantify and characterize the current practices and needs of citrus growers using a survey and direct dialogue with focus groups and interviews with stakeholders. The project will culminate in a white paper. We have assembled multi-disciplinary, multi-institutional, and multi-state advisory committee to guide the proposed project and extend our reach throughout the U.S. citrus community.The needs assessment will be conducted with four tasks; the target audience includes stakeholders, farmers and experts working in organic citrus production. The study will evaluate and characterize the needs of organic producers using a focus group and survey.Task 1: Central to the success of this proposal is ensuring sufficient and representative stakeholder input. As such, our first task is to convene our advisory committee composed of, diverse stakeholders and includes organic citrus producers, industry members that utilize organic citrus products, citrus experts and researchers from across the U.S. To date we have identified 14 advisory committee members. The advisory committee will meet a minimum of two times by webinar, with additional conference calls and email communication as needed to plan Task 2.Task 2: Advisory committee members will work collaboratively with Angella Jagiello to create a survey with the objective of assessing current methods being used by organic citrus growers to combat Huanglongbing and gather information on research and extension. The questionnaire will be sent to organic farmers belonging to national and state organizations. Participants will be asked about specific topics including the extent to which their groves are infected with Huanglongbing, use of monitoring protocols and preventative measures, types of treatment to combat infection, and where they get information for managing groves infected with or at risk for infection with Huanglongbing. Our survey will be publicized via listservs (e.g., organic farmer organizations, conferences, and newsletters), and members of the organizations involved in this proposal (e.g. Organic Center, CCOF, FOG, OTA). In the absence of a unique sample frame, i.e., list of the organic farmers to be drawn from, a non-probability sampling will be conducted in order to obtain a maximum number of participants. Participants will be invited to complete a web-based confidential survey and we aim to have a response rate of at least 20%.Task 3: Stakeholders and advisory committee members, identified in Task 1, will meet for a 1.5 day-long workshop at the US Horticultural Research Laboratory (USDA, ARS) in Ft. Pierce, Florida. The workshop will focus on 1) current preventative and treatment practices utilized by organic citrus growers 2) prioritization of Huanglongbing research needs and; 3) extension needs. The overall goal of this workshop is to gather information about how organic citrus growers in different regions of the U.S. are addressing Huanglongbing in their groves, and to determine needs and priorities for combating Huanglongbing in organic citrus. We will use this workshop to gain insight about the committee members\' views on research needs to combat Huanglongbing, which will be pivotal in the development of a future large-scale proposal that directly addresses stakeholder needs.Task 4: Compilation of the data and communication of the findings with stakeholders: Qualitative and quantitative methods will be used to evaluate the survey data. A final report will be generated as a white paper, and distributed to all the participating stakeholders and the organic citrus community. This report will be used as the basis for a full OREI multi-regional proposal to follow our planning project. **Progress** 09/01/19 to 08/31/21 **Outputs** Target Audience:Organic citrus producers, researchers and policy makers were the focus of our project. Details of some are listed below Growers/Industry Ben McLean is an organic citrus grower and Vice President of Uncle Matt's Organic. Uncle Matt's is the oldest organic orange juice in the United States and the State of Florida's largest organic citrus grower. Jeffrey Steen serves on the California Citrus Research Board as Chair for the California New Varieties Committee, Vice Chair for the Research Development and Implementation Committee, Chair for the Ad Hoc Science Review Process Improvement Committee and a member of the Priority Screening and Vectored Disease Committee Dr. Ramkrishnan Balasubramanian is the Interim Executive Director of Florida Organic Growers (FOG), a grassroots, non-profit corporation established in 1987 to promote organic and sustainable agriculture. FOG is well connected with citrus farmers across the state. Rick Kress is President of Southern Citrus Gardens. Southern Citrus Gardens is one of the largest growers and suppliers of 100% pure not-from-concentrate orange juice and is dedicated to environmentally friendly farming. Cathy Calfo is the Executive Director of California Certified Organic Farmers (CCOF), a non-profit organic certification agency, advocacy organization, and charitable foundation which advocates on behalf of over 3,000 organic farms and processors across the U.S. Scott Mabs is the Chief Executive Officer of Homegrown Organic Farms which has been marketing and selling organic citrus since 1998 and represents over 30 different organic citrus growers in California. Garff Hathcock is the Organic Division Manager for Corona College Heights Orange and Lemon Association, a 115-year-old citrus packing cooperative based in California. Dennis Holbrook is the President of South Texas Organics, the largest organic citrus operation in Texas. Education/Extension Sonia Rios is Subtropical Horticulture Farm Advisory at the University of California Cooperative Extension-Riverside. Ben Faber is Farm Advisor in the University of California Cooperative Extension for Ventura and Santa Barbara counties where the dominant crop is citrus. Researchers Dr. Carolyn Slupsky, Professor in the Department of Food Science and Technology at the University of California, Davis. Dr. Slupsky's work focuses on the impact of agricultural practices and pathogen infection on tree metabolism. Dr. Reza Ehsani is a Professor of Agricultural and Biological Engineering in the School of Engineering, University of California, Merced, CA. His research area has been focused on developing engineering tools and techniques for citrus production including developing heat treatment systems for Huanglongbing infected citrus trees. Policy Gwendolyn Wyard is the Regulatory Director of Organic Standards and Food Safety, Organic Trade Association Changes/Problems:COVID-19 situation changed our plans of in-person meeting and we resorted to a virtual workshop on \"Organic HLB Control\" What opportunities for training and professional development has the project provided?Several meetings and a workshop provided opportunities for the stakeholders to discuss in detail the situation regarding the management of huanglongbing particularly under organic production systems and understand the future needs. How have the results been disseminated to communities of interest?Written details of the discussions from the meetings were summarized and distributed to the stakeholders in the emails. Stakeholders' suggestions on the management of the huanglongbing were very helpful and incorporated in the stakeholder survey which was distributed electronically. Findings from the stakeholders survey were presented to them by the Project Director in the \"Organic HLB Control\" workshop and incorporated in the OREI grant submitted to NIFA. What do you plan to do during the next reporting period to accomplish the goals? Submit the OREI grant entitled \"\"Systems approach to organic management of the Asian citrus psyllid.\" which is the primary vector of the huanglongbing disease, will be submitted to NIFA in 2022. **Impacts** What was accomplished under these goals? A survey to assess the needs and priorities for organic management of HLB and several conference calls and meetings between October 2019 and August 2021 including a two day workshop on \"Organic HLB Control\" were conducted.Multiple stakeholder groups from across citrus-producing states in the U.S. participated and identified Asian citrus psylid vector and associated citrus greening disease as the top concern for the organic citrus industry and provided input through workshops and surveys conducted during the 2019-2021.The planning grant was guided by an advisory board comprised of organic citrus growers, organic grower groups, extension agents, industry members, citrus researchers, and policymakers who helped develop survey questions, interpret the impacts of the findings, and leverage outreach and communication. Details of some of those meetings were provided in the annual report. The details of topics discussed by the experts from different states are listed below for the \"OrganicHLB Control\" workshop conducted in November 2020. Day 1: 10:00am Welcome Jessica Shade 10:10am Introductions All 11:10am OREI proposal goals and program priorities Amber Sciligo 11:20am Survey Outcomes Jawwad Qureshi 11:30am Break 11:45am Integrated Management of Asian citrus psyllid Jawwad Qureshi 11:55am Xavier Research Summary (IPM) Xavier Martini 12:05pm Breeding HLB Tolerance for Organic Production Mikeal Roose 12:15pm Synthesis Discussion All Day 2: 9:00am Welcome back Jessica Shade 9:05 am Research in Organic Citrus in Southern California Monique Rivera 9:15am Mamoudou Research Summary (Texas) Mamoudou Setamou 9:25am Ben Presentation (Florida) Ben McLean 9:35am Jeff Presentation (California) Jeff Steen 9:45am OREI Priorities Recap Amber Sciligo 10:00am Break 10:15am Discussion: Developing a multiregional OREI proposal All The advisory board was later active in developing the goals of a full OREI proposal based on these findings that was submitted to NIFA in 2021. Unfortunately, it was not funded in the first round, so it will be submitted again in 2022. **Publications** **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:Growers/Industry Ben McLean is an organic citrus grower and Vice President of Uncle Matt's Organic. Uncle Matt's is the oldest organic orange juice in the United States and the State of Florida's largest organic citrus grower. Jeffrey Steen serves on the California Citrus Research Board as Chair for the California New Varieties Committee, Vice Chair for the Research Development and Implementation Committee, Chair for the Ad Hoc Science Review Process Improvement Committee and a member of the Priority Screening and Vectored Disease Committee Dr. Ramkrishnan Balasubramanian is the Interim Executive Director of Florida Organic Growers (FOG), a grassroots, non-profit corporation established in 1987 to promote organic and sustainable agriculture. FOG is well connected with citrus farmers across the state. Rick Kress is President of Southern Citrus Gardens. Southern Citrus Gardens is one of the largest growers and suppliers of 100% pure not-from-concentrate orange juice and is dedicated to environmentally friendly farming. Cathy Calfo is the Executive Director of California Certified Organic Farmers (CCOF), a non-profit organic certification agency, advocacy organization, and charitable foundation which advocates on behalf of over 3,000 organic farms and processors across the U.S. Scott Mabs is the Chief Executive Officer of Homegrown Organic Farms which has been marketing and selling organic citrus since 1998 and represents over 30 different organic citrus growers in California. Garff Hathcock is the Organic Division Manager for Corona College Heights Orange and Lemon Association, a 115-year-old citrus packing cooperative based in California. Dennis Holbrook is the President of South Texas Organics, the largest organic citrus operation in Texas. Education/Extension Sonia Rios is Subtropical Horticulture Farm Advisory at the University of California Cooperative Extension-Riverside. Ben Faber is Farm Advisor in the University of California Cooperative Extension for Ventura and Santa Barbara counties where the dominant crop is citrus. Researchers Dr. Carolyn Slupsky, Professor in the Department of Food Science and Technology at the University of California, Davis. Dr. Slupsky's work focuses on the impact of agricultural practices and pathogen infection on tree metabolism. Dr. Reza Ehsani is a Professor of Agricultural and Biological Engineering in the School of Engineering, University of California, Merced, CA. His research area has been focused on developing engineering tools and techniques for citrus production including developing heat treatment systems for Huanglongbing infected citrus trees. Policy Gwendolyn Wyard is the Regulatory Director of Organic Standards and Food Safety, Organic Trade Association Changes/Problems:COVID-19 situation changed our plans of in-person meeting and we resorted to a virtual meeting What opportunities for training and professional development has the project provided?Several meetings provided opportunities for the stakeholders to discuss in detail the situation regarding the management of huanglongbing particularly under organic production systems and understand the future needs. How have the results been disseminated to communities of interest?Written details of the disussions from the meetings were distributed to the stakeholders in the emails. Stakeholders suggestions on the management of the huanglongbing were very helpful andincorporated in the stakeholder survey whichwas distributed electronically. What do you plan to do during the next reporting period to accomplish the goals?Plan a virtual workshop on \"Organic HLB Control\" and discuss the research priorities for OREI research grant on organic management of HLB. **Impacts** What was accomplished under these goals? We were able to develop a detailed survey on the management of HLB for the organic citrus producing stakeholders which was distributed electronically. This survey incorporated questions and options on the management of huanglongbing or citrus greening disease and its vector Asain citrus psyllidwhich was based on the detailed discussion with the stakeholders in several meetings . Survey was distributed to the stakeholders to gather information on the organic management of this disease and assess the research priorities that can be proposed in an OREI grant. **Publications**

↑ Return to Index

A Comprehensive Assessment of Industrial Hemp as a Potential Crop for Organic Farmers

Accession No.	1020483
Project No.	IND90000794G
Agency	NIFA IND\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30532
Proposal No.	2019-03061
Start Date	01 SEP 2019
Term Date	31 AUG 2022
Grant Amount	$955,458
Grant Year	2019
Investigator(s)	Gibson, K.; Turco, RO.; Marshall, MA.; Beckerman, JA, L..; Couture, JO.; Smith, AN.; Omondi, EM.; Caton, TA.

NON-TECHNICAL SUMMARY

The 2019 Farm Bill removed industrial hemp from the federal government\'s list of controlled substances and, given the enormous interest in the crop, opened the floodgates for hemp to be planted on a national scale. However, the knowledge needed to grow hemp has largely been lost and there is very little peer-reviewed research on this crop. Research must be initiated now to ensure that organic farmers are able to make informed decisions and avoid costly mistakes. We propose experiments that will allow us to 1) assess the integration of hemp into cropping systems that include cover crops and no till practices, and 2) determine the effect of location and planting date on the performance of multiple hemp cultivars. We will use these experiments to examine issues related to soils and soil microbial communities, pests, pollinators, and economics. We also propose an assessment of the supply chain for hemp that will decrease the gulf between growers, manufacturers, and retailers. Finally, we will provide training on industrial hemp for Extension Educators and disseminate information to farmers directly through workshops, field days, and publications. Cumulatively, our research will help producers better understand how to integrate hemp into their organic systems plans.

OBJECTIVES

The primary goal of this project is to develop and communicate research-based information on soil health, pests, cropping systems, and markets that will help organic farmers make informed decisions about industrial hemp. First, we will conduct field experiments to 1) assess the integration of hemp into cropping systems that include cover crops and no till practices, and 2) determine the effect of location and planting date on the performance of multiple hemp cultivars. We will use these experiments to examine issues related to soils and soil microbial communities, pests, pollinators, and economics. Second, we will assess the supply chain for hemp in order to decrease the gulf between growers, manufacturers, and retailers. Finally, we will provide training on industrial hemp for Extension Educators and disseminate information to farmers directly through workshops, field days, and publications.

APPROACH

We propose experiments that will allow us to 1) assess the integration of hemp into cropping systems that include cover crops and no till practices, and 2) determine the effect of location and planting date on the performance of multiple hemp cultivars. We will examine 2-year crop sequences that vary in the use of legumes (hairy vetch and soybean) to reduce the need for compost or manure, in the reduced use of tillage to plant cash and cover crops, and in the number of unique crops in each crop sequence which may affect pest lifecycles and populations. We propose eight treatments that address these interests. Treatments 1 and 2 assess the effect of hemp on winter wheat planted with and without tillage. Treatments 3 to 5 assess a hemp-rye-soybean sequence in which rye is planted with and without tillage and terminated by roller-crimping or with tillage. Treatments 6 to 7 assess a hemp-vetch-corn rotation in which is planted with and without tillage and terminated by roller-crimping or with tillage. Farmers are interested in both seed and fiber varieties and we will assess these sequences using both a seed and fiber variety. We will follow well-established tillage, planting, cultivation, and harvesting/termination practices for organic corn, soybean, wheat and cover crops and assess the effects of treatments on soil health, soil microbial communities, pests, and plant tissue chemistry of hemp. For the cultivar trials, we will assess the growth, phenology, and yields of seed and fiber varieties. We anticipate a combination of mixed-model ANOVAs and regression modeling for data analysis. The economics component is focused on understanding the supply chain for hemp from production to consumption. We will study existing supply chains for hemp to determine the possibilities available for new hemp farmers in the Midwest. In the Midwest, there are 3929 certified organic cropland and pasture operations. We will conduct an online survey of these operations in the Midwest to understand producer preferences for and understanding of production of hemp fiber, seed, and oil. We will use appropriate discrete choice models such as mixed-logit to analyze online survey responses. We will develop and submit at least one peer-reviewed Extension publication on beneficial and harmful insects, one on plant pathogens, one on the cropping systems research, and one on the economics research. We will cross-publish on our university and institutional websites. Presentations will be developed and shared with Extension educators and NCRS personnel to extend impact as more agronomic research is developed. We anticipate strong demand for our products given the level of interest in hemp among farmers, the general public, hemp industry associations, and the media. We will further disseminate the results of our research through field days at each institution in each year and workshops for farmers at each institution in the second and third year of the grant. We will conduct pre- and post-surveys of participants to document changes in knowledge. We will amplify our messages by providing training workshops on industrial hemp during early winter 2021 and 2022 to Extension Educators and NRCS personnel in each state. Learning objectives will include participants increasing their understanding of the legal status of hemp and associated products, hemp biology and agronomics, cultivar performance and potential seed sources, markets and infrastructure. We will assess changes in knowledge with pre- and post-surveys and we will resurvey participants after 6 months to determine if the workshop improved their ability to support farmers interested in hemp. Progress 09/01/19 to 08/31/24 Outputs Target Audience:Our primary target audiences were farmers in Indiana and Pennsylvania interested in growing hemp organically, and researchers interested in hemp production. Changes/Problems:Stand establishment was poor for the seed variety planted at all sites in the cropping systems experiment during the first growing season, and we terminated the plots well before harvest. We modified our crop rotation experiment so that cover crops and agronomic crops would follow two complete sequences of fiber hemp. This change was necessary but required an additional year of field research beyond what was initially proposed. In general, poor hemp stand establishment limited our ability to draw robust conclusions from the data. What opportunities for training and professional development has the project provided?On average, the project supported three graduate students and two undergraduate students in each year of the grant. Graduate students worked one-on-one with faculty and staff to improve their understanding of hemp biology, experimental design, project management as well as economics and survey development. Undergraduates received training in field and lab techniques. How have the results been disseminated to communities of interest?Results were communicated through field days, tours of the experiments, conferences, and virtual presentations to nearly 2000 people during the grant. Presentations were given during Farm Bureau meetings, the national FFA conference, the Small Farms conference in Indiana, and as part of summer annual field days at Rodale and Purdue\'s experimental research stations. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Year 1 Activities In the first year, we focused on establishing field experiments and developing survey instruments for economic research. Cropping systems and cultivar trials were initiated at sites near West Lafayette, IN, Kutztown, PA, and Vincennes, IN. Seed and fiber hemp varieties were planted in spring 2022, following hairy vetch. Soil cores were collected to establish baseline conditions, and the weed seedbank was sampled at the Indiana sites before hemp was planted. Data were collected on hemp stand establishment, vegetative biomass, and yields. Survey instruments were developed to assess hemp economics in Indiana and a grower survey was created for farmers in Michigan, Illinois, Ohio, and Kentucky. Field days were planned but canceled due to the pandemic. Restrictions imposed on research and travel limited our ability to manage field plots and collect data. The extension and economics team members gave nine virtual presentations to approximately 430 participants. Year 2 Activities In the second year, we continued field experiments, economics research, and dissemination of information to farmers. The cropping systems and planting date trials were continued at the same sites. Hemp establishment was particularly poor for the seed variety planted in the first year. The cropping system experiment was modified to exclude the seed variety and to include two full sequences in which fiber hemp was followed by wheat, rye, and hairy vetch, planted with and without tillage. Soil and pest data were collected, including weed seedbank data. Preliminary analyses suggested low hemp seedling emergence at two sites, high weed levels, but smaller weed seed banks after hemp. Insect damage was relatively low in fiber hemp. Tillage was noted as necessary for robust cover crop stands. Data on hemp economics were collected and analyzed, revealing that costs were as expected or higher, but revenues were lower. The hemp market was perceived as very risky. Demographic characteristics influencing hemp adoption were identified. Growers who are more risk-loving and who had a family member who grew hemp had a higher likelihood of adopting hemp. Women had a lower likelihood of adopting hemp and racial and ethnic minorities have a stronger likelihood of adopting hemp. Purdue and Rodale hosted field days and gave presentations to approximately 1000 participants, primarily farmers interested in hemp. Year 3 Activities In the third year, we continued field experiments and disseminated information to farmers through virtual and in-person venues. The cropping systems experiments were continued at the same sites, with modifications to include new crop sequences. Soil and pest data were collected, and hemp, corn, and soybean tissues were analyzed for heavy metal concentrations. Early planting dates were associated with greater herbivory. Field days and presentations engaged approximately 500 participants, primarily farmers interested in hemp. Year 4 Activities In the fourth year, a no-cost extension was granted to conclude research, process samples, and analyze data. The cropping experiment was terminated in fall 2022, and data analyses suggested that crop rotations had little effect on soil characteristics. Hemp establishment continued to be lower than expected, and plots were weedy. However, the weed seedbank generally decreased after hemp, largely due to a reduction in broadleaf weed seed production due to the relatively early hemp harvests. Heavy metal concentrations were low across all crops, with no significant differences between hemp and soybean. Conclusions The research grant provided valuable insights into hemp cropping systems. Key findings include: Hemp establishment was lower than expected, with high weed levels. Poor stand establishment limits the abilty of hemp to compete with weeds. Weed seedbanks decreased after hemp, in most years and at most sites. This likely reflects the timing of hemp harvest relative to broadleaf weed seed production. Early planting dates were associated with greater herbivory. Crop rotations and tillage had little effect on soil characteristics. This likely reflects the relatively short duration of the study. Heavy metal concentrations were low across all hemp, soybean, and corn and do not appear to be an issue for hemp grown on productive agricultural land. The hemp market is perceived as risky, with costs often exceeding revenues. Publications Progress 09/01/22 to 08/31/23 Outputs Target Audience:Our primary target audiences for this year of the grant were farmers in Indiana and Pennsylvania interested in growing hemp organically and researchers interested in hemp production. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?A PhD student was supported by the project and gained experience in data analyses, writing, and in presenting results to farmers through extension events and other venues. How have the results been disseminated to communities of interest?Results were primarily communicated through conference presentations and publications What do you plan to do during the next reporting period to accomplish the goals?A no-cost extension was granted to finalize work on the project.Our primary focus will be to prepare and submit articles for publication. Impacts What was accomplished under these goals? A no-cost extension was granted to conclude our research, analyze data, and develop presentations and publications.The cropping experiment was terminated in fall 2022 and soil and plant samples processed over the winter and data analyzed in 2023.Data analyses are incomplete but suggest that the rotations had little effect on soil characteristics such as organic matter or nutrient concentrations.Plant pathogens were found in hemp but did not impact fiber yields.Hemp establishment was generally lower than expected and plots were weedy.However, the weed seedbank generally decreased after hemp, largely due to a reduction in broadleaf weeds. No-till and reduced tillage plots were particularly weedy in the hemp - corn rotation. Heaveymetal concentrations were relatively low for all three crops and no differences in heavy metal concentrainons were found between hemp and soybean. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Lapham, C., K. Gibson, J. Couture, E. Omondi, F. Etemadi, A. Smith, and R. Afshar. Impact of Reduced Tillage on Corn and Soybean in a Rotational Organic System with Hemp \Oral Presentation\. ASA-CSSA-SSSA International Annual Meeting. Nov 6-9, 2022. Baltimore, MD. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Lapham, C., K. Gibson, J. Couture, E. Omondi, F. Etemadi, A. Smith, and R. Afshar, R. Optimum Planting Date for Industrial Hemp in Northeast USA \Poster Presentation\. ASA-CSSA-SSSA International Annual Meeting. Nov 6-9, 2022. Baltimore, MD. Type: Journal Articles Status: Published Year Published: 2023 Citation: Abendroth JA, Gondhalekar AD, Scharf ME, Couture JJ (2023) Cannabidiol reduces fall armyworm (Spodoptera frugiperda) growth by reducing consumption and altering detoxification and nutritional enzyme activity in a dose-dependent manner. Arthropod-Plant Interactions 17: 195-204 Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Ron Jolly Show. April 19, 2023. What is hemp and its applications. Industrial hemp economics and the state of the hemp industry. M. Bolt was interviewed, Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Bolt, M. (2023). Get Growing. In GPN Cannabis and Hemp Week. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Bolt, M. (2023). Hemp Production and Research. In Agribusiness Council of Indiana. Noblesville, IN. Progress 09/01/21 to 08/31/22 Outputs Target Audience:Our primary target audience for the third year of the grant was farmers in Indiana and Pennsylvania interested in growing hemp organically. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Graduate students continued to work one-on-one with faculty and staff to improve their understanding of hemp biology, experimental design, project management as well as economics and survey development. Undergraduates received training in field and lab techniques. How have the results been disseminated to communities of interest?Results were communicated through field days, tours, and presentations.Information on hemp was presented to approximately 80 participants during field days at Purdue.Rodale hosted 400 participants during their summer filed day and approximately 35 people participated in tours of the hemp experiments. Cumulatively, the Purdue and Rodale teams presented to over 500 participants during 2022. What do you plan to do during the next reporting period to accomplish the goals?A no-cost extension was granted to continue work on the project.The crop rotation experiments will conclude and data collected during the experiments will be analyzed.Results from the field experiments will be presented at conferences and through extension activities.Insect collections from the field experiments will continue to be processed and analyzed. Data from the heavy metal research will be analyzed and a manuscript developed. Impacts What was accomplished under these goals? During the third year of the grant, we continued our field experiments and disseminated information to farmers through virtual and in-person venues.1. Field experiments. The cropping systems experiments were continued at sites near West Lafayette and Vincennes, IN and Kutztown, PA. The cropping system experiment was modified in 2021 to include two full sequences in which fiber hemp was followed by wheat, rye, and hairy vetch planted with and without tillage. Rye and hairy vetch were terminated through tillage or roller-crimping and corn and soybean planted in 2022 to complete the final sequence. Soil and pest data were collected, including weed seedbank data. Wheat was harvested in July 2022 and the agronomic crops were harvested during fall 2022. Hemp, corn, and soybean tissues were collected in 2021 from the crop rotation experiment at the West Lafayette and Kutztown sites and analyzed for heavy metal tissue concentrations in 2022.Fiber and seed varieties were planted mid-May to mid-June at the Kutztown site for the final year of the timing trial . In general, fiber biomass and seed weight decreased with delayed planting in 2020 but not in 2021. Early planting dates were associated with greater herbivory than later planted hemp. 2.Dissemination of information. Purdue and Rodale hosted field days and gave presentations to approximately 500 participants, primarily farmers interested in hemp, during 2022. Publications Progress 09/01/20 to 08/31/21 Outputs Target Audience:Our target audience for the second year of the grant was farmers, primarily in Indiana and Pennsylvania, interested in growing fiber or seed hemp organically. Changes/Problems:We modified our crop rotation experiment so that there woudl be two full sequences of fiber hemp followed by cover crops followed by agronomic crops. Two full sequences will improve our ability to draw robust conclusions from the data but will also require an additional year of field research beyond what was originally proposed. What opportunities for training and professional development has the project provided?Graduate students continued to work one-on-one with faculty and staff to improve their understanding of hemp biology, experimental design, project management as well as economics and survey development. Undergraduates received training in field and lab techniques. How have the results been disseminated to communities of interest?Purdue hosted two field days in 2021. Information on industrial hemp was presented to 18 participants at a Small Farms Feed Day and to 50 participants during a field day focused on fiber hemp, soil managements, and cover crops. A presentation on hemp production and research was given to 48 participants at a Farm Bureau meeting. Finally, we staffed a booth on fiber hemp production and organic systems an the FFA national convention. Rodale hosted 680 participants (450 in-person, 230 virtual) in July 2021 as part of a field day. They also hosted approximately 30 participants in July and August who toured the hemp field trials. Cumulatively, the Purdue and Rodale teams presented to approximately 1000 participants during 2021. What do you plan to do during the next reporting period to accomplish the goals?We will focus on the final phase of our crop rotation experiment in which we evaluate agronomic crops (wheat, corn, soybean) grown after fiber hemp. We will conclude our economics research and submit manuscripts for publication. We will analyze our weed seedbank data and submit a manuscript for publication. We have collected insects from all three sites and will continue to process and analyze the collections. We will host field days at both Purdue and Rodale and present at conferences and other venues. We will provide training based on our findings to Extension Educators. Since the duration of the crop rotation experiment was extended by a year, we anticipate finishing our analyses and submitting manuscripts for publication after the next reporting period. Impacts What was accomplished under these goals? During the second year of the grant, we continued our field experiments, supply chain and economics research, and disseminated information to farmers through virtual and in-person venues. 1. Field experiments. The cropping systems and planting date trials were continued at sites near West Lafayette, IN and Kutztown, PA and the cropping system trial was continued at a third site near Vincennes, IN. The cropping system experiment was modified to include two full sequences in which fiber hemp was followed by wheat, rye, and hairy vetch planted with and without tillage. Rye and hairy vetch were terminated through tillage or roller-crimping and corn and soybean planted to complete the sequence. Soil and pest data were collected, including weed seedbank data. The cropping sequence is incomplete but preliminary analyses suggest that 1) low hemp seedling emergence at two sites contributed to low stand densities and relatively high levels of weeds, 2) despite relatively weedy plots, weed seed banks were smaller after hemp, possibly because the fiber hemp was harvested before most weeds produced seed, 3) insect damage varied across locations but was relatively low in fiber hemp (less than 1% foliar area removed), and 4) tillage may be necessary after hemp to establish robust cover crop stands. Fiber and seed varieties were planted mid-May to mid-June. In general, fiber biomass and seed weight decreased with delayed planting although early planting dates were associated with greater herbivory than later planted hemp. 2. Supply chain and economics. We collected and analyzed data on hemp economics and on individual and business-related factors that contribute to the adoption of hemp in the Midwest. We surveyed hemp licensees in Indiana following the 2020 season. A majority of hemp licensees reported that costs were as expected or higher but revenues were lower. A majority of the licensees reported that their crop was still waiting to be sold or had been destroyed. A majority of the licensees perceived the hemp market as very or extremely risky. Our study on hemp adoption found that growers who are more risk-loving and who had a family member who grew hemp had a higher likelihood of adopting hemp. Women had a lower likelihood of adopting hemp and racial and ethnic minorities have a stronger likelihood of adopting hemp. These demographic characteristics should be of interest to policy makers and Extension personnel. 3. Dissemination of information. Purdue and Rodale hosted field days and gave presentations to approximately 1000 participants, primarily farmers interested in hemp, during 2021. **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:Our primary planned target audience for the first year was farmers, primarily in Indiana and Pennsylvania, interested in growing fiber or seed hemp organically. Changes/Problems:Stand establishment was poor for the seed variety planted at all sites in the cropping systems experiment and we terminated the plots well before harvest. In our original design, we hoped to compare the effect of seed vs fiber varieties on subsequent crops. Since this was no longer possible, we decided to focus on fiber hemp by planting the same fiber variety in 2022 in the plots that formerly contained the seed variety. This approach will result in two full sequences in which fiber hemp is followed by wheat, corn and soybeans at three sites. While we will not be able to compare seed and fiber varieties, we will have a stronger data set to assess the effect of fiber hemp on subsequent crops as well as on soil characteristics and pests. What opportunities for training and professional development has the project provided?Graduate students worked one-on-one with faculty and staff to improve their understanding of hemp biology, experimental design, project management as well as economics and survey development. Undergraduates received training in field and lab techniques. 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?During the second year, we will launch and analyse surveys to better understand hemp economics as well as perceived risks and benefits associated with hemp production. We will analyzed datacollected during the first year of the grant and repeat our hemp cultivar experiments. We continue with our cropping systems experiment, including the weed seedbank project,by planting agronomic crops (wheat, corn, soybean) with and without tillage. We will also plant fiber hemp so that we will have an additional cropping sequence of hemp followed by agronomic crops under till and no-till conditions. **Impacts** What was accomplished under these goals? Impacts are limited because the first year of the grant was devoted primarily to establishing our field experiments and developing survey instruments and sampling databases to conduct our economic research. The cropping systems and cultivar trials were initiated in fall 2019 at the sites near West Lafayette, IN and Kutztown, PA and at a third site near Vincennes, IN. Seed and fiber hemp varieties were planted in spring 2022, following hairy vetch. Soil cores were collected and analyses conducted to establish baseline conditions. The weed seedbank was sampled at the Indiana sites before hemp was planted and a greenhouse emergence study used to assess weed densities and species composition. Data were collected on hemp stand establishment, vegetative biomass, and yields. Data analyses were initiated near the end of the growing season. Survey instruments were developed and distributed to assess hemp economics in Indiana and a grower survey intended for farmers in Michigan, Illinois, Ohio and Kentucky was developed to assess individual and business-related factors that contribute to the adoption of hemp in in Midwest. Field days were planned but canceled because of the pandemic. The extension and economics team members gave nine virtual presentations to approximately 430 participants. We hired and trained four graduate students. **Publications** ** **

↑ Return to Index

Tomato Organic Management and Improvement Project (tomi): Part Ii

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Project No.	IND00045774G
Agency	NIFA IND\
Project Type	OTHER GRANTS
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Contract / Grant No.	2019-51300-30245
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Investigator(s)	Hoagland, L.; Egel, DA, S..; Davis, JE, MA.; Myers, JA, R.; Mengiste, TE.; Colley, MI.; Gu, SA.; Dawson, JU.; Fulk, RA.; Jaiswal, AM.

NON-TECHNICAL SUMMARY

Demand for organic, locally grown tomatoes continues to increase, yet growers struggle to meet this demand due to diseases that move quickly through fields and decimate entire crops. High tunnels can help reduce susceptibility to some diseases, but can increase susceptibility to others. Copper fungicides can reduce disease severity, but can accumulate in soil and negatively impact soil and water quality. Modern hybrid varieties with resistance are available, but they lack the flavor demanded by organic consumers, and resistance in these varieties can be overcome and could increase susceptibility to other pests. This multi-state, interdisciplinary project will address these challenges by: 1) identifying factors that mediate disease suppressive activity in soil and control the efficacy of bio-pesticides in the field, 2) integrate selection for beneficial plant microbial relationships that help plants withstand disease outbreaks into a breeding program, and 3) develop new open-pollinated tomato varieties that have durable disease resistance, are adapted to local regions/production systems, and produce fruit with great flavor. Tomato growers will be actively involved in all aspects of this project, and will gain practical hands-on experience with soil health, disease management, and participatory breeding. They will also develop a strong network of researchers, Extension educators and their peers, and learn how to conduct on-farm trials to address new challenges as they arise. This project brings together a strong team of experienced organic researchers and growers from areas with thriving organic industries, with those in underrepresented areas to increase adoption of organic practices across the U.S.

OBJECTIVES

The goals of this project are to:1) identify key factors mediating disease suppressive soil and survival and efficacy of bio-pesticides; 2) integrate selection for beneficial plant-microbial relationships that help suppress diseases into a tomato breeding program; and 3) develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and a participatory breeding approach.

APPROACH

Focus area #1: Increase biological control of pathogens by improving soil health and bio-pesticide efficacy in the field The objectives of this focus area are to: 1) identify soil properties and management practices that promote disease suppressive soils, and 2) identify factors affecting the survival and proliferation of bio-pesticides in field environments. To accomplish these goals, we will quantify difference in soil chemical properties and soil microbial communities at all on-station and on-farm trials, and determine how these factors affect the potential for these soils to help plants withstand soil-borne and foliar pathogens. This data will be compared with management practices employed at each site, to identify which practices are most likely to contribute to pathogen dynamics. On-station and on-farm field trials will be conducted in diverse environments across IN to determine how the presence of resident soil and phyllosphere microbial community structure and application of leaf mold compost, affect the survival and efficacy of one soil- and one foliar-applied bio-pesticide. These studies will be co-led by Hoagland and Egel, with support from Jaiswal and a graduate student (TBD). Focus area #2: Integrate selection for induced systemic resistance (ISR) into breeding programs The objectives of this focus area are to: 1) identify tomato genotypes most responsive to ISR for use in breeding and epigenetics studies, and 2) identify epialleles associated with ISR expression and determine the extent to which they are passed to progeny via selection and production in diverse ecoregions. To achieve these goals, tomato genotypes will be evaluated for ISR responsiveness using methods developed in TOMI I, and subject to ChiPSeq analysis to identify epialleles, and GBS sequencing to identify single nucleotide polymorphisms (SNPs) associated with ISR responsiveness. Progeny derived from this genotype will be evaluated for ISR responsiveness after four years of selection within five distinct ecoregions, and the data will be combined with soil analyses to determine the extent to which soil properties affect selection for this important trait. These studies will be co-led by Hoagland, Mengiste and Jaiswal. Focus area #3: Select new disease resistant tomato varieties best adapted to local, organic farming systems using genomic selection and a participatory approach. The objectives of this focus area are to: 1) develop improved tomato varieties with durable disease resistance, marketable yield and flavor using a participatory breeding approach, and 2) analyze the stability and regional adaptation of tomato breeding populations developed in unique ecoregions across the U.S. To achieve these objectives, we will select from segregating breeding populations in on-farm and on-station breeding trials across the U.S. in collaboration with growers, and predict the performance of new crosses based on traditional and genomic prediction methods. The relative stability and specificity of varieties, populations, and traits, including ISR responsiveness, will be analyzed in divergently selected tomato populations. Colley, Zystro and McKenzie will lead the participatory breeding aspects of these studies with input from Gu, Davis, Dawson and Myers in their respective ecoregions, and Dawson and Myers will lead the genomic selection and stability analysis component of the project. Progress 09/01/19 to 08/31/24 Outputs Target Audience:The target audience for this project included organic and conventional vegetable growers, marketers, and consumers; personnel at vegetable seed companies and organic biopesticide companies; scientists and students in horticulture, plant breeding, plant pathology, and soil science; as well as Extension educators and others involved in outreach to vegetable growers such as personnel at the NRCS and SWCD. In all cases, efforts were made to reach underrepresented audiences in agriculture, such as racial and ethnic minorities, by including faculty and staff from an 1890\'s land grant institutions and students/staff from many countries and backgrounds worldwide in our research and outreach activities. Changes/Problems:Many of our field trials and some greenhouse and lab trials were delayed due to the COVID-19 pandemic, and this greatly reduced our capacity to conduct outreach activities for several years. However, over the past two years, we were able to make up for these delays and achieve our goals with our one-year extension of the project. Our breeding program has also not advanced as rapidly as we\'d hoped since our germplasm did not do as well in the Midwest. However, we have identified new ways to overcome this challenge, including focusing on more regional breeding programs, for our new efforts in TOMI3. What opportunities for training and professional development has the project provided?Our interdisciplinary research project provided many opportunities for training and development for undergraduate and graduate students, post-docs, as well as principal investigators and key personnel. Effectively tackling production challenges in agriculture systems requires that scientists take an interdisciplinary approach, and this project allowed project PI\'s and key personnel to strengthen their skills in this area. For example, plant breeders learned more about soil microbiology and plant pathology, soil microbiologists learned more about plant pathology and plant breeding, and plant pathologist learned more about plant breeding and soil microbiology, and all learned how to work effectively as part of an interdisciplinary team. In addition, the project PI\'s and key personnel improved their outreach skills and mastered new techniques, such as how to develop and deliver webinars. Many undergraduate students participated in field, greenhouse and laboratory activities associated with this project, gaining valuable experience in how to conduct research, as well as deepening their understanding of soil science, pathology, plant breeding, fruit sensory analyses and seed production. Several of these students have the leveraged skills they gained through their participation in this project by gaining acceptance into graduate programs and professional internships in industry. Graduate students and post-docs who conducted studies as part of this project also strengthened their research skills as well as knowledge in these three interrelated scientific disciplines. Moreover, they strengthened their communication skills by participated in field days, presentations at scientific and grower-oriented meetings, and publication of results in scientific and extension manuscript. Several graduate students associated with this project have gone onto to post-docs or professional positions. Finally, the project PI, Dr. Lori Hoagland, gained valuable leadership skills by managing this large, multistate, interdisciplinary project. How have the results been disseminated to communities of interest?Results of this project have been disseminated broadly via our project website, which was regularly updated to reflect events including webinars broadcast via eOrganic, field days, workshops and presentations at scientific and grower-oriented meetings. Since establishment, our website has received at total of 9,490 views. During TOMI2, we conducted 8 webinars, which are archived on our website and have received a total of 8,127 views total (including in-person attendance during recording; and our previous 8 webinars from TOMI1 received 5,526 views during the TOMI2 period; during TOMI1 In total 684 attended and they received an additional 7,549 during TOMI 1). We delivered 4 interviews or podcasts during TOMI2 (attendance/# listening to recordings unknown); we put on 6 workshops with 950 in attendance, gave 7 presentations at academic conferences reaching 400, gave 35 presentations at grower-oriented meetings reaching 2,540, and put on 32 field days with 2,353 in attendance. In total, we estimate we have reach at least 20,016 people with our events during TOMI2 alone. During all of these events, growers, Extension and industry personnel, and students gained new skills in soil health, disease management, plant breeding and seed saving, and learned about the results of our projects. Results of our TOMI2 project have also been summarized in six scientific manuscripts and five extension publications to date, which have likely reached many of our stakeholders as well. Finally, results of our TOMI2 project were disseminated via blogposts and articles on the Organic Seed Alliance (OSA) webpage, and the Hoagland Soil Microbial Ecology website. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Goal #1: Identify key factors mediating disease suppressive soil and survival and efficacy of bio-pesticides: We conducted a diverse set of field, greenhouse and laboratory trials aimed at identifying composts, along with what factors about them (ie. feedstocks and processing conditions), influence their capacity to support beneficial microbes with pathogen suppressive activity and reduce the severity of foliar diseases in tomato. This included efforts to characterize the microbiomes of these composts, and how they alter the composition and functional capacity of soil and tomato root and foliar microbiomes. At the same time, we conducted several trials aimed at understanding how these soil amendments alter tomato root exudate profiles with the goal of better understanding why tomato genotypes differ in their responsiveness to induced systemic resistance (see objective 2). Results of these trials have been summarized in one graduate student thesis and several undergraduate theses, presented at national meetings, and summarized in scientific publications. In the final year of the project, we also conducted studies investigating the potential for nanoemulsions derived from essential oils to suppress foliar disease in tomato. Given positive results, we conducted follow up studies aimed at quantifying how these nanoemulsions altered tomato microbiomes and plant defense responses using RNA-seq to better understand the mechanisms. Results of these final trials have been presented at national meetings and summarized in a scientific publication that is currently under review. Finally, results and practical implications were shared broadly at various grower-oriented venues. Goal #2: Integrate selection for beneficial plant-microbial relationships that help suppress disease into a tomato breeding programs: During TOMI1, we determined that tomato genotypes vary in their capacity to support beneficial soil microbes that can induce systemic resistance and therefore, reduce the severity of diseases caused by foliar pathogens. During TOMI2, we investigated mechanisms responsible for these differences with the long-term goal of integrating selection for this beneficial trait into our tomato breeding program (see Obj. 3). First, we completed an RNA-seq experiment where we identified physiological and defense pathways that are up or down regulated in a responsive vs. unresponsive genotype. Next, we conducted trials to quantify the composition of root exudate profiles (or root metabolomes) and root microbiomes in the same most responsive and non-responsive genotype to understand how these important traits influence ISR responsiveness. We identified specific compounds released, as well as a set of bacteria and fungi that are recruited by the plant and act synergistically to induce tomato defense responsiveness. Results of the both studies were summarized in scientific publications and are currently in review. To build upon these studies, we crossed responsive and unresponsive genotypes with the goal of creatin five recombinant inbred lines (RILs) that will allow us to better understand the mechanisms responsible for ISR-responsiveness and identify genetic markers that can be used to screen segregating breeding populations. While the RILs were under development, we completed two studies evaluating large F2 populations investigating whether we could use genomic prediction models to select for the critical traits associated with responsiveness to ISR. To prepare for these studies, first we developed protocols to clone individual plants since plants in the F2 population were segregating and we needed clones that were genetically identical plants to inoculated or not, with our model ISR inducer. In the first experiment, we quantified ISR-responsiveness alone. In the second experiment using a cross with a wild genotype that is most highly responsive, we also quantified root metabolomes and root microbiomes to learn more about the mechanisms and identify markers for these important traits which could also influence other benefits such as resistance to soil-borne pathogens and nutrient and water acquisition. Results are being summarized in preparation for publication within a doctoral dissertation and in several scientific publications. We completed trials investigating whether induced systemic resistance (ISR) can be transmitted to progeny via epigenetic changes; follow up studies using ChIP-seq are underway to better understand the mechanisms are underway. Finally, we conducted studies to determine if ISR-responsiveness be transmitted from responsive rootstocks to non-responsive scions via grafting.

These studies will also allow us to further understand the mechanisms behind genetic differences in ISR responsiveness, and if it works, enhance resistance to foliar pathogens now by grafting valuable scions onto responsive rootstocks that do not contain desirable fruit quality traits. Goal #3: Develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and participatory breeding: During the course of TOMI2, we continued to advance breeding lines developed in TOMI1, and made several new crosses using germplasm we knew was more responsive to ISR (see Obj. 2), and material from Cornell with resistance to early blight and Septoria leaf spot, and good flavor. The goal has been to integrate methods aimed at pyramiding multiple qualitative and quantitative sources of resistance and other important traits like flavor. Initial crosses were made at OSU, and evaluated and advanced in field trials across the country (WA, CA, OR, WI, and in two locations in NC).. Seed was saved at each site based on performance from selected individual plants in selected families. Each year data were and reviewed to support decisions around which families to advance in subsequent trials. We also used existing genetic markers each year to screen from segregating populations and advance lines with the best traits. We identified alleles in these populations and determined whether resistance requires the resistance allele to be homozygous or if it also works in a heterozygous state. We began validating the markers for Septoria resistance and obtaining enough data to determine the dosage effect (whether heterozygous lines show sufficient resistance to be commercially viable, or whether homozygosity for the resistant allele is required). Preliminary results show that one of the Septoria resistance QTL must be homozygous for the resistance allele while the other shows dominance and can be effective in the heterozygous state. For the early blight markers, one was not showing significant differences between classes, which may be due to having a mild year for early blight infection, or to the change in genetic background making the marker less tightly linked to the putative QTL. The second early blight marker was not polymorphic in Midwest germplasm and so we are working to develop a marker that will be polymorphic in our germplasm and still tightly linked to the QTL. Segregation ratios for F2 progeny of crosses where one parent had that putative QTL did display the expected patters for a major effect gene, but the marker we have is not segregating. We conducted a greenhouse assay with Wisconsin isolates of early blight to determine whether we could overcome heterogeneous field infection to determine the dosage effects of the first resistance source, and develop a second marker more tightly linked to the resistance allele from the second source. Advanced lines from our breeding program are currently being evaluated by commercial seed companies for consideration of release. If the varieties are release, we will obtain PVP and patent them to help support our long-term breeding efforts. Other advanced breeding lines will continue to be evaluated and advanced in TOMI3. Publications Type: Journal Articles Status: Under Review Year Published: 2024 Citation: Luis, M., Jaiswal, A., Mengiste, T., Myers, J., Hoagland, L., (in review). Identification of mechanisms mediating induced systemic resistant in wild vs. domesticated tomato using RNA-seq. Phytopathology Type: Journal Articles Status: Under Review Year Published: 2024 Citation: Luis, M., Johnson, L.D., Vega-Vasquez, P., Ristroph, K., Hoagland, L., (in review). Use of cinnamon essential oil nanoemulsions to manage gray mold in tomato. Plant Disease Type: Journal Articles Status: Under Review Year Published: 2024 Citation: Feiler, H., Jaiswal, A., Cooper, B., Myers, J., Hoagland, L., (in review). Tomato genotypes responsive to induced systemic resistance harbor a distinct metabolome and support a diverse assortment of other beneficial microbes. New Phytologist Type: Journal Articles Status: Published Year Published: 2019 Citation: Egel, D., Hoagland, L., Davis, J., Marchino, C., Bloomquist, M. 2019. Efficacy of organic disease control products on common foliar diseases of tomato in field and greenhouse trial. Crop Protection, 122, p. 90-97. https://doi.org/10.1016/j.cropro.2019.04.022 Type: Other Status: Under Review Year Published: 2024 Citation: Salinas, C., Luis, J.M., Hoagland, L., (in final prep). Managing beneficial and pathogenic microbes in tomato seeds. eOrganic extension publication Type: Other Status: Published Year Published: 2021 Citation: McKenzie, L. and Zystro, J. 2021. Tomato Seed Production Guide. Organic Seed Alliance. https://seedalliance.org/publications/tomato-seed-production-guide/ Type: Other Status: Published Year Published: 2019 Citation: Egel, D., Jaiswal, A.K., Abdelrazek, S., Hoagland, L., 2019. Managing diseases of tomato in the Midwest using organic methods. https://eorganic.org/node/33835 Type: Conference Papers and Presentations Status: Published Year Published: 2019 Citation: Jaiswal, A.K., Mengiste, T., Myers, J., Hoagland, L., 2019. A look on the wild side of tomato plants to tackle biotic stress. International Society for Molecular Plant-Microbe Interactions 18th Congress, Glasgow, Scotland (poster abstract) Type: Theses/Dissertations Status: Published Year Published: 2023 Citation: Erica Cortez (Post-Bachlorette Program) Sep. 2022-May 2023 Project: Quantifying mechanisms associated with disease suppressive composts Type: Other Status: Published Year Published: 2024 Citation: 2023 Efficacy of fungicides for organic tomato production https://newcropsorganics.ces.ncsu.edu/2023/10/efficacy-of-fungicides-for-organic-tomato-production/ Type: Theses/Dissertations Status: Published Year Published: 2021 Citation: Silenze Silvae Benjamin (Purdue, FNR Dept.) January 2020-August 2021 Project: Quantifying the effects of rising atmospheric carbon dioxide levels on induced systemic resistance against foliar disease in tomato Type: Theses/Dissertations Status: Published Year Published: 2020 Citation: Chengxuan Zhang (Purdue, Biology Dept.) January 2019-August 2020 Project: Changes in rhizosphere microbial community structure and susceptibility to foliar pathogens in tomato grown in different organic potting media Type: Other Status: Published Year Published: 2019 Citation: 2019 - Spring at the

Research Farm. K. Miller Organic Seed Alliance. Type: Conference Papers and Presentations Status: Published Year Published: 2019 Citation: Jaiswal, A.K., Mengiste, T., Myers, J., Hoagland, L., 2019. Does the tomato domestication process alter plant interactions with above-ground pathogens and below-ground beneficial microbes? American Phytopathology Society Annual Meeting, Cleveland, OH (poster abstract) Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Hoagland, L., Colley, M., Dawson, J., Davis, J., Egel, D., Gu, S., Myers, J., Zystro, J, 2020. Leveraging beneficial microbiomes to help suppress diseases in organic tomato production systems. American Association of Horticulture Science Annual Conference (poster abstract) Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Davis, J., 2024. Tomato organic management and improvement project (TOMI). Winter Vegetable Conference, Asheville, NC (poster abstract) Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Luis, M., Vega-Vanzquez, P., Wei, X., Johnson, L., Jin, J., Ristroph, K., Hoagland, L., 2024. Assessing the effect of essential oil nanoemulsions against tomato gray mold using hyperspectral imaging. NAPPN Conference, West Lafayette, IN (poster abstract) Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Hoagland, H., Blevins, M., Bloomquist, M., Carvallo, A., Coffey, P., Colley, M., Davis, J., Dawson, J., Davis, J., Egel, D., Feiler, H., Gu, S., Jaiswal, A., Learn, K., Luis, M., McCluskey, C., Mengiste, T., Myers, J., Qu, L., Salinas, C., Richardville, K., Zystro, J., 2024. Agronomy, Crop Science, Soil Science Societies International Meeting, San Antonio, TX. (poster abstract) Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Feiler, H., Jaiswal, A.K., Cooper, B., Myers, J., Hoagland, L., 2024. Understanding the impact of tomato domestication on rhizosphere metabolites and root microbiomes. Agronomy, Crop Science, Soil Science Societies International Meeting, San Antonio, TX. (poster abstract) Type: Theses/Dissertations Status: Under Review Year Published: 2025 Citation: Feiler (expected May 2025). Genetic markers associated with root microbiome and metabolome and responsiveness to induced system resistance in tomato Progress 09/01/22 to 08/31/23 Outputs Target Audience:The target audience for this project includes organic and conventional vegetable growers, marketers, and consumers; personnel at vegetable seed companies and organic biopesticide companies; scientists and students in horticulture, plant breeding, plant pathology, and soil science; as well as Extension educators and others involved in outreach to vegetable growers such as personnel at the NRCS and SWCD. In all cases, efforts were made to reach underrepresented audiences in agriculture, such as racial and ethnic minorities, by including faculty and staff from an 1890\'s land grant institutions and students/staff from many countries and backgrounds in our research and outreach activities. Changes/Problems:Many of our field trials and some greenhouse and lab trials were behind due to the COVID-19 pandemic, and we were behind on our outreach activities because of this as well. However, over the past year we have been able to make up for these delays and achieve our goals with our one-year extension of the project. Our breeding program has also not advanced as rapidly as we\'d hope since our germplasm did not do as well in the Midwest as we had hoped. However, we are exploring new ways to overcome this challenge, including bringing in new germplasm from other programs. What opportunities for training and professional development has the project provided?One post-doctoral research associates, several graduate and undergraduate students, and visiting scholars continued to build their knowledge and skills needed to conduct greenhouse, lab, and field trials associated with soil health, disease dynamics and plant breeding. Students also gained skills presenting and publishing the results of their research trials How have the results been disseminated to communities of interest?Results were communicated to stakeholders across the country during field days, scientific and grower-oriented conferences, and virtual meetings (ie. webinars). Results are also being summarized in peer-reviewed publications. What do you plan to do during the next reporting period to accomplish the goals?We will continue conducting laboratory, greenhouse and field trials to meet the objectives in our three focus areas. This will include on-going efforts to quantify critical factors responsible for generating disease suppressive soils, integrate ISR into tomato breeding programs, and screen for foliar pathogen resistance using genetic markers and visual observations. We expect to submit at least 3 scientific publications covering results of our research in the next year. Impacts What was accomplished under these goals? Goal #1: Identify key factors mediating disease suppressive soil and survival and efficacy of bio-pesticides: We have continued conducting trials to identify composts, and what factors about them (ie. feedstocks and processing conditions), influence their capacity to support beneficial microbes with pathogen suppressive activity and reduce foliar diseases in tomato. This has included efforts to characterize the microbiomes of these composts, asw how they alter soil and tomato root and foliar microbiomes. Trials were conducted in the greenhouse, field, and in Purdue\'s new controlled environment phenotyping facility. At the same time, we have been conducting trials to understand how these soil amendments alter root exudate profiles with the goal of better understanding why tomato differ in their responsiveness to induced systemic resistance (see objective 2). Preliminary results of these trials have been summarized in student thesis and presented at national meetings. New studies investigating the potential for nanoemulsions derived from essential oils to suppress foliar disease in tomato were initiated, along with studies to quantify how these nanoemulsions alter tomato microbiomes, and what role this could have in the pathogen suppressive activity observed. Goal #2: Integrate selection for beneficial plant-microbial relationships that help suppress disease into a tomato breeding programs: We completed trials investigating whether induced systemic resistance (ISR) can be transmitted to progeny via epigenetic changes. Since we do have evidence that indeed, this induction can be transmitted to progeny via seed, follow up studies to better understand the mechanisms are underway. We also continued to advance the development of four recombinant inbred lines (RILs) that were designed to help us identify markers and mechanisms associated with ISR responsiveness. For this project, we also optimized our protocols to quantify ISR responsiveness in the F2 populations from the crosses used to generate these RILs, so we can determine whether we can identify markers to predict selection for this trait, which was make it much easier and more efficient to integrate into breeding programs. This included identifying protocols to clone individual plants since plants in the F2 population are segregating and we need clones to compare genetically identical plants inoculated or not with our ISR inducer (Trichoderma harzianum). Next we evaluated ISR responsiveness in one of our F2 populations developed from our crosses to create RILs in the greenhouse using our new protocol. Plant tissues were collected from each of the individual plants in the population, DNA was extracted and PCR amplified, and the products are now being sequenced using a genotype by sequencing (GBS) approach at the University of Wisconsin Biotechnology Center. We also initiated new trials using grafting to determine if the ISR signal can be transmitted from responsive rootstocks to non-responsive scions. This will also allow us to further understand the mechanisms behind genetic differences in ISR responsiveness, and if it works, enhance resistance to foliar pathogens now by grafting valuable scions onto responsive rootstocks that do not contain desirable fruit quality traits. Finally, we have followed up with trials investigating differences in root exudate profiles between -ISR responsive and non-responsive genotypes, with the goal of understanding how these important mediators of root microbiomes play a role in ISR responsiveness, as well as how whole microbiomes rather than just the inducer we have been testing are involved in this phenomena. Goal #3: Develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and participatory breeding: We have continued to advance crosses from our breeding program and evaluate the progeny in field trials across the country. In 2023 trials of the TOMI tomato breeding populations were conducted in WA, CA, OR, WI, and in two locations in NC. These trials were randomized complete block designs and included 8 F4 breeding populations advanced from previous generations, two early blight resistant breeding lines from Cornell University, and two commercial standard check varieties. Data recorded as part of the trials included transplant survival; growth habit; disease incidence and severity when observed for Septoria leaf spot, late blight, early blight, bacterial speck, bacterial spot, and verticillium; marketable and unmarketable count; marketable and unmarketable weight; flavor; Brix; and acidity. Photos and descriptive notes were taken. Seed was saved at each site based on performance from selected individual plants in selected families. Data are being compiled and reviewed to support decisions around which families to advance to 2024 trials. Due to the poor performance of many lines in the midwest for resistance to septoria and early blight (we have particularly bad disease pressure here), we are exploring methods of pyramiding multiple qualitative and quantitative sources of resistance. In addition, many varieties released with some resistance in other regions have poor flavor under our conditions and so new varieties combining better flavor and disease resistance need to be developed if Midwestern organic farmers are to benefit from them. In partnership with Martha Mutchler (Cornell University, Emeritus) and Mark McCaslin (Frogsleap Farm), we have been testing new sources of major gene resistance to Septoria leaf spot and early blight. These sources of resistance were identified by Martha Mutchler and incorporated into commercially viable germplasm at Cornell. We have used these sources of resistance in crosses designed for the upper midwest and are testing molecular markers designed to track the resistance alleles in these populations and determine whether resistance requires the resistance allele to be homozygous or if it also works in a heterozygous state. We conducted our first field trial in 2022 and repeated the experiment in 2023, focused primarily on validating the markers for Septoria resistance and obtaining enough data to determine the dosage effect (whether heterozygous lines show sufficient resistance to be commercially viable, or whether homozygosity for the resistant allele is required). Preliminary results show that one of the septoria resistance QTL must be homozygous for the resistance allele while the other shows dominance and can be effective in the heterozygous state. For the early blight markers, one is not showing significant differences between classes, which may be due to having a mild year for early blight infection, or to the change in genetic background making the marker less tightly linked to the putative QTL. The second early blight marker was not polymorphic in Midwest germplasm and so we are working to develop a marker that will be polymorphic in our germplasm and still tightly linked to the QTL. Segregation ratios for F2 progeny of crosses where one parent had that putative QTL did display the expected patters for a major effect gene, but the marker we have is not segregating. We conducted a greenhouse assay with Wisconsin isolates of early blight to determine whether we could overcome heterogeneous field infection to determine the dosage effects of the first resistance source, and develop a second marker more tightly linked to the resistance allele from the second source. Publications Type: Other Status: Published Year Published: 2023 Citation: Kemble, J.M., senior editor. (multiple authors from the Southeast, including J.M. Davis) 2023. Southeastern US Vegetable Production Handbook. Type: Other Status: Published Year Published: 2023 Citation: Egel, D., Adair, A., Hoagland, L., 2023. Efficacy of selected fungicides listed for organic production for tomato disease management. https://eorganic.org/node/35737 Type: Conference Papers and Presentations Status: Published Year Published:

2023 Citation: Feiler, E., Sanchez, M., Hoagland, L., 2023. Relationship between compost microbiome and induction of induced systemic resistance in tomato. Agronomy, Crop Science, Soil Science Societies International Meeting, St. Louis, MO. Type: Theses/Dissertations Status: Submitted Year Published: 2024 Citation: Naomy Perez (Zamorano University) Senior Thesis Project: Microbiome changes associated with tomato grafting Type: Theses/Dissertations Status: Awaiting Publication Year Published: 2024 Citation: Esteban Villamizar (National University of Colombia-Bogota) Senior Thesis Project: Can grafting on wild rootstocks transfer induced systemic resistance in tomato Type: Websites Status: Published Year Published: 2023 Citation: 2023 Efficacy of fungicides for organic tomato production https://newcropsorganics.ces.ncsu.edu/2023/10/efficacy-of-fungicides-for-organic-tomato-production/ **Progress** 09/01/21 to 08/31/22 **Outputs** Target Audience:The target audience for this project includes organic and conventional vegetable growers, marketers, and consumers; personnel at vegetable seed companies and organic biopesticide companies; scientists and students in horticulture, plant breeding, plant pathology, and soil science; as well as Extension educators and others involved in outreach to vegetable growers such as personnel at the NRCS and SWCD. In all cases, efforts were made to reach underrepresented audiences in agriculture, such as racial and ethnic minorities, by including faculty and staff from an 1890's land grant institutions and students/staff from many countries and backgrounds in our research and outreach activities. Changes/Problems:Many of our field trials and some greenhouse and lab trials are behind due to the COVID-19 pandemic preventing us from making progress during 2020. However, we have since been able to get back on track with most of our research activities. We are also behind in conducting many of our outreach activities, but expect to be able to ramp back up over the next year. What opportunities for training and professional development has the project provided? Several post-doctoral research associates, graduate students, undergraduate students, faculty and staff learned how to conduct greenhouse, lab, and field trials associated with soil health, disease dynamics and plant breeding. Students also gained skills presenting and publishing the results of their research trials. How have the results been disseminated to communities of interest? Results were communicated to stakeholders during field days, scientific and grower-oriented conferences, and virtual meetings (ie. webinars), though we have still not been as active in these events as planned due to some continued restrictions associated with the COVID pandemic. However, we expect to be back at full capacity during 2023. Results were also formally published in one peer-reviewed journal article, and several additional articles are in preparation and will be submitted for publication in 2023. Finally, the results of several of our recent publications were picked up by the popular press and further reported by others and via media interviews. (see other products and other products/outputs sections for further details) What do you plan to do during the next reporting period to accomplish the goals? We will continue conducting laboratory, greenhouse and field trials to meet the objectives in our three focus areas. This will include on-going efforts to quantify critical factors responsible for generating disease suppressive soils, integrate ISR into tomato breeding programs, and screen for foliar pathogen resistance using genetic markers and visual observations. We expect to submit at least 3 scientific publications covering results of our research in the next year. **Impacts** What was accomplished under these goals? Goal #1: Identify key factors mediating disease suppressive soil and survival and efficacy of bio-pesticides: Several greenhouse projects were conducted to evaluate the potential for 10 different types of compost amendments to boost tomato growth and induce systemic resistance (ISR) against foliar pathogens (ie. Botrytis cinerea) in tomato plants. Follow-up experiments were conducted in the laboratory to identify microbial communities present in the compost and/or stimulated in the soil in response to the compost that could have contributed to the plant growth promoting and pathogen suppressive capabilities of some composts using culture dependent and independent assays, and various bioinformatic and statistical programs. Individual microbial isolates that could be cultured from the roots of plants in these studies were also subject to laboratory assays to quantify their pathogen suppressive capabilities. Soils from 18 farms across the state of Indiana were also characterized using a range of soil physical, chemical and biological assays, and the pathogen suppressive capabilities of these soils was evaluated using microcosm studies in the laboratory. Follow-up studies to quantify relationships between soil management practices, soil characteristics, and pathogen suppressiveness are underway. Goal #2: Integrate selection for beneficial plant-microbial relationships that help suppress disease into a tomato breeding program: We have continued to conduct follow-up studies from ISR responsive and non-responsive germplasm identified in TOMI1 to identify mechanisms responsible for the variability in the ISR response. This has included greenhouse and laboratory assays to quantify differences in root metabolomic profiles and how this correlates with the capacity to recruit and host individual microbial taxa in tomato roots that can directly suppress pathogens via antibiotic/antifungal capabilities, and indirectly via ISR. We have also evaluated results of our RNA-seq studies and determined that auxin and flavonoid pathways are critical to ISR-responsiveness. Finally, we determined that in some genotypes, the ISR response can be transferred to the plant's offspring, and this appears to be related to changes in global methylation. Plant material from these studies was submitted for Whole-Genome Bisulfide sequencing to determine which genes are methylated. The results of these studies have important implications for future efforts to breed for this trait and propagate seeds with better disease resistance. In an effort to begin actively breeding for ISR, we conducted preliminary trials using tomato genotypes in our new TOMI2 breeding programs. Lines that had varying ISR responses when first inoculated with Trichoderma harzianum to induce

ISR, then challenged with either of the pathogens Botrytis cinerea or Phytophthora infestans were selected for further studies. In particular, six lines were selected and crossed to produce four populations. These are Mountaineer Pride x LB21-7-4, Mountaineer Delight x LB21-7-4, NC1LF x OSU1815 and Thatchmore Farm 18F1 x LB21-7-4. The first two crosses were created to study the ISR response to B cinerea, where LB21-7-4 shows a positive ISR response and Mountaineer Pride and Delight show negative responses. The second two crosses were created to study the ISR response to P. infestans. In this case, Thatchmore Farm 18F1 and OSU1815 both have positive ISR responses while NC1LF and LB21-7-4 have negative responses. The F1 was advanced to the F2 generation in 2021. From these, 175-190 individuals per population were selected and advanced by single seed descent (SSD) to the F3 generation during the spring and summer of 2022. We did suffer some plant loss in the greenhouse due to B. cinerea infection, but plants were replaced during summer 2022 from remnant seed. The final production from all of the replants are expected to be harvested for F4 seed in January-February 2023. Total number of F4 individuals generated is expected to be \~200 NC1LF x OSU1815, \~180 Thatchmore Farm 18F1 x LB21-7-4, \~150 Mountaineer Delight x LB21-7-4, and \~100 Mountaineer Pride x LB21-7-4. All harvested F4 seed will be planted in the field in Spring/Summer 2023 and F5 seed harvested in the Fall. Our plan is to advance by SSD to the F5 generation to achieve a high level of homozygosity, then generate families for phenotypic and genotypic evaluation in replicated trials. A population of 200 seeds from one of these crosses (Mountaineer Delight x LB21-7-4) was grown in the greenhouse at Purdue, and each individual plant was cloned for subsequent ISR testing. Plant material from each plant was flash frozen for gene expression studies using RT-qPCR with select genes to verify differences in ISR responsiveness. Plant material was also stored for future efforts to extract DNA and sequence each plant to try and identify alleles associated with ISR responsiveness. Goal #3: Develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and participatory breeding: Crosses, laboratory and genetic evaluations - At the start of TOMI2, we made 30+ new crosses between existing TOMI breeding material and Alternaria donor lines in greenhouses at OSU by Myers and Davis. Some of these crosses performed well in trials in our field trials on the west coast, but not in the Midwest or Southeast. Thus, new TOMI breeding material and donor lines were screened for Alternaria resistance in greenhouse pathogen trials by Purdue plant pathologist Dan Egel, and the most promising lines will be included in new crosses during 2023. In addition, Dawson has begun exploring methods of pyramiding multiple qualitative and quantitative sources of resistance in partnership with Martha Mutchler (Cornell University, Emeritus) and Mark McCaslin (Frogsleap Farm). This has included testing new sources of major gene resistance to Septoria Leaf Spot and Early Blight. These sources of resistance were identified by Martha Mutchler and incorporated into commercially viable germplasm at Cornell. We have used these sources of resistance in crosses designed for the upper Midwest and are testing molecular markers designed to track the resistance alleles in these populations and determine whether resistance requires the resistance allele to be homozygous or if it also works in a heterozygous state. Preliminary results show that one of the Septoria resistance QTL must be homozygous for the resistance allele while the other shows dominance and can be effective in the heterozygous state. For the early blight markers, one is not showing significant differences between classes, which may be due to having a mild year for early blight infection, or to the change in genetic background making the marker less tightly linked to the putative QTL. The second early blight marker was not polymorphic in Midwest germplasm and so we are working to develop a marker that will be polymorphic in our gemplasm and still tightly linked to the QTL. Segregation ratios for F2 progeny of crosses where one parent had that putative QTL did display the expected patterns for a major effect gene, but the marker we have is not segregating. Field trials - 40 entries (TOMI parental lines, crosses and potential donor lines) were evaluated for Alternaria and other foliar diseases in California, and 4 entries in Washington for marketable and unmarketable yield, sweetness, acidity, overall flavor, and disease resistance. Several entries stood out for their combination of high yield, good flavor and foliar disease resistance, includingLB55-23 x Galahad, Damsel x NC1LF, NC1LF x OSU1815, andMountaineer Pride x LB55-23, and will continue to be evaluated on the west coast in future years. Field trials in the Midwest and Southeast were suspended during 2022 until new crosses are available to trial during summer 2023. **Publications** - Type: Journal Articles Status: Published Year Published: 2022 Citation: Richardville, K., Egel, D., Flachs, A., Jaiswal, A., Perkins, D., Thompson, A., Hoagland, L., 2022. Leaf mold compost reduces waste, improves soil and microbial properties, and increases tomato productivity. Urban Agriculture and Regional Food Systems. doi.org/10.1002/uar2.20022. - Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: \" Hoagland, L., Colley, M., Davis, J., Dawson, J., Formiga, A., Gu, S., Jaiswal, A., McCluskey, C., Myers, J., Richardville, K., Qu, L., Zystro, J., 2022. The TOMI project: updates and on-going efforts to mitigate disease outbreaks in organic tomato crops. American Society of Horticultural Science Annual Meeting, Chicago, IL. - Type: Other Status: Published Year Published: 2022 Citation: Leaf mold compost shows benefit for tomato plants in degraded urban soils. Soil Science Society of America Science News. https://www.soils.org/news/science-news/leaf-mold-compost-shows-benefit-tomato-plants-degraded-urban-soils/#:\~:text=The%20plants%20that%20received%20leaf,help%20plants%20withstand%20disease%20pressure. - Type: Other Status: Published Year Published: 2022 Citation: Lori Hoaglands research on beneficial soil and plant microbiomes. High Mowing Organic Seed Catalog. https://www.highmowingseeds.com/blog/2022-catalog-beneficials-part-2/ - Type: Theses/Dissertations Status: Published Year Published: 2022 Citation: Quantifying the impact of compost composition and quality on induced systemic resistance in tomato (Maria Sanchez Feb. 2022) - Type: Theses/Dissertations Status: Published Year Published: 2022 Citation: Relationships between compost microbiomes and tomato resilience against foliar diseases (Nelsy Arboleda Aug. 2022) **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:The target audience for this project includes organic and conventional vegetable growers, marketers, and consumers; personnel at vegetable seed companies and organic biopesticide companies; scientists and students in horticulture, plant breeding, plant pathology, and soil science; as well as Extension educators and others involved in outreach to vegetable growers such as personnel at the NRCS and SWCD. In all cases, efforts were made to reach underrepresented audiences in agriculture, such as racial and ethnic minorities, by including faculty and staff from an 1890's land grant institutions and students/staff from many countries and backgrounds in our research and outreach activities. Changes/Problems:Many of our field trials and some greenhouse and lab trials are behind due to the COVID-19 pandemic preventing us from making progress during 2020. However, we have since been able to get back on track with most of our research activities. We are also behind in conducting many of our outreach activities, but expect to be able to ramp back up over the next year. What opportunities for training and professional development has the project provided? Post-doctoral research associates, graduate students, undergraduate students, faculty and staff learned how to conduct greenhouse, lab and field trials associated with disease suppression, soil health and plant breeding. Students also gained skills presenting and publishing the results of their research trials. How have the results been disseminated to communities of interest? Results were communicated to stakeholders during a few field days and virtual meetings held during spring and summer, though we have not been as active in these events as planned due to continued restrictions associated with the COVID-19 pandemic. Results were also submitted for publication in one scientific manuscript and one abstract. What do you plan to do during the next reporting period to accomplish the goals?We will continue conducting laboratory, greenhouse and field trials to meet the objectives in our three focus areas. We expect to submit at least 4 publications covering our ISR trials for publication. We also expect that while we will continue to conduct outreach activities to stakeholders in a virtual format given on-going restrictions around the COVID-19 pandemic, we will be able to hold more in person outreach activities over the next year. **Impacts** What was accomplished under these goals? Goal #1: Identify key factors mediating disease suppressive soil and survival and efficiacy of bio-pesticides: Results of our two-year field trial evaluating the capacity for a leaf mold compost to boost beneficial soil microbials and support a beneficial microbial antagonist and suppress foliar diseases in tomato was accepted for publication in a scientific journal. We also initiated follow up greenhouse trials using this leaf mold compost as well as several other types of locally derived composts generated from different feedstocks. We are currently quantifying microbial communities in these composts and their capacity to suppress foliar diseases in greenhouse trials. We continued optimizing procedures for greenhouse pathogen bioassays to evaluate disease suppressive soil using Rhizoctonia solani and Fusarium oxysporum f. sp. radicis-lycorsici for upcoming experiments using soil collected from our breeding trials collected during summer 2021 (see below). Goal #2: Integrate selection for beneficial plant-microbial relationships that help suppress disease into a tomato breeding programs: We finished evaluating results from our RNA-seq, microbiome and root metabolomic studies in responsive and unresponsive tomato genotypes to ISR to quantify potential mechanisms and working on four manuscripts covering theses results.We completed studies quantifying ISR responsiveness against two foliar pathogens in the 10 parent genotypes we are using for our breeding program (see below), and we are currently planning follow up studies that will allow us to use GBS sequencing data of these parental lines to try and predict ISR responsiveness in our progeny. We also initiated our trials to quantify whether ISR responsinvess induced by beneficial soil microbes can be inherited based on epigenetic studies. Goal #3: Develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and participatory breeding: Crosses derived from the 10 new parental genotypes being used in our TOMI2 breeding program were grown and evaluated in field trials inOregon, California, Washington, Wisconsin, and two sites in North Carolina alongside commercial lines. Plants were evaluated for disease, yield and flavor. Seeds were selected from the most promising lines and sent to OSU where they will be selfed this winter to generate F3's and screened using markers for major disease genes using leaf disks to narrow down our breeding populations. **Publications** - Type: Journal Articles Status: Awaiting Publication Year Published: 2021 Citation: Richardville, K., Egel, D., Flachs, A., Jaiswal, A., Perkins, D., Thompson, A., Hoagland, L., (in press). Closing the loop in the city: leaf mold compost improved soil properties, supported beneficial microbe and increased tomato productivity. Urban Agriculture and Regional Food Systems.

PROGRESS

2019/09 TO 2020/08 Target Audience:The target audience for this project includes organic and conventional vegetable growers, marketers, and consumers; personnel at vegetable seed companies and organic biopesticide companies; scientists and students in horticulture, plant breeding, plant pathology, and soil science; as well as

Extension educators and others involved in outreach to vegetable growers such as personnel at the NRCS and SWCD. In all cases, efforts were made to reach underrepresented audiences in agriculture, such as racial and ethnic minorities, by including faculty and staff from an 1890\'s land grant institutions and students/staff from many countries and backgrounds in our research and outreach activities. Changes/Problems:The COVID-19 pandemic prevented us from being able to evaluate breeding material in Wisconsin and North Carolina. It also prevented us from being able to sequence our parent lines at UW-Madison, conduct on-farm biopesticide trials, or quantify the microbiome and disease suppressive capacity of the soils at our breeding nurseries. Finally, we were unable to conduct in person field days or workshops during summer 2020 and we decided to delay our on-line activities such as lunch room chats, due to on-line meeting fatigue by many in the farming community. As such, we expect to apply for a one year no-cost extension to ensure we can meet the activities planned in our proposal. What opportunities for training and professional development has the project provided?Post-doctoral research associates, graduate students, undergraduate students, faculty and staff learned how to conduct greenhouse, lab and field trials associated with disease suppression, soil health and plant breeding. Students also gained skills presenting and publishing the results of their research trials. How have the results been disseminated to communities of interest?Results were communicated to stakeholders atfield days during fall 2019 and grower oriented meetings during winter prior to the COVID-19 pandemic. Starting in March 2020, all outreach activities were moved on-line and disseminated to stakeholders via webinars, pod-casts and on-line meetings. Results were also submited for publication in one scientific manuscript, conference proceedings and abstracts. Finally, activities associated with the project were communicated via popular press news articles. What do you plan to do during the next reporting period to accomplish the goals?We will continue conducting lab, greenhouse and field trials associated with each of our three project objectives and expect to submit several new scientific publications based on our research associated with biological control of pathogens and ISR. Our breeding plans were delayed due to the COVID-19 pandemic during summer 2020, though we expect to be able to get back on track with these trials during 2021. Finallly, we expect to be able to get back on track with outreach activities, including in person field days and workshops once conditions associated witht the COVID-10 pandemic allow.

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? Goal #1: Identify key factors mediating disease suppressive soil and survival and efficiacy of bio-pesticides:The second year of a field trial in West Lafayette, IN was completed evaluating the potential for a leaf mold compost amendment to better support the survival and efficacy of a beneficial microbial antagonist(Trichoderma harzianum) in the field was completed. This trial also evaluated whether the survival and efficacy of this microbial inoculant would vary based on two tomato genotypes that varied in the potential to support this microbe in greenhouse trials. The effects of these treatments on many indicators of soil health, transplant survival, vigor, disease incidence and severity, yield and quality of tomato fruit was quantified. Results of this two year field trial were summarzied in a master\'s thesis, and were shared in an on-line webinar. We also obtained pathogen isolates and begin optimizing procedures for greenhouse pathogen bioassays to evaluate disease suppressive soil using Rhizoctonia solani and Fusarium oxysporum f. sp. radicis-lycorsicifor upcoming experiments. Goal #2: Integrate selection for beneficial plant-microbial relationships that help suppress disease into a tomato breeding programs:We finished evaluating results of trials quantifying differences in responsiveness to induced systemic resistance against two foliar pathogens (Phytophthora infestans and Botrytis cinerea) by Trichoderma harzianum, in 26 tomato genotypes representing a range of domestication. A scientific manuscript covering these trials was accepted for publication. We have also begun evauating results of follow up RNA-seq, microbiome and root metabolomic studies in responsive and unresponsive tomato genotypes to ISR to quantify potential mechanisms. We obtained the 10 parent genotypes from our new tomato breeding program and prepared for ISR trials to quantify their responsinvess. Finally, preliminary trials were conducted to prepare for upcoming epigenetic studies associated with ISR. Goal #3: Develop new disease resistant tomato varieties that have great flavor and are best adapted to local farming systems using genomic selection and participatory breeding:10 tomato genotypes were selected for use as parents in our new breeding program. The crosses were made at OSU, and grown in replicated trials during summer in Oregon, California and Washington alongside commercial lines. Plants were evaluated for disease, yield and flavor. Some additional crosses were made and seed was saved from F1s. Breeding nurseries in Wisconsin and North Caroline were not conducted this summer due to restrictions associated with the COVID-19 pandemic. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 1. Type: Journal Articles Status: Awaiting Publication Year Published: 2021 Citation: Jaiswal, A., Mengiste, T., Myers, J., Egel, D., Hoagland, L. (in press). Tomato domestication has attenuated responsiveness to a beneficial soil microbe for plant growth promotion and induction of systemic resistance to foliar pathogens. Frontiers in Microbiology. 2. Type: Conference Papers and Presentations Status: Accepted Year Published: 2021 Citation: Hoagland, L., Bloomquist, M., Colley, M., Davis, J., Dawson, J., Egel, D., Formiga, A., Fulk, R., Gu, S., Jaiswal, A., McCluskey, C., McKenzie, L., Mengiste, T., Myers, J, Qu, L, Zystro, J., 2020 (postponed to 2021). Tomato Organic

Management and Improvement (TOMI) Project. Proceedings Organic World Congress, Rennes, France. 3. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2020 Citation: Jaiswal, A, Hoagland, L., 2020. Does domestication impact the metabolome and microbiome of tomatoes? American Society for Microbiology Annual Meeting, Chicago, IL 4. Type: Conference Papers and Presentations Status: Other Year Published: 2019 Citation: Hernandez, M., L. Hoagland, Beck N. Cerruti, M. Colley, J. Davis, J. Dawson, ,D. Egel, ,B. Emerson, ,S. Gu, L. Zubieta Hernandez. ,T. Jones, ,C. McCluskey, L. Mckenzie, T. Mengiste, J. Myers, L. Qu,, J. Zystro. 2019. Evaluating TOMI for foliar pathogen in Pacific Northwest. National Association of Plant Breeders meeting, Table Mountain, GA 8/24-8/29/19. (poster) 5. Type: Theses/Dissertations Status: Awaiting Publication Year Published: 2021 Citation: Richardville (2020). Overcoming barriers in urban agriculture to promote healthy eating on college campuses. M.S. Thesis, Purdue University. 262p. 6. Type: Other Status: Published Year Published: 2019 Citation: Southeast FarmPress, Initiative to create organic tomatoes that resist disease, taste good, 11/23/2019, <https://www.farmprogress.com/vegetables/initiative-create-organic-tomatoes-resist-disease-taste-good>. 7. Type: Other Status: Published Year Published: 2019 Citation: AgriView, Organic-tomato research boosted 12/9/2019, <https://www.agupdate.com/agriview/briefs/crop/organic-tomato-research-boosted/articlee5f9efab-0c8f-5e27-9577-fee27292d16a.html>. 8. Type: Other Status: Published Year Published: 2019 Citation: OSA Blog, New Organic Tomatoes & Disease Management Tools Coming Soon, 11/19/2019, <https://seedalliance.org/2019/new-organic-tomatoes-disease-management-strategies-coming-soon/>. 9. Type: Other Status: Published Year Published: 2019 Citation: OSA Blog, Research Award Will Focus on Helping Organic Tomato Growers Better Manage Diseases, 11/21/2019, <https://seedalliance.org/press/tomi2-announcement/>

↑ Return to Index

Integrating Vegetable, Poultry, and Cover Cropping to Enhance Resiliency in Organic Production Systems

Accession No.	1020515
Project No.	IOW05589
Agency	NIFA IOW\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30244
Proposal No.	2019-03101
Start Date	01 SEP 2019
Term Date	31 AUG 2023
Grant Amount	$1,998,589
Grant Year	2019
Investigator(s)	Nair, A.; Delate, KA.; Dickson, JA, S.; Ahn, DO, D.; Mitchell, JE, P.; Shaw, AN, MA.; Pitesky, MA.; McDaniel, MA.; Bobeck, EL, A.; Plastina, AL, S.
Performing Institution	IOWA STATE UNIVERSITY, 2229 Lincoln Way, AMES, IOWA 50011

NON-TECHNICAL SUMMARY

Organic producers everywhere are striving for closed, integrated organic farms, relying on on-farm or locally produced inputs as much as possible to meet crop and livestock needs for food and nutrition. Building or maintaining soil C and N pools for subsequent crop use is an important consideration in developing sustainable systems. Integrated crop-livestock systems will ensure organic farming resilience and economic viability while contributing to conservation of limited resources, establishing healthy soils, and reducing off-farm input. Integration of crop and livestock production is highly sought after but there are concerns about contamination and food safety implications. There is limited information on the presence and abundance of soil-bound pathogens, such as and Salmonella, in pasture-raised poultry systems and how regional weather patterns affect contamination. This project will create new knowledge in that area and develop safe crop-animal integrated systems that lead to diverse crop rotation, enhance animal health, productivity, and welfare, and improve overall farm profitability of organic growers. Successfully integrated crop-poultry production will increase soil quality and fertility while reducing off-farm input and enhancing on-farm diversity. For development of a sustainable integrated system, an in-depth economic analysis is needed to compare existing crop-only organic systems with crop-livestock integrated systems. To help growers better understand the economics the project will create enterprise and partial budgets, sensitivity analysis, and decision-making tools that assist with whole farm planning and income projections. The field and laboratory studies of this project will train graduate and undergraduate students and provide Cooperative Extension personnel opportunities to realize the importance of on-farm diversity. This project will constitute an advisory panel (growers, industry leaders, and processors) that will assist in implementation, evaluation, and disseminating project results and outcomes. Grower and industry outreach will include information dissemination through existing sustainable agriculture websites, blog, on-farm trials, field days, and trade journal articles.

OBJECTIVES

The overall goal of this multi-regional (IA, KY, and CA) four-year project is to assist organic vegetable producers better integrate poultry and cover crops in their rotations. Crop, animal, and cover crop integration, along with diverse crop rotations will increase soil quality, reduce off-farm input, increase farm diversity and profitability. This project will also investigate food safety, meat quality, and wellness attributes in plant-animal integrated systems. Field objectives - 1) Evaluation of vegetable, cover crop, and bird performance in integrated organic production system, and 2) Investigation of impact of integrated systems on soil health indicators (physical, chemical, and biological properties, weed population, etc.) and pest management - meet priorities of organic producers. Given current updates in Food Safety Modernization Act, this project will provide baseline analysis of microbiological load and concentrations (Salmonella) in crop-poultry integrated system. We will also conduct economic analysis of integrated crop-poultry system and compare it with existing practice of strictly raising vegetable crops. Economic analysis outputs would include enterprise and partial budgets, sensitivity analysis, and decision-making tools that assist whole farm planning and facilitate grower adoption of integrated organic systems. The field and laboratory studies of this project will train graduate and undergraduate students and provide Cooperative Extension personnel opportunities to realize the importance of on-farm diversity. Based on input from organic producers we conducted a preliminary trial in 2017, which validated the feasibility of establishing an integrated system. This project will constitute an advisory panel (growers, industry leaders, and processors) that will assist in implementation, evaluation, and disseminating project results and outcomes. Grower and industry outreach will include information dissemination through existing sustainable agriculture websites, blog, on-farm trials, field days, and trade journal articles

APPROACH

The study will be conducted on certified organic crop land at university research stations in Iowa, Kentucy, and California. At the research station the experimental design will evaluate: i) vegetable and cover crop performance in integrated systems to monitor produce yield, quality and establishment and biomass attributes of cover crop species, ii) bird performance/productivity and wellness assessments in broilers under pasture-based production, and iii) compare meat quality/nutritional characteristics between pastured-birds and birds raised indoors under organic production systems. Making these observations and comparisons across four years in three geographic regions with sharply differing weather patterns and growing conditions will broaden applicability and adoptability of project results. On-farm trial will also be set up at grower plots. The experimental design will flexible at grower plots to accommodate grower resources and schedule. We will evaluate and assess growth and performance of vegetables, birds, and cover crop under the following three rotation treatments:1. Vegetable (spring) - chickens (summer) - cover crop (fall)2.Vegetable (spring) - cover crop (summer) - chickens(fall)3. Vegetable (spring) - cover crop (summer) - vegetable (fall)For Treatment 1, 2, and 3 vegetable cropswill be transplanted in April. Another set of planting for Treatment 3 will take place in early August. Each treatment will be a 30 ft. × 30 ft. plot and include five rows of vegetables. Weeds will be managed using straw mulch. Vegetable growth data collected at all three locations (IA, KY, CA) will include plant height, stem diameter (crop dependent), leaf area, nutrient concentration in tissues, and amount of vegetable residue left after harvest. Plant height and stem girth will be collected three times during the growing season (early, mid, harvest), while leaf area, tissue nutrient concentration, and vegetable residue will be collected at harvest. Vegetable yield and quality data will be collected at harvest and will include marketable and non-marketable yield, insect and disease damage, fruit firmness, and total soluble solutes (wherever applicable).Cover crop data collection will include above ground biomass (two sub samples per rep/treatment using two 50 × 50 cm quadrats). Cover crop biomass will be dried at 60 °C to determine dry weight and later ground for nutrient analysis (C and N). Cover crop data for treatment 1 and 3 will be collected each year-end of October and beginning of August, respectively. For treatment 1 cover crop data will be collected right before the introduction of chickens to the plot. Chickens will be raised at the Poultry Research Facility in IA, KY, and CA for 2 weeks before being introduced to the vegetable or cover crop plots (Treatment 1 & 2). Chicks will be raised strictly under organic standards (NOP Final Rule Section 205.236; feed, sanitation, living conditions, etc.). They will be moved to the plots at three weeks and housed in 5 ft × 4 ft × 3 ft chicken tractors (coops with no floor that are moved around the pasture).The use of chicken tractors aids in more even distribution of nutrients, provides birds with fresh forage daily, and prevents destruction of the cover crop/pasture from over-foraging and scratching. Each chicken tractor will be stocked with 10 birds providing a stocking density of 2 ft2/bird, which is higher than the standard (1.5 ft2/bird), set by the American Pastured Poultry Producers Association (APPPA). The breed Red Ranger will be used because of its adaptability to pasture-based system. Birds will receive an organic feed ration; a starter ration followed by a finisher ration and water ad libitum. Focal birds will be individually wing-banded for identification during the study, and then placed on a digital gram scale, weighed at the start of the experiment, and at each performance period for the duration of the 9-week experiment. At the end of the trial, birds will be transported to a nearby organically certified poultry processor (KB Poultry, LLC, Utica, MN for IA). University of Kentucky samples will be sent to Iowa State University for analysis. Two of the carcasses from each treatment/replication will be used for microbial study (carcass rinse) and the rest will be used for carcass yield and meat quality measurement. Soil and cover crop samples will be taken from the field four times per year (i.e., April, June, August, and October). Boot swab sampling techniques will be utilized to collect soil and cover crop samples for analysis of Salmonella. This method is simple, safe, cost-effective and user-friendly for assessment of Salmonella prevalence in poultry flocks. Boot swabs will be utilized in a z-sampling pattern to determine Salmonella presence. For chickens raised indoors, floor residue samples from their pens will be collected before and after the chickens are placed into treatment. There will be 4 pseudo-replications or plots within each treatment and 3 treatments at each of the sampling time periods (12 plot/rotations) in the field. Soil and cover crop samples (1 of the sample type per time) will be taken within each of these 12 plot/rotations at the 4 times per year (April, June, August, and October) (n=48 samples per year/site or 576 samples total).An integral data collection system of actual expenses and labor and machinery use will be developed and implemented across the three locations to calculate enterprise budgets and estimate the cost per pound of vegetable and chicken meat produced in each plant-animal system. Enterprise budgets will account for actual expenses incurred in the production of each vegetable crop, cover crop and poultry, as well as the opportunity cost of own labor, management time, and machinery use (if any). Partial budgets will be developed to analyze the changes in costs and revenues associated with the introduction of poultry into a crop-only system to assess the economic viability of switching practices of current organic vegetable producers. To estimate the profitability of each production system, local prices for organic vegetables and organic chicken meat will be tracked and imputed to the budget analyses after adjusting them to the farm gate level (accounting for transportation, farmers market fees).The project will constitute an advisory panel (growers, industry leaders, and processors) that will assist in implementation, evaluation, and disseminating project results and outcomes (Objective 5). Grower and industry outreach will include information dissemination through existing sustainable agriculture websites, blog, on-farm trials, field days, and trade journal articles. Progress 09/01/19 to 08/31/24 Outputs Target Audience:The target audience included organic vegetable growers, growers practicing pastured poultry, extension staff, local food coordinators, Master Gardeners, Food Systems working group professionals, high school FFA teachers, industry professionals, and agriculture stakeholders. Changes/Problems:Although the project start date was September 2019, project investigators received initial funding starting in March 2020 (due to the shifting of NIFA headquarters to Kansas City and other administrative issues). Due to the outbreak of the COVID-19 pandemic starting in March 2020, the project could not get started in full swing due to restrictions and shutdowns. The project did not start in California (UC Davis) due to the complete lockdown, although Iowa and Kentucky were able to start the project on a scaled-down version. But from 2021 onwards, there were no major issues, and the project progressed as planned. What opportunities for training and professional development has the project provided?The project provided training and professional development for fivegraduate students, two technical staff members, and 16 undergraduate research assistants. Graduate students in Horticulture, Animal Science, and Soil Science gained valuable insights about integrated systems and created theses and dissertations. Their training opportunities included field experiment design, setting up of field and lab studies, data analysis, presentation at field days and grower conferences,preparation of manuscripts for publication, and authorship of outreach products, including extension publications. How have the results been disseminated to communities of interest?Results from the project have been disseminated through presentations, YouTube video clips,field days, webinars, andpresentingposters, and oral presentations at state, regional, andnational grower and scientific conferences. By addressing topics such as nutrient management, manure and compost, crop rotationand animal integration, chicken tractors, cover cropping, food safety, and poultry meat quality,the project increased growers\' knowledge of integrated systems. This resulted in changed behavior by growers reaching out to the project team forchicken tractor models, sketches, and design and incorporating cover crops in their systems. Specialty crop producers (100%) identified increased knowledge from attending Field Days, workshops, and short courses, which were organized as part of this project. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Integrating poultry with vegetable production and cover crops in an organic production system showed benefits to soil health, crop yields, and cover crop performance. Poultry integration increased the soil inorganic N, P, K, and other essential plant nutrients, supporting increases in vegetable crop yields and cover crop biomass. Although, concerns of excessive nutrient accumulation from poultry manure require further exploration. A summer cover crop included in the rotation further increased benefits from those provided by poultry integration alone, including decreasing weed populations, increasing earthworm abundance, and improving field-saturated hydraulic conductivity. Increasing on-farm diversity by integrating livestock and growing cover crops can provide substantial benefits to organic producers, reducing off-farm inputs and improving soil health. Integrating poultry in an organic vegetable production system did not lead to substantial changes in soil bacterial community composition, but increases in soil bacteria diversity were found. The abundance of bacteria at the phylum level stayed relatively consistent between poultry and no poultry plots, as well as the commonness of soil bacteria genera. Importantly, human pathogens Listeria and E. coli were not found in the soil following poultry integration, potentially made unviable by the cold Iowa winter. Explorations of the soil microbiome are complex and challenging, and fundamental questions remain to be answered. As technologies continue to advance and increase in accessibility, our understanding of the impact our management practices have on the soil microbiome will grow, deepening the need for advanced agroecological strategies. An experimental objective was to compare the performance, physiological, and economic outcomes of Freedom Ranger broilers raised in outdoor pastures versus conventional indoor settings. One hundred seventy-six slow-growing Freedom Ranger broilers were started in brooders for 21d, and then half were transferred to either indoor floor pens or outdoor chicken tractors for a 6-week grow-out cycle. Performance and welfare measures were recorded weekly. At d64, 40 birds per treatment were euthanized for tibia collection, and bone mineral density was analyzed by Dual-energy X-ray Absorptiometry (DXA). Under our research conditions, performance and welfare measures were not significantly affected by housing treatments, but bone mineral content and density were significantly increased by 37.9% and 15.4%, respectively, in the outdoor flock (P\<0.05). Assessment of meat quality of pasture-raised birdswas also a key objective of this study. The study utilized two breeds, Freedom Ranger and Ross 708 broiler chickens, to understand how meat quality differs when raised in integrated pasture systems versus traditional confinement systems. At three weeks old, 40 pullets of each breed were put onto pasture to graze on crop residue, while 40 were kept in confinement. At nine weeks, the meat quality was assessed. For Freedom Rangers, the rearing system used did not lead to any difference in carcass yield; however,pasture-raised birds hadhigher a* values in the thigh and b* values in the breast meat. These values are usedfor measuring meat color and represent the following: redness (a*),yellowness (b*), and lightness (L*). Both Freedom Ranger and Ross 708 breedsraised on pasturehad slightly higher levels of omega-3 fatty acids that can be beneficial to human health. The project extensively engaged growers, grower organizations, and stakeholders to create a robust extension and outreach program. Project team members delivered a number of presentations at grower meetings, professional meetings, and workshops and created YouTube videos, extension publications, and peer-reviewed journals. Numerous field days and grower conference presentations also shared the project\'s findings widely. Project evaluation was conducted in the final year, which focused on formative and outcome indicators to measure the extent to which the research team has coalesced, progress has been made towards research objectives, and outcomes met among target audiences. Methods included participant observation, partner interviews, outputs tracking, a survey of attendees at farmers conferences, a farmer survey, and a survey of ISU Fruit and Vegetable Field Day attendees. The following are highlights of the evaluation results: The research has successfully implemented similar research methods at three locations (IA, KY, and CA), yielding results of interest to farmers. All interviewees described the advisory board meetings, team meetings, and stakeholder engagement as pivotal experiences, bringing greater clarity for how to move forward. All interviewees said that working with a variety of disciplines has been the best part of working on this team. Growers appreciated direct access to researchers and their graduate students. Webinars, presentations, workshops, and field days were engaging and practical and taught growers the basic infrastructure to integrate poultry into vegetable systems. Growers highly rated the workshop that discussedhow to build chicken tractors. As a result of this project, organic vegetable growers in Iowa, Kentucky, and Californiahave gained a deeper insight into how poultry, vegetables, and cover crops can be effectively used as a rotation tool. Showing that integrated systems can be created without causing food safety risks was a game changer. Integrated systems can help ensure higher soil quality and health, a consistent marketable yield for vegetables, reduced off-farm inputs, and thereby opening new local market opportunities for organic produce. Publications Type: Peer Reviewed Journal Articles Status: Published Year Published: 2025 Citation: Anne M. Carey, C. Dutter, K. Mbacke, M.D. McDaniel, and A. Nair. 2025. Integrating poultry improves soil health and vegetable yield in organic, cover-cropped system. Agriculture Ecosystems & Environment 382. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Moriah T. Bilenky, Ajay Nair, Marshall D. McDaniel, Angela M. Shaw, Elizabeth A. Bobeck, and Kathleen Delate. 2024. Integrating pastured meat chickens into organic vegetable production increased nitrogen and microbial biomass with variability in presence of E. coli and Salmonella spp. Renewable Agriculture and Food Systems. 2024;39:e11. Type: Other Journal Articles Status: Accepted Year Published: 2025 Citation: Carey, A. and A. Nair. 2025. Evaluating ecosystem services of summer cover crop mixtures for organic cabbage production. Renewable Agriculture and Food Systems Type: Other Journal Articles Status: Published Year Published: 2024 Citation: Elmore, K., A. Nair, and E. Bobeck. 2024. Production, Bone Health, and Economic Comparison of Indoor versus Pasture-Raised Red Ranger Broilers. ISU Animal Husbandry Report Type: Other Status: Published Year Published: 2024 Citation: Carey, A. and A. Nair. 2024. Integrating poultry and vegetable production. Annual Conference of Practical Farmers of Iowa, Jan. 2024, Des Moines, IA. Type: Other Status: Published Year Published: 2024 Citation: Carey, A., A. Nair, and R. Calvey. 2024. Multi-species cover crop in vegetable cropping systems. Annual Conference of Practical Farmers of Iowa, Jan. 2024, Des Moines, IA. Type: Other Status: Published Year Published: 2024 Citation: Carey A. and A. Nair. 2024. Integrating poultry with vegetables and cover crops in organic production systems. Graduate Program in Sustainable Agriculture Symposium, Ames, IA Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Anne Carey, Ajay Nair, and Adam Thoms. 2024. Evaluating the Soil Block Method and Growing Media in Organic Vegetable Transplant Production. HortScience 59(4):542-551. Type: Other Status: Published Year Published: 2024 Citation: Nair, A. 2024. Sustainable vegetable cropping systems including poultry integration. Horticulture and Crop Sciences Departmental Seminar, University of Nebraska, Lincoln. Progress 09/01/22 to 08/31/23 Outputs Target Audience:The target audience included fruit and vegetable growers, growers practicing pastured poultry, extension staff, local food coordinators, Master Gardeners, Food Systems working group professionals, high school FFA teachers, industry professionals, and agriculture stakeholders. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Several graduate and undergraduate students were trained as a result of this project. The project organized a team meeting atUC Davis (9-11 October 2022), which was attended by project directors, graduate students, undergraduate interns, and professional and scientific staff from all three states (IA, KY, and CA). This meeting provided professional development opportunities through presentations and site visits to local organic farms (Full Belly Farm, Guinda, CA; UC Davis Student Organic Farm) and agricultureenterprises (Mariani Nut Company, Winters, IA). How have the results been disseminated to communities of interest?Graduate students presented posters and oral presentations at national conferences highlighting research results and lessons learned. Results from this project were disseminated through field days, workshops, webinars, podcasts, research farm progress reports, and presentations made at grower and academic conferences. YouTube videos were created to expand the educational platform and outreach component of the project. What do you plan to do during the next reporting period to accomplish the goals?The team is working on publishing results aspeer-reviewed publications. Several graduate students are working on completing theirthesis and dissertations. The team continues to engage stakeholders and advisory board members to disseminate research findings and observations. Team members will be presenting results at grower and academic conferences. Impacts What was accomplished under these goals? One of the objectives of this multistate study, is the examination of theeffect of integrating chickens in vegetable cropping systems on insect pest management, with the hypothesis that chickens may help manage pests. Three treatments were established at ISU Horticulture Research Station: Treatment 1 rotation was Vegetable, Chickens, and then Cover crops; Treatment 2 was Vegetable, Cover crops, then Chickens; and Treatment 3 was Vegetable, Vegetable, and Cover crops. Pitfall traps were established in two plots per treatment and contents examined weekly. The first round of data were collected during the middle part of the rotation cycle starting in July, where Treatment 1 had chickens after a broccoli crop, Treatment 2 was planted to cover crops, and Treatment 3 was planted to vegetables. The cover crop mix was seeded on June 23, and was a mixture of cowpea (80 lb/acre) and teff (8 lb/acre). The vegetables were sweet potatoes and were transplanted on June 23. The chickens were moved to plots on June 22, and the pitfall traps were placed in those plots on June 27. The chicken tractors were over the traps on July 3 and July 18. In this cycle, no pests were observed on the sweet potatoes during weekly monitoring. The first collection from the pitfall traps occurred on July 5, 2023, after chicken tractors had been over the traps. Trap contents revealed no significant differences in insect populations between treatments, with apparently minor foraging on insects by chickens. Among the six main species of arthropods collected from traps (springtails, spiders, ground beetles, crickets, ants, and parasitic wasps) in the first collection, there were no significant differences in their populations between treatments. Springtails were the predominant group of arthropods found in traps, and even when their populations were not graphed, there were no significant differences among treatments. Plots with the chicken averaged 22 spiders and 11 ground beetles, while the cover crop plots averaged 15 spiders and 13 ground beetles, and vegetable plots averaged 13 spiders and 1 ground beetle. The plots with cover crops tended to support more crickets than the other treatments, averaging 4 per trap while the Chicken and Vegetable plots had 2 and 0 crickets per plot, respectively. In the cover crop plots, there was a trend towards more insects, outside of spiders and ground beetles. The second pitfall collection occurred on July 14, 2023. While there were no significant differences in insect populations among treatments, there was a trend towards more spiders, averaging 48 per trap; ground beetles, averaging 18 per trap; crickets, averaging 13 per trap; and ants, averaging 20 per trap, in Chicken plots. The Cover Crop plots tended to have more parasitic wasps than the other plots, averaging 5 per trap.The third pitfall collection occurred on July 24, 2023. The Cover Crop plots supported significantly greater populations of crickets, at 32 per trap, compared to Chicken and Vegetable plots, which averaged 6 and 10 crickets per trap, respectively. There was a trend towards more ground beetles and ants in the Chicken plots, compared to the Vegetable and Cover Crop plots. Spiders tended to be greater in the Cover Crop plots, with an average of 17 per trap, and more parasitic wasps, with an average of 5 per trap. Overall, the Vegetable plots tended to have less insects. The second round of the experiment began on August 30, 2023, when Treatment 1 rotated to Cover Crops, Treatment 2 became the Chicken plots, and Treatment 3 continued as Vegetables. Chickens arrived August 22 and the first set of data was collected on September 6. The chickens were over the traps on August 28 and September 12.Data from the September 6 pitfall trap collection showed some significant differences between treatments, with the Cover Crop plots having greater ant populations, averaging 13 per trap, while Vegetable and Chicken plots averaged 4 and 2 per trap, respectively. Overall, the Chicken plots tended towards supporting more insects, with averages of 8 spiders, 9 ground beetles, 5 crickets, and 15 parasitic wasps per trap. Cover Crop plots averaged 100 springtails per trap. Data from the September 15, 2023, collection showed no significant differences between treatments. Chicken plots averaged 6 spiders, and 15 parasitic wasps. Cover Crop plots averaged 6 spiders per trap, 6 crickets, 50 springtails, and 7 ants, while Vegetable plots averaged 2 ground beetles per trap. Data from the September 22, 2023, collection showed no significant differences between treatments. Chicken plots averaged 7 parasitic wasps per trap, while Cover Crop plots averaged 10 spiders, 16 crickets, 20 springtails and 4 ants per trap (Figs. 3-4). The Vegetable plots tended to have the least number of insects. The final collection occurred on

October 2, 2023. The Cover Crop plots again supported significantly greater ant populations, averaging 9 per trap, while Vegetable and Chicken plots averaged 2 and 3, respectively. Cover Crop plots averaged 13 spiders, 4 ground beetles, 21 crickets, 50 springtails and 14 parasitic wasps per trap. Vegetable plots again appeared to support the least number of insects overall. In 2023, no significant pest or beneficial insect population differences were observed between the treatment where chickens foraged and treatments without chickens. Thus, this experiment did not support the hypothesis that chickens will aid in pest management in integrated vegetable systems. Cover crops appeared to exert the most significant effect on insect populations, perhaps due to the extensive cover in the plots, leading to greater populations in a more amenable climate/environment. The project also evaluatedfive certified organic sweet potato cultivars (B-14, Bayou Belle, Bellevue, Covington, and Orleans) for performance and quality under Upper Midwest growing conditions. Key takeaways include: B-14 had a greater number of marketable sweet potatoes than Bayou Belle, Covington, and Bellevue, although they did not differ in marketable weight, indicating a smaller average root weight of B-14. Bellevue produced more Jumbo grade sweet potatoes than the other cultivars and had the lowest Brix content. Covington sweet potatoes had the highest Brix content, but a greater number of small or misshapen roots and lower number of marketable sweet potatoes than most cultivars. In all, B-14 (Beauregard), with the highest number of marketable roots and a high Brix content, can be considered the best performing of the evaluated cultivars. Publications Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: Carey, A. and A. Nair. 2023. Soil Blocking in organic vegetable transplant production. Great Plains Growers Conference, St. Joseph, MO (1/12/2023). Type: Other Status: Other Year Published: 2023 Citation: Nair, A. and D. Fillius. 2023. Integrated pest management in organic vegetable systems. Workshop for Amish and Mennonite produce growers, Lamoni Produce Auction, Lamoni, IA (2/8/2023). Type: Other Status: Other Year Published: 2023 Citation: Nair, A. and D. Fillius. 2023. Integrated pest management in organic vegetable systems. Workshop for Amish and Mennonite produce growers, Kalona Produce Auction, Lamoni, IA (3/22/2023). Type: Other Status: Other Year Published: 2023 Citation: Nair, A. 2023. Cover crops in vegetable cropping systems. USDA NRCS Field Day, Des Moines, IA (4/12/2023). Type: Other Status: Other Year Published: 2023 Citation: Nair, A., A. Carey, M. Pitesky, F. Duan, and D. Gonthier. 2023. ISU-CA-KY Workshop and Field Day - Integrating chicken tractors in vegetable rotations. ISU Horticulture Research Station, Ames, IA. (9/7/2023) Type: Other Status: Other Year Published: 2023 Citation: Carey, A. and A. Nair. 2023. Organic sweet potato cultivars in the Upper Midwest. Farm Progress Report. Type: Theses/Dissertations Status: Published Year Published: 2023 Citation: Halmos, Viktor, \"Costs and Benefits of Integrating Poultry into Cover Crop - Vegetable Rotations\" (2023). Theses and Dissertations\--Entomology. 79. https://uknowledge.uky.edu/entomology_etds/79 Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Halmos, V., Gonthier, D.J. Costs and benefits of integrating poultry into vegetable rotations. Organic Association of Kentucky Annual Meeting. Frankfort, KY (January 27, 2023). Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Gonthier, D.J Agricultural multifunctionality: Harmonizing the costs and benefits of wild and managed birds in agriculture. Hope College, Biology Departmental Seminar. Holland, MI (February 17, 2023). Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Gonthier, D. Integrating poultry into vegetable rotations: What poultry density increases crop yields. Beginning Farmer and Rancher Development Program. (2023). Virtual Webinar Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: KM Elmore and EA Bobeck. 2023. Vegetable-poultry-cover crop system vs. conventional housing: Year 2 broiler performance, bone quality, and welfare outcomes in a multi-year study. Poultry Science Association Annual Meeting. Philadelphia, PA. Type: Other Status: Published Year Published: 2023 Citation: Elmore, K., Nair, A. & Bobeck, E., (2023) Production, Bone Health, and Economic Comparison of Indoor versus Pasture-Raised Red Ranger Broilers, Iowa State University Animal Industry Report 20(1). doi: https://doi.org/10.31274/air.15445 Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Delate, K. (2023) Organic Gardening. Winter Gardening Expo, Marion IA, February 18, 2023. Attendees: 82 Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Delate, K. (2023) Integrated Organic Crop and Livestock Systems. Midwest Organic and Sustainable Education Service (MOSES) Organic Conference, LaCrosse, WI, February 24, 2023. Attendees: 76 Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Delate, K. (2023) Organic Research Update. Organic Crop Imporvement Association Annual Meeting, Madrid, IA, March 17, 2023. Attendees: 45 Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Delate, K. (2023) Measuring the Effect of Chickens on Insect Populations in Organic Specialty Crop Rotations. OREI Field Day, Gilbert, IA, September 7, 2023. Attendees: 20 Type: Other Status: Published Year Published: 2023 Citation: Shulan Xiao and Dong Ahn. 2023. Chicken meat quality raised in an integrated organic production system. Iowa State University Animal Industry Report. DOI:10.31274/air.16193 Progress 09/01/21 to 08/31/22 Outputs Target Audience:The target audience included fruit and vegetable growers, growers practicing pastured poultry, extension staff, local food coordinators, Master Gardeners, Food Systems working group professionals, high school FFA teachers, industry professionals, and agriculture stakeholders. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?There have been many training and professional development activities associated with this project, including field days, workshops, and conference presentations, webinars, YouTube videos, etc. These activities provided opportunities for graduate and undergraduate students, technicians, Extension specialists, and farmer-educators to interact, implement, and discuss this project with peers, growers, and scientific community. This project also trained several undergraduate and graduate students field plot techniques, statistical design and interpretation, and data presentation skills. How have the results been disseminated to communities of interest?Results have been disseminated through field days, workshops, and conference presentations, webinars, and YouTube videos. Several conference presentations were made at grower and academic conferences. Two on-farm grower collaborator trials in Iowa engaged growers and led to farmer led information dissemination. What do you plan to do during the next reporting period to accomplish the goals?The final season of field activities will continue with data collection on crop and poultry production. A comprehensive soil data will be collected in all three states that will focus on soil physical, biological, and chemical characteristics. Economic analysis will continue to develop enterprise budgets. Meat and poultry behavior analysis will also continue. Impacts What was accomplished under these goals? In this experiment, at Iowa State University Horticulture Research Station, three treatments were established: Treatment 1 rotation was Vegetable, Chickens, and then Cover crops; Treatment 2 was Vegetable, Cover crops, then Chickens; and Treatment 3 was Vegetable, Vegetable, and Cover crops. Pitfall traps were established in two plots per treatment and contents examined weekly. In 2022, among the seven main species of arthropods collected from traps (springtails, spiders, ground beetles, crickets, ants, flea beetles and parasitic wasps), there were only two significant differences in their populations between treatments. Springtails were the predominant group of arthropods found in traps, and when their populations were not graphed, other patterns emerged. The plots with cover crops had an average of 5 spiders in traps, which was significantly greater than those collected in plots with vegetables. Vegetable and chicken plots had averages of 2 and 1 spiders, respectively. There was a trend towards more insects, except for ground beetles, recovered in traps in cover crop plots. The second pitfall collection occurred on July 15, 2022. While there were no significant differences in insect populations among treatments, there was a trend towards more ground beetles, averaging 7 per trap; parasitic wasps, averaging 14 per trap; and ants, averaging 19 per trap, in cover crop plots. The chicken plots tended to have more spiders than the cover crop plots, averaging 13 per trap; springtails, averaging 100 per trap; and crickets at an average of 12 per trap. Meat quality - One hundred and sixty broiler chickens from two strains (Freedom Ranger and Ross70, 80 for each strain) were raised in traditional confinement (CR) and integrated (FR) conditions (40 birds per each raising condition) and slaughtered. The carcasses were harvested, and parts yield, nutrient composition, and meat quality parameters were measured. Some significant differences in the yields of major parts (breast, thigh, and drumstick), meat color, the protein, fat, and ash contents, cooking yield, and tenderness of breast and thigh between the CR and FR groups within a strain were found, but the differences were small. However, the chickens raised in the FR had higher DHA content than the CR system. Between the strains, however, significant differences in parts yield, protein content, and color values were found: Ross70 had significantly higher breast yield, breast protein content, and cooking yield but lower color b*-value than Freedom Ranger. The results indicated that the plant-animal integrated (FR) conditions do not have any negative impact on the quality parameters of broiler meat and the integrated (FR) system is a good alternative to the traditional confinement production system that can enhance farm diversity, land use efficiency, and sustainability of farm agriculture. Food safety analysis-The presence and absence and quantification of Salmonella in soil, pasture, the finished produce and poultry occurred in California, Iowa, and Kentucky. The results from all sites revealed no Salmonella in the soil, pasture, and finished produce. In California Salmonella was present in one sample of poultry upon arrival but not at harvest. This is expected based on present knowledge of the low presence of Salmonella in poultry. Kentucky In spring of 2022, we maintained a randomized block experiment at the University of Kentucky Horticultural Research Farm (in the organic certified section) that manipulated three rotation treatments: low density poultry rotation (spring vegetable, summer cover crop, and fall poultry at a density of 10 broilers per plot), high density poultry rotation (spring vegetable, summer cover crop, and fall poultry at a density of 10 broilers per plot), and vegetable rotation without poultry (spring vegetable, summer and fall cover crops). Plots were approximately 32 x 32 ft in size and replicated 4 times in 4 treatment blocks. Crop productivity - Results suggest that integrating poultry in the fall of 2021 resulted in benefits to lettuce productivity in the spring of 2022, but only for the high poultry rotation treatment (following the same pattern as in 2021). Plots that received a high density of poultry had roughly 42% higher lettuce yields relative to plots that did not have poultry (in fall of 2020). However, there was no difference in lettuce yield between plots receiving low density poultry and no poultry. We also initiated a split-plot fertilizer experiment within each rotation treatment plot to assess the relative impact of poultry mediated yield augmentation relative to fertilizer mediated yield augmentation. Each of the 12 rotation plots received three pre-plant fertilizer (Nature Safe) treatments: no fertilizer, 3.5 lbs/A (med), and 71 lbs/A fertilizer treatment (high fertilizer). We found that the high fertilizer treatment had \~72% higher yields than the no fertilizer treatment, suggesting poultry integration had a smaller impact on lettuce yields than a full pre-plant fertilizer treatment. ??Arthropod biodiversity - Across two years, we examined how no poultry, low- and high-densities of broilers impacted cover crop biomass, ground-dwelling arthropods, and plant-dwelling arthropods in a rotationally grazed mixed-cover crop system. High- and low-density poultry treatments had 7.8-fold and 3.5-fold less cover crop biomass compared to the control treatment after 1-3 days of access, respectively. Despite the depletion of cover crops, there were substantial positive effects on ground-dwelling arthropods. Most striking was the impact on house fly larvae where high-density poultry treatments had \~1432-fold more house fly larvae relative to the control treatments. Dung beetle mean relative abundance increased 47-fold from the control treatment to the high-density poultry treatment. The mean relative abundance of ground-dwelling predators such as spiders and Staphylinid beetles was 2.4-fold and 3.5-fold higher respectively, in the high-density treatment relative to the control. In contrast, the mean relative abundances of plant-dwelling arthropod orders Coleoptera, Hemiptera, and Hymenoptera were 4-, 5-, and 3.6-fold higher, respectively, in the control treatment relative to the high-density poultry treatment. However, the composition of vegetation-dwelling arthropods at the order level did not significantly differ by treatment. Overall, these results suggest that pasture-raised poultry may promote the abundance of ground-dwelling arthropods through bottom-up mechanisms by depositing fecal material but decreasing the abundance of plant-dwelling arthropods, likely by destroying their habitat and food resources (via consumption and trampling of cover crop vegetation) and direct consumption of arthropods.? California The field study was carried out with 1 acre of tomatoes harvested, and data collected on the yield and fruit quality of the experimental plots. 116 pastured chickens were raised in each autumn (after the tomato crop) and spring (after the cover crop) based on the study design and data such as weight gain, feed intake, and feed conversion ratio were collected and compared to indoor controls. A cover crop was grown using a mixture of bell beans, oats, peas and common vetch over the winter and data was also collected on cover crop biomass. From June through September 2022, a crop of butternut squash was cultivated in the progression of the field study. Canopy cover data were collected during early growth of the squash crop. Soil samples were collected at 3 points of the season during the reporting period according to the experimental schedule and submitted for analysis in order to measure soil health indicators and to inform crop nutrient application needs (October 21\' after harvest of the tomato crop, March 22\' before termination of the cover crop, June 22\' after planting of the squash crop). Publications **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:Target audience reached during this reporting period included organic vegetable growers, commercial vegetable growers, pastured poultry enterprises, cover crop seed vendors, extension professionals, and representatives of grower organizations (Practical Farmers of Iowa,Iowa Fruit and Vegetable Growers Association, Organic Association of Kentucky, and The American Pastured Poultry Producers Association). Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Iowa • One graduate studentlearned about meat quality parameters and trained for their assessment methods. • Two graduate and sixundergraduate studentsexperienced slaughtering process of chickens • Onegraduateand two undergraduate students in the Poultry Nutrition Lab were trained to collect bird welfare and bone density data • Twograduate and fiveundergraduate students assisted with the field work of growing vegetables, raising chickens, insect data collection, and seeding cover crops. They also actively participated and presented the research at the Iowa State University Fruit and Vegetable Field Day Kentucky Viktor Halmos, MS Graduate Student, Department of Entomology, University of Kentucky, gained fieldresearch experience and assisted with field work,development of outreach materials, and presentation of results. Karina Garcia, PhD Candidate, Department of Entomology, University of Kentucky -Field research experience, development of outreach materials, and presentation of results. Several undergraduate students also participated in the field work and data collection. California Over 10 undergraduate students and 1 graduate student gained valuable research experience through this project. How have the results been disseminated to communities of interest?Results have been disseminated through presentations, field days, podcasts, newsletters, extension publications, and posters at national conferences. What do you plan to do during the next reporting period to accomplish the goals?In Iowa, we plan to plant a spinach or lettuce crop within our rotations. We look forward to integrate poultry for the 2022growing season and collect data on poultry health, behavior, feed intake, meat quality, prevalence of food-borne pathogens, and a comprehensive soil nutrient testing and analysis. The vegetable only plot will be planted in to pepper squash after the spring lettuce crop. In Kentucky, the three rotations in 2022will be repeated with different crops (spring, summer, fall, winter): 1. Lettuce-eggplant-beets-cover crop (no poultry) 2. Lettuce-eggplant-cover crop- high-density poultry (20 birds per plot) 3. Lettuce-eggplant-cover crop- low-density poultry (10 birds per plot) In California, the next crop in rotation will be winters quash. Cover crop termination is scheduled for March 2022 that will then be followed by insertion of the chickens in the post-cover crop chicken treatment ahead of land preparation, cover crop incorporation and tillage work prior to transplanting of winter squashn transplants that will be grown and monitored in the summer of 2022. Economic analysis of this project will start in 2022 with development of enterprise budgets. We will continue to present the work at local and regional conferences. **Impacts** What was accomplished under these goals? Iowa trial Vegetable crop data All three rotations (vegetable-chicken-cover crop, vegetable-cover crop-chicken, and vegetable-vegetable-cover crop) started with spinach (Spinacia oleracea), a high value crop for organic growers in Iowa. Spinach is known to bolt, or go to seed, in warmer weather. Specific cultivars have been developed to tolerate higher temperatures of spring planting with delayed bolting, allowing growers to harvest spinach into early summer and increase the length of marketability and sales. The project utilized the spinach plantings to identify spinach cultivars best adapted to direct seeding for spring growth under Upper Midwest growing conditions. The nine cultivars evaluated include Acadia, Seaside, Kolibri, Red Tabby (Johnny's Selected Seeds, LLC), Renegade, Verdil (High Mowing Organic Seed Company), and Apache, Space, and Aztec (Seedway, LLC). Aztec, with the highest number and weight of marketable leaves per plot performed the best among the nine cultivars. Seaside, with the lowest number and weight of marketable leaves performed the worst. With the highest total soluble solid content, Aztec would be the most preferred in taste to consumers. Seaside, with the lowest total soluble solid content, would be the least preferred. Verdil, with the only incidence of bolting and the worst insect damage, appears to not perform well in spring planting. Growers in Iowa considering spinach cultivars for spring planting should consider Aztec to be the best performer in terms of marketable yield and total soluble solid content. Seaside could pose challenges due to low yields and low total soluble solid content and Verdil due to the incidence of bolting and susceptibility to insect damage. Poultry data Year 1 of the poultry project was completed on farm- in conventional floor housing at the poultry farm as well as the horticulture Research Station where birds were kept in tractors on alternating food plots. Data pertaining to performance, feed intake, weight gain, welfare, bone density, and behavior were collected. Data are being analyzed from the first 2 sets of live bird replicates. The effects of two raising systems (integrated vegetable-poultry-cover crop system and conventional system) on the meat quality parameters of broilers were determined. The meat quality parameters, including carcass and carcass component yield, cooking yield, proximate analysis, color, pH and fatty acid profiles and tenderness of the breast and thigh meat, were determined. There were some differences in meat quality parameters, especially color values (L, a* and b*-values) and protein content, between the chickens raised in the integrated vegetable-poultry-cover crop and the conventional system when the Spring and Fall chickens were compared within the same slaughtering time. However, the differences were not consistent and clear when the values from the chickens slaughtered in July (Spring) and September (Fall) were considered. In summary, the quality parameters of chickens in the integrated vegetable-poultry-cover crop and conventional systems were not different. However, it is too early to conclude that the two raising systems do not affect the quality of broiler chickens. The results will be clearer when the upcoming studies (years 2 and 3) are compiled with the current ones. Kentucky trial In spring of 2021, we established a randomized block experiment at the University of Kentucky Horticultural Research Farm (in the organic certified section) that manipulated three rotation treatments: low density poultry rotation (spring vegetable, summer cover crop, and fall poultry at a density of 10 broilers per plot), high density poultry rotation (spring vegetable, summer cover crop, and fall poultry at a density of 10 broilers per plot), and vegetable rotation without poultry (spring vegetable, summer and fall cover crops). Plots were approximately 30 x 30 ft in size and replicated 4 times in 4 treatment blocks. For this project, we will repeat these rotational sequences for 4 years and measure the impacts of integrating poultry on soil health, vegetable productivity, arthropod biodiversity, and profitability. Crop productivity -In the spring of 2021, the first measurements of poultry integration impacts on the vegetable productivity were taken. The results suggest that integrating poultry in the fall of 2020 resulted in benefits to spinach productivity in the spring of 2021, but only for the high poultry rotation treatment. Plots that received a high density of poultry had roughly 37% higher spinach yields relative to plots that did not have poultry (in fall of 2020). However, there was no difference in spinach yield between plots receiving low density poultry and no poultry. We also initiated a split-plot fertilizer experiment within each rotation treatment plot to assess the relative impact of poultry mediated yield augmentation relative to fertilizer mediated yield augmentation. Each of the 12 rotation plots received three pre-plant fertilizer (Nature Safe) treatments: no fertilizer, 3.5 lbs/A (med), and 71 lbs/A fertilizer treatment (high fertilizer). We found that the high fertilizer treatment had \~37% higher yields than the no fertilizer treatment. Importantly, this result suggests that integrating high densities poultry into vegetable rotations increased yield in spring vegetables at a roughly equivalent rate as applying a 71 lbs/A rate of pre-plant fertilizer. Food safety - One of the greatest concerns for the integration of poultry into vegetable production systems is the possibility of increasing contamination rates with food borne pathogens given that poultry are known carriers of Salmonella spp. and other human pathogens. At the end of each rotation sequence (spring, summer, fall), we used boot-swab soil samples to test for the presence of Salmonella in each plot. In 2021, all samples taken across these integrated treatments were found to be negative for the presence of Salmonella (spring spinach, summer cover crop, and fall poultry), suggesting poultry integration into rotations is a low risk practice. California trial Questions including: at what extent does manure deposited by poultry on the farm reduce the need for off-farm soil fertility inputs? What benefits can we observe when crop residue is used to supplement the diets of the chickens? What stocking rate of chickens is the most advantageous in these systems? What type of crops and breeds of chicken work the best in such integrated systems across the country? and is it feasible to squeeze in a successful yield of broiler production into the transition window between different crop seasons? Finally, can all this be done effectively from a food safety perspective and economically from both a farmer and consumer level? To better understand and evaluate the potential to integrate poultry within vegetable cropping systems, panning multiple perspectives, the research objectives focused on evaluating growth yields, quality of agricultural outputs, food safety risks, agroecological impacts on soil and pests, and economic feasibility of such systems. Specific parameters measured included comparing the body weight of broilers raised in pasture versus those raised indoors showed that for both spring and fall chickens, there was no significant difference between final weights (at 6.5 weeks of age) of any of the 4 groups housed outdoors or the 1 group housed indoors. Comparing the body weight of broilers raised in the fall versus those raised in the spring, we found that although chickens raised in the spring achieved on average a higher BW than those in the fall, this difference was not statistically significant. Additionally, our results showed the average weight gain of fall chickens was greater than spring chickens (1109.9 g vs. 1093.1 g); however, this difference was not statistically significant. **Publications** - Type: Other Status: Other Year Published: 2021 Citation: Nair, A. and A. Carey. 2021. Poultry, cover crop, and vegetable integrated systems. ISU Fruit and Vegetable Field Day 7/22/2021. - Type: Other Status: Other Year Published: 2020 Citation: Delate, K. (2020) Small Farm Sustainability Podcast: Iowa Organic Update, November 11, 2020, Iowa State University, Ames, IA https://www.extension.iastate.edu/smallfarms/small-farm-sustainability-podcasts - Type: Other Status: Other Year Published: 2020 Citation: Delate, K. (2020) Iowa Organic Conference, Nov. 23, 2020, ISU Dept. of Horticulture, Ames, IA: https://www.iowaorganic.org/2020_iowa_organic_conference - Type: Other Status: Other Year Published: 2020 Citation: Delate, K. (2020) OATS (Organic Agronomy Training Series) Podcast: The Dirt on Organic Farminghttps://www.organicagronomy.org/the-dirt-on-organic-farming - Type: Other Status: Other Year Published: 2021 Citation: Viktor Halmos. Multifunctionality of poultry-vegetable integrated systems. MS Proposal Seminar in the University of Kentucky, Department of Entomology Seminar Series. November, 4 2021. - Type: Other Status: Other Year Published: 2021 Citation: Karina Garcia, Delia Scott Hicks and David J Gonthier. Ecological impacts of organic pasture raised poultry on cover crop and arthropod communities. August 2, 2021. Ecology Society of America. - Type: Other Status: Published Year Published: 2021 Citation: Pitesky, M., F. Duan, and J.P. Mitchell. 2021. Do chickens boost soil health, increase profits on organic vegetable farms?. in Morning Ag Clips. April 19, 2021. - Type: Other Status: Published Year Published: 2021 Citation: Scientists to see whether chickens boost soil health, increase profits on organic vegetable farms in UCANR Green Blog. April 16, 2021. - Type: Other Status: Published Year Published: 2021 Citation: Duan, F., M. Pitesky, and J.P. Mitchell. 2021. Integrating Chicken and Vegetable Production in Organic Farming. Organic Farmer Magazine. December 2021. - Type: Other Status: Published Year Published: 2022 Citation: Carey, A. and A. Nair. 2021. Appropriate Spinach Cultivars for Spring Planting. Iowa State University Horticulture Research Station Farm Progress Report. https://www.iastatedigitalpress.com/farmreports/article/id/15494/ - Type: Other Status: Published Year Published: 2022 Citation: Carey, A. and A. Nair. 2021. Evaluating Mini-Butternut Cultivars in the Upper Midwest. Iowa State University Horticulture Research Station Farm Progress Report. https://www.iastatedigitalpress.com/farmreports/article/id/15490 - Type: Other Status: Published Year Published: 2021 Citation: Chickens-Tomatoes-Cover Crop, Chickens-Tomatoes-Cover Crop, Chickens-Tomatoes-Cover Crop; by Faye Duan, Jeff Mitchell, and Maurice Pitesky, Poultry Ponderings Edition 23, 2021 - Type: Other Status: Other Year Published: 2021 Citation: Delate, K. (2021) NRCS Webinar: Organic Research to Support Transitioning, February 18, 2021, Des Moines, IA - Type: Other Status: Other Year Published: 2021 Citation: Delate, K. (2021) Surviving COVID, Derecho, and Drought Lessons from2020- Midwest Organic and Sustainable Education Service (MOSES) Organic Conference, La Crosse, WI, 2/25/21 https://www.dropbox.com/s/lgceptpiwih34vp/Surviving%20COVID%2C%20Derecho%2C%20and%20Drought%20Lessons%20of%20Resilience%20in%202020%20edited.mp4?dl=0 - Type: Other Status: Other Year Published: 2021 Citation: Delate, K. (2021) Risk Management for Organic Production: March 10, 2021, ISU-FFED, Ames, IA https://www.extension.iastate.edu/ffed/specialty-crops-risk-management-webinar-series/ - Type: Other Status: Other Year Published: 2021 Citation: Delate, K. (2021) Grain Place Foundation Field Day, July 17, 2021 http://www.grainplacefoundation.org/news/ **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:Target audience reached during this reporting period included dorganic vegetable growers and representatives of grower organizations (Practical Farmers of Iowa and Iowa Fruit and Vegetable Growers Association). Collaborators in Kentucky connected with representatives from Organic Association of Kentucky. Changes/Problems:Although the project start date was September 2019, project investigators received initial funding starting in March 2020 (due to shifting of NIFA headquarters to Kansas City and other administrative issues). Due to the outbreak of COVID-19 pandemic starting in March 2020, the project could not get started in full swing due to restrictions and shutdowns. The project did not start in California (UC Davis) due to complete lockdown, although Iowa and Kentucky were able to start the project on a scaled-down version. No animals could be introduced in Iowa plots due to COVID lockdown. Iowa trials were modified to run broccoli cultivar trials that identified appropriate heat tolerant broccoli cultivars for organic vegetable growers. What opportunities for training and professional development has the project provided?In Iowa, two undergraduates worked on the project and assisted with raising transplants, plot establishment and management, data collection and entry. Students were trained on field plot techniques, use of tools and equipment, production of broccoli, seeding and establishment of cover crops. The graduate student, Anne Carey, started in Fall 2020 and was trained on soil sampling protocols, data collection, and statistical methods and analysis. At Kentucky, Karina Garcia, Ph.D. candidate, Department of Entomology, University of Kentucky, was trained inField and lab research experience and data analysis. AnotherPh.D. student, Kantima Thongjued, Department of Entomology, University of Kentucky learned about

Field and lab research experience; meta-barcoding techniques; and data analysis. At California, to date, no formal external training and professional development activities have been conducted associated with the UC Davis project due to the postponement of our work. Invitations have been sent to three prospective farmer Advisory Board members in January 2021. How have the results been disseminated to communities of interest?At Iowa, discussions were held with growers at Practical Farmers of Iowa about the broccoli cultivar trial results. No formal presentations and field days have been organized. At Kentucky, Kantima Thongjued, presented preliminary research findings to the Department of Entomology during a Departmental Seminar. At California, informal conversations have been engaged with prospective project Advisory Board farmers. What do you plan to do during the next reporting period to accomplish the goals?In Iowa, we plan to plant a spinach crop within our rotations. We look forward to integrate poultry for the 2021 growing season and collect data on poultry health, behavior, feed intake, meat quality, prevalence of food-borne pathogens, and a comprehensive soil nutrient testing and analysis. The vegetable only plot will be planted in to winter squash after the spring spinach crop. In Kentucky, the three rotations in2021will be repeated with different crops (spring, summer, fall, winter): Spinach-eggplant-beets-cover crop (no poultry) Spinach-eggplant-cover crop- high-density poultry (20 birds per plot) Spinach-eggplant-cover crop- low-density poultry (10 birds per plot) In California, we intend to fully begin the work at the UC Davis site during the coming months and are now underway to do so. Cover crop termination is scheduled for March 2021 that will then be followed by insertion of the chickens in the post-cover crop chicken treatment ahead of land preparation, cover crop incorporation and tillage work prior to transplanting of organic processing tomato plants that will be grown and monitored in the summer of 2021. The tomatoes will be transplanted around the 1st of May and likely machine harvested by the end of August at which time the post-vegetable chickens will be introduced. Work is beginning on fabricating the movable chicken cages to be ready by the time the 2021 cover crop will be terminated. **Impacts** What was accomplished under these goals? Although the project start date was September 2019, project investigators received initial funding starting in March 2020 (due to shifting of NIFA headquarters to Kansas City and other administrative issues). Due to the outbreak of COVID-19 pandemic starting March 2020, the project could not get started in full swing due to restrictions and shutdowns. The project did not start in California (UC Davis) due to complete lockdown, although Iowa and Kentucky were able to start the project on a scaled-down version. OBJECTIVE 1. Evaluate vegetable (growth, yield, and quality), cover crop, and bird performance in integrated organic production Iowa trials Because of COVID restrictions in 2020, the vegetable rotation with chickens was changed to a simple vegetable cultivar trial to deal with lockdowns and labor limitations. The objective of this study was to identify broccoli cultivars that could be transplanted late spring and would perform well irrespective of early summer high temperatures. High temperatures often lead to early bolting, increased disease incidence, and a high rate of unmarketable heads. The study was conducted on certified organic land at the ISU Horticulture Research Station. Broccoli cultivars were selected for being the most popular cultivars grown on Iowa vegetable farms and for their described heat tolerance by seed suppliers. Six broccoli cultivars- Belstar (High Mowing, LLC), Covina (High Mowing, LLC), Emerald Crown (Johnny's, LLC), Green Magic (Johnny's, LLC), Gypsy (Johnny's, LLC), and Imperial (Johnny's, LLC) were seeded at the Department of Horticulture greenhouses on March 17, 2020. Broccoli marketable yield.There was no statistically significant difference among the different cultivars for the number or weight of marketable heads per plot, ranging from 9-17 heads, weighing between 1.2-2.6 kg. Belstar produced the lowest number (9) and lowest weight (1.2 kg) of marketable heads per plot. Green Magic and Covina produced the largest number of marketable heads per plot, 17 and 16, respectively, both with a weight of marketable heads per plot reaching 2.3 kg. Imperial produced the largest weight of marketable heads per plot with 2.6 kg, from 14 heads, with the highest average weight per head of 186 g. Non-marketable broccoli.There was no statistically significant difference among cultivars for the number and weight of non-marketable heads per plot. Broken down into non-marketable categories, statistically significant differences between cultivars were found. Gypsy had significantly more brown discoloration than all other cultivars, with an average of three heads per plot. Covina was the only cultivar to experience beading of the heads, with an average of one head per plot. Emerald Crown and Covina heads had the most yellow eyes, with 2.8 and 2.3 heads per plot respectively, but no significant difference between cultivar was present. Belstar heads bolted significantly more than the other cultivars, with 5.3 heads per plot. Peak production.Belstar and Imperial broccoli heads reached peak production later than other cultivars, with the highest number of heads harvested per plot occurring on July 31, the sixth harvest. Green Magic and Gypsy were the earliest cultivars to reach peak production, with the highest number of heads harvested occurring on the first two harvest, July 2, and July 8. Covina reached peak production in the middle of the season, with the highest number of heads harvested occurring July 20. Emerald Crown held a steady yield throughout the first four harvests, with between 17-20 heads harvested each week from July 2-July 20. All other cultivars experienced a quick peak of number of marketable heads, lasting only one or two harvests. This information can be useful to Iowa growers seeking to use cultivar selection in a succession plan for late season planting for continuous harvest from a broccoli planting. Insect populations were censused throughout the summer on six cultivars, and nematode populations were determined after 6-inch soil samples were sent to the ISU Plant Diagnostic Lab for analysis. Due to the dry weather and, possibly, the isolation of the crop from other crucifers, very few insects were present at the experimental site this summer. The main insect pests included flea beetles, aphids, and imported cabbage worm. Due to high biodiversity in the surrounding area of the trial, parasitic wasp activity was observed in parasitized aphids (mummies) counts. Other beneficial insects were detected, including lady beetles and syrphid larvae. Damage ratings averaged less than 10% damaged leaves across all cultivars. Overall, there were no significant differences in insect pests, pest damage, and disease incidence between broccoli varieties. Kentucky trial To determine the impact of incorporating poultry into vegetable rotations, a 4-year rotation project was established with 3 rotation treatments (spring, summer, fall, winter): broccoli -cover crop-cover crop rotation (no poultry) broccoli-cover crop-high-poultry density- cover crop rotation (20 broilers per field) broccoli-cover crop-low-poultry density-cover crop rotation rotation (10 broilers per field). During the spring, summer and fall soil samples, Salmonella soil samples (food safety), arthropod abundance, vegetative biomass, and crop or poultry productivity were measured. Baseline spring broccoli yields and soil nutrient content did not differ between experimental treatments (measured before the treatment effect of poultry was introduced to the rotation). After the high- and low-density poultry treatments were established in the fall, poultry treatments had significant impact on the cover crop plant communities and on arthropod communities. Plots in the high- and low-density poultry treatments had significantly less cover crop biomass than the treatment that remained in cover crop (broccoli-cover crop-cover crop treatment). Further, an analysis of similarity revealed that the high- and low-density poultry treatment had different arthropod communities compared to the cover crop treatment without poultry. After the poultry treatments were completed in the fall, 1 of 4 high-density poultry plots tested positive for Salmonella, 1 of 4 low-density poultry plots tested positive for Salmonella and no vegetable-cover crop plots (without poultry) tested positive for Salmonella. California trial Due to the COVID situation in California and UC Davis policies significant delays occured. However, we have modified our timeline accordingly and expect to meet all the project objectives. Due to the University of California, Davis conducting a curtailment of research during the spring of 2020 because of the COVID-19 pandemic, the decision was made to postpone implementation of the field work at the UC Davis site until the fall. Among other meetings an onsite project planning meeting was held on February 7, 2020 with California project leaders Maurice Pitesky and Jeff Mitchell along with Iowa State lead PI Ajay Nair and Brandon, and the manager of the Long-Term Research on Agricultural Systems facility where the project will be implemented, Israel Herrera. Initial experimental design planning was done and a visit of the intended study field was conducted. Plans were outlined for baseline soil sampling, sample processing and archiving. A mixture of one of the Multiplex commercial mixes of Lockewood Seed and Grain in Chowchilla, CA including 30% bell beans, 20% oats, 30% Dundale peas, and 20% common vetch (by weight) was seeded across the entire 1-ac experimental field in November ahead of the anticipated onset of winter rainfall at a rate of 125 lbs/ac. No fertilizer or irrigation were applied to the cover crop. **Publications** - Type: Other Status: Published Year Published: 2020 Citation: Carey, A. and A. Nair. 2020. Comparing Broccoli Cultivars in Late Spring Planting. Iowa State University Horticulture Research Station Report. - Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Organic Research in Iowa- Horticulture Dept., University of Florida, Gainesville, FL, 3/18/20 (via Zoom) - Type: Other Status: Published Year Published: 2020 Citation: Video: Virtual Neely-Kinyon Farm Organic Field Day: 8/3/20 https://www.youtube.com/watch?v=P_PplV5EmT4 - Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Video: Gardening While Isolated: Organic Pest Management (with P. Lawlor): 5/11/20 https://www.youtube.com/watch?v=YrT1SymMKYA - Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Iowa Organic ProgramSmall Farm Sustainability Podcast: 11/11/20 https://www.extension.iastate.edu/smallfarms/small-farm-sustainability-podcasts - Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Iowa Organic Conference: 11/23/20 https://iastate.app.box.com/s/u5d44k2ngn2jr8behked7hq0pvdipmyk - Type: Other Status: Published Year Published: 2020 Citation: Delate, K. 2020. Organic Agriculture Concerns Amid COVID-19. ISU Extension and Outreach, May 5, 2020. Available at: https://www.extension.iastate.edu/news/organic-agriculture-production-concerns-amid-covid-19 - Type: Journal Articles Status: Published Year Published: 2020 Citation: Galindo, F.S., Delate, K., Heins, B., Phillips, H., Smith, A., and Pagliari, P.H. 2020. Cropping System and Rotational Grazing Effects on Soil Fertility and Enzymatic Activity in an Integrated Organic Crop-Livestock System. Agronomy 10: 803: https://www.mdpi.com/2073-4395/10/6/803 - Type: Journal Articles Status: Published Year Published: 2019 Citation: Carr, P.M., Cavigelli, M.A., Darby, H., Delate, K., et al. 2019. Green and animal manure use in organic field crop systems. Agronomy Journal. 2020:1-27: https://doi.org/10.1002/agj2.20082 - Type: Other Status: Other Year Published: 2020 Citation: Press release: Gardening While Isolated: Transplanting and Fertilizing Your Seedlings, May 19, 2020 (with B. Turnbull): https://www.extension.iastate.edu/news/gardening-while-isolated-transplanting-and-fertilizing-your-seedlings - Type: Other Status: Published Year Published: 2020 Citation: How to spread compost efficiently in organic fields: https://www.youtube.com/watch?v=PxcDvQUEF6k&t=21s

↑ Return to Index

Resilient Systems for Sustainable Management of Cucurbit Crops

Accession No.	1020780
Project No.	IOW05599
Agency	NIFA IOW\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30248
Proposal No.	2019-03098
Start Date	01 SEP 2019
Term Date	31 AUG 2022
Grant Amount	$2,000,000
Grant Year	2019
Investigator(s)	Gleason, M. L.; Williams, MA, AL.; Bessin, RI, TO.; Beattie, GW, A.; Nair, AJ, .; Iles, LA, JE.; Zhang, WE, .; Morton, LO, WR.
Performing Institution	IOWA STATE UNIVERSITY, 2229 Lincoln Way, AMES, IOWA 50011

NON-TECHNICAL SUMMARY

Our goal is to validate two innovative strategies that will enable organic cucurbit-crop growers to suppress insect pests, diseases, and weeds while achieving consistently high marketable yields. Cucumber beetles and bacterial wilt, squash bug and cucurbit yellow vine disease, squash vine borer, powdery mildew, downy mildew, and weeds cost growers \>\$100 million annually and limit organic marketing opportunities. Three years of field experiments and on-farm trials with muskmelon and acorn squash in Kentucky, Iowa, and New York will optimize mesotunnels - season-long tunnels that can sharply increase marketable yield and suppress pests and diseases - to control weeds, build soil quality with living mulches, and achieve efficient pollination (Objective 1). Concurrently, we will develop biological controls to suppress bacterial and fungal diseases, both as a companion strategy to mesotunnels and as a stand-alone practice (Objective 2). Growers will provide continuous feedback via an Advisory Panel, grower surveys and listening sessions, and on-farm cooperator trials. We will use results of the field experiments to calculate profitability in the South, Midwest, and Northeast, and grower viewpoints will inform rates of adoption of these new tools (Objective 3). A multi-strategy outreach program will reach 7,000 cucurbit growers throughout these regions (Objective 4). The project directly addresses four OREI priorities: trialing innovative practices that can mitigate pest and disease damage (Priority 1), comparing costs and profitability of new management approaches with existing practices (Priority 2), conducting on-farm trials to insure adaptability of new approaches (Priority 6), and conserving beneficials and improving soil quality (Priority 7).

OBJECTIVES

A complex of pests and diseases are acutely challenging for organic cucurbit vegetable growers, as they lack access to management tactics that provide reliable protection against crop failure. Inconsistency of organic marketable yields limits profit opportunities at all levels from direct on-farm sales to wholesaling. Organic cucurbit growers urgently need pest and disease management systems that will reliably deliver high marketable yields in order to capitalize on the expanding market for organic produce (see Section 1.2, page 2, and Section 1.5, page 4).The long-term goals of the proposed project are to:1) Control major insect and disease pests all season to ensure consistently high marketable yield and profitability of organic muskmelon and winter squash production.2) Protect pollinators and natural-enemy insects by eliminating the need for insecticide use.3) Suppress weeds while enhancing soil health attributes.4) Gain additional flexibility in disease management through diverse physical and biological control options.

APPROACH

Objective 1. We will conduct three annual field trials on certified organic land at the Iowa State University (ISU) Horticulture Research Station near Gilbert, IA, the University of Kentucky (UK) Organic Farming Unit in Lexington, KY, and the Cornell University AgriTech\'s Gates West Research Farm in Geneva, NY. We will assess weed control, pollinator efficiency, and pest/disease control in separate field experiments on muskmelon (cv. Athena) and acorn squash (cv. Table Ace). Experimental design will be a randomized complete block with four replications per treatment. The weed control experiment (Task 1.1) will include a living mulch, a shredded crop residue control, and a bare ground control. The pollination optimization experiment (Task 1.2) hypothesizes that in our 200-ft-long subplots, stocking two bumble bee (Bombus impatiens) colonies will increase pollination and marketable yield across an entire mesotunnel, whereas stocking a single colony will result in diminished pollination rates with increasing distance from the colony. The pest and disease control experiment (Task 1.3) will monitor for insect pests (cucumber beetles, squash bugs, squash vine borers, and aphids) and bacterial diseases (bacterial wilt and CYVD) to evaluate the effectiveness of the mesotunnels for excluding insect pests and their associated pathogens.Objective 2. A primary screen will evaluate candidate biocontrol agents for activity against Erwinia tracheiphila and Serratia marcescens. Candidates will include bacteria that trigger induced systemic resistance (ISR) in cucurbits, bacteria with biocontrol activity against similar diseases in other crops, and mixtures of bacterial pathogen-specific phages (viruses that attack bacteria). We will use a rapid cucurbit seedling assay as a primary screen in growth chambers to apply suspensions of the biocontrol candidates to 2-week-old muskmelon and acorn squash seedlings, with wounding, prior to inoculation with the bacterial pathogens, and determine efficacy based on disease symptom severity across at least 20 replicate plants in each of at least three replicate experiments. Bacterial agents active in biocontrol against either pathogen will be examined in a similar assay for control of powdery mildew (Podosphaera xanthii) or downy mildew (Pseudoperonospora cubensis). Biocontrol agents will be selected for further screening if they reduce the incidence or severity of any of these diseases. Agents selected in the primary screen in the laboratory (Task 2.1) will be examined in greenhouse studies (Task 2.2). We will identify the minimal dose required for effective control against the target pathogens, and the biocontrol efficacy provided by mixtures of the agents to explore opportunities for synergy.During the growing seasons of Years 2 and 3, we will field test the biocontrol agents that exhibit significant protection against disease in the greenhouse (Task 2.3). A randomized complete block design will be used with shredded mulch for weed control. Treatments will be: Up to four candidate biocontrol agents, each applied in a separate mesotunnel;?a water-inoculated mesotunnel control; and a non-mesotunnel control (no biocontrol agents).In Years 2 and 3, the field tests will be performed at ISU\'s Horticulture Research Station, and in Year 3, in Kentucky and New York (Task 2.4). In Year 2, the biocontrol agents will be applied as foliar sprays immediately before transplantation. In Year 3, we will use the optimal application and formulation approaches identified in Task 2.2. Populations of bacterial biocontrol agents will be estimated by plate counts. We will assess yield and produce quality at harvest.Objective 3.We will use economic and social theories and methods to: compare the profitability and cost effectiveness of mesotunnel systems and biological control approaches, alone and in combination, with current organic systems for muskmelon and acorn squash production; understand growers\' perceptions and experiences with pest and disease threats, high-priority concerns associated with cucurbit crop production, cautions and concerns about mesotunnels and biocontrols, and determine knowledge, skills, and economic, social, and psychological barriers to and enabling factors for adopting these technologies; and ensure grower-scientist collaboration and knowledge exchanges to produce useable science and technologies. We will use mixed methods including partial budget analysis, surveys, semi-structured multidisciplinary team discussion processes, listening sessions, and evaluative tools in concert with an external evaluator. Objective 4. We will expand our CoP website The Current Cucurbit\39\, which uses short video clips to share the project\'s activities. The site will increase to 2,000 page views per week by the end of Year 2.A twice-monthly blog will push the project\'s messages to Extension educators and stakeholders and drive traffic to the CoP website. Blog segments of 150 to 300 words will capsulize various aspects of project activities and link to resources on the CoP site and elsewhere. Availability of each blog will be tweeted to followers throughout the eastern half of the U.S. We will produce 30 YouTube video segments, and solicit feedback twice per year via online reactionnaire surveys. Two Year 3 webinars will invite participation from the Advisory Panel as well as extension educators and crop advisers throughout the eastern U.S., and be posted to the national eOrganic website and the project website. There will be 3 on-farm demonstration trials per state annually. Participants will select one or more trials using mesotunnels andd/or biological controls. In Year 3, the PIs will prepare and upload a manual for organic cucurbit growers in the South, Midwest, and Northeast on using mesotunnels and biological control. Progress 09/01/19 to 02/29/24 Outputs Target Audience:Commercial growers of cucurbit crops in the central and eastern U.S. Changes/Problems:The COVID-19 pandemic caused significant delays in field and laboratory research by preventingaccess to these sites for as long as one year (2020-2021) in some cases. For example, replicated field experiments in NY (Cornell University) were prohibited during the first field season (2020). The pandemic also disrupted plans for in-person annual project meetings and in-person grower interviews. Fortunately, the timely availabilityof videoconferencing technology allowed us to switch to monthly project meetings via Zoom and to substitute phone interviews for in-person grower interviews. 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Undergraduate research assistants gained experience in field research design, conduct, and data analysis; organization and conduct of phone surveys of cooperating growers; and co-authorship of outreach and research publications. How have the results been disseminated to communities of interest?The mainoutreach product for target growers was the Growers Manual outlining practical take-homemessages for cucurbit growers from our team\'s multi-year experiences with mesotunnels for organic cucurbits in experimental and on-farm contexts. 100 print copies were produced and distributed to growers in each participating state, and the Growers Manual is available onlineat: https://www.cucurbit.plantpath.iastate.edu/growers-manual. All additionaloutreach products and presentations are summarized under Products, Other Products, and the project\'s External Evaluation (appended to this final report). What do you plan to do during the next reporting period to accomplish the goals? 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Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Graduate students trained: Sharon Badilla Kephas Mphande Kathleen Fiske Kaitlin Diggins Alexis Gauger Ryan Kuesel Research coordinators trained: Jose Gonzalez Kellie Damann Abigail Tikhtman Undergraduate research interns trained: Kaitlin Diggins Isabel Danicich Catherine Esparza Jessica Fischer Mateo Garcia Alexandra Guy Ben Morrison Mallory Sparks How have the results been disseminated to communities of interest? See Products section of this report. What do you plan to do during the next reporting period to accomplish the goals?Our final-year plans include: Publish 6 additional research papers based on project findings under Objectives 1, 2, and 3. Transition the project website, The Current Cucurbit (https://www.cucurbit.plantpath.iastate.edu), to North Central IPM Center website to ensure its outputs are accessible to all interested parties for an additional 5 years beyond the end of the project period. Prepare the final project report. Impacts What was accomplished under these goals? Year 4 was a no-cost extension year. Under Objective 1 (field trials to optimize mesotunnel use) we submitted two research manuscripts based on New York research. The manuscript on acorn squash, summarizing experiments evaluating alternatives to accomplish pollination and weed control under mesotunnels, was accepted pending revision by Plant Health Progress. The NY mesotunnel manuscript on muskmelon is in review with another journal. A third manuscript, from Iowa field trials on muskmelon, will be submitted to Plant Disease in December 2023; this manuscript includes an economic analysis of the field trials. A fourth manuscript, reporting findings of the Iowa acorn squash field trials in mesotunnels, is in preparation for submission to HortTechnology in April 2024. Objective 2 (laboratory research on the bacteria that cause cucurbit bacterial wilt and cucurbit yellow vine disease, aka CYVD) featured: i) development of the first quantitative pathogenicity assay for the CYVD bacterium, Serratia marcescens, which is a major step forward for resistance breeding; ii) discovery, using GFP labeling and microscopy, that S. marcescens invades through intercellular spaces adjoining the phloem (a major change from previously accepted dogma about how this pathogen attacks plants); iii) identification of genes in the CYVD bacterium associated with its abillity to infect plants; iv) the first experimental evidence that cucumber beetles - previously known to spread only the cucurbit bacterial wilt pathogen, Erwinia tracheiphila - can also spread the CYVD bacterium from plant to plant (a finding that has immense applications for practical control of CYVD); v) experimental proof that several biocontrol bacteria can also suppress cucurbit bacterial wilt; and vi) evidence that some of these biocontrol bacteria can suppresws bacterial wilt when applied as a spray, which is a major breakthrough toward making biological control practical as an alternative to sythetic chemical insecticides. Manuscripts reporting these important findings are in preparation. Objective 3 (socioeconomic analysis): we completed economic analysis of the Iowa field experiments and published a report summarizing findings of a national survey of cucurbit vegetable growers. Objective 4: We published a Growers Manual summarizing the key practical tips for using mesotunnels. See Products section of this REEport for details on Year 4 outputs. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Badilla Arias, S., Gleason, M.L., and Beattie, G.A. 2023. Screening for biocontrol agents of bacterial wilt of cucurbits. National meeting of American Phytopathological Society, Denver, Colorado, August 13-16, 2023. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Mphande, K., LaSarre, B., Gleason, M.L., and Beattie, G.A. 2023. Exploring the molecular mechanisms of pathogenicity and localization of Serratia marcescens, which causes cucurbit yellow vine disease. National meeting of American Phytopathological Society, Denver, Colorado, August 13-16, 2023. Type: Other Status: Published Year Published: 2023 Citation: Cheng, N., Zhang, W., Gonzalez, J., and Gleason, M.L. 2023. Controlling Pests and Diseases Using Mesotunnels: Understanding Organic Cucurbit Crop Growers\' Preferences and Choices. Report EB 05-2023, Charles H. Dyson School of Applied Economics and Management, Cornell University, June 2023. Type: Other Status: Published Year Published: 2023 Citation: Gonzalez, J., Gonthier, D., Pethybridge, S., Bessin, R., Nair, A., Zhang, W., Cheng, N., Fiske, K., Gauger, A., Damann, K., Murphy, S., Badilla, S., Mphande, K., and Gleason, M. 2023. Mesotunnels for organic management of cucurbit pests and diseases: tips for growers. NCPA 038, North Central IPM Center. Bulletin NCPA 038, North Central IPM Center, University of Minnesota, St. Paul, MN. 8 pp. Type: Websites Status: Published Year Published: 2023 Citation: The Current Cucurbit (project website). https://www.cucurbit.plantpath.iastate.edu/. \~1,200 visits in 2023. Type: Journal Articles Status: Submitted Year Published: 2024 Citation: Mphande, K., Badilla-Arias, S., Cheng, N., Gonz�lez-Acu�a, J., Nair, A., Zhang, W., and Gleason, M.L. 2023. Evaluating pollination and weed control strategies under mesotunnel systems for organic muskmelon production in Iowa. HortTechnology: Submitted. Type: Journal Articles Status: Under Review Year Published: 2023 Citation: Pethybridge, S., Damann, K., Murphy, S., Diggins, K.R., and Gleason, M.L. 2023. Evaluation of mesotunnels for organic muskmelon production in New York, USA. Renewable Agriculture and Food Systems: Accepted pending revision. Type: Journal Articles Status: Accepted Year Published: 2023 Citation: Pethybridge, S.J., Damann, K., Murphy, S., Diggins K., and Gleason, M.L. Gleason. 2023. Optimizing Integrated Pest Management in Mesotunnels for Organic Acorn Squash in New York. Plant Health Progress: Accepted. Type: Other Status: Published Year Published: 2023 Citation: Diggins, K., and Gonzalez, J. 2023. Cucurbit Grower Perceptions of Mesotunnel Systems: 2022 Grower Interview Findings. Power Point presentation, June 12, 2023. https://www.cucurbit.plantpath.iastate.edu/files/inlinefiles/diggins%202022%20Cooperator%20Perceptions%20summary%2010.23%20FULL.pdf. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Gonthier, D.J. 2023. Plastics-based protection systems in organic agriculture. Conference on Reducing Plastics Along the Entire Organic Supply Chain. The Organic Trade Association, Washington, DC. May 9, 2023. Oral presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Gonthier, D. 2022. Pollination strategies for cucurbit crops under mesotunnels. Michigan State University & Great Lakes Fruit, Vegetable, & Farm Market Expo. Grand Rapids, MI (December 7, 2022). Oral presentation. Progress 09/01/21 to 08/31/22 Outputs Target Audience:The target audience for this project is commercial growers of cucurbit crops. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Kathleen Fiske, PhD candidate, Department of Entomology, University of Kentucky -Field research experience, mentoring of undergraduate research assistants, development of outreach materials (blog posts), and presentation of results at academic and grower\'s meetings. Alexis Gauger, PhD candidate, Department of Entomology, University of Kentucky -Field research experience, mentoring of undergraduate research assistants, development of outreach materials (blog posts), and presentation of results at academic and grower\'s meetings. Ryan Kuesel, PhD candidate, Department of Entomology, University of Kentucky -Field research experience, mentoring of undergraduate research assistants, development of data analysis skills. Helder Avendano, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Chelsea Avery, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Raine Esparza, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Mateo Garcia, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Jacob Hollar, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Sarah Jones, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Ben Morrison, undergraduate researcher, Department of Entomology, University of Kentucky -Field research experience. Abby Tikhtman, temporary technician, Department of Entomology, University of Kentucky -Field research experience. Sharon Badilla-Arias, PhD candidate, Dept. of Plant Pathology, Entomology, and Microbiology, Iowa State University - Field research experience, mentoring of undergraduate research assistants, development of outreach materials (blog posts) and presentation of results at academic and grower\'s meetings. Kephas Mphande, PhD candidate, Dept. of Plant Pathology, Entomology, and Microbiology, Iowa State University - Field research experience, mentoring of undergraduate research assistants, development of outreach materials (blog posts) and presentation of results at academic and grower\'s meetings. Jose Gonzalez-Acuna, Research Associate, Dept. of Plant Pathology, Entomology, and Microbiology, Iowa State University - Coordination of field research and outreach components; field research experience, mentoring of undergraduate research assistants, development of outreach materials (blog posts, podcasts, and videos) and presentation of results at academic and grower meetings. Nieyan Cheng, Ph.D. graduate, Dept. of Economics, Iowa State University; Developed economic analysis model and calculated economic indexes for all field experiments. Izzy Danicich, undergraduate research assistant, Iowa State University. Assisted in field projects. Kaitlin Diggins, undergraduate research assistant, Iowa State University. Assisted in field and laboratory projects. Kaylee Hyser, undergraduate research assistant, Iowa State University. Assisted in field projects. Jackson Goshen, undergraduate research assistant, Iowa State University. Assisted in field projects. Evelyn Bauer, undergraduate research assistant, Iowa State University. Assisted in field projects. Elijah Perrault, undergraduate research assistant, Iowa State University. Assisted in field projects. Kellie Damann, Research Associate, Cornell University. Directed performance of field experiments and conducted data analysis. Sean Murphy, Research Associate, Cornell University. Co-supervisor with Ms. Damann for field experiments. How have the results been disseminated to communities of interest?Please see the sections of this report entitled \"Products\" and \"Other Products\" for a description of the outreach products and activities. What do you plan to do during the next reporting period to accomplish the goals? Complete the project\'s grower manual (currently in the final editing stage) and disseminate it in both print versions (as a North Central IPM Center publication) and electronically (via the project website). Upload an additional year of podcast episodes to the project\'s podcast channel. Complete economic analysis (partial budget, cost efficiency ratio) of all replicated field experiments and publish the results in grower journals (e.g., American Vegetable Grower). Publish the results of field experiments (including economic analyses) from each state in academic journals (e.g., HortTechnology). Assure long-term post-project availability of the project\'s website resources via transfer of the entire website to the North Central IPM Center in mid-August 2023 (this has already been agreed upon with the NCIPMC). Continue laboratory experiments with biological control of cucurbit bacterial wilt. Begin gene deletion/complementation experiments to clarify genes responsible for the pathogenicity of CYVD using the pathogenicity assay developed in Year 3. Impacts What was accomplished under these goals? OBJECTIVE 1.Kentucky.A mesotunnel weed control trial on acorn squash compared teff living mulch mowed once during bloom, teff non-mowed, bare ground mowed once during bloom, and landscape fabric. Plots were 30 ft long, three rows with four reps, and ends opened during flowering. Bareground-mowed had significantly higher weed biomass than all other treatments, and landscape fabric had a higher marketable yield than all other treatments.

Pest pressure and wilt incidence did not differ across treatments. A muskmelon pollination trial in mesotunnels (120-ft-long triple rows, four reps) compared: 1) full-season tunnels with bumble bees added at flowering (\'full season\'); 2) removal of ends of the tunnels during flowering (\'open-ended); 3) permanent removal of covers when bloom began (\'on-off\'); and 4) non-covered control with organic insecticides. There were significantly fewer cucumber beetles in the full season and open-ends vs. the control. Open-ends had more marketable yield (lbs) than the other treatments, but the differences were not significant. A muskmelon variety trial crossed varieties (Astound, Athena, Divergent, and Hannah\'s Choice) with treatments (mesotunnel open-end vs. non-covered) on 20-ft-long, 3-row plots. Astound out-yielded Divergent and Hannah\'s Choice but not Athena. The mesotunnel treatment had a significantly higher yield than the non-covered treatment. Iowa.In a pollination trial, muskmelon in 150-ft-long, 3-row subplots had the following treatments: 1) one bumble bee hive/subplot, tunnels sealed all season (full-season); 2) open-ends (ends opened when bloom began, re-covered two weeks later), and 3) on-off-on (nets removed at start of bloom, re-installed two weeks later). Marketable yield was equivalent for full-season and on-off-on treatment but lower for open-ends. For weed management, muskmelon seedlings were transplanted into 30-ft-long, 3-row subplots. Full-season had bumble bee boxes for pollination. Treatments: 1) weed fabric; 2) teff seeded at 4 lb/acre, mowed three weeks after sowing; 3) teff, not mowed; 4) bare ground mowed three weeks after transplanting; and 5) bare ground, not mowed. Marketable yield was statistically the same for weed fabric and mowed teff but significantly higher than the other treatments. Weed fabric had the lowest weed biomass. In a pollination trial on acorn squash, seedlings were transplanted into 3-row, 150-ft-long rows for three treatments: 1) full-season mesotunnels with one bumblebee hive in the center row of each subplot (Full season); 2) nets removed at bloom for two weeks to allow natural pollination, then resealed (On-off-on); 3) both ends opened for two weeks at bloom, then resealed (Open ends). Visual observations of bees and squash bugs were made twice a week for two weeks during bloom. There were no significant differences in marketable yield among the treatments (Table 1). For weed management on acorn squash, seedlings were transplanted into 30-ft-long triple rows. Treatments: 1) landscape fabric; 2) teff seeded at 4 lb/acre, mowed at bloom; 3) teff at 4 lb/acre, non-mowed; 4) bare ground, mowed, and 5) bare ground, non-mowed. Covers on all treatments were removed for two weeks at bloom, then replaced. Marketable yield was highest for landscape fabric, did not differ significantly from either mowed treatment and was lowest for non-mowed bare ground and teff. New York.In a pollination trial, muskmelon plots (150\' long x 3 rows wide) were compared on/off/on, open ends, and full-season treatments. Treatment had no significant effect on powdery mildew, downy mildew, or Alternaria leaf spot incidence. Bacterial wilt incidence and epidemic progress was significantly reduced in on/off/on and full season compared to open ends. Cucumber beetle populations were significantly lower in on/off/on than the other treatments. In week 4, bumblebee numbers were significantly higher in full-season than open ends. Marketable weight was also significantly higher in on/off/on than the other treatments. On/off/on for muskmelon resulted in significantly less bacterial wilt, higher populations of pollinators, and significantly higher marketable yield. In a weed control trial, treatments were: non-covered plots with landscape fabric; mesotunnel plots with landscape fabric; mesotunnel + ryegrass; and mesotunnel + ryegrass/white clover. Incidence of CYVD and pest insects was significantly suppressed in mesotunnels compared to uncovered plots. In both crops, landscape fabric significantly suppressed weeds compared to rye/clover or rye-only cover crops. OBJECTIVE 2. At ISU, we conducted pathogenicity trials for biocontrol of bacterial wilt on muskmelon seedlings, using bacterial agents previously reported to have biocontrol activity against other pathogens. Two-week-old seedlings were wound-inoculated with the pathogen in each of the following two experimental protocols: co-inoculation with a mixture of the pathogen and an equal concentration of a candidate biocontrol bacterium; and prior (3 days earlier) spray inoculation with a biocontrol candidate. Progress of bacterial wilt was monitored daily by counting the number of wilted and non-wilted leaves per seedling. In the co-inoculation trials, 11 of 20 species of biocontrol bacteria significantly suppressed wilting, whereas, in the prior-spray-inoculation trials, 5 of 12 bacteria showed significant wilt suppression. These results suggest that cucurbit bacterial wilt may be amenable to management by biological control. In addition, we developed the first pathogenicity trials for CYVD, using summer squash (cv. Zephyr) seedlings. We compared two wound-inoculation methods - using a florist frog and using a syringe - to introduce the CYVD pathogen, Serratia marcescens. For each method, inoculation was performed either once (at the expanded-cotyledon stage) or twice (the second inoculation done seven days later), using ten plants per treatment. The most consistently successful inoculation method was to inject seedlings at the cotyledon stage. Symptoms within two weeks included phloem browning and stem elongation, as well as lower dry biomass than the non-inoculated control plants. This assay represents an important breakthrough in the study of CYVD because it opens the way for further experiments to test biological control candidates and investigate host-pathogen interactions at the genetic level. OBJECTIVE 3. With guidance from the project\'s economists, analysis of the costs and profitability of all management options that were tested in replicated field trials in all three states is ongoing. OBJECTIVE 4. The numerous outreach activities of the project are described under Products and Other Products. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Mphande, K., Gonzalez-Acuna, J., and Gleason, M.L. 2022. Weed control on muskmelon in organic mesotunnel systems. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Mphande, K. Gleason, M.L., and Beattie, G.A. 2022. Developing a pathogenicity assay for Serratia marcescens on squash (Cucurbita pepo). Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Gonthier, D. 2022. Limiting pests using exclusion netting in fruits and vegetables. University of Kentucky IPM Training School (March 9, 2022). Virtual Presentation. 20 attendees. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Fiske, K., Bessin, R., Williams, M., Gonthier, D. 2022. Row covers provide sustainable resiliency to cucurbit pests. IPM Coordinators Meeting, Denver, CO. (February 28, 2022). Poster. Presented by Ric Bessin. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Fiske, K. 2022. Row cover systems for cucurbits: Insights from research and growers perspectives. Kentucky Fruit and Vegetable Conference (January 4, 2022). Virtual presentation. 23 attendees in person. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Fiske, K., Gonthier, D., Bessin, R., Williams, M. 2022. Row cover systems for cucurbits: Insights from research and growers perspectives. Southeast Regional Fruit and Vegetable Conference (January 7, 2022). Virtual presentation. 35-40 attendees in person. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Fiske, K., Bessin, R., Williams, M., Gonthier, D. 2022. Use of row covers increases marketable yield and profit and decreases cucumber beetles and powdery mildew. University of Kentucky Department Retreat (August 12, 2022). Poster. \~50 attendees in person. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Gauger, A., Fiske, K., Gonthier, D. 2022. Foraging environment affects reproductive success in commercial Bombus impatiens colonies. University of Kentucky Department Retreat (August 12, 2022). Poster. \~50 attendees in person. Type: Other Status: Published Year Published: 2022 Citation: Dammann, K., and Pethybridge, S. 2022.Reflecting on the 2022 Mesotunnel Research Trials in NY. https://www.cucurbit.plantpath.iastate.edu/post/reflecting-2022-mesotunnel-research-trials-ny. Blog post, Current Cucurbit website, December 13, 2022 Type: Websites Status: Published Year Published: 2022 Citation: The Current Cucurbit (project website). https://www.cucurbit.plantpath.iastate.edu/. 1,748 visits in 2022. Type: Other Status: Published Year Published: 2022 Citation: Gauger, A. 2022. Who pollinates cucurbits? https://www.cucurbit.plantpath.iastate.edu/post/who-pollinates-cucurbits. 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Type: Other Status: Published Year Published: 2022 Citation: Anonymous. 2022. Bacterial wilt of cucurbits. https://www.cucurbit.plantpath.iastate.edu/infographics. Infographic, The Current Cucurbit website. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Badilla-Arias, S., Gonzalez-Acuna, J., and Gleason, M. 2022. Optimizing pollination of organic acorn squash in mesotunnels in Iowa. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022.

Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Badilla-Arias, S., Gleason, M.L., and Beattie, G.A. 2022. Screening for biocontrol agents of cucurbit bacterial wilt in muskmelon. Poster presented at annual meeting of American Phytopathological Society, Pittsburgh, PA, August 2022. **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:Commercial vegetable growers in the U.S. Changes/Problems: Limitations due to COVID-19 were far less evident than in Year 1, but still present. Field trials in all 3 states proceeded as described in the proposal (Objective 1), and biological control research (Objective 2) began when it was possible to access ISU laboratory space in January 2021. Annual face-to-face meetings of the project team have not been possible, but we have held monthly Zoom team meetings throughout Years 1 and 2, as well as two Advisory Panel Zoom meetings in Year 1 and three in Year 2. We have also been able to resume grower field days and in-person conference presentations to a limited extent. Field experiments. One change planned for Year 3 in Iowa is to time mowing of teff based on the height of the grass (15-18 inches) rather than crop phenological stage (start of the flowering period) in order to optimize the tradeoff between weed suppresison and crop yield. Results of Year 3 trials may help to clarify which approaches are best for using mesotunnels in each region and crop. What opportunities for training and professional development has the project provided? Jose Gonzalez, Research Associate, Department of Plant Pathology and Microbiology, Iowa State University. Responsible for all aspects of project coordination and oversight of project outreach activities. Sharon Badilla, PhD candidate, Department of Plant Pathiology and Microbiology, Iowa State University - Responsible for planning and carrying out Iowa field experiments on acorn squash, and laboratory experiments on biological control of bacterial wilt of cucurbits. Participated in monthly project team meetings and Advisory Panel meetings. Kephas Mphande, PhD candidate, Department of Plant Pathology and Microbiology, Iowa State University. Planned and carried out field experiments on muskmelon, developed of a laboratory-based pathogenicity assay for cucurbit yellow vine disease (CYVD) on squash seedlings, and mentored undergraduate assistahnts. Nieyan Cheng, PhD candidate, Department of Economics, Iowa State University. Planned and conducted economic analysis of project results, and designed and executed project surveys of stakeholders. Kathleen Fiske, PhD candidate, Department of Entomology, University of Kentucky - oversaw and coordinated field experiments at University of Kentucky, mentored undergraduate assistants, and participated in monthly project team meetings and Advisory Panel meetings. Kellie Damann, Research Associae, Cornell University. Oversaw and coordinated New York field experiments and on-farm trials, mentored undergraduate assistants, and participated in monthly project team meetings and Advisory Panel meetings. Sean Murphy, Research Associate, Cornell University - Carried out New York field trials, mentored undergraduate assistants, and participated in project team meetings Alexis Gauger, undergraduate student. Field research assistant, summer 2021, University of Kentucky Chelsea Avery, undergraduate student. Field research assistant, summer 2021, University of Kentucky Kaitlin Diggins, undergraduate student. Field and lab research assistant, 2021. Iowa State University. Participated in monthly project team meetings and Advisory Panel meetings, assisted with analysis of 2020 stakeholder and project team surveys, and conducted end-of-season telephone interviews with all nine on-farm trial cooperators in 2021. Benjamin Diener, undergraduate student. Field and lab research assistant, 2021. Iowa State University. How have the results been disseminated to communities of interest?Please see the \"Products\" and \"Other Products\" sections of this report for details of our extensive and multi-featured outreach efforts in Year 2. What do you plan to do during the next reporting period to accomplish the goals?All four Objectives will proceed as described in the proposal, subject to COVID-19 restrictions and the changes described in the next section. **Impacts** What was accomplished under these goals? OUTCOMES and FINDINGS this project period. Organic food crops are the fastest-growing category in U.S. agriculture. But organic growers struggle to manage devastating diseases and insect pests with few effective tools. Our project is fine-tuning a new system called mesotunnels to help growers of organic cucurbit crops (squash, melon, cucumber) solve these problems. Mesotunnels, which are nylon-mech barriers that keep pests and diseases off crops, can ensure consistent yields. Our field trials (Objective 1) are optimizing pollination and pest, disease, and weed control in mesotunnel systems. We are also testing promising microbes for their ability to control bacterial diseases of cucurbit crops (Objective 2). We are using economic and sociological analysis to find out where and when mesotunnels and biocontrol make sense for organic growers to use (Objective 3), and our outreach intiiatives ((Objective 4) are sharing our progress with growers nationwide. Our research has found that marketable yield in organic mesotunnel systems has been strongly influenced by the crop (muskmelon vs. acorn squash) and the geographic region where the trials are held. In Iowa, for example, pollination trials for muskmelon have consistently shown that the full-season mesotunnel approach has higher yield than on-off-on or open-ends mesotunnel treatments, whereas the full-season treatment has had the lowest marketable yield for acorn squash. In weed control trials, living-mulch species and seeding rates have differed among states based on regional recommendations. We have also found that a single mowing of living mulches during bloom of the cucurbit crop can increase marketable yield in some cases (for example, muskmelon in Iowa) but not for acorn squash in Iowa, and not consistently for either crop in other regions. OBJECTIVE 1. POLLINATION AND WEED CONTROL TRIALS This project year. Replicated experiments with muskmelon and acorn squash took place during 2021 (Year 2 of the project) in Iowa, Kentucky, and New York. Iowa. Pollination trials on both crops used 150-ft-long, 3-row mesotunnels. Treatments:

tunnels closed all season, with a purchased hive of bumble bees to provide pollination (\"full season\"); tunnels opened for 2 weeks during flowering, then re-closed (\"on-off'-on\"); and tunnel ends opened for 2 weeks during flowering, then re-closed (\"open ends\"). For muskmelon (cv. Athena), marketable yield was highest for full-season than the other treatments. For acorn squash (cv. Table Ace), the on-off-on and open-ends treatments had much higher marketable yield than full-season. Weed management trials were done on 30-foot-long, triple-row mesotunnels; muskmelon trial used the \"full season\" strategy and acorn squash used \"on-off-on.\" Treatments (applied to the soil alleys between crop rows): landscape fabric; teff, mowed when nets were removed; teff with no mowing; bare ground, mowed when nets were removed; and bare ground without mowing. Marketable yield for muskmelon (cv. Athena) was highest for landscape fabric and mowed teff, and 25-30% lower for the other treatments. Mowing teff and bare-ground plots halved the end-of-season weed biomass. For acorn squash (cv. Table Ace), landscape fabric out-yielded than other treatments, and mowing reduced end-of-season weed biomass. For muskmelon, mowing teff at mid-season minimized yield drag, but not for acorn squash. Kentucky. Pollination. An acorn squash (cv. Table Ace) trial in mesotunnels (120-ft-long triple rows, 4 replications) compared 4 treatments: full-season tunnels with purchased bumble bees (\"full season\"); covers removed for 2 weeks during bloom (\"on-off-on\"); ends uncovered for 2 weeks during bloom (\"open ends\"); and permanent removal of covers when bloom began (\"on-off\"). The full season treatment had fewer pollinators than other treatments, suggesting the purchased bumble bee colonies were less efficient pollinators compared to wild bees. There was no difference in marketable yield among treatments. Weed management. Another acorn squash trial, in triple-row, 30-ft-long plots with open-ends mesotunnels, compared 4 treatments: landscape fabric, teff non-mowed, teff mowed once during squash bloom, and buckwheat mowed once during squash bloom. There were no differences among treatments in either weeed biomass or marketable yield. Foliar disease management. An acorn squash trial assessed impact of mesotunnels and fungicide spraying on powdery mildew. Experimental design was a 2x2 factorial (open-ends mesotunnels vs no tunnels, and sprayed vs. unsprayed) in 30-ft-long, triple-row subplots with 4 replications. Mesotunnels significantly reduced the percentage of leaf area with powdery mildew, but organic fungicide treatments had no significant effect. New York. Weed, disease, and insect pest control. A field trial evaluated mesotunnels and weed suppression options for muskmelon (cv. Athena) and acorn squash (cv. Table Ace). Treatments: (i) non-covered plots with landscape fabric for weed suppression; and full-season mesotunnels with (ii) landscape fabric (iii) ryegrass; and (iv) ryegrass/white clover. Powdery mildew incidence was significantly higher in muskmelon than acorn squash, but severity was higher in acorn squash. Bacterial wilt (BW) and cucurbit yellow vine disease (CYVD) appeared only in muskmelon and acorn squash, respectively. Cucumber beetles and squash bugs were significantly higher in uncovered plots than mesotunnels. The mesotunnels significantly reduced incidence of cucumber beetles and squash bugs as well as BW and CYVD. In muskmelon, marketable fruit weight was significantly lower in mesotunnels and not significantly affected by cover crop. In acorn squash, the non-covered plot had significantly more unmarketable fruit than in mesotunnels. Unmarketable acorn squash was mainly attributed to being soft and misshapen; incidence of soft fruit was significantly higher in uncovered plots compared to the mesotunnels. In sum, mesotunnels resulted in lower marketable yield for muskmelon and but did not impact marketable yield in acorn squash. OBJECTIVE 2. BIOLOGICAL CONTROL TRIALS Bacterial wilt. Lab trials at Iowa State University (ISU) evaluated more than 20 strains of bacteria previously shown to be effective in suppressing plant-pathogenic bacteria. Biological control strains and the bacterial wilt pathogen, Erwinia tracheiphila (Et), were cultured, mixed together, and inoculated into 2-week-old muskmelon (cv. Athena) seedlings. Wilting was monitored every 2 days for 3 weeks. Several biological control candidates suppressed bacterial wilt symptoms significantly in repeated trials. In addition, several strains of phage (bacterial virus) were isolated from striped cucumber beetles from IA and KY cucurbit fields. These phages were purified and their concentrations are being amplified. Cucurbit yellow vine disease (CYVD). A new inoculation method resulted in clear-cut symptoms (browning of the vascular system and roots) within 3 weeks after injection of stems with the CYVD bacterium (Serratia marcescens). This opens the door to determining which bacterial genes and enzymes are responsible for causing CYVD - and to developing ways to neutralize them and protect cucurbit crops. OBJECTIVE 3. SOCIOECONOMIC ANALYSIS The project team created a final version of a Year 3 grower survey to be sent to vegetable growers throughout IA, NY, KY, and neighboring states in January 2021 to gauge project impact. The economics team also finalized a template for analysis of economic data for all years of the project, based on results of field experiments. OBJECTIVE 4. OUTREACH The project's extensive face-to-face and online outreach (blogs, videos, podcasts) are posted on the project website and spread by social media (Facebook and Twitter). See \"Products\" and \"Other Products\" sections of this report for details. **Publications** - Type: Websites Status: Published Year Published: 2020 Citation: The Current Cucurbit (project website). <https://www.cucurbit.plantpath.iastate.edu/>. Total visits, January-October 2021: 895 (188 from mobile devices, 707 from desktop computers). Twitter impressions, January-October 2021: 1,031. - Type: Other Status: Published Year Published: 2021 Citation: Damann, K., and Pethybridge, S. 2021. The Current Cucurbit podcast series. Veg Edge newsletter, Vol. 17, Cornell University Cooperative Extension. October 4, 2021. p. 11. - Type: Other Status: Published Year Published: 2021 Citation: Damann, K., and Pethybridge, S. 2021. Mesotunnels: Next Best Tool for Organic Cucurbit Growers in the

Northeastern US. Produce Pages, Cornell University Cooperative Extension, April 2021. p. 6. - Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Fiske, K. 2021. Optimizing row cover systems for cucurbits in Kentucky, Kentucky Fruit and Vegetable Conference, Lexington, KY, January 12, 2021. 158 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Gonthier, D. 2021. Multi-functional agriculture: Balancing trade-offs to improve sustainability. Seminar, Department of Entomology, University of Kentucky, April 1, 2021. 30 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Gonthier D. 2021. Multifunctional agriculture: Balancing trade-offs to improve sustainability. University of Kentucky. Department of Plant and Soil Science. Department Seminar. March 23, 2021. 35 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Gonthier D. 2021. Multi-functional agriculture: Balancing pest/disease control with pollination: A case study of using row covers in squash. Classroom case study presentation. Agroecology SAG/PLS390 February 26, 2021. 21 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Gleason, M. 2021. Do mesotunnels make sense for organic cucurbit production? Seminar, Department of Plant Pathology, University of Wisconsin-Madison, December 7, 2021. 26 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Diggins, K., and Morton, L.W. 2021. o What are growers saying about mesotunnel systems for organic cucurbits?https://www.cucurbit.plantpath.iastate.edu/post/what-are-growers-saying-about-mesotunnel-systems-organic-cucurbits - Type: Other Status: Published Year Published: 2021 Citation: Damann, K., and Pethybridge, S. 2021. Reflecting on the 2020 Preliminary Results of the Mesotunnel System in NYhttps://www.cucurbit.plantpath.iastate.edu/post/reflecting-2020-preliminary-results-mesotunnel-system-ny - Type: Other Status: Published Year Published: 2021 Citation: Badilla, S. 2021. On-site presentation of OREI acorn squash field trials, Iowa State University Field Day, ISU Horticulture Research Farm, Ames, Iowa, July 22, 2021. 225 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Mphande, K. 2021. On-site presentation of OREI muskmelon field trials, Iowa State University Field Day, ISU Horticulture Research Farm, Ames, Iowa, July 22, 2021. 225 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Nair, A. 2021. Presentation during field day at OREI on-farm trial site, Scattergood Farm, West Branch, Iowa, September 15, 2021. 125 participants. - Type: Other Status: Published Year Published: 2021 Citation: Badilla, S. 2021. Dos and don\'ts when using mesotunnels in commercial organic acorn squash production https://www.cucurbit.plantpath.iastate.edu/post/dos-and-donts-when-using-mesotunnels-commercial-organic-acorn-squash-production - Type: Other Status: Published Year Published: 2021 Citation: Fiske, K. 2021. Reflecting on University of Kentuckys 2020 mesotunnel experimentshttps://www.cucurbit.plantpath.iastate.edu/post/reflecting-university-kentuckys-2020-mesotunnel-experiments - Type: Other Status: Published Year Published: 2021 Citation: Cheng, N., and Zhang, W. 2021. What do Farmers and Researchers Think About Mesotunnels and Biological Controls for Cucurbit Crops? Responses from 2020 surveyshttps://www.cucurbit.plantpath.iastate.edu/post/what-do-farmers-and-researchers-think-about-mesotunnels-and-biological-controls-cucurbit-crops - Type: Other Status: Published Year Published: 2021 Citation: Avery, C. 2021. Efficacy of pest control and pollination management in organic cucurbit production with row covers. November 30, 2021. Agricultural and Medical Biotechnology 395/399 Undergraduate Student Symposium, University of Kentucky, Lexington, KY. 20 attendees. - Type: Other Status: Published Year Published: 2021 Citation: Fiske, K. 2021. Optimizing row covers in cucurbit production. Symposium: Expanding the Pest Management Tool-kit: Adapting Pest Management Alternatives for Diverse Farming Communities. June 23, 2021. North Central Branch, Entomology Society of America. Virtual presentation. 28 attendees.

PROGRESS

2019/09 TO 2020/08 Target Audience:Commercial growers of cucurbit vegetable crops in the eastern half of the U.S. Changes/Problems:A project-wide obstacle in Year 1 was the coronavirus pandemic. The pandemic constricted field trials (Objective 1) at Cornell University due to a state-mandated lockdown, delayed plans to start the biological control experiments (Objective 2) at Iowa State University by 8 months, prevented in-person interviews to be conducted for the socioeconomic portion of the research (Objective 3), and sharply limited in-person collaboration of project personnel with cooperators in on-farm demonstration trials (Objective 4). The outlook for overcoming these Year 1 imitations in Year 2 is uncertain, but the project team will adjust to whatever the pandemic throws at us. Despite the pandemic, our project advanced significantly in Year 1. Objective 1 field experiments in Iowa and Kentucky, and a nonreplicated trial in New York, advanced knowledge about mesotunnels in several ways: Pollination in mesotunnels played out differently for muskmelon than acorn squash. The fact that acorn squash foliage filled the full-season-mesotunnels much more than muskmelon may have made it more difficult for bumble bees to find acorn squash flowers, which in turn may have limited pollination and yield. In muskmelon, on the other hand, full-season mesotunnel treatments often out-yielded other treatments, suggesting that bees found flowers more readily on that crop. Interestingly, mesotunnels in which only the ends were opened yielded only slightly less than the full-season tunnels (muskmelon) and, in acorn squash, sometimes exceeded the yield from full-season tunnels. On-off-on treatments - which removed the cover fabric entirely for 2 weeks during bloom - had the most pollinator visits but often the lowest yields, apparently because pest and disease pressure was greatest in these treatments. These findings offer encouraging evidence that an open-ends strategy could provide a \"sweet spot\" for organic mesotunnel systems by allowing enough natural-pollinator access to assure acceptable yield while limiting crop access by pest insects and the bacteria they vector. We therefore plan to continue trialing open-ends treatments on both cucurbit crops. Weed management. Seeding teff as a living mulch was highly effective in suppressing weed growth between crop rows. Interestingly, teff depressed crop yield in both crops in Iowa, but not in Kentucky. The yield depression in Iowa coincided with a dry summer; vigorous root growth by teff, which is drought-adapted, may have diverted water and nutrients from the cucurbit crops, and shading by teff may have also contributed to yield loss. For Year 2, therefore, Objective 1 trials will include mid-season mowing of teff mulch in an effort to preserve its weed-suppressive benefit while minimizing its competition with the cucurbit crops. Unexpectedly, foliar diseases - powdery mildew, downy mildew, and Alternaria leaf spot - were less severe under mesotunnels compared to exposed treatments. A possible reason for this is shorter dew periods under the mesotunnels, which could curtail high-humidity periods that can promote these diseases. In Year 2, therefore, we plan to compare relative humidity and the duration of wet periods inside vs. outside mesotunnels to see if mesotunnels modify the crop microenvironment to mitigate disease development. Objectives 2, 3, and 4 will proceed as described in the proposal, to the extent possible with coronavirus restrictions. What opportunities for training and professional development has the project provided?Research Associate training and professional development: Jose Gonzalez, Iowa State University, Research Associate - Research project coordination, creation of electronic outreach products (websites, blog posts, videos), promotion of project via social media, mentoring of graduate students and undergraduate research assistants Kellie Damann, Cornell University, Research Associate - Field research coordination and conduct; development of outreach products (blog posts), mentoring of undergraduate research assistants Sean Murphy, Cornell University, Research Associate - Field researchcoordination and conduct; development of outreach products (blog posts), mentoring of undergraduate research assistants Delia Scott-Hicks, University of Kentucky - Field research coordination and conduct Graduate student training and professional development: Kephas Mphande, PhD candidate, Department of Plant Pathology & Microbiology, Iowa State University - Field and lab research experience; development of outreach products (blog posts, instructional videos), Sharon Badilla, M.S. candidate, Department of Plant Pathology & Microbiology, Iowa State University - Field and lab research experience; development of outreach products (blog posts),mentoring of undergraduate research assistants Nieyan Cheng, PhD candidate, Department of Economics, Iowa State University - Research experience in economic analysis and grower surveys; development of outreach products (blog posts) Katie Fiske, M.S. candidate, Department of Entomology, University of Kentucky - Field research experience, mentoring of undergraduate research assistants Robby Brockman, M.S. candidate, Department of Entomology, University of Kentucky - Field research experience, mentoring of undergraduate research assistants How have the results been disseminated to communities of interest?Despite pandemic-imposed limitations, the team has developed and posted to the project\'s website, The Current Cucurbit (https://www.cucurbit.plantpath.iastate.edu), many virtual outreach products, as well as delivered many person and Zoom-facilitated grower education sessions. For details, please see the \"Products\" and \"Other Products\" sections of this report. What do you plan to do during the next reporting period to accomplish the goals?Objectives 2, 3, and 4 will proceed as described in the proposal, to the extent possible with coronavirus restrictions.

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? Impact of the project: Organic food crops are the fastest growing category in U.S. agricuture. But organic vegetable growers also strugggle to manage devastating diseases and pest insects with few effective tools. Our project is fine-tuning a new system called mesotunnels to help growers of organic cucurbits (squash, melon, cucumber) solve these problems. Mesotunnels - nylon-mesh barriers that keep pests and diseases off crops - can ensure consistent yields. Our mesotunnel field trials (Objective 1) aim to optimize pollination and pest, disease and weed control in this new management system. We are also testing promising microbial candidates for their ability to control bacterial diseases of cucurbits (Objective 2), alone and in combination with mesotunnels. We will use economic and sociological analysis to find out where and when mesotunnels and biological control are adaptable by organic cucurbit growers, and our outreach (Objective 4) will share the advances with growers nationwide. This project year\...In Objective 1, replicated field experiments with muskmelon and acorn squash took place on university farms in Iowa and Kentucky, and a demonstration trial was conducted at Cornell University. Iowa. Results of pollination trials - on triple-row, 150-foot-long mesotunnels - differed between the two crops. Treatments were: tunnels closed all season, with a purchased hive of bumble bees placed underneath to provide pollination (\"full season\"); tunnels opened completely for 2 weeks during flowering of the crop, then re-closed (\"on-off-on\"); and tunnel ends opened for 2 weeks during flowering (\"open ends\") The on-off-on and open-ends treatments depended on natural polinators rather than purchased bees. For muskmelon, marketable yield was highest for the full-season treatment, intermediate for the open-end treatment, and lowest for the on-off-on treatment. For acorn squash, in contrast, marketable yield was highest yield in the on-off-on treatment, lowest in the full-season treatment, and intermediate in the open-ends treatment. Weed management trials - in full season mesotunnels on replicated, 30-ft-long, triple-row plots - compared 4 treatments: 1) polyethylene landscape fabric; 2) teff (a cereal crop used as a mulch) seeded at 4 lb/acre; 3) teff at 8 lb/acre; and 4) bare ground (control). In muskmelon plots, marketable yield for landscape fabric was about twice as high as the other three treatments, although teff suppressed weeds almost as well as landscape fabric. Acorn squash marketable yield showed less advantage for landscape fabric over teff, and teff treatments out-yielded the bare-ground control. The yield penalty from teff in both crops could be caused by competition with the crop for nutrients, water, and sunlight. Kentucky. Pollination. An acorn squash trial in mesotunnels (120-ft-long triple rows, 4 replications) compared 4 treatments: full-season tunnels with purchased bumble bees added (\"full season\"); complete removal of covers for 2 weeks during bloom (\"on-off-on\"); removal of the ends of the covers for 2 weeks during bloom (\"open ends\"); and permanent removal of covers when bloom began (\"on-off\"). Marketable yield was significantly higher in the open-ends treatment than the other treatments, and bee abundance was significantly lower in the full-season treatments than the other treatments. A parallel experiment on muskmelon differed in that subplot length was 30 ft rather than 120 ft.; in that trial, the full season treatment had significantly higher marketble yield than the on-off or on-off-on treatments and the open-ends treatment was intermediate. Weed management. Another acorn squash trial, in replicated, triple-row, 30-ft-long plots with on-off-on mesotunnels, compared 4 living much treatments for the soil strips between black-plastic crop rows: buckwheat (seeded at 90 lb/A) and three seeding rates of teff: 12, 24, or 36 lb/A. Marketable yield did not differ significantly among the treatments, but weed suppression was more effective for buckwheat and the two higher rates of teff than for the lowest rate of teff. Foliar disease management. An acorn squash trial assessed impact of mesotunnels and fungicide spraying on powdery mildew, the most important fungal disease of cucurbits. Experimental design was a 2x2 factorial (on-off-on mesotunnels vs no tunnels, and sprayed vs. unsprayed) in 30-ft-long, triple-row subplots with 4 replications. Both mesotunnels and fungicide spraying significantly suppressed powdery mildew, and combining both practices gave the most suppression. The mesotunnel treatments also had significantly higher marketable yield than the no-tunnel treatments. New York. A nonreplicated demonstration trial - the only type of trial allowed in NY in 2020 due to New York\'s pandemic lockdown rules - was a 2x2 combination of crop (\'Honey Bear\' acorn squash and \'Athena\' muskmelon) and crop covering (full-season mesotunnels with purchased bumble bees inserted, and a non-covered control). Triple-row, 50-ft-long plots had landscape-fabric mulch between rows. Acorn squash. Marketable yield was similar for the 2 treatments. Striped cucumber beetle and squash bug populations were much higher on non-covered plants, whereas aphid populations built up under mesotunnels by the end of the season. Downy mildew, powdery mildew, and CYVD severity, although low, was much higher in the non-covered than the mesotunnel plot. Muskmelon. Number of marketable fruit in the mesotunnel plot was nearly 3x higher than for the control plot. Severity of bacterial wiltwas much lower in the mesotunnel than the control; while powderyand downy mildew incidence was higher in the covered plot but very low in general (less than 2%). Objective 2 (biological control of cucurbit bacterial diseases). Year 1 experiments at Iowa State were delayed by lockdowns of laboratory facilities that persisted through most of 2020. However, we obtained numerous species of biological-control-candidate bacteria from our own and other labs, and have obtained many strains of the target pathogens - Erwinia tracheiphila and Serratia marcescens - in preparation for starting in vitro and in vivo screening for suppression of the pathogens in January 2021. Objective 3. Socio-economic research included development of written surveys for stakeholders, as well as conducting telephone interviews with cucurbit growers in Iowa, Kentucky, and New York, in order to gauge their viewpoints on the project and its new strategies. Data analysis and interviews are ongoing. The team also finalized criteria to be measured in economic analyses of project data. Objective 4. Although face-to-face outreach was prohibited from March 2020 to the present due to the pandemic, numerous presentations at grower conferences and other gatherings carried the project\'s messages to stakeholders. A project website, The Current Cucurbit (https://www.cucurbit.plantpath.iastate.edu) includes numerous blog posts as well as the first in a series of videos (see \"Products\" and \"Other Products\" sections of this report). The project\'s Advisory Panel has met twice (July and October 2020) by Zoom with project PIs and graduate students. On-farm trials took place in all 3 states(3 in Iowa, 3 in New York, and 2 in Kentucky) where different mesotunnel settings were tested and different cucurbit crops were covered. Yield data and - in some cases - pest-disease incidence was recorded. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 1. Type: Websites Status: Published Year Published: 2020 Citation: https://www.cucurbit.plantpath.iastate.edu/ 2. Type: Conference Papers and Presentations Status: Other Year Published: 2019 Citation: Bessin, R. 2019. IPM for small farms. IPM class, University of Kentucky, December 4, 2019. 20 students. 3. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Vegetable insect pest update. South farm, University of Kentucky, February 18, 2020. 50 attendees. 4. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Outmaneuvering insect pests. Harlan County Webinar. June 4, 2020. 23 attendees. 5. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. IPM for Small Farms. County Agent Training Webinar. 46 attendees. 6. Type: Conference Papers and Presentations

Status: Other Year Published: 2020 Citation: Nair, A. 2020. Disease and pest management strategies in key vegetable crops. Iowa Fruit and Vegetable Growers Association, January 23, 2020. 35 attendees. 7. Type: Other Status: Published Year Published: 2020 Citation: Nair, A. 2020. Small Farms Podcast. Planting, cool-season-crop row covers, and high tunnels. March 24, 2020. 150 downloads. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Nair, A. 2020. Pest Management Workshop. https://www.extension.iastate.edu/vegetablelab/iowa-vegetables-pest-management. April 9, 2020. 1,445 views. 9. Type: Other Status: Published Year Published: 2020 Citation: Nair, A. 2020. Small Farms Podcast.Raised bed vegetable production. April 14, 2020. 75 downloads. 10. Type: Conference Papers and Presentations Status: Other Year Published: 2019 Citation: Bessin, R. 2019. Pumpkin Insect Management. Pumpkin webinar. December 19, 2019. 44 attendees. 11. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Scaling up IPM. Kentucky Vegetable Growers Association. January 6, 2020. 61 attendees 12. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Insect challenges from 2019. Lincoln Count, Kentucky, Produce Auction. January 16, 2020. 53 attendees. 13. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Managing key vegetable insect pests. Kentucky County Agent webinar, February 6, 2020. 53 attendees. 14. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Bessin, R. 2020. Vegetable insect update. Growers School. Mt. Vernon, IL, February 5, 2020. 27 attendees. ** **

↑ Return to Index

Organic Farm Financial Benchmarking in the Upper Midwest

Accession No.	1020512
Project No.	MIN-14-G32
Agency	NIFA MIN\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30484
Proposal No.	2019-03063
Start Date	01 SEP 2019
Term Date	31 AUG 2022
Grant Amount	$956,102
Grant Year	2019
Investigator(s)	Hadrich, J.; Van Nurden, PA.

NON-TECHNICAL SUMMARY

Benchmark analysis provides a summary of production and financial performance measures which allows producers to evaluate their individual performance to a cohort with similar characteristics. Conventional farming operations have numerous resources to complete benchmark analysis, while there are limited analysis available for organic producers. Organic farms are not immune to negative price swings and decreasing profit margins. Benchmark analysis allows producers to examine how to remain competitive with market fluctuations, but data to complete certified organic benchmark analysis is lacking at a state and regional level. This project proposes to provide a consistent way to collect financial data for organic farmers to complete benchmark analysis across the Upper Midwest (Minnesota, Wisconsin, and North Dakota). Specifically, this project aims to: (1) collect data on farm production and financial performance measures for certified organic row crop, forage, and dairy farms to investigate the financial performance of certified organic farms in the Upper Midwest. (2) Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms, (3) develop and deliver Extension programming to address the educational needs of organic producers and the agricultural professionals that advise them. These goals will integrate on-farm data collection, comprehensive data analysis, and benchmark analysis in a multi-faceted outreach program that will be used by organic farmers, farm business management instructors, policy makers, and agricultural professionals who support organic production. Additional info from University of Minnesota website, <https://finbin.umn.edu/>. > *"FINBIN is one of the largest and most accessible sources of farm > financial and production benchmark information in the world. FINBIN > places detailed reports on whole farm, crop, and livestock financials > at your fingertips. > "In 2021, the University of Minnesota's Center for Farm Financial > Management partnered with Environmental Defense > Fund > to establish a financial data-gathering process for cover crops. As a > result of this continuing effort, more Cover Crop Impact reports are > now available in FINBIN. > "Look at the following reports to compare corn and soybeans grown with > and without cover crops in Minnesota in 2022. Each report contains > four columns to compare the impact cover crop production has on > enterprise profitability."*

OBJECTIVES

This integrated regional project proposes to enhance the current FINBIN database by increasing the number of certified organic farms that participate in the Farm Business Management (FBM) program across Minnesota, North Dakota, and Wisconsin. This will increase the number of organic farms participating in FBM by 170 farms or 161% in the Upper Midwest. These three states currently collaborate on benchmarking efforts for conventional production, and this project provides a natural extension of current work and existing infrastructure. As the number of organic farms increases in the FINBIN database, the more familiar FBM instructors will be with organic production to better connect with a currently underserved population within FBM programs across the country.This integrated regional project has the long-term goal of enhancing the economic viability of organic row crop and dairy farms by providing comprehensive financial benchmark analysis to improve the efficiency of organic farm management decisions. This long-term goal will be addressed through the following supporting objectives: Objective 1: Recruit up to 170 organic farmers from the Upper Midwest region (MN, ND, WI) who do not currently participate in a farm business management program and compile data on farm production and financial performance measures. Objective 2: Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms to evaluate relationships between yield, efficiency, production, and financial performance of organic production and how it affects farm management decisions over time. Objective 3: Develop and deliver extension programming that helps farmers understand the relationship between farm management decisions and farm profitability for certified organic producers, transitioning organic producers, potential organic producers, and agricultural professionals that support organic producers.

APPROACH

The following methods will be used for each of the objectives defined previously: Objective 1: Recruit 170 organic row crop and/or dairy farms in Upper Midwest Recruit: Manyorganic farmers participate in a member association group to gain additional educational insight to improve efficiencies on their farming operation while jointly building a network of organic farmers. Each member association (MOSES, NFO, and NPSAS) has identified a target contact to lead the recruitment effort. Recruitment may include sponsoring workshops at annual conferences, contacting current members via mail, email, or phone, print ads in local newspapers or newsletters, among other factors. Other recruitment efforts include working with FBM instructors to reach out to current organic farmers, in addition to the Advisory Board members reaching out to their network.Train: Astep-by-step guideline for new FBM instructors working with organic farms will be created to ensure data is entered uniformly. A webinar will also be created and posted on the benchmarking website as a resource for all FBM instructors working with an organic farm to ensure everyone has the same background and methodology.Enroll: FBM instructors in Minnesota, North Dakota, and Wisconsin will enroll a target 170 certified organic row crop and/or dairy farms in FBM Education. We anticipate enrolling an additional 100 MN farms, 20 ND farms, and 50 WI farms. To encourage participation in the program we will offer two levels of cost-shares. This cost-share will compensate producers for the time needed to organize records and become familiarized with a new record keeping system and process. Across all states, existing certified organic FBM participants will receive a 25% fee cost-share for the three years of data collection. All new FBM participants will receive an annual 50% fee cost-share for the duration of the project. Each FBM program will administer the fee cost-share through a sub-contract of this grant.Data Compilation: FBM instructors will meet one-on-one with participating farmers according to a schedule that is mutually agreeable. Sessions will include farm management principles, including financial goals and planning, identification, and organization, monitoring, and use of appropriate farm records. At the end of the year, instructors will work with participants to assemble accounting and production records into a detailed analysis of whole farm and enterprise performance. Once complete, the data from this analysis will be transferred to CFFM for inclusion in the FINBIN database.Objective 2: Develop organic financial benchmarks for the Upper MidwestDevelop: Annual organic data will be reviewed and validated toidentify any new variables needed to be calculated or added to capture specific organic production processes. Strict protocols protect the confidentiality of data belonging to individual operations and a minimum of number of observations are needed to be uploaded to the public FINBIN benchmarking database.Analyze: Sixty-five certified organic farms are currently in the FINBIN database. Their historical records will be available to the project and will provide the foundation to complete time-series analysis which will help inform financial management decisions for this project.Monitor: The advisory board will meet on an annual basis prior to the MN organic conference to review current benchmark analysis, the number of farms recruited, and discuss the most effective ways to disseminate information to farmer groups.Objective 3: Develop and deliver Extension and educational programming Curriculum Development: Outputs will be shared with academics, producers, FBM instructors, lenders, public policy makers, organic farmer member associations, and other interested communities. Annual reports will be made available on-line through the FINBIN database and each state\'s FBM and/or Extension webpages.Delivery to Educators: Benchmark analysis will be presented at annual FBM educator meetings in MN, ND, and WI b to provide additional outreach across the region.Delivery to producers: FBM instructors working with enrolled farmers will provide direct delivery of information produced by this project to the farm community. Benchmark analysis will be incorporatedinto current Extension programming andnew programs will be developedwhen appropriate. **Progress** 09/01/19 to 08/29/23 **Outputs** Target Audience:Over the course of the four years of the project we were able to work with four target audience groups: 1. Organic agricultural producers in Minnesota, North Dakota, Wisconsin, and Iowa 2. Organic member associations 3. Agricultural professionals that work with organic producers, which includes farm business management instructors, agricultural lenders, organic certifiers, and organic input suppliers. 4. Academic professionals, which includes faculty, Extension specialists, and Extension educators. Each of these audiences were reached across a various of formats. These included public presentations, invited seminars, in-person meetings, as well as output posted on UMN\'s CFFM website. Changes/Problems:The project team acknowledges that we have not achieved our target recruitment and enrollment goals for this project. We have discussed the potential causes of low enrollment and conclude that the following had a significant impact on program participation: Prevention of in-person recruitment and programming for three years due to the COVID-19 pandemic; Mental and physical fatigue due to pandemic (more labor came from unpaid on-farm labor) precluded interest in \"trying something new\"; and Lack of general familiarity with FBM programming. To mitigate these issues for future grants, we would suggestpreliminary enrollment committment from farmers prior to submitting the grant. This would help identify target participants while jointly building an internal promotional network for the opportunity. The research team had strong support and excitement for this project from organic producers and member organizations in 2018 when the grant was submitted, however beginning recruitment in Fall 2019 and Spring 2020 made it difficult to achieve our recruitment targets. What opportunities for training and professional development has the project provided?Over the course of the project a number of training activities were completed. Graduate student training - two graduate students were funded through this grant opportunity. The PI met with the students on a weekly basis and helped develop critical skills regarding agricultural economic analysis and organic production. Farm Business Management Instructors - instructors that previously worked with organic producers worked with new instructors to provide insight regarding unique data collection processes for organic production. Academic Professionals - output from this project was presented in a number of ways to share the information more broadly. The one-page summaries have been used in various Extension programs to easily present the output from this work. How have the results been disseminated to communities of interest?The results have been disseminated to a number of communities via numerous communication methods. The items listed below are in addition to what has been reported in previous annual reports. A print version of the 2021 benchmark report was distributed to each state\'s FBM lead contact (September 2022); An electronic copy of the 2021 benchmark report is posted on the Center for Farm Financial Management\'s website and cross-linked with the AgCentric\'s organic website (September 2022); Electronic fact sheets were distributed to farm lenders at the FBM annual farm lender meeting (November 2022); Electronic copies of the 2021 benchmark report were distributed directly to communities of interest direct emails (November 2022). A press release was issued via the University of Minnesota\'s Communications Department to Extension educators and targeted ag press (November 2022). Articles appeared in Feedstuffs (November 7, 2022) and on the UMN College of Food, Agricultural and Natural Resource Sciences website (October 2022) and the Minnesota Crop Improvement Association website (January 12, 2023). The Benchmark report has been visited 105 times at the Center for Farm Financial Management webpage during year 4 of the project (9/1/22 - 8/17/23) The Ag Centric website\'s organic benchmarking site was visited 187 times (total page views) in year 4 (9/1/22 - 8/7/23); 252 timesin year 3 (9/1/21 - 8/17/22) and 284 times in year 2 of the project (9/1/20 - 8/15/21). Please note that the print and electronic versions of the 2020-2022 benchmark report are in their final review stage and will be distributed in a similar manner at the 70th annual Farm Business Management Meeting in September 2023. The website hosting these outputs will also be updated. What do you plan to do during the next reporting period to accomplish the goals?This was the fourth and final year of our project. While the project end date is August 31, 2023, we do have a number of speaking engagements and outputs planned for September 2023. Each of the items are detailed below. Presentation at the 70th Annual Minnesota Farm Business Management conference (September 10-11, 2022); Press release via University of Minnesota College of Food, Agricultural and Natural Resource Sciences to Extension educators, lenders, government agencies and ag press; Press release to farm organizations and certification agencies in Minnesota, Wisconsin, North Dakota and Iowa; Peer-reviewed journal article under development. The article will explore the hypothesis that organic farms are more resilient during general economic instability by comparing organic and conventional farm performance in the Upper Midwest during a pre-COVID period (2017-2019) and during the COVID-19 pandemic (2020-2022). **Impacts** What was accomplished under these goals? Below each of the objectives are listed in bold with a description of achievements over the 4 years of the project. We have included further details regarding specific achievements made in Year 4 of the project (9/01/2022 - 8/31/23) during our 1-year no-cost extension. Objective 1: Recruit up to 170 organic farmers from the Upper Midwest region (MN, ND, WI) who do not currently participate in a farm business management program and compile data on farm production and financial performance measures. Minnesota: 74 farms (2022). Previous years: 64 farms (2019), 84 farms (2020), 93 farms (2021); Wisconsin: 14 farms (2022). Previous years: 11 farms (2019), 13 farms (2020), 16 farms (2021); and North Dakota: 0 farms (2022). Previous years: 1 farm (2019), 1 farm (2020), 2 farms (2021). In an effort to further improve enrollment in the fourth year, tuition cost-share for farm business management programming was expanded to include organic farmers in Northern Iowa. The following activities were initiated to promote the expanded tuition cost-share programming in year four (2022): Electronic ads were developed for MN Organic Conference and these were \"aired\" during all break sessions throughout the conference (January 6-7,2023). Presentations about project, recruitment and scholarship availability were made by team project members to: Farm Business Management Annual Meeting, St. Cloud, MN (September 13, 2022); Iowa Organic Conference, Ames, IA (November 21, 2022); MN Organic Conference, St. Cloud, MN (January 5, 2023); and Marbleseed Organic Conference, La Crosse, WI (February 23-25, 2023) While these efforts did result in additional farms enrolled in the program during Spring 2023, they were not able to contribute data for the 2022 report. Additionally, farm numbers in 2022 were lower due to an FBM instructor retirement which resulted in the data not being uploaded to the database. We would also be remiss not to acknowledge that the dairy industry has faced a number of challenges during the time period of the study with the number of Minnesota dairy farms decreasing by close to 50% over the study time period. Objective 2: Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms to evaluate relationships between yield, efficiency, production, and financial performance of organic production and how it affects farm management decisions over time. The PI and Co-PI worked with farm business management instructors in MN, ND, and WI to ensure organic data was compiled systematically. This data was used to generate the Upper Midwest Organic report, which was released in September each year. As more data was included in the database, the annual report included a rolling average of all financial estimates. Each year\'s report can be obtained on the Center for Farm Financial Management\'s website at https://www.cffm.umn.edu/farm-business-management-annual-reports/. Objective 3: Develop and deliver extension programming that helps farmers understand the relationship between farm management decisions and farm profitability for certified organic producers, transitioning organic producers, potential organic producers, and agricultural professionals that support organic producers. Extension activities were reported in each annual report. The project team continued to develop a suite of materials to connect with a number of audiences over the duration of the project. A list of the 4 Extension activities completed in Year 4 of the project are included below\--these activities included information across the duration of the project and can be viewed as a Extension outputs for the entirety of the project. The Upper Midwest Organic 2020-2021 Annual Report along with one-page fact sheets were promoted at fall/winter 2022/2023 events including the Iowa Organic Conference (Ames, IA), Minnesota Organic Conference (St. Cloud, MN) and the Marbleseed Organic Conference (LaCrosse, WI). Benchmarking results from 2020-2021 were compiled and presented by a graduate student as a poster at the Marbleseed Conference (LaCrosse, WI) (February 2023). The poster was awarded second place in the annual Marbleseed competition. Results from the 2020-2021 benchmark report were shared with FBM instructors at the annual Farm Lender meeting (60-70 people) (November 9, 2022). A project team member continued to meet with new MN FBM instructors to discuss project objectives, data availability and organic cost-share opportunities (October 2022 - March 2023). **Publications** - Type: Other Status: Under Review Year Published: 2023 Citation: DiGiacomo, G. 2023. 2020-2022: Organic Farm Performance in the Upper Midwest, Whole Farm & Enterprise Reports. Available at: https://www.cffm.umn.edu/farm-business-management-annual-reports/ **Progress** 09/01/21 to 08/31/22 **Outputs** Target Audience:Three target audiences have been reached in the 3rd year of the project: 1. Organic agricultural producers in Minnesota, North Dakota, and Wisconsin 2. Organic member organizations 3. Agricultural professionals that work with organic producers, which includes farm business management instructors, agricultural lenders, organic certifiers, and organic input suppliers. Changes/Problems:The project team acknowledges that we have not achieved our target recruitment and enrollment goals for this project. As evidenced with our annual accomplishment report, we continue to meet with organic producers and present our results at relevant workshops to promote this opportunity. We continue to observe increased engagement with organic producers as more in person events occur. The project team continues to recruit organic farms into the program and are confident that the data will continue to be enhanced with the 1 year no cost extension. What opportunities for training and professional development has the project provided?The following opportunities for training and development were completed in the third year of the project. PI met monthly with graduate student and research staff to review data, analysis and presentations. UMN graduate student and research fellow presented 2020 results and analysis at the National Farm Business Management Conference, Fort Collins, CO (June, 14, 2022). How have the results been disseminated to communities of interest? The results have been disseminated to a number of communities via numerous communication methods. Information regarding the cost-share opportunity has been included in numerous industry newsletters in addition to a website, agcentric.org, developed to promote the content. The benchmark report has been distributed to each state's FBM lead contact and is posted on the Center for Farm Financial Management's website and cross-linked with the AgCentric's organic website to ensure it is easily available to our target audience. The Benchmark report has been visited X times at the Center for Farm Financial Management webpage during year 3 of the project (9/1/21 - 8/17/22) The Ag Centric website's organic benchmarking site was visited 252 times (total page views) in year 3 (9/1/21 - 8/17/22) and 284 times in year 2 of the project (9/1/20 - 8/15/21). What do you plan to do during the next reporting period to accomplish the goals?In the final year of the project under a no-cost-extension, the following items will be completed: Objective 1: Continued recruitment of organic farms to participate in the benchmarking cost-share opportunity in Minnesota, Wisconsin, and North Dakota. Objective 2: Compilation of the 2021 data and development of the 2020-2021 Upper Midwest Organic Benchmarking report. This will include 2020-2021 two-year average whole farm and enterprise analyses as well as estimates by individual year, farm size and certification status (total organic, partial organic, transitioning). Objective 2: Delivery of a 2-hour workshop during the MN Organic Conference in January 2023 where benchmark results will be shared by the project team and discussed by a farmer panel. Objective 3: Electronic and hard copy benchmark reports will be distributed at annual FBM educator meetings and at winter farmer conferences. **Impacts** What was accomplished under these goals? Each of the objectives are listed below with a description of achievements made in Year 3 of the project (9/01/2021 - 8/31/22). Objective 1: Recruit up to 170 organic farmers from the Upper Midwest region (MN, ND, WI) who do not currently participate in a farm business management program and compile data on farm production and financial performance measures. Prior to beginning the benchmarking project, a total of 67 farms were enrolled in the farm business management program with their data included in the FINBIN database for benchmark reporting. At the end of the third year of the project, enrollment had increased by 66% to 111 farms as follows: Minnesota: 93 farms (2021). Previous years: 64 farms (2019), 84 farms (2020); Wisconsin: 16 farms (2021). Previous years: 11 farms (2019), 13 farms (2020); and North Dakota: 2 farms (2021). Previous years: 1 farm (2019), 1 farm (2020). In an effort to further improve enrollment, tuition cost-share for farm business management programming was expanded to include all organic farms - regardless of farm size, enterprise type or certification status. The following activities were initiated to promote the expanded tuition cost-share programming in year three (2021): Customized press releases and emails were distributed multiple times to 58 groups representing Extension, ag press, state ag departments, farm organizations, certifiers and UMN research centers (December 1, 2021 - March 2, 2022). An article describing project and scholarships appeared in Organic Broadcaster, \"Benchmarking project offers organic farmers reduced tuition for state farm business management programs\" (October 6, 2021). An article describing project and scholarships appeared in Minnesota Agriculture, \"Scholarships available for FBM program\" (April 2022). Electronic ads were developed for MN Organic Conference and these were \"aired\" during all break sessions throughout the conference (January 6-7,2022). PI, AgCentric Assistant Director and UMN Research Fellow staffed a booth at the MOSES farm conference to distribute cost-share promotional materials and year 2 benchmarking results (February 28-29, 2022). Advisory board members met to discuss recruitment efforts and to brainstorm outreach options for fall/winter 2022-2023. This meeting was completed virtually without any travel incurred (July 21, 2022). Presentations about project, recruitment and scholarship availability were made by team project members to: Annual MN Farm Business Management Conference (September 14, 2021); Minnesota Fruit and Vegetable Expo (February 4, 2022); MOSES conference (February 26, 2022); MDA Minnesota Organic Advisory Task Force (March 30, 2022); MDA Emerging Farmer Working Group (April 8, 2022); and MDA Marketing Group (July 11, 2022) Objective 2: Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms to evaluate relationships between yield, efficiency, production, and financial performance of organic production and how it affects farm management decisions over time. • PI and Co-PI worked with farm business management instructors in MN, ND, and WI to ensure organic data was compiled systematically. The second year of data was collected in 2021 and is being compiled into a benchmarking report for distribution at the farm business management conference in September 2022 and at several organic farming conferences in winter 2023. Objective 3: Develop and deliver extension programming that helps farmers understand the relationship between farm management decisions and farm profitability for certified organic producers, transitioning organic producers, potential organic producers, and agricultural professionals that support organic producers. The Upper Midwest Organic 2020 Annual Report along with one-page enterprise reports and a whole-farm financial report for organic farms were promoted at fall/winter 2021/2022 events and via press releases to farm organizations and organic certification agencies throughout Minnesota and Wisconsin. The report includes whole farm and enterprise financial data for certified organic and transitioning farms in MN and WI. A project team member met with two new MN FBM instructors to discuss project objectives, data availability and organic cost-share opportunities (August 4, 2022). **Publications** **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:Three target audiences have been reached during Year 2: Organic Agricultural Producers that raise row crop and dairy farms in MN, WI, and ND. Organic member organizations: two organizations have agreed to help promote and recruit organic producers to participate in the program. Agricultural professionals that work with organic producers, which includes farm business management instructors, agricultural lenders, and input suppliers. Changes/Problems: Recruitment of farms to participate in this project began in January 2020, and over the past 18 months, the project team has struggled to recruit participants to the level of the goals indicated in the project proposal due to the shift from in-person to virtual farm management due to the global pandemic. A number of new strategies has been employed over this time period to address the low numbers, which include designating 8 hours of a FBM instructors time for 25 weeks to focus on recruitment, building a website, and creating a promotional video. However, the lack of in-person meetings seems to have decreased the project teams ability to promote the project and explain the benefits to a large group of individuals compared to one-on-one meetings held via zoom or over the phone. As more in-person meetings have been scheduled during Summer 2021, we observed a renewed interest in this project from potential organic farmers. In the third year of the project the PI and Co-PI are working with collaborators to build visually representative 1-pagers which highlight the financial benchmarks. We are hopeful that these 1-pagers will be easily distributed to organic farmers, input suppliers, and agricultural lenders to futher enhance the reach of this work while jointly building a recruitment network. Another challenge faced by this project was the inability to hire a graduate student in Year 2 to work on the project. The 2020-2021 academic year was a hybrid model a the University and many graduate students deferred enrollment for a year. In order to continue completing the tasks of the project designated to the graduate student (eg. compiling the benchmarking report, creating the 1-pagers, etc), a portion of the graduate student line item was re-budgeted to a pay 20% of an Agribusiness Management Regional Extension Educators time for 8-10 weeks to develope Extension content from the organic financial data. This has allowed us to continue achieving our Extension and outreach goals during a highly abnormal 18 months. The project team acknowledges that we have not hit our target recruitment numbers in addition to not funding a graduate student, but we have continued to achieve our outputs and deliverables so the project can provide useful financial content to agricultural producers in the Upper Midwest. What opportunities for training and professional development has the project provided?The following opportunities for traning and development were completed in the second year of the project. Organic data collection and analysis training for FBM instructors on Dec. 10, 2019 with 30 Minnesota and Wisconsin instructors in attendance. The webinar was recorded and is available on the CFFM benchmarking website z.umn.edu/benchmarking Closeout manual enhancements: 2020 edition updated with more detailed information on organic analysis procedures and related information, including screenshots of FINPACK data entry methodology for clarity and instructor learning. Updated April 2021 based on data cleaning efforts completed with 2020 data updated in FINBIN. Greater data integrity review prior to datasubmission - organic farm information was closely reviewed, vetted, and 'fixes' were suggested prior to submission to the national database. This pre-review improved data accuracy and integrity and also ensured analysis procedures were followed. In July 2021 the Upper Midwest bencharking results were presented at theMAAE conference to over 60 FBM instructors. Discussion followed the presentation, which focused on ways to improve recruitment during the remainder of the project as well as simplify data collection methods. How have the results been disseminated to communities of interest?Information regarding the cost-share opportunity has been included in numerous industry newsletters in addition to a website developed to promote the content. The benchmark report has been distributed to each state's FBM lead contactand is posted on the Center for Farm Financial Management's website and cross-linked with the AgCentric's organic website to ensure it is easily available to our target audience. What do you plan to do during the next reporting period to accomplish the goals?In the third year of the project, the following items will be completed. Objective 1: Continued effort on recruitment of organic farms to participate in the bencharking opportunity in Minnesota, Wisconsin, and North Dakota. Objective 2: Compile the 2021 data and generate the 2021 Upper Midwest Organic Benchmarking report. This will include the 2020 estimates to provide a year to year comparison. Jointly, one page documents for each enterprise that contributes data will be developed and distributed to showcase the financial performance at an enterprise level compared to a whole farm level. Objective 3: Benchmark reports will be distributed at annual FBM educator meetings that occur in 2022. Results will be presented at appropriate Extension effects as well as organic conferences. **Impacts** What was accomplished under these goals? Each of the objectives are listed below with a description of achievements made in Year 1 of the three year project. Objective 1: Recruit up to 170 organic farmers from the Upper Midwest region (MN, ND, WI) who do not currently participate in a farm business management program and compile data on farm production and financial performance measures. Two participating industry organizations (MOSES and NPSAS) developed promotional materials to recruit certified organic farms to participate in the project. This has included email correspondence as well as information included in newsletters and their annual publications. In an effort to improve recruitment methods during Covid-19, a portion of the budget was re-allocated to dedicate 20% of a farm business management instructor's time for 25 weeks to recruiting farms in MN, WI, and ND. The following items were completed by this individual: 642 farms received a postcard in August 2020, 150 of these farms were contacted via email or phone (depending on information available on the organic certification website). Ag Centric Website (https://agcentric.org/farm-business-management/organic-farming-resources/) focused on organic production released: 284 page visits (as of 1/22/21-8/9/21) Organic video developed and released on Ag Centrics website in February 2021 Efforts were made to reach out to organic certifiers as well as input suppliers to further broaden the reach of recruitment efforts. Monthly meetings starting September 2020 to check in on recruitment and enrollment numbers (9/29, 11/2, 12/10, 1/19, 2/22, 3/8, 4/12). As of August 2021, enrolled farm participants include: Minnesota: 67 farms enrolled in 2020 analysis, 73 farms enrolled for 2021 analysis Wisconsin: 13 farms enrolled in 2020analysis, 2021 numbers not available at this time North Dakota: 1 farmenrolled in 2020 analysis, 2 farms enrolled for 2021 analysis Objective 2: Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms to evaluate relationships between yield, efficiency, production, and financial performance of organic production and how it affects farm management decisions over time. PI and Co-PI worked with farm business management associations in MN, ND, and WI to ensure organic data was compiled systetematically. Advisory board members met in February 2021 to discuss preliminary data and in July 2021 to review final Benchmark report. Note, all meetings were completed virtually without any travel incurred due to

Covid. Upper Midwest Benchmark report was released July 2021. Objective 3: Develop and deliver extension programming that helps farmers understand the relationship between farm management decisions and farm profitability for certified organic producers, transitioning organic producers, potential organic producers, and agricultural professionals that support organic producers. Year 2 - in progress, first year of full data was collected in 2020. One page summaries of enterprise financial benchmarks are in development and will be released on-line as well as distributed via newsletters to showcase the benchmarking efforts as well as provide additional learning opportunities for the agricultural professionals that support organic farmers. **Publications** - Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Hadrich, J.C. and P. Van Nurden. 2021. Organic Benchmarking Update. Presented at MAAE Conference, July 7, 2021, Moorhead, MN. - Type: Other Status: Other Year Published: 2021 Citation: University of Minnesota Extension. July 2021. \"Upper Midwest Organic Farm Business Management 2020 Annual Report. Available at: https://www.cffm.umn.edu/wp-content/uploads/2021/07/Upper-Midwest-Organic-Farm-Business-Management-2020-Annual-Report-Final2.pdf **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:Three target audiences have been reached during Year 1: 1. Organic Agricultural Producers that raise row crop anddairy farms in MN, WI, and ND. 2. Organic member organizations: Three organizations have agreed to help promote and recruit organic producers to participate in the program. 3. Agricultural professionals that work with organic producers, which includes farm business management instructors, agricultural lenders, and input suppliers. Changes/Problems:The PI and Co-PI were notified in November 2019 that the award paperwork was in progress, and quickly collected farm information for recruitment efforts, developed recruitment materials, and cost-share applications to verify organic certification. However, the funds were not distributed until Summer of 2020, which decreased our ability to cover cost-shares at the participating farm business management associations. Summer is a time when recruitment for farm business programs occurs, and we have a strategy to increase our numbers participating. We would be remiss not to mention the reality that much of farm business management is one-on-one hands on learning between the organic farmer and the farm business management instructors. This normal strategy has been disrupted over the past 6 months, and a new virtual setting is being implemented in the farm business management learning model. The virtual opportunities may result in increased participation numbers. We acknowledge that we did not hit our targets for the first year of the project, but have a plan and strategy in place to continue recruitment and reach our goals. What opportunities for training and professional development has the project provided?Training and Professional Development for this project are defined as the following: Objective 1:Farm business management instructors are working with new and existing organic farms to develop their book keeping and financial skills to provide more detailed organic financial analysis. Objective 2:Outcomes of the benchmark analysis will provide more information to farmers considering transitioning to organic production. Additionally, the results of the benchmark analysis will be used by existing organic producers and agricultural lenders to provide a target for financial performance. Objective 3:Nothing to report in Year 1. How have the results been disseminated to communities of interest?Information regarding the cost-share opportunity has been included in numerous industry newsletters in addition to a website developed to promote the content. A benchmark report specific to this project is in development, which specific organic budgets can be accessed for each state at finbin.umn.edu What do you plan to do during the next reporting period to accomplish the goals?In the second year of the project, the following items will be completed: Objective 1:Continue recruitment of organic farms to hit the targets outlined in the grant. Each participating state has identified an individual to be the lead recruiter to work with MOSES, NPSAS, and NFO as well as state level farm business management programs toincrease farm participation. Objective 2:Finalize benchmark report for Year 1 and seek input from stakeholder advisory board. Continue working with FBM instructors adding new organic farms to the database to ensure data accuracy. Objective 3:Benchmark reports will be distributed at annual FBM educator meetings that occur in Winter 2020-2021. Work with the UMN AgBusiness Management Extension team to build organic benchmarking workshops for Summer 2021. **Impacts** What was accomplished under these goals? Each of the objectives are listed below with a description of achievements made in Year 1 of the three year project. Objective 1:Recruit up to 170 organic farmers from the Upper Midwest region (MN, ND, WI) who do not currently participate in a farm business management program and compile data on farm production and financial performance measures. The three participating industry organizations (MOSES, NPSAS, and NFO) have developed promotional materials to recruit certified organic farms to participate in the project. This has included email correspondence as well as information included in newsletters. PI and Co-PI developed application and verification spreadsheet to award cost-shares to existing and new organic row crop and dairy operations. A certified organic farmer contact list meeting the specifications of the grant was obtained from the USDA organic Integrity Database (https://organic.ams.usda.gov/integrity/) to identify farms to recruit. This resulted in 689 MN farms, 415 WI farms, and 22 ND farms Postcards were sent to 689 MN organic row crop and dairy farms in November 2019. MN farm business management instructors have also included recruitment information in their quarterly or monthly newsletters. As of August 2020, 27 MN farms received a 25% scholarship and 21 received a 50% scholarship in Year 1 of the program. A dedicated farm business instrucotr has been identified to provide more targeted recruitment efforts to increase farm participation in Year 2. North Dakota Farm Business Management

Association contacted 30 certified and/or transitioning to organic farming operations to participate in the program. Collaboration with the North Dakota State Local Food Specialist and industry newsletters were also used for recruitment. As of August 2020, 1 ND received a 50% scholarship in Year 1 of the program. Additional marketing materials are in development to increase farm participation in Year 2. The Wisconsin farm business management program collaborated with 2 organic milk processors to provide information about the cost-share opportunity via correspondence in monthly milk check mailings. Informational sessions have also been offered, but with low attendance due to sessions being offered in the first quarter of 2020. As of August 2020, WI has not been able to recruit additional organic farms to the database. New marketing materials are in development to increase recruitment to meet target goals in Year 2. Objective 2: Develop benchmark reports for certified organic row crops (corn, soybeans, and wheat), forage (hay and corn silage), and dairy farms to evaluate relationships between yield, efficiency, production, and financial performance of organic production and how it affects farm management decisions over time. PI and Co-PI worked with farm business management associations in MN, ND, and WI to ensure organic data was compiled systematically. Benchmark work is in progress, to be presented to the Advisory Board meeting in Winter 2020-2021. Objective 3: Develop and deliver extension programming that helps farmers understand the relationship between farm management decisions and farm profitability for certified organic producers, transitioning organic producers, potential organic producers, and agricultural professionals that support organic producers. Nothing to report in Year 1. **Publications** - Type: Other Status: Published Year Published: 2020 Citation: Hadrich, J.C., and P. Van Nurden. 2020 Benchmarking project offers organic farmers reduced tuition for state farm business management programs. Organic Broadcaster. Available at: https://mosesorganic.org/publications/broadcaster-newspaper/reduced-tuition-for-farmers/ - Type: Websites Status: Other Year Published: 2020 Citation: Resources for Organic Farmers: https://agcentric.org/organic-farming-resources/ ** **

↑ Return to Index

A Systems Approach to Improve Quality and Shelf Life of Organic Dairy Products for Domestic and Export Markets

Accession No.	1020550
Project No.	NYC-143550
Agency	NIFA NY.C\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30242
Proposal No.	2019-03076
Start Date	01 SEP 2019
Term Date	31 AUG 2023
Grant Amount	$2,000,000
Grant Year	2019
Investigator(s)	Wiedmann, M.; Goddik, LI.; Formiga, AL, K.; Alcaine, SA, DA.; Pereira, RI.; Bianchini, AN.; Ganda, ER, KO.

NON-TECHNICAL SUMMARY

Sporeforming bacteria are an important group of spoilage organisms in dairy products. Originating from natural environments such as soil and plant materials, spores are abundant on dairy farms and are frequent contaminants of raw milk. Unlike most types of bacteria, bacterial spores are unique in their ability to endure harsh conditions, a property which allows these organisms to survive processing hurdles in dairy processing such as pasteurization. These bacteria are thus a considerable challenge to the dairy industry, ultimately accounting for nearly 50% of fluid milk spoilage, cause a serious spoilage defect in certain cheese styles and even prevent US dairy powders from reaching export markets. While sporeforming bacteria have been widely studied in the conventional dairy continuum, little research has been done to address these organisms in the organic dairy industry. Dairy represents the top organic commodity for US farms, contributing \$1.4 billion to a total of \$7.6 billion of sales for all certified organic commodities combined. More specifically, presence of spores in raw milk can (i) decrease the shelf life of organic fluid milk; (ii) lead to more quality defects in certain organic cheeses, and (iii) reduce the value and utility of dairy powders as an ingredient in production of other organic products. Therefore, the overall goal of this project is to implement a comprehensive system to control spores at the farm and processing facility level, ultimately enabling the organic dairy industry to grow markets. This goal will be pursued through; i) benchmarking spore contamination from farm to finished product; ii) developing digital dairy tools to predict spoilage frequencies to inform decision-making; iii) evaluating intervention strategies for sporeformer reduction; iv) implementing strategies to improve finished product quality, and; v) technology transfer through mixed model training. This project will not only develop a systems approach to reduce organic dairy product spoilage by sporeforming bacteria, it will allow the US organic dairy industry to use evidence based tools to optimize product quality and reach new markets.

OBJECTIVES

Goal 1: Define frequency and scope of contamination with sporeformers in organic dairy production from farm to finished product with a focus on fluid milk, powders, and hard cheesesGoal 2: Develop Monte Carlo simulations to allow for prediction of spoilage issues and frequencies in organic fluid milk, powders, and hard cheeses and to assess effectiveness of different mitigation strategiesGoal 3: Develop and validate new and existing interventions for sporeformers that are compatible with organic production and processing practicesGoal 4: Perform implementation trials, for sporeformer reduction and finished product quality improvement, on organic farms and production facilitiesGoal 5: Develop comprehensive mixed model training and technology transfer demonstration activities to facilitate rapid system-wide adoption of strategies to reduce sporeformer-based spoilage issues in organic dairy products

APPROACH

This project will be accomplished through approaches that combine microbiological, molecular, mathematical modeling and outreach methods. Goals 1, 3 and 4 will utilize field studies across the United States as well as wet-lab experiments to develop knowledge regarding the prevalence, levels and types of sporeforming bacteria relevant to the organic industry continuum. For Goal 1 we will develop a farm to product baseline of sporeforming bacteria present in organic raw milk, fluid milk, cheese and dairy powders. We will further use farm questionnaires and Multi-model inference (MMI), a statistical model averaging approach, to assess on-farm management practices that are associated with the levels of spores in organic bulk tank raw milk. Using the data and bacterial isolates collected in Goal 1, we will evaluate existing and novel methods to reduce sporeforming bacterial contaminants in the organic dairy chain including; i) evaluation of organic approved sanitizers against know sporeforming bacteria of interest (Goal 3); ii) evaluation of known protective cultures and novel phage control strategies to reduce sporeforming bacteria (Goal 3), and; iii) evaluation of various strategies to reduce on-farm contamination with sporeforming bacteria (Goal 4). Effectiveness of different interventions will be assessed using multi-level mixed effect linear models. Monte-Carlo simulations will be used to predict the effects of interventions. This knowledge will be critical to develop and refine mathematical modeling tools (i.e., Monte Carlo simulations) in Goals 2, 3 and 4, including a model for organic fluid milk, cheese and powder. MC models will be assessed through sensitivity analyses, which will identify the model parameters that will have the largest impact on finished product quality and shelf life. Outcomes from these analyses can be used to prioritize which additional data will need to be collected to improve the MC models. These modeling tools will be modified to account for farm or processing level spore reductions and will be made available for use to organic dairy stakeholders through an accessible web-based application. Outcomes of Goal 4 will include the development of best practices for reducing spores at the farm level for organic dairy producers, and will be compiled based on implementation field trials. These best practices will be communicated to organic producers and processors through a comprehensive on-line and in-person training program (Goal 5). Training materials will be developed using data generated in Goals 1, 2, 3 and 4, and will leverage the extensive extension experience of the Co-PDs and project collaborators. Knowledge gain will be assessed through pre- and post-tests administered at every in-person training and for every on-line training session; tests will be a mixture of multiple choice, fill in blank and true-false. A database of people trained will be maintained to facilitate follow-up assessments for behavioral change; every participant will be surveyed 12 months after the training through a www-based survey that will include questions to assess (i) change of practices (e.g., application of interventions to improve raw milk quality); (ii) quantifiable improvements as a result of change of practice (e.g., extended shelf life of fluid milk), and (iii) obstacles to behavioral changes and implementation of new practices and interventions. Pre-post test comparisons and survey results will be used to identify and implement improvements to training programs. Progress 09/01/19 to 08/31/24 Outputs Target Audience:The target audiences during the reporting period include dairy producers, cooperatives, processors, extension professionals, retailers, scientists, and regulatory agencies who are currently involved or who plan to become involved in the organic dairy industry. We have engaged with our target audience during the reporting period through advisory council meetings, field days, webinars, and extension efforts. Additionally, reports and report guides have been distributed to all participating farmers. Changes/Problems:For Goal 4, only half of the Gouda cheeses have been produced. The remaining half were scheduled to be produced in November; however, this timeline will likely extend through the end of the calendar year. Cheesemakes were delayed due to performance problems with the selected starter cultures and an ongoing graduate student strike. Assuming cheesemakes can be completed by the end of the year, cheeses will age throughout most of Winter term. Final data will be prepared for publication with a goal of submission in March/April 2025. This faced additional complications due to the shutdown and construction schedule of the OSU creamery during the funded period. The cheese vat had to be relocated multiple times throughout the study period and its use prioritized with other research demands. We are confident that all this work will be completed within the next six months and no additional funding is needed. What opportunities for training and professional development has the project provided?During the reporting period we completed 4 outreach events and training sessions targeted towards organic dairy producers and processors, 1 article targeted towards organic dairy farmers, and 1 informational video. The first outreach and training event was the 2024 Marbleseed Organic Farming Conference in La Crosse, Wisconsin in February 2024. As part of their Organic University series, Dr. Nicole Martin and Guy Jodarski and Kevin Jahnke from Organic Valley delivered a day long workshop that focused on the physical, chemical, microbial, and sensorial aspects of raw milk quality, how handling practices impact testing results, and how practices and factors at the farm influence the different raw milk quality parameters. The second outreach event was a webinar hosted by eOrganic, one of the project\'s collaborators, in August 2024. Dr. Nicole Martin presented on \"Factors affecting bacterial spores in organic bulk tank milk\" which discussed our results from Goals 1 and 4. This event was recorded, and the recording was distributed to all participants as well as made available through the eOrganic website. For our third outreach event, we attended Penn State\'s Ag Progress Days for three days in August 2024. Our team engaged with attendees, presented the udder hair removal video created by project staff, and distributed fact sheets on thermoduric bacteria, sporeforming bacteria in milk, and udder singeing. The udder hair removal video was also published on YouTube which was also published on YouTube (https://youtu.be/NT7Sm33K-bQ?si=L2lfN3jw5wLI1eii). Lastly, we held a virtual field day in collaboration with NOFA-NY in August 2024. This field day was focused on \"Using udder hair removal to reduce sporeforming bacteria in raw milk,\" delivered by Dr. Nicole Martin. The virtual field day was recorded and distributed to all participants as well as made available through NOFA-NY\'s website. In addition to the outreach and training events, we also published an article targeted towards organic dairy farmers in NODPA News in January 2024, had one peer-reviewed scientific journal article accepted, and submitted three others. The paper citations can be found listed above in the \"Publications\" section of this report. How have the results been disseminated to communities of interest?During the reporting period, the results of this project have been disseminated to communities of interest through 4 outreach events and training sessions targeted towards organic dairy producers and processors, 1 article targeted towards organic dairy farmers, 1 informational video, and 4 scientific papers as described in the \"Publications\" section as well as in the events described above. Additionally, final reports were distributed to each of the 102 farmers who participated in this first objective. Reports included individual results from each microbial test performed throughout the sampling year as well as the averages of each test from all of the farms in the study as well as averages for the participating farms in their region. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Goal 1 A notable outcome from the analysis of the data collected previously in Goal 1 was the determination that organic dairy producers who had been certified for fewer than 9 years had consistently higher levels of spores in their bulk tank raw milk than producers who had been certified for more than 9 years. We interviewed five producers both virtually and through a survey to determine what challenges they faced when transitioning to organic dairy farming and during their first few years of shipping certified organic milk. All the farmers touched on how difficult it was to find a veterinarian who was familiar with organic practices, and discussed how other farmers in the organic community were the most helpful resources. We hope to use their responses to continue research and extension efforts. Characterization of 4,194 bacterial isolates isolated from organic raw milk, powders, HTST milk, and raw milk to be used for cheesemaking was completed. We observed that Bacillus spp. dominated the aerobic sporeformers isolated from farm raw milk, pasteurized milk, and powders. Nonmetric multi-dimensional scaling showed that aerobic sporeformer populations in organic farm raw milk differ significantly between climate zones at genus, species, and AT levels, indicating there may be climate driven differences in sporeforming bacterial diversity. The anaerobic/facultative anaerobic sporeformers isolated from farm and cheese raw milk samples represented the orders Clostridiales and Bacillales. Evaluation of the gas produced by anaerobic/facultative anaerobic sporeforming bacteria isolates showed that (i) gas production varied significantly between Clostridiales clades and (ii) one Bacillales clade produced gas amounts that were not significantly different from most Clostridiales clades. Overall, our data indicate (i) a substantial diversity of aerobic and anaerobic sporeformers in U.S. organic dairy supplies with predominant genera and species similar between organic and conventional dairy supplies as previously described, (ii) both anaerobic and facultative anaerobic sporeformers found in organic raw milk produce gas, and (iii) climate may impact aerobic sporeformer diversity in farm raw milk. Goal 2 We developed a web-based interface using Shiny app. This webpage contains 4 existing models that can predict dairy spoilage, including milk spoilage due to sporeformers and post-pasteurization contamination, cheese late blowing, and heat resistant sporeformers in dairy powder. With the data generated from the organic dairy farms as a part of this grant, we enable the autofilling of key microbial inputs specific to organic milk once the users select their milk source. This platform can allow the organic dairy producers to assess the risk of spoilage when using organic milk to produce different dairy products and evaluate various intervention strategies that can potentially reduce the spoilage likelihood. For example, if a dairy processor wants to evaluate the impact on shelf for a transition from producing conventional milk to organic milk, using our model with PSC collected from organic milk, the dairy processor can find that, on average, the organic milk will have 26 days of shelf life while the conventional milk will have 22 days of shelf life, in which the shelf life is defined as 50% of milk exceeding the spoilage threshold of 20,000 CFU/mL. Given that organic milk, on average, has slightly higher BAB, MSC, and TSC, the model simulation showed that cheese and powder made from organic milk might lead to more spoilage. Specifically, the semi-hard cheese aged at 13°C and made from organic milk was simulated to have 24.8% of cheese with late blowing defects at day 60 compared to 9.2% for those made from conventional milk. However, these results are only an example use of our model and do not reflect the relative spoilage risk between organic and conventional dairy products as each individual farm and processor will need their own data for drawing conclusions. Goal 3 There are no updates on this goal for the reporting period, but the key takeaways from our past studies include the following 1) hydrogen peroxide was the only effective sanitizer tested, able to achieve a \>2 log reduction against all the strains tested on all three different surface materials. Moreover, it can be considered a highly efficient sanitizer against Anoxybacillus, P. peoriae, and B. pumilus, 2) LB is an effective neutralizer with no sporicidal effect for all strains except for B. pumilus, and 3) treatment with 1% LOX and 5% lactose is effective as growth inhibitor against G. stearothermophilus and B. mycoides on rubber surfaces, while no inhibition was observed against the other two strains for the same concentration. This study highlights the potential of hydrogen peroxide, added directly or as a byproduct of lactose oxidation, as an organic-friendly effective sanitizer against relevant dairy spore forming bacteria on common work surfaces. Goal 4 Using the survey and microbiological data collected previously in Goal 1, udder hair removal was identified as a factor of importance for the level of bacterial spores in certified organic bulk tank raw milk. Four organic dairy farms that had not routinely removed udder hair were recruited, and bulk tank samples were collected for 1 week prior to and 1 week after a singeing intervention on all lactating dairy cows. Raw milk samples as well as whole milk powder manufactured from the raw milk collected before and after the intervention were assessed for different groups of dairy relevant bacterial spores. Raw milk samples were evaluated for mesophilic, thermophilic, and psychrotolerant spores as well as butyric acid bacteria. Mesophilic and thermophilic spore concentrations were determined in the whole milk powder. A numerical reduction from pre- to post-intervention was observed in the mean raw milk mesophilic spore count, thermophilic spore count, and butyric acid bacteria most probable number, while a numerical increase was observed in the mean raw milk total bacteria count and psychrotolerant spore most probable number, although none of these changes were significant. The mean mesophilic spore count and thermophilic spore count in whole milk powder manufactured from pre- and post-intervention raw milk was, however, significantly reduced from 2.46 to 1.58 log10 cfu/g and 1.44 to 1.22 log10 cfu/g, respectively. The results of our study indicate that udder hair removal may aid in reducing key populations of spores found in organic raw milk and resulting dairy powders manufactured from that raw milk, although the small sample size in our study likely impacted the significance of our results. Preliminary cheese inoculation studies were performed using C. tyrobutyricum vegetative cells inoculated into pasteurized milk at a higher inoculum level (\~3 log CFU/mL) with aging at 13-20°C for up to 12 weeks (84 days). Cheeses were vacuum packaged at the beginning of aging, but packaging expanded to become pressurized during aging. Most cheese wheels were distorted, and the wax casing was often cracked. Computed tomography (CT) scanning images showed holes, cracks, and a single extremely large split were observed in cheese after 5 weeks of aging. Gas also accumulated below the wax causing a separation between the cheese and the wax. Goal 5 During the reporting period we completed 4 outreach events and training sessions targeted towards organic dairy producers and processors, 1 article targeted towards organic dairy farmers, 1 informational video, and 4 scientific papers. The papers can be found in the Publications section and a description of each of these events can be found in the responses below. Publications Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Lee, R.T., R.L. Evanowski, H.E. Greenbaum, D.A. Pawloski, M. Wiedmann and N.H. Martin. Troubleshooting high laboratory pasteurization counts in raw milk requires characterization of dominant thermoduric bacteria, which includes non-sporeformers as well as sporeformers. J. Dairy Sci., 107 (2024), pp. 3478-3491 Type: Other Status: Under Review Year Published: 2024 Citation: Lee, R.T., R.L. Weachock, Z.D. Wasserlauf-Pepper, M. Wiedmann and N.H. Martin. Sporeforming bacterial populations from organic raw milk and other dairy products are diverse and appear to differ by climate of origin. J. Dairy Sci. Type: Other Status: Under Review Year Published: 2024 Citation: Qian, C., R.T. Lee, R.L. Weachock, M. Wiedmann, and N.H. Martin. A machine learning approach reveals that spore levels in organic bulk tank milk are dependent on farm characteristics and meteorological factors. J. Food Prot. Type: Other Status: Under Review Year Published: 2024 Citation: Wasserlauf-Pepper, Z. R. L. Evanowski, C. Geary, M. Wiedmann, and N.H. Martin. Spore levels in bulk tank organic raw milk and whole milk powder are reduced by udder hair singeing. J. Dairy Sci. Comm Type: Other Status: Published Year Published: 2024 Citation: Lee, R.T and Nicole Martin. Understanding the Role of Laboratory Pasteurization Count in Organic Dairy Practices. NODPA News 24:1. January 2024, pp. 17-19. Progress 09/01/22 to 08/31/23 Outputs Target Audience:The target audiences during the reporting period include dairy producers, cooperatives, processors, extension professionals, retailers, scientists, and regulatory agencies who are currently involved or who plan to become involved in the organic dairy industry. We have engaged with our target audience during the reporting period through advisory council meetings, webinars, conferences, field days, and extension efforts. Changes/Problems:A notable outcome from the analysis of data collected in Goal 1 was the determination that organic dairy producers who had been certified for less than 9 years had consistently higher levels of spores in their bulk tank raw milk than producers who had been certified for more than 9 years. Of the 28 random forest models conducted, certification year was found in the top variables of importance in 25 models. We hypothesize that this outcome is related to specific conditions encountered by organic dairy farmers in the first several years of becoming certified organic. However, the current study was not designed to assess these conditions, so in addition to the experiments outlined in this report for the next reporting period we will also include a follow-up survey that will be administered to the organic dairy farmers that participated in Goal 1 in order to investigate what could be driving this result. If needed we will also conduct a virtual focus group with a subset of those dairy farmers. What opportunities for training and professional development has the project provided?During the reporting period, the project has provided training and learning opportunities through the events described in Goal 5. How have the results been disseminated to communities of interest?In addition to direct dissemination of results from this study to organic producers and processors, other academic institutions, and related organizations, we disseminated results to communities of interest through three infographics, three outreach events, two posters presented at the American Dairy Science Association annual meeting, one peer-reviewed publication in review, and two additional peer reviewed publications are in preparation. What do you plan to do during the next reporting period to accomplish the goals?Goal 1 In the next reporting period, characterization of the sporeforming bacterial isolates collected from raw milk samples will be completed and used to facilitate progress on Goals 2 and 4. Two peer reviewed publications that are currently in progress will be submitted to the Journal of Dairy Science. Goal 2 Using the data collected in Goal 1, our baseline Monte Carlo simulations will be updated with organic dairy-specific sporeforming bacterial subtypes and the Monte Carlo simulation for organic dairy powder will be completed. Goal 3 Based on the previous results an additional experiment will be implemented in the next reporting period focused on the development of an antimicrobial tool by combining the effect of LOX with other natural antimicrobials for a more efficient and target-directed growth inhibition effect. Goal 4 Using the survey and microbiological data collected in Goal 1, intervention trials on-farm and in processing facilities will begin in the next reporting period. To evaluate the impact of the intervention we will manufacture processed dairy products, including fluid milk, cheese, and dairy powders at pilot facilities. Spore levels, and shelf-life results when appropriate, will be used to further enhance the Monte Carlo models developed in Goal 2. Goal 5 Project staff will work with project collaborators NOFA-NY and RODALE Institute to complete two additional field-days focusing on disseminating results of the project to communities of interest. A compilation of online training modules will be completed and disseminated through eOrganic and through collaborator pathways. We will also conduct an Organic University workshop at the annual Marbleseed conference in February 2024 and are preparing a farmer focused article on thermoduric bacteria in organic raw milk that is planned to be published in the Northeast Organic Dairy Producers Alliance newsletter. Impacts What was accomplished under these goals? Goal 1 During the previous reporting period, a total of 4,434 isolates were collected from HTST milk (n=156), powders (n=19), cheese raw milk (n=88), farm raw milk (n=4,171). Of the 4,171 farm raw milk isolates, 3,088 were aerobic sporeformers and 1,083 were butyric acid bacteria. Characterization of isolates has occurred during the current reporting period and is ongoing with 2,995 isolates successfully sequenced. The aerobic sporeforming bacteria isolated from HTST milk, powders, and farm raw milk were largely represented by Bacillus and Paenibacillus and the anaerobic sporeforming bacteria isolated from cheese raw milk and farm raw milk were largely represented by Clostridium and Bacillus. Analysis of spore count data collected from 102 certified organic dairy farms across the US along with farm practices survey data and meteorological data were analyzed using a random forest model with 1,000 trees trained to predict spore counts in organic raw milk. A total of 7 data subsets were assessed, including i) all available data, ii) 2 data sets stratified by whether the farm used a parlor or no parlor for milking, iii) 2 data sets stratified by whether the associated raw milk sample was collected when lactating cows had been on pasture or not on pasture, and iv) 2 data sets stratified by the number of years the farm had been certified organic (e.g., ≤9 years or \>9 years). High level results from these analyses indicate that weather conditions (e.g., humidity, precipitation, etc.) are variables of importance to spore levels in organic raw milk, especially under certain conditions. For example, when lactating cows are on pasture, the top three variables of importance for anaerobic butyric acid bacterial spores are weather related, whereas when lactating cows are housed, weather variables do not show up in the top 15 variables of importance. Further, results show that udder hair removal and number of years certified organic consistently show up in the top 15 variables of importance for all spore types and regardless of data stratification. These results are important for implementing on-farm interventions in the remaining reporting period. Goal 2 Base Monte Carlo simulation development for organic fluid milk and organic cheese was completed during the reporting period, using spore distribution data collected in Goal 1. Final model completion will occur in the next reporting period as these models may need to be modified to reflect parameters specific to spore allelic types in organic raw milk. Identification and allelic type assignment on \~4,100 raw milk sporeformer isolates will be used to update the models when completed in the next reporting period. Further, our group has completed the development of an online, user-friendly tool that can be utilized by organic dairy industry stakeholders in the future to improve organic dairy product quality. The final Monte Carlo simulation for organic dairy powders is in development and will be completed in the next reporting period. Goal 3 For this aim, four treatments for each sanitizer and bacterial strain were carried out. The treatments consisted of water (control) or sanitizer inoculated with the bacterial strain, in which LB was added before or after incubation at the optimal growth temperature. Results of the first two parts of the study indicated that only hydrogen peroxide was an effective sanitizer, able to achieve a \>2 log reduction against all the strains tested on all three different surface materials. Moreover, it can be considered a highly efficient sanitizer against Anoxybacillus, P. peoriae, and B. pumilus. LB proved to be an effective neutralizer with no sporicidal effect for all strains except for B. pumilus. The third part of the study evaluated the effect of the addition of lactose oxidase (LOX) together with lactose to release hydrogen peroxide as a byproduct of the oxidation of lactose to lactobionic acid. In these tests the same procedure was carried out with the simultaneous addition of LOX and lactose in a concentration necessary to achieve 0.5-1% LOX and 5%

lactose, as the test sanitizer. Inhibition against four of the most resistant strains tested in the first part of the study was assessed: G. stearothermophilus, B. mycoides, B. licheniformis, and B. pumilus. Results indicate that a treatment with 1% LOX and 5% lactose is effective as growth inhibitor against G. stearothermophilus and B. mycoides on rubber surfaces, while no inhibition was observed against the other two strains for the same concentration. Altogether, this study highlights the potential of hydrogen peroxide, added directly or as a byproduct of lactose oxidation, as an organic-friendly effective sanitizer against relevant dairy spore forming bacteria on common work surfaces. Based on the previous results a new study designed over the last few months contemplates the development of an antimicrobial tool by combining the effect of LOX with other natural antimicrobials for a more efficient and target-directed growth inhibition effect. Goal 4 Based on results from data analysis conducted in Goal 1, we have identified an intervention target for spore levels in organic bulk tank raw milk, namely the removal of udder hair. Of the 28 random forest models conducted, udder hair removal through clipping or flaming was found in the top variables of importance in 21 of the models. Udder hair removal is further an appropriate target for implementation trials as this is a simple, low-cost intervention that can be adopted across organic dairy producers, regardless of location or size, with little investment. An evaluation of this intervention will be conducted in the next reporting period. Goal 5 During the reporting period we completed three outreach events and trainings targeted toward organic dairy producers and processors. The first event was held as part of the winter conference for project collaborator, NOFA-NY in January 2023. The presentation was delivered by project team member, Dr. Nicole Martin and was entitled \"Bacterial Populations in Organic Raw Milk Impacting Finished Product Quality\" with a focus on the implications of sporeforming bacteria in organic dairy systems, and practices of importance for transmission of spores into organic bulk tank raw milk. The second event was a field day conducted by Rodale Institute in July 2023. Our team engaged with attendees, presented two posters on the project, and distributed infographics on thermoduric bacteria and sporeforming bacteria in organic raw milk. Lastly, we held a virtual field day in collaboration with NOFA-NY in November 2023. This field day was focused on \"Understanding thermoduric bacteria in organic raw milk and the laboratory pasteurization count\", delivered by Dr. Nicole Martin. The virtual field day was recorded and the recording was distributed to participants as well as made available through the NOFA-NY website: https://nofany.org/resources/dairy-resources/. In addition to the outreach events described here, our team submitted a proposal to conduct an Organic University workshop at the upcoming 2024 Marbleseed conference that will be held in La Crosse, WI in February. This proposal was accepted and team members are collaborating with Organic Valley staff to develop this workshop. Publications Type: Journal Articles Status: Under Review Year Published: 2023 Citation: Lee, R.T., R.L. Evanowski, H.E., Greenbaum, D.A. Pawloski, M. Wiedmann and N.H. Martin. Troubleshooting high laboratory pasteurization counts in raw milk requires characterization of dominant thermoduric bacteria, which includes non-sporeformers as well as sporeformers. J. Dairy Sci. In Review. Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: Bacteria enumerated by laboratory pasteurization count in organic raw milk are predominantly Gram-positive sporeformers and Gram-positive cocci. R. Lee*1, R. Evanowski 1, H. Greenbaum 2, M. Wiedmann 1, and N. Martin 1, 1 Cornell University, Ithaca, NY, 2 University of Southern California, Los Angeles, CA. Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: Machine learning models suggest farm management practices and weather conditions only account for a small proportion of variance in spore levels of organic raw milk. C. Qian*, R. T. Lee, R. Evanowski, M. Wiedmann, and N. H. Martin, Cornell University, Ithaca, NY. Progress 09/01/21 to 08/31/22 Outputs Target Audience:The target audiences during the reporting period include dairy producers, cooperatives, processors, extension professionals, retailers, scientists and regulatory agencies who are currently involved or who plan to become involved in the organic dairy industry. We have engaged with our target audience during the reporting period through advisory council meetings, webinars, workshops, research and extension efforts. Changes/Problems:In 2022, several organic producers enrolled in the Goal 1 study described here, expressed concern regarding the results of their routine (non-project related) Lab Pasteurization Count (LPC) and how it would affect their status in their cooperative. The LPC is often used as a quality marker for raw milk prior to pasteurization at the processor level, and a proxy for spore concentration. The LPC test consists of pasteurizing the raw milk (63oC for 30 minutes) followed by plating on Standard Plate Count Agar and incubating at 32oC for 48 hours. This test is often required by farm cooperatives and/or fluid milk processors to quantify the quality of raw milk, with quality cutoffs ranging between \~200-300 CFU/ml. This led the project team to conduct a study on a subset of the raw milk samples from Goal 1 to determine the concentration and characterization of bacteria recovered from LPCs in organic milk and their relationship with spore levels in organic raw milk. An initial proof of concept experiment was conducted to determine if freezing raw milk samples prior to LPC testing impacted the total bacteria concentration as well as the types of bacteria recovered after pasteurization. Project members collected 15 duplicate samples of raw milk, froze one replicate for 24h at -20°C, and conducted an LPC on the fresh versus frozen samples. In addition to LPC results, 150 bacterial isolates were characterized at the Genus level by 16S sequencing. Mean log concentrations (CFU/ml) for fresh and frozen samples were 1.805 and 1.853, respectively. There was no significant difference ($p = 0.78$) between the two sets of samples. Characterization results also did not differ between the fresh and frozen samples. Isolates from fresh raw milk LPC tests (n=77) were 45% Bacillus, 17% Brachybacterium, 19% Microbacterium, 8% Streptococcus, and 10% other while isolates from the matched frozen milk LPC tests (n=73) were 47% Bacillus, 16% Brachybacterium, 18% Microbacterium, 8% Streptococcus, and 11% other. After comparing the results, the team moved forward with using frozen milk samples in the study. The LPC concentration and population characterization of raw milk samples (n=93) from one round of sampling from the organic milk producers enrolled in the raw milk study were determined. The mean concentration (log CFU/ml) for the samples was 1.28 with a standard deviation of 0.84. Unique surface colony morphologies and a representative number (up to 5) of sub-surface colonies were isolated and characterized using 16S sequencing. A total of 372 isolates were identified at the family level, with the highest proportion of isolates representing the family Bacillaceae (36%), followed by Dermabacteraceae (14%), Micrococcaceae (18%), Streptococcaceae (10%), Microbacteriaceae (9%), and other (13%). The addition of these experiments to the planned goals of this study will provide key knowledge to organic dairy stakeholders including producers, cooperatives, processors and others. What opportunities for training and professional development has the project provided?During the reporting period, the project has provided training and learning opportunities through the fluid milk processor module and the producer workshop described in Goal 5. The modules and presentations from the workshop are available on the project website. How have the results been disseminated to communities of interest?Farmers who provided samples for Goal 1 were provided preliminary reports with results from tests on their raw milk. In the next reporting period, we will provide them detailed results comparing the data collected from all 102 farms in the study. What do you plan to do during the next reporting period to accomplish the goals?Goal 1 In the next reporting period, characterization of the sporeforming bacterial isolates collected from raw milk samples will be completed and used to facilitate progress on Goals 2 and 4. Analysis of farm survey data along with microbiological data will be completed to identify appropriate intervention strategies for Goal 4. Goal 2 Using the data collected in Goal 1, our baseline Monte Carlo simulations will be updated with organic dairy-specific sporeforming bacterial concentrations and subtypes. Goal 3 Further studies in the next reporting period will be focused on testing the sanitizing effectiveness of lactose oxidase combined with lactose on the same strains and surface materials utilized in the current reporting period. Goal 4 Using the survey and microbiological data collected in Goal 1, intervention trials on-farm and in processing facilities will begin in the next reporting period. Goal 5 Project staff will work with project collaborators NOFA-NY and RODALE Institute to plan and execute field-days focusing on disseminating results of the project to date. Impacts What was accomplished under these goals? Goal 1 Sample collection and testing of organic finished products was completed during the reporting period. Two additional organic dairy farms were recruited to participate in Goal 1, for a total of 102 farms. Participating farms were located in PA (n=28), NY (n=26), CA (n=17), OR (n=5), CO (n=5), WA (n=7), WI (n=5), ID (4), VT (n=3), IA (n=1) and MN (n=1). During the 2021-2022 reporting period, a total of 563 raw milk samples were collected, and a total of 2,121 microbiological tests performed (Aerobic Plate Count (APC): n=536, Mesophilic Spore Count (MSC): n=528, Thermophilic Spore Count (TSC): n=559, Psychrotolerant Spore Count - Most Probable Number (PSC-MPN): n=536, Butyric Acid Bacteria - Most Probable Number (BAB-MPN): n=498). Inconsistencies in test numbers are a result of lab errors and insufficient volumes of milk for all testing procedures. From those tests a total of 4,108 sporeforming bacterial isolates were collected and saved for characterization in the next reporting period. Average sporeformer concentrations (log CFU/ml) for organic raw milk versus for conventional raw milk from previous studies were: MSC, 0.78 (organic) vs 0.26 (conventional); TSC, 0.44 (organic) vs 0.26 (conventional); PSC-MPN, -1.5 (organic) vs -0.72 (conventional); BAB-MPN, 2.17 (organic) vs 1.7 (conventional) Producers completed surveys for each raw milk sample collected; the first survey asked farmers questions about their farm, housing style, milking parlor, feed, etc. Each subsequent survey was a shorter version of the first survey to understand any seasonal changes made on the farm. Results from these surveys will be analyzed in the next reporting period to determine associations between these practices and the microbiological data collected. Goal 2 No progress on during this reporting period Goal 3 The lactoperoxidase system (LPS) is a natural antimicrobial system present in milk. LPS is activated in the presence of H_2O_2, which is produced during the oxidation of lactose to lactobionic acid by lactose oxidase (LO). The application of LO to improve the efficacy of the LPS and inhibit microbial growth is an approach that can be used to enhance the shelf life of dairy products. Previous research has shown that lactose oxidase can effectively control organisms such asPseudomonasspp.,Listeria monocytogenes, molds, and yeast. However, it was still unknown if this antimicrobial system would also be effective against spore formers. The aim of this work was to evaluate the antimicrobial effect of LO in the LPS against 28 strains of frequent dairy spore formers isolated for this project from organic dairy products and facilities, and to determine the effective concentration for growth inhibition. For this aim, an overlay inhibition assay was performed. LO was applied in different concentrations (0, 0.1, 1, and 10 g/L) to Brain Heart Infusion and Reinforced Clostridial Media agar containing 2.5% wt/wt lactose, added to the media before sterilization. Plates were then overlaid with inoculated agar and incubated at optimal growth temperatures. The average radius of the inhibition zone for each concentration and strain was calculated and differences between the control and the different LO concentrations were analyzed using one-way ANOVA (P\< 0.05). All experiments were performed in biological triplicates. Results indicated that 15 out of 28 strains were inhibited by the lowest LO concentration (0.1 g/L), 10 additional strains showed inhibition at 1 g/L, and the 3 remaining strains were inhibited at the highest LO concentration of 10 g/L. This latter group was composed of bacteria from the genusBacillusspeciessubtilis,paralicheniformis, andgibsonii, which were the most resistant strains, inhibited only by the highest LO concentration. In conclusion, LO proved effective as a growth inhibitor of dairy spore formers and can contribute to enhance the shelf life of milk and other organic dairy products, when added in early production stages. Further studies will focus on testing the effectiveness of the addition of this enzyme directly to dairy products. Effect of alternative sanitizers compatible with organic production against dairy spore formers on common work surfaces - The use of chlorine-based sanitizers in organic dairy production is limited by maximum labelled rates, and these rates are normally insufficient to address the growth of dairy spore formers. Therefore, there is a need to identify alternative sanitizers, such as organic acids and enzymes, that would be effective as natural antimicrobials for the disinfection of dairy processing surfaces. The aim of this study is to prove the effectiveness of hydrogen peroxide, phosphoric acid and Oxysan® (a commercial sanitizer containing hydrogen peroxide, peracetic acid, and acetic acid) as alternative sanitizers against dairy spore formers on common work surfaces. The sanitizers were tested according to the AOAC Method 2008.05, which simulates three different methods of bacterial removal and assesses the bacterial load after each. Chemical concentrations and exposure times were applied as recommended by their manufacturers on PVC, food grade stainless steel, and rubber coupons. Seven aerobic spore-forming strains were selected based on their rate of occurrence in and relevance to dairy processing facilities. According to the official method, a sanitizer must achieve a microbial load reduction of at least two logarithmic units to be considered effective. Results indicate that only hydrogen peroxide was able to achieve such a reduction against all the strains tested and on all three different surface materials. Based on these results and on the results obtainedin vitrofor lactose oxidase, further studies are currently being conducted to test the sanitizing effectiveness of lactose oxidase combined with lactose on the same strains and surface materials Goal 4 No progress on during this reporting period. Goal 5 In December 2021 the project team held an organic producer focused workshop, \"Managing Organic Milk Quality on the Farm\" which consisted of 2 online modules and a live virtual workshop with 5 guest speakers.Over 100 participants attended the live virtualworkshop, with producers from 28 states and Puerto Rico.Individuals who both attended the live presentation and completed both online modules were given a certificate of completion. The online modules focused on raw milk quality parameters that impact the shelf-life of pasteurized fluid milk and on the factors that affect these parameters at the farm level. The first 50 participants who signed up for the course were provided a sensory defect kit to accompany the online modules. These kits provided participants with a more complete understanding of how certain farm practices can impact finished product quality. The live virtual workshop included 5 presentations that built off the topics discussed in the pre-workshop modules. Presenters were Dr. Paula Ospina, Lechear, Dr. Ernest Hovingh, Pennsylvania State University, Dr. Blake Nguyem, Cornell University, Dr. Valeria Alanis, Universidad Nacional Autonoma de Mexico, and Dr. Paul Virkler, Cornell University. Each hour-long presentation focused on specific farm management practices such as teat and udder health, mastitis, environment and housing, bedding, and milking system management. In March 2022, the project team added a module on organic systems and regulations to an existing fluid milk workshop provided by the Cornell University Dairy Foods Extension. This hybrid online and live virtual course is offered yearly by Cornell and targets fluid milk processors both within and outside of NY. The workshop covers a wide range of topics, all aiming to inform processors on improving the quality and safety of their final products. There are graded evaluations throughout this course and participants who finish with a passing grade are given a Dairy Foods Certificate in Fluid Milk. Publications **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:The target audiences during the reporting period include dairy producers, cooperative, processors, extension professionals, retailers, scientists and regulatory agencies who are currently involved or who plan to become involved in the organic dairy industry. We have engaged with our target audience during the reporting period through advisory council meetings, webinars, project participant recruitment and extension efforts. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?During the reporting period the project has provided training and learning opportunities through the Dairy Systems Summit as well as through an eOrganic webinar as described above. 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? Goal 1 In the next reporting period we plan to complete the baseline raw milk sampling and survey data collection from the 100 organic dairy farms enrolled in the study. We will complete characterization of the sporeforming bacterial isolates collected from these samples to inform the subsequent experimental implementation for Goals 2, 3 and 4, as well as the education and outreach in Goal 5. Goal 2 Using the data collected in Goal 1, our baseline Monte Carlo simulations developed and refined in the current reporting period will be updated with organic dairy specific sporeforming bacterial concentrations and subtypes. Goal 3 Our work with LOX will continue into the next reporting period where we will begin to test the efficacy of LOX to control outgrowth of sporeforming bacteria in organic dairy products including fluid milk, powder and cheese. Goal 4 Microbiological and survey data collected as part of Goal 1 will be analyzed in the next reporting period to determine appropriate targets for intervention trials on-farm and in processing facilities. Goal 5 Project staff will implement producer and processor focused workshops on organic raw milk and finished dairy product quality in the next reporting period. This will include production focused, in-person, hands-on training programming in conjunction with NOFA-NY and RODALE Institute field-days. Workshops focused on improving the quality of organic finished dairy products will be offered during the next reporting period in conjunction with current Cornell Dairy Foods Extension workshops focused on fluid milk, dairy powders and cheese. **Impacts** What was accomplished under these goals? Goal 1 Sample collection and testing of organic finished products was completed during the reporting period. A total of 37 LTLT/HTST fluid milk samples, 11 powder samples, 10 raw milk samples from organic cheesemakers were collected from organic manufacturers. A total of 100 organic dairy farms were recruited to participate in Goal 1. Farms are located in PA (n=28), NY (n=26), CA (n=17), OR (n=5), CO (n=5), WA (n=5), WI (n=5), ID (4), VT (n=3), IA (n=1) and MN (n=1). During the reporting period a total of 168 raw milk samples have been collected, and a total of \~1,008 microbiological tests performed. From those tests we have collected \~1,625 sporeforming bacterial isolates for characterization. Goal 2 Project staff have finalized a baseline cheese Monte Carlo simulation model that will be used to predict spoilage of semi-hard and hard aged organic cheeses once the baseline sporeformer data is complete. Additionally, project staff have made improvements to the baseline fluid milk Monte Carlo simulation model that will be used to predict spoilage of organic fluid milk. Project staff have additionally developed a beta version of the online interface for use of the predictive Monte Carlo simulations by organic dairy stakeholders. Goal 3 PD Alcaine has completed diffusion assays on sporeforming bacterial isolates of concern to the organic dairy industry to test the effectiveness of Lactose Oxidase (LOX) as a novel intervention for sporeforming bacteria in organic dairy products. A total of 28 sporeforming bacterial isolates were evaluated at 4 LOX concentrations, with varying effectiveness based on strain. Goal 4 No progress on during this reporting period. Goal 5 With feedback from our Advisory Council, we have developed a hybrid workshop targeted toward organic dairy producers and stakeholders. The workshop will consist of a 2h online module with interactive components followed by a half-day live virtual workshop. Content will be focused on raw milk quality parameters that influence organic dairy food quality and farm management practices for controlling these parameters, with a focus on sporeforming bacteria. The live virtual workshop is scheduled for December 16, 2021. **Publications** **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:The target audiences during the reporting period include dairy producers, processors, extension professionals, retailers, scientists and consumers who are currently involved or who plan to become involved in the organic dairy industry. This project will not only define the scope of sporeformer contamination levels, population and resulting spoilage, but will provide key guidance and knowledge and technology transfer outreach to industry stakeholders. Specifically, with the knowledge gained and tools developed from this project, our team will be able to train the organic dairy industry on approaches to reduce spoilage by sporeforming bacteria, extend shelf-life to access new distribution channels and take advantage of export opportunities. During this reporting period we have engaged with organic dairy producers, processors, retailers, extension professionals and academic experts. Changes/Problems:At the beginning of the reporting period our laboratory and those of our co-PDs were shut down due to the COVID-19 pandemic. Due to these closures and ongoing travel restrictions at our individual institutions as well as implemented by our State and local governments, our project timeline has been pushed back. No changes have been made to the overall project scope due to these timeline delays. What opportunities for training and professional development has the project provided?Our team has planned a system wide organic dairy summit that addresses opportunities and challenges in the organic dairy industry. Speakers include organic dairy producers, extension and training agents, processors, retailers and academia. This event will be held on December 8, 2020 and has been widely distributed to organic dairy stakeholders. Further, our team has developed three initial educational videos on the challenges that sporeforming bacteria present to the dairy industry and on the project funded here. We continue to work closely with our co-PDs and collaborators to promote these events and educational materials to a broad range of organic dairy stakeholders. How have the results been disseminated to communities of interest?Baseline spore testing results from individual processors have been reported directly back to the key personnel from those companies. In addition, our team has developed extension materials related to sporeforming bacteria and the project funded here, as well as advertising for our organic dairy systems summit (to be held on December 8, 2020) via our project website and existing mailing lists of project personnel, collaborators and advisory council members. What do you plan to do during the next reporting period to accomplish the goals?In the next reporting period we will continue to collect organic finished product samples to establish a sporeformer baseline for organic fluid milk, cheese and powder. Bacterial sporeformer isolates will continue to be collected and characterized from these finished product samples. Our team will begin sampling of raw bulk tank milk with a revised protocol in order to maintain social distancing and current public health recommendations. Progress will continue on Objective 3 to test novel solutions to reduce spores in the organic dairy system. Finally, we will continue to development of extension and training materials targeted toward the organic dairy industry (Objective 5) along with disseminating project information to key target audiences through scheduled webinars and task-force meetings. **Impacts** What was accomplished under these goals? During the reporting period major activities completed include; i) recruitment of organic fluid milk, cheese and dairy powder processors as well as organic dairy producers (Goal 1); ii) initiation of spore baseline testing in organic finished products (Goal 1); iii)

Development of a management practices survey targeted toward organic dairy producer to be administered during each raw milk sampling time point (Goal 1); iv) Development of extension materials ranging from project flyers to educational videos (Goal 5); v) Implementation of an in-person kick-off meeting between project PDs and project advisory council in February 2020; vi) Planning of a system wide organic dairy summit to be held in December 2020 (Goal 5); vii) Development of a project website (Goal 5), and; viii) Initiation of experiments to identifynew and existing sporeformer interventions (Goal 3). **Publications** ** **

↑ Return to Index

Value-added Grains for Local and Regional Food Systems Ii

Accession No.	1020555
Project No.	NYC-149559
Agency	NIFA NY.C\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30258
Proposal No.	2019-03041
Start Date	01 SEP 2019
Term Date	31 AUG 2020
Grant Amount	$47,629
Grant Year	2019
Investigator(s)	Sorrells, M.; Selman, LA.

NON-TECHNICAL SUMMARY

We propose a two-day planning grant session that will lead to a full OREI proposal in January 2020. The goal of the planning session is to bring together stakeholders from throughout the organic grains value chain in order to identify opportunities and challenges for expanded production of organic, value-added food grains. Our long-term goal is to provide organic growers, processors, and consumers with nutritious, high-value grains that will be economically rewarding and sustainable. Currently, organic grain production is challenged by limited information about the best varieties, availability of quality seed, grain accumulation and distribution channels, and production best practices. The eastern and midwestern regions are traditionally soft winter wheat growing regions. However, there is growing demand for locally-grown organic hard wheat for artisan bakeries and elementary school kitchens that are incentivized to include locally-grown whole grains in their meals. In addition, there is growing demand for hulless oats, barley and ancient grains that include emmer, einkorn and spelt. Sourcing organic seed as well as accumulation and distribution of these grains is often challenging because the volume of seed is limited and seed borne diseases are an issue. Our outreach objectives will be to familiarize growers, processors and consumers with the benefits and challenges of organic, value-added grains and to provide guidance for capitalizing on the advantages these varieties can offer.

OBJECTIVES

Specifically, the objectives for this project are to:1) Evaluate varieties of small grain crops with potentially high market value including heritage and modern bread wheat, emmer, spelt, einkorn, hulless barley and hulless oats for adaptability to organic systems and for desirable grain, malting, distilling, and baking characteristics, including nutritional quality;2) Optimize grain quality through identifying management techniques, from planting through harvest, cleaning, and storage, that are cost-effective and appropriate for small- and larger-scale production;3) Investigate multiple strategies for accessing and producing organic seed stocks;4) Improve grain accumulation and distribution channels by identifying and working with local and regional markets.

APPROACH

Methods: This planning grant grew out of discussions with stakeholders regarding the challenges of incorporating grains into organic production and marketing systems. The greatest challenges identified were weed competitive ability of grains (especially spring grains), identification of adapted, high-yielding grain varieties, sourcing disease-free organic seed of different grains, and identification of accumulators and distribution to identified markets. From our previous project we found that consumers expressed interest in varieties of wheat that we were unable to bring to market for various reasons. Discussions included plant breeders, who shared the status of germplasm development of high-value grains in their programs, and their enthusiasm for expanding organic breeding. Varieties and selections are already positioned for release and commercial production at the outset of this grant. Therefore, it will be possible to immediately proceed to commercialization and assessment. GrowNYC worked with stakeholders and found that marketing efforts among suppliers are disconnected and in need of further support as the market for small grains and other field crops continues to develop. On the market end, consumers, including professionals, are in need of education on small grains, particularly when it comes to varietal performance, as well as with ingredients that have not been part of the market basket in the Northeast for generations, if at all. The next step in the process was identified as a focused and broad-based discussion amongst stakeholders, researchers, and outreach specialists to chart the most effective path forward for future research. Evidence of a successful planning grant will be the submission of a sucessful full proposal.

PROGRESS

2019/09 TO 2020/08 Target Audience:The target audience of this project was the 30 participants involved in planning the development of a full proposal to the USDA OREI program. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?We provided early career scientists involved in the project the opportunitiesto learn how to put together a successful project and how to organize a group of scientists. How have the results been disseminated to communities of interest?The minutes and plans from the planning meeting were summarized and distributed to all participants. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? The objectives listed above are not for this project. The goals for this project were: We proposed a two-day planning grant session that led to a full OREI proposal in 2020. The goal of the planning session was to bring together stakeholders from throughout the organic grains value chain in order to identify opportunities and challenges for expanded production of organic, value-added food grains. Our long-term goal was to provide organic growers, processors, and consumers with nutritious, high-value grains that will be economically rewarding and sustainable. Our goals were accomplished. We held the planning meeting, established a plan to develop a full proposal, and we submitted a full proposal in January that was successfully funded. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 No publications reported this period.

↑ Return to Index

Building Resilient Foliar Disease Management Strategies for the Organic Table Beet Industry

Accession No.	1020475
Project No.	NYG-625580
Agency	NIFA NY.G\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30246
Proposal No.	2019-03050
Start Date	01 SEP 2019
Term Date	31 AUG 2021
Grant Amount	$500,000
Grant Year	2019
Investigator(s)	Pethybridge, S. J.; Taylor, AL, G..; Rea, MA, S.; Kikkert, JU, R..

NON-TECHNICAL SUMMARY

This is an Integrated (Targeted) research and extension project in New York (NY). NY is the center of table beet production in the United States for processing into cans/jars, snack foods and juices. Table beets are also popular for fresh market sales. The viability of the organic table beet industry is critically threatened by the lack of efficacious and sustainable disease management practices. The priority fungal diseases are Cercospora leaf spot (CLS; caused by Cercospora beticola), and Phoma leaf spot (PLS; caused by Phoma betae). These diseases deleteriously affect foliar health and defoliation makes harvesting by top-pulling machinery impossible resulting in crop loss. In conventional production, foliar disease management relies upon synthetic fungicides. Our goal is to identify components of an integrated disease management program of immediate benefit to organic farmers focusing on improved OMRI-approved seed treatments for P. betae control, OMRI-approved foliar sprays for CLS and PLS, cultivars with enhanced disease resistance, and UV-C for CLS control. Dissemination of findings is ensured through on-farm trials and collaboration with Cornell Cooperative Extension. Our project aligns with FY19/20 USDA-OREI program priorities: (1) and (6).

OBJECTIVES

The long-term goal of this project is to ensure the sustainability and profitability of the organic table beet industry by implementing integrated disease management strategies for foliar diseases using immediately available knowledge for short-term practical solutions and optimization of UV-C for field deployment.1. Quantify the efficacy of OMRI-approved seed treatments for P. betae management, and OMRI-approved materials for CLS and PLS management in on-farm trials;2. Evaluate cultivar susceptibility to CLS and PLS to identify those with improved resistance;3. Optimize UV-C dosage for CLS control in table beet and evaluate performance on-farm; and4. Disseminate findings as integrated disease management strategies and provide decision making tools to farmers through a broad range of outreach methods.

APPROACH

Objective 1. OMRI-approved seed treatments for seedborne Phoma betae and OMRI-approved materials for foliar disease management (Pethybridge, Taylor and Kikkert).The efficacy of OMRI-approved foliar sprays for CLS and PLS will be evaluated in on-farm trials. This trial will be conducted at two locations in each of two years.

These field trials will also be established in organic, broad-acre table beet fields in western New York in 2020 and 2021. Trials will be established within the commercial field following planting and crop establishment when crop stand is evaluated for homogeneity to ensure plant population is not a confounding factor in the analysis of treatment. The experimental design for each trial will be a completely randomized block with five replications of each treatment. Treatments will be the nontreated control and four treatments. Each plot will be two rows wide (0.6 m between rows) and 6.1 m long rows separately by 3.1 m within rows, and two rows between blocks. Treatments will be applied with a carbon dioxide-pressurized backpack sprayer with four TeeJet 8002VS flat fan nozzles at an approximately volume of 250 L/ha. Products will be applied five times at 7 to 10 day intervals.CLS and PLS incidence and severity will be assessed at five, regularly spaced intervals throughout the season on each of 20 arbitrarily selected leaves. This data will be used to calculate temporal disease progress in each plot according to the area under the disease progress stairs (AUDPS). A hand-held multispectral radiometer will also be used to measure canopy reflectance in the near infrared range (830 nm) on the same day as the disease severity assessments. Yield components will be quantified according to the protocol described for trial 1a to provide data on dry foliage weight, root weight, and root shoulder diameter.Objective 2: Table beet cultivar susceptibility to CLS and PLS (Pethybridge and Kikkert).These small-plot, replicated trials will be conducted on organic-certified land at the field research facilities of Cornell AgriTech at The New York State Agricultural Experiment Station, Geneva, New York.The susceptibility of up to ten table beet cultivars to infection by local populations of P. betae and C. beticola will be assessed in each trial. The trials will be physically separated as CLS epidemic progress is likely to be more rapid than PLS which may compromise our results for the latter disease. We will include cultivars of known susceptibility from our previous studies (Rhonda, Ruby Queen, Merlin \organic industry standard and highly susceptible to both diseases\, and selected others based on conversations with seed companies and industry stakeholders for suitability for organic production. For example, Bejo has several cultivars reported as less susceptible to CLS: Bresko, Manolo, Boro, and Bohan. All cultivars will be established from organic and/or untreated seed as available. Each trial will be planted using an identical, randomized block design and cultivars replicated five times. A plot will consist of two rows (76 cm between rows) each 4.6 m long. Two buffer rows of cv. Ruby Queen will separate plots among rows and a 1.5 m unplanted buffer area established between plots within rows. The trial will be established with a Monosem vacuum planter at an in-row planting density of 30 seeds/m.The entire areas of each trial will be inoculated with isolates representative of the New York populations of P. betae and C. beticola at around 40 DAP when plants have approximately 6 to 8 true leaves. In-row plant density, and PLS and CLS incidence and severity will be evaluated in each plot. In-row plant density counts (number of plants/m) will be conducted at 25 to 30 DAP following stabilization of plant stands. Disease incidence and severity will be evaluated on 20 arbitrarily selected leaves from each of two rows (20 leaves per plot) as described in Objective 1. Disease assessments will be made five times throughout the season and epidemic progress calculated using AUDPS. Trials will be harvested by hand (\~ 85 to 90 DAP). Plants will be removed from two 0.5 m sections within each plot and separated into foliage and roots. The fresh and dry weight of foliage will be calculated, fresh weight of roots recorded, and a subsample of 20 roots randomly selected from each plot for measurement of shoulder diameter (Objective 1).Objective 3. Optimize UV-C dosage for CLS control in table beet and test on-farm (Pethybridge, Gadoury, Rea, Radetsky, and Kikkert)In vitro. We will expose C. beticola conidia and mycelia to varying quantities of UV-C (100 to 1,500 J/m2). We will collect conidia by culturing isolates of clarified V8 agar medium and incubating at room temperature for 6 days with a photoperiod of 12 h of white fluorescent light. Conidia will be harvested by flooding the plates with 5 ml of sterile distilled water, dislodging the spores using a sterile glass spreader, and passing the suspension through three layers of sterile cheesecloth. Aliquots of the conidial suspensions will be transferred onto 3% water agar (WA) plates and exposed to UV-C. Five replicates of each isolate and dose combination will be evaluated.In planta. The goal of the in planta experiments is to identify the optimal time for UV-C application and the efficacious of different doses on C. beticola fecundity, CLS severity, and leaf area. Table beet cultivar Merlin plants will be grown in the greenhouse with organic production practices from seed and inoculated when 7 to 8 weeks old (3 to 6 true leaves) with a conidial suspension prepared as described above, using a hand-held spray bottle. Two doses of UV-C from the in vitro studies will be used (one low; 200 J/m2 and one high; 1,250 J/m2): (i) pre-inoculation; (ii) post-inoculation (24 h); (iii) at early disease development (1 CLS lesion per leaf); and (iv) sporulation (pseudostromata and conidia visible in lesions). Nontreated and noninoculated controls will also be included in the experiment. Five replicate plants will be included for each treatment and the entire experiment will be repeated twice.Phytotoxicity. We will evaluate the potential for phytotoxicity from UV-C within in planta trials in five cultivars popular amongst organic growers, including those showing enhanced resistance to CLS from trials in Objective 2. Ten replicate plants will be exposed within each cultivar at various growth stages ranging from seedling, 4 to 8 true leaves, 10 to 12 true leaves, and 18 to 20 true leaves, representing different crop development stages.Field studies. The goal of this study is to apply the findings from the in vitro and in planta trials to the field and design the fabrication of a UV-C dosing apparatus to be built and operated by organic farmers. As in several other funded studies, the LRC will work closely with the farmers to design and engineer a prototype mobile UV-C field unit that will provide the prescribed dose from the laboratory studies and can connect to the farmer\'s tractor. The farmers will build the unit from commercially available UV-C equipment under the direction of LRC staff. This trial would take place in an organic field identified in collaboration with Love Beets USA in the second year of the study.Objective 4. Extend research findings\... (All Team Members).Wewill synthesize information for farmers, to include both efficacy in disease control and cost-effectiveness. Findings will be disseminated through innovative content delivery and engage farmers in the projects with experiential learning activities in visits to the on-farm trials. Guides will be developed to the technical aspects of disease management in organic table beet production. **Progress** 09/01/19 to 08/31/24 **Outputs** Target Audience:The target audience reached throughout this project were organic vegetable growers that include table beets in their rotations and conventional table beet growers considering shifting to organic production to meet exponential growth in demand. The organic table beet processors (Love Beets USA, and associated growers) that purvey the roots into value added products were highly engaged in this project. The Love Beets USA factory is located in Rochester, NY, but sources organic table beet roots from across the United States, including growers in CO, TX, GA, OH, IL, WI, MN, and eastern Canada.Organic table beet growers in these states (and NY) received updates on findings from this project magnifying our reach and impact.Each year, the stakeholder advisory panel met twice (\~November/December and April/May) to review the project findings and directions for the next cropping season, including advice on treatments within the trials. The stakeholder advisory panel consisted of 10 growers, extension educators, and industry purveyors. These growers also provided access to their crops for sample collection, monitoring, and on-farm trials. Some members of the stakeholder advisory panel also visited the research farm trials in July/August of each year, to discuss how the efficacious treatments could be evaluated on a broader scale on their farms. Results and outcomes were disseminated to the stakeholder advisory panel and broader grower communitythrough multiple avenues including factsheets, extension commodity presentations, and research articles. Over the entire project, approximately 1,000 growers were reached in these various formats, over 50% of which participated in presentations. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project has provided agraduate student (Pratibha Sharma) with training and professional development in organic agriculture and vegetable production. They were involved in all objectives of the research. The student presented their researchat the International Congress of Plant Pathology Conference (Lyons, France; August 2023), Plant Health 2023 (Pittsburgh, PA; August 2023), Plant Health 2024 (Memphis, TN; August 2024), and APS Northeast Division Meeting (2023). The expected date for the student\'s graduation is May 2025. A Post Doctoral Research Associate was also supported partially on this project in Years 2 and 3. The experience they gained in fungalidentification and applied plant pathology research and extension enabled them to secure a position as Senior Extension Associate at the Long Island Horticulture Research and Extension Center in vegetable pathology. How have the results been disseminated to communities of interest?Results have been disseminated to the communities of interest and target audience through our multimodal extension and outreach program within Objective 4.We also engaged our advisory group on a regular basisto ensure our research and treatment selection (where relevant) was of practical significance, and to ensure our extension messages were targeting the most effective venues. Results were highlighted at presentations at grower conferences in the Northeast region (NY, PA, and New England) which reached over 500 participants. A foliar disease guide and regular research updates were also published in the Cornell Cooperative Extension publication, VegEdge (distributed to over 200 growers weekly) each year.Several extension bulletins/disease fact sheets were prepared and provided in English and Spanish. These are available for free download from the Cornell Vegetables website. In the final two years of the project, we also regularly conducted foliar evaluationsof organic table beet crops with management suggestions that were publishedin the Cornell VegEdge weekly newsletter. These recommendations were combined with monitoring of our CLS forecasting program in organic table beet production (also published weekly in Cornell VegEdge). These recommendations were published in newsletter format and growers voluntarily also received a personal text update. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **Impacts** What was accomplished under these goals? Objective 1a. Seedborne disease research. Experiment 1 -Phoma betae. Initial research documented the mycoflora associated with 38 commercial organic table beet seed lots using plate testing. The incidence of P. betae in the seed lots was further quantified by plate testing and PCR. Nearly half (45.7%) of the seedlots had no detectable P. betae. Of the seed lots in which P. betae was detected, incidence varied between 0.7% and 3.7%, but between 9.3% and 9.7% in seed lots that were nontreated and rejected for commercial sale. The mean incidence of P. betae in infested seedlots was 3.2%. The incidence of P. betae estimated by plate tests was positively correlated with the number of sub-samples testing positive by P. betae by PCR. Small plot, replicated field trials were conducted in each of two years at two locations. The trials were conducted with two cultivar seedlotsand for each cultivar, two seedlots were used. One of the seedlots for each cultivar consisted of seed rejected for commercial sale due to a high incidence of P. betae, and the other with no detectable P. betae. Treatments applied to the seed were different OMRI-approved boron and copper treatments. Each seed treatment was replicated four times within each of the four cultivar/seedlots.The number of roots was significantly increased by an average of 117.4% in plots established with seed treated with OMRI-listed copper and copper+ boron, and not different from each other.Total root weight and average root weight was not significantly affected by seed treatment. The incidence of root decay was also significantly reduced by seed treatment (\<1%) compared to nontreated plots (18.8%), and not significantly different between treatments. This research has been resubmitted to Annals of Applied Biology. Experiment 2-Cercospora beticola. In seed plate testing, the fungus, Cercospora beticola(cause of Cercospora leaf spot (CLS)) was also found to be at high incidence in over 75% of the organic table beet seed lots. Seed-to-seedling transmission of C. beticolahas been reported.We evaluated the localization of C. beticola in table beet seed and contribution of infested seed to CLS epidemics in field studies. In seed dissection experiments, C. beticola was more frequently isolated from the pericarp and operculum compared to the true seed. Field trials in Geneva and Freeville, New York (NY) showed significantly higher CLS incidence, severity, and epidemic progress in plots established from the infested seed lot than those from the noninfested lot. Cercospora beticola populations collected from infested seeds and field plots were genotyped using 11 microsatellite loci. The infested seed lot population exhibited high genotypic diversity, mating type equilibrium, and linkage equilibrium, suggesting random mating. Field populations showed mixed mating types and microsatellite linkage patterns, indicating a mixed mode of reproduction. Two clonal lineages of C. beticola were identified. Populations from infested seeds and infested seed lot plots grouped into cluster 1, while cluster 2 contained populations from noninfested seed lot plots. The background population in NY was dominated by a few multilocus genotypes and genetically distinct from the infested seed lot population. Our findings highlight the potential of C. beticola-infested seed to serve asprimary inoculum. This information can shape management strategies to reduce the impact of seedborne inoculum of CLS in organic table beet production. This research has been submittedto the journal, Plant Disease. Objective 1b. Foliar disease control.Small-plot replicated field trials were conducted in each year of this project to evaluate the efficacy of OMRI-listed products for CLS and PLS control. For PLS control,LifeGard, Cueva and Double Nickel significantly reduced PLS severity compared to nontreated control plots, and were not significantly different between each other. These products showed consistently moderate reductions in disease severity. For CLS control, Double Nickel + Cueva was also highly efficacious and significantly decreased final CLS severity and AUDPS by 94.3% and 88.8%, compared to the nontreated control, respectively. LifeGard, Cueva and Double Nickel (each applied alone) provided moderate control. These results were published in Plant Disease Management Reports in each year of the project and presented at all extension events to our target audience. Objective 2. Cultivar susceptibility to CLS and PLS. The susceptibility of selected table beet cultivars (Bohan, Bresko, Manolo, Pablo, Red Cloud, Ruby Queen, Subeto, and Bazzu/Irazu) and suitability for organic production were evaluated in glasshouse experiments and small plot-replicated trials.Bohan wasmoderately and highly susceptible to CLS and PLS, respectively. Bresko was moderately susceptible to CLS, and among the least susceptible to PLS. Manolo was one of the least susceptible toPLS but highly susceptible to CLS. Pablo and Red Cloud were moderately or highly susceptible to both diseases. Subeto was moderately susceptible to CLS but the least susceptible to PLS. Ruby Queen, the processing standard, was the least susceptible to PLS, and moderately susceptible to CLS. Bazzu and Irazu (2021 and 2022, respectively) were among the least susceptible to PLS and the only cultivars tested with reduced CLS susceptibility. These findings emphasize the need to evaluate table beet cultivar susceptibility to the spectrum of foliar diseases. This information may underpin cultivar selection based on the varying importance of diseases in specific production situations.Growers from our stakeholder advisory panel also trialled the most promising of these cultivars (Bazzu/Irazu) with decreased susceptibility to CLS on their own farms in large plots (\~20-30 acres) compared to the organic standard with similar susceptibility results and favorable root yields and quality. Some adjustments had to be made to harvesting equipment because the tops of the plants of the newer cultivars were overly healthy! Objective 3: UV-C control of CLS.We evaluated the efficacy of nighttime applications of UV-C for suppression of CLS in table beet. In vitro lethality of UV-C to germinating conidia increased with increasing dose, with complete suppression at 1,000 J/m2. Greenhouse-grown table beet tolerated relatively high doses of UV-C without lethal effects despite some bronzing on the leaf blade. A UV-C dose \>1,500 J/m2 resulted in phytotoxicity severities greater than 50%. UV-C exposure to ≤750 J/m2 resulted in negligible phytotoxicity. Older (6-week-old) greenhouse-grown plants were more susceptible to UV-C damage than younger (2 and 4-week-old) plants. Suppression of CLS by UV-C was greater when applied within 6 days of C. beticola inoculation than if delayed until 13 days after infection in greenhouse-grown plants. In field trials, there were significant linear relationships between UV-C dose and CLS control and phytotoxicity severity, and a significant negative linear relationship between phytotoxicity and CLS severity at the final assessment. Significant differences between UV-C doses on the severity of CLS and phytotoxicity indicated an efficacious dose near 800 J/m2. Collectively, these findings illustrate significant and substantial suppression by nighttime applications of UV-C for CLS control on table beet, with potential for incorporation in both conventional and organic table beet broadacre production systems. Objective 4. Dissemination of research findings. As detailed earlier, \~1,000 growers were reached over this project through our multi-modal extension programming. A final stakeholder advisory panel meeting has also been conducted in which the feedback on integration of foliar sprays and less susceptible cultivars for organic table beet production could be immediate. The panel was also strongly interested in the development of the UV-C research to reduce the dependence upon foliar sprays. **Publications** - Type: Peer Reviewed Journal Articles Status: Published

Year Published: 2024 Citation: Pethybridge, S. J., Rea, M., Gadoury, D. M., Murphy, S. P., Hay, F. S., Skinner, N. P., and Kikkert, J. R. 2023. Nighttime applications of germicidal ultraviolet light (UV-C) to suppress Cercospora leaf spot in table beet. Plant Dis. 108:2518-2529. - Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Sharma, P., Murphy, S. M., Kikkert, J. R. and Pethybridge, S. J. 2024. Susceptibility of table beet cultivars to foliar diseases in New York. Plant Health Progr. 25: 399-409. - Type: Peer Reviewed Journal Articles Status: Published Year Published: 2025 Citation: Sharma, P. S, Murphy, S. P., Kikkert. J. R., and Pethybridge, S. J. 2025. Evaluation of foliar fungicides for Cercospora leaf spot management in table beet in New York. Crop Protection 188:107028. - Type: Other Status: Published Year Published: 2024 Citation: Pethybridge, S. J., Sharma, P., Murphy, S., Simangunsong, R., and Kikkert, J. R. 2024. Efficacy of fungicides for Cercospora leaf spot control in table beet, 2023. Plant Dis. Manage. Rep. 18:V022. - Type: Other Journal Articles Status: Submitted Year Published: 2025 Citation: Sharma, P. S., Murphy, S. P., Kikkert, J. R., and Pethybridge, S. J. 2024. Role of infested seed as primary inoculum for Cercospora leaf spot epidemics in table beet. Plant Dis. PDIS-12-24-2624-RE. Submitted 11 December 2024. - Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Sharma, P., Branch, E., Murphy, S., Kikkert, J. R., and Pethybridge, S. J. 2024. Residue management as an alternative to manage Cercospora leaf spot of table beet and its effect on the soil microbiome. Proc. APS-North East Division Meeting, Ithaca, NY. Pp. 11. 6 March 2024. - Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Sharma, P., Murphy, S., Kikkert, J. R., and Pethybridge, S. J. 2024. Role of infested seed as a primary inoculum source in Cercospora leaf spot epidemics in table beet. Proc. APS Annual Meeting, Memphis, TN. Phytopathology. Technical Session. - Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Pethybridge, S. J. 2024. Building resilient foliar disease management strategies for the organic table beet industry. USDA NIFA Organic Programs Project Directors Meeting Abstracts. Pp. 10. **Progress** 09/01/22 to 08/31/23 **Outputs** Target Audience:The target audience reached during this project period were organic vegetable growers that include table beets in their rotations and conventional table beet growers considering shifting to organic production. Table beet industry stakeholders (personnel of companies that receive and process organic table beets) were also reached and engagedin multiple ways including as members of the stakeholder advisory panel providing advice on experimental design and treatments, land and crops for on-farm trials, and giving feedback on the results and findings of the project. The stakeholder advisory panel, consisting of 10 growers, extension educators and industry personnel, met twice during this period (December 2022 and April 2023). Stakeholders also visited the trials personally during July 2023. Results have been distributed through multiple avenues including factsheets, extension commodity presentations, and research articles. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?In this reporting period, the graduate student received training in conducting a small plot replicated training evaluating the efficacy of OMRI-listed products (Objective 1b) and quantifying the efficacy of trade-offs of using UV-C for CLS control (Objective 3). The graduate student was also involved in all aspects of our extension and outreach activities (Objective 4). The student was able to present parts of this research at the International Congress of Plant Pathology Conference (Lyons, France; August 2023). How have the results been disseminated to communities of interest?Results have been disseminated to the stakeholder advisory panel (organic table beet growers and industry stakeholders) in a broad range of formats. Evaluations of the health of organic table beet crops throughout the 2023 cropping season were published in the Cornell VegEdge weekly newsletter with recommendations and links to our results from Objective 1b. Results from our CLS forecasting program in organic table beet production were also published on a weekly basis supporting the in-seasoncontrol recommendations. These recommendations were published in newsletter format but growers also received a personal text on a weekly basis to facilitate rapid disease management decisions. Moreover, recommendations surrounding cultivar selection based on disease resistance were also discussed with the stakeholder advisory panel and individual growers directly summarizing the results of Objective 2. What do you plan to do during the next reporting period to accomplish the goals?In the next reporting period, results from all objectives will be compiled for the communities of interest. Four scientific publications are being prepared for submission to journal articles (one each from objectives 1a, 1b, 2, and 3). This information will also be rephrased to reach organic table beet growers in extension presentations and factsheets. We will also present an overview of the results to our stakeholder advisory panel, and continue discussions to expand the findings of objective 3 (UV-C foliar disease control) to the next stages for larger unit deployment for use by organic table beet growers. **Impacts** What was accomplished under these goals? Activities undertaken in 2022/23 were approved under the no-cost extension. Objective 1a. OMRI-approved seed treatment research was completed in 2021. Objective 1b. A small-plot replicated trial was conducted to evaluate the efficacy of selected OMRI-listed pesticides for the control of Cercospora leaf spot. The trial had 12 microbial biopesticides and plant defense activators. The trial was inoculated with a mycelial suspension of selected C. beticola isolates representing the genotypic diversity of NY populations. Treatments were applied four times at 7-day intervals. Results identified several microbial biopesticides, including Theia and Howler, that provided moderate control of CLS. Copper hydroxide (as Champ) provided excellent CLS control. This is the third year that copper hydroxide has been identified as a superior product and equivalent to several of the fungicides with site-specific modes of action. Given the high prevalence of resistance to single site mode of actions fungicides, including the strobilurins, the inclusion of copper hydroxide in the foliar disease program will be beneficial for both organic and conventional growers. The information obtained from this trial will form the basis of our extension recommendations for organic table beet growers that will be discussed in extension presentations and summarized in factsheets. The results will also be submitted to the technical journal, Plant Disease Management Reports in November 2023. Objective 2. Work within this objective was completed in 2022. Objective 3. In 2023, a small plot replicated trial was conducted to evaluate the reproducibility of the CLS control obtained with UV-C. Promising results were again obtained and the efficacious dose was identified as 750 Watts/m2, providing CLS control equivalent to moderately effective fungicide without incurring yield-limiting phytotoxicity. Results from the field trials and in vitro studies performed in the first two years of this project will now be combined for an article to be submitted to the journal, Plant Disease. Results have also been discussed with the stakeholder advisory panel, after visits to the field trial. There is considerable enthusiasm from stakeholders to extend this technology to a broad-acre reality. We are discussing the next steps to achieve this objective with the project team. Objective 4. Results were presented to members of the stakeholder advisory panel (twice throughout this reporting period) and to the broader vegetable community. We estimate a reach of approximately 150 growers and industry stakeholders. **Publications** - Type: Journal Articles Status: Published Year Published: 2023 Citation: Heck, D. W., Sharma, P., Kikkert, J. R., and Pethybridge, S. J. 2023. Sampling, a new iOS application for assessment of damage by diseases and pests using sequential sampling plans. Plant Dis. 107:1714-1720. - Type: Journal Articles Status: Published Year Published: 2023 Citation: Saif, M. S., Chancia, R., Hassanzadeh, A., Pethybridge, S. J., Murphy, S. M., and van Aardt, J. 2023. Forecasting table beet root yield from spectral and textural features from hyperspectral UAS imagery. Remote Sensing 15:794. - Type: Journal Articles Status: Published Year Published: 2023 Citation: Branch, E. B., Pethybridge, S. J., Murphy, S. M., and Kikkert. J. R. 2023. Efficacy of fungicides for control of Rhizoctonia damping-off and root rot in table beet, 2022. Plant Dis. Manage. Rep. 17:V026. **Progress** 09/01/21 to 08/31/22 **Outputs** Target Audience:The target audiences reached during this period were current organic table beet growers and those considering growing in the subsequent season to meet exponentially increases in demand. The organic table beet processors that purvey the roots into value added products were also highly engaged in this project. Love Beets USA (located in Rochester, NY) is the predominant processor of organic table beets in the United States and sources roots from multiple states (CO, FL, TX, GA, VA, MN and WI). Organic table beet growers in these states (in addition to those in NY) also received updates on findings from this project enhancing our reach and impact.The direction of the project and results were reviewed by the project advisory group (consisting of 10 growers, extension educators, and purveyors) met twice during this reporting period(December 2021 and April 2022). Personnel from Love Beets and Seneca Foods also visited the trials personally during July 2022. The project was also featured at annual research and extension commodity events (January 2021) organized by Cornell Cooperative Extension and the Mid-Atlantic Vegetable and Fruit Convention (Hershey, 2022). Changes/Problems:A no-cost extension on this project was granted until 31 August 2023 to allow for the COVID delays at the start of the project and to concentrate on extension of the findings to communities of interest. What opportunities for training and professional development has the project provided?The Graduate Student received expert training in plant pathology and agronomy, organic production, conducting field trials, and extension and outreach techniques. They also presented research on fungicide efficacy for CLS control at the Plant Health 2022 conference (Pittsburgh, PA; August 2022). How have the results been disseminated to communities of interest?Results from this project have been connected to the organic table beet growers and purveyors, and organic vegetable growers in the region. We have engaged our advisory group at 6- monthly intervals to ensure our selection of treatments are highly relevant to production and would be easily adoptable if shown to be efficacious. We have also participated and presented results at the Mid-Atlantic Fruit and Vegetable Convention (Hershey, PA) which attracts organic vegetable growers from across the region. Several extension bulletins were prepared and provided in English and Spanish. What do you plan to do during the next reporting period to accomplish the goals?The next reporting period for this project is a no-cost extension to concentrate on extension of results to the communities of interest (scientific audience through journal articles; and organic growers through a broad range of extension programming). We will also provide a final overview of the results to the project advisory meeting to assist in identifying future directions for our organic table beet research. **Impacts** What was accomplished under these goals? Objective 1a. OMRI-approved seed treatment research was completed in 2021. Results from 2020 and 2021 are now being combined for a journal article and extension materials for a diverse audience. Objective 1b. A small-plot, replicated trial was conducted to evaluate the efficacy of OMRI-listed materials for CLS and PLS control. In addition, two demonstration style on-farm trials were conducted with collaboratoring organic growers at North Rose, and Clarence, NY. The small plot trial contained a broad range of OMRI-listed copper products and several microbial biopesticide and plant defense activators. The trial was inoculated with mycelial suspensions ofCercospora beticolaand products were applied three times at 14-day intervals. Disease incidence and severity was assessed at six intervals throughout the growing season and harvest was conducted in the first week of September by removing plants and separating foliage and roots to quantify yield components. Results from this trial will form the basis of our extension messages for 2022-23. The on-farm trial at North Rose identified an-OMRI listed product (FungOut) that the grower reported excellent foliar disease control. The field at Clarence will be harvested in October and the OMRI-listed program will be compared to a nontreated control by evaluating disease incidence and severity. In addition, two trials have not been conducted to evaluate the efficacy of OMRI-listed products for the control of Phoma leaf spot and root decay. This information is awaiting publication in the journal, Plant Diseasehttps://doi.org/10.1094/PDIS-11-21-2506-RE. Objective 2. The second year of evaluating cultivar susceptibility to PLS and CLS has now been completed. This small-plot replicated trial was harvested in the second week of September. The trials contained the same 10 red table beet cultivars newly emerging from private and public table beet breeding programs. These trials were inoculated with the respective pathogens (Phoma betaeandCercospora beticola) and disease incidence and severity evaluated on six regular occasions throughout the cropping season. Yield components were also evaluated that were of relevance to the grower (foliage architecture and biomass; root number, weight, diameters, sugar content). Results from the two years of trials will be combined and analyzed for submission as a journal article and results included in extension outputs. Objective 3. Two years of small plot replicated trials have now been conducted to evaluate the efficacy of UV-C on CLS. Five different doses (identified from in plant and in vitro trials) were identified and applied at night with UV-C lights on a wagon. Preliminary analysis has identified that doses of 500 to 750 Watts/m2 are optimal for CLS control and do not incur substantial phytotoxicity. Results from this objective over the two years of trials will be combined and analyzed for submission as a journal article and results included in extension outputs. Objective 4. In this reporting period, we developed extension bulletins on the important diseases affecting organic table beet production in English and Spanish, to assist in diversifying the outcomes of our project. Results were also presented to the table beet advisory board and purveyors of organic table beet. We estimate direct contact with approximately 300 growers, while extension bulletins and resources have been placed on websites so they are freely available for download and distributed at events. **Publications** - Type: Journal Articles Status: Published Year Published: 2021 Citation: Heck, D. W., Kikkert, J. R., Hanson, L. E., and Pethybridge, S. J. 2021. Development of a sequential sampling plan using spatial attributes of Cercospora leaf spot epidemics of table beet in New York. Plant Dis. 109:2453-2465. - Type: Journal Articles Status: Published Year Published: 2022 Citation: Sharma, S., Kikkert, J. R., Heck D. W., Branch, E. A., and Pethybridge, S. J. 2022. Cercospora leaf spot of table beet. Disease Lesson. The Plant Health Instructor 22: 10.1094/PHI-P-2022-02-0101. - Type: Journal Articles Status: Published Year Published: 2022 Citation: Spanner, R., Neubauer, J., Heick, T. M., Grusak, M. A., Hamilton, O., Rivera-Varas, V., Hamilton, O., de Jonge, R., Pethybridge, S. J., Webb, K. M., Leubner-Metzger, G., Secor, G. A., and Bolton, M. D. 2022. Seed-borne Cercospora beticola can initiate disease in sugar beet (Beta vulgaris L.). Phytopathology 112:1016-1028. - Type: Journal Articles Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J., Murphy, S., Hay, F. S., Branch, E. B., Sharma, P., and Kikkert, J. R. 2022. Control of Phoma leaf spot and root decay of table beet in New York. Plant Dis. Just Published 15 June 2022. - Type: Journal Articles Status: Published Year Published: 2022 Citation: Pethybridge, S. J., Sharma, P., Murphy, S., and Sharma, S. 2022. Efficacy of fungicides for Cercospora leaf spot control in table beet, 2021. Plant Dis. Manage. Rep. 16:V039. - Type: Book Chapters Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J. 2022. Cercospora leaf spot. Chenopodiaceae Chapter in World Handbook of Vegetables. - Type: Book Chapters Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J. 2022. Black leg. Chenopodiaceae Chapter in World Handbook of Vegetables. - Type: Book Chapters Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J. 2022. Bacterial leaf spot. Chenopodiaceae Chapter in World Handbook of Vegetables. - Type: Book Chapters Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J. 2022. Aphanomyces root rot. Chenopodiaceae Chapter in World Handbook of Vegetables. - Type: Book Chapters Status: Awaiting Publication Year Published: 2022 Citation: Pethybridge, S. J. 2022. Southern root rot. Chenopodiaceae Chapter in World Handbook of Vegetables. - Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Sharma, P., Murphy, S., Kikkert, J. R., and Pethybridge, S. J. 2022. Fungicide based control of Cercospora leaf spot in table beet. Plant Heath 2022 Meeting. Abstract. **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:The target audiences reached during this period were organic table beet and mixed vegetable farmers across New York. Vegetable farmers and beet growers in neighboring states and Wisconsin were also reached through our communication of results. The project advisory group met twice during this period to review results (December 2020 and March 2021) to discuss results and plan trials for 2021. The project was also featured at annual research and extension commodity events (January 2021) organized by Cornell Cooperative Extension. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The Post Docoral Research Associate employed partially on this project received training in plant pathology and agronomy, conducting field trials, and trouble-shooting in the construction and deployment of the UV-C wagon. They also gained experience in preparing extension bulletins and presenting their findings to a scientific audience remotely through attendance of the online Plant Health 2021 conference. How have the results been disseminated to communities of interest?The results of this project have been disseminated to the communities of interest including the advisory group at regular (6-monthly) meetings and vegetable growers and industry stakeholders throughout NY and the Northeast region (including Wisconsin, which also grows table beets), reaching over 200 participants. Four new extension bulletins were published in the Cornell Cooperative Extension publication, VegEdge (distributed to over 200 growers weekly). What do you plan to do during the next reporting period to accomplish the goals?Objective 1 (a and b). Research results will be compiled from the last two years and prepared for submission to a scientific journal. Objectives 1 and 2. This research will also be combined and used to form the basis of the third year combination treatments in demonstration style plots for organic growers. Objective 3. Results will be discussed with the project team, repeated in 2022, and determined if sufficient data is present to deploy to larger on-farm demonstration plots with a larger machine. Objective 4. We will continue to disseminate our researching findings to the communities of interest including on-farm trials, additional research bulletins, field inspection of trials, and regional and local extension meetings. The advisory committee for this project will also be regularly engaged (December and March). Impact of the project will be evaluated through summative and formative assessments as described in the proposal. **Impacts** What was accomplished under these goals? Objective 1a (Year 2). A small-plot replicated field trial was again conducted to evaluate the efficacy of OMRI-approved seed treatments on damping-off and root disease and decay caused by the fungus, Phoma betae, and table beet populations. The trial was conduted with two cultivar seedlots (Ruby Queen and Kestrel). These seedlots had been rejected for commercial sale because of the high incidence of P. betae and obtained through our seed industry partners on the advisory group for this project. Our laboratory tests found an incidence of P. betae of around 20% in each seedlot. The trial was planted on 15 June and included three boron and copper treatments and compared to a nontreated control for each cultivar. Regular assessments of plant population and foliar disease incidence and severity have been made. This trial will be harvested in late September. At this time, the weight of foliage and roots will be quantified. Roots will also be measured using digital calipers and the incidence of root disease assessed at harvest and following storage for 8 weeks. The effect of cultivar seedlot of treatment will be evaluated with a two-way analysis of variance. Objective 1b. OMRI-approved foliar disease control for CLS. A field trialwas conducted at Cornell AgriTech in Geneva, New York. The crop was planted on 20 May using a Monosem planter at the rate of 17 seeds/ft with 30-in. row spacing. Treatments (n = 5) were arranged in a randomized complete block design with four replications, including a nontreated control. The trial was irrigated as necessary using solid set sprinklers for optimal plant growth and disease development. Plots consisted of 10-ft sections of two adjacent rows, with a nontreated buffer of 5-ft between plots within rows. Two nontreated rows separated adjacent plots. Fungicides were applied using a CO2-pressurized backpack sprayer (15.9 gal/A; psi = 30), with three TeeJet 8002VS flat fan nozzles spaced 19 in. apart along a 38-in. boom. Fungicides were applied at 53, 61, 68, and 75 DAP. A backpack sprayer was used to apply an inoculum suspension (4.1 × 103 viable cfu/ml) at 65 and 66 DAP, containing a mixture of eight Cercospora beticola isolates representative of the New York genotypes. Plant density was assessed at 19 DAP by counting the number of plants in a 3.2-ft section within each row. Cercospora leaf spot (CLS) severity (%) was quantified by estimating the area of the leaf covered by disease compared to the entire leaf area on 20 arbitrarily selected leaves within each plot (10/row) at 47, 63, 71, 78, and 85 DAP, and used to calculate epidemic progress (area under the disease progress stairs; AUDPS). At 85 DAP, the normalized difference vegetative index (NDVI) was measured using a GreenSeeker hand-held radiometer by scanning the entire length of one row, 3.2-ft above the canopy. At 92 DAP, the effect of treatment on foliar biomass was evaluated by removing foliage from plants within a 3.2-ft section of each plot and recording weight after drying at 140ºF for 48 h. The effect of fungicides on average CLS severity at 85 DAP, AUDPS, NDVI, root number and weight, and dry weight of foliage was analyzed using a generalized linear model. Means for each variable were separated by a Fisher's protected least significant difference test at P = 0.05 (Genstat Version 17.2). Final CLS severity in nontreated plots was of moderate intensity with an average of 64.4%. Plant density was not significantly different across the trial at 19 DAP (P = 0.267) and varied between an average of 23 and 29.4 plants per 3.2-ft section. Root number at 92 DAP was not significantly affected by treatment (P = 0.861). Treatment also had no significant effect on root weight (P = 0.784). All treatments significantly reduced CLS severity at 85 DAP and AUDPS. Four applications of Double Nickel + Cueva was also highly efficacious and significantly decreased final CLS severity and AUDPS by 94.3% and 88.8%, compared to the nontreated control, respectively. Four applications of LifeGard provided moderate CLS control and final CLS severity was six times higher than plots receiving only Double Nickel + Cueva. The separation of treatments based on NDVI were also reflected in the dry weight of foliage. The dry weight of foliage was also significantly higher than the nontreated control plots in all other treatments except for the LifeGard and Double Nickel + Cueva rotation and those receiving only LifeGard. OMRI-approved foliar disease control for PLS. A second field trial was also conducted to evaluate a range of OMRI-approved products for the control of PLS. The trial was established in the same manner as for the CLS trial outlined above, and inoculated with 1,500 conidia/ml of five P. betae NY isolates with a backpack sprayer. As in the first year of this trial, LifeGard, Cueva and DoubleNickel significantly reduced PLS severity compared to nontreated control plots, and were not significantly different between each other for PLS control. The trial will be harvested in late September 2021. Objective 2. Cultivar susceptibility to CLS and PLS. Two replicated field trials were conducted with eight selected red table beet cultiars to evaluate their susceptibility to CLS and PLS. The cultivars were selected with on advisory group member, Bejo Seeds.The trials were inoculated with C. beticola and P. betae NY isolates at around 40 DAP and disease severity was evaluated five times throughout the season. Both trials will be harvested to evaluate yield components in early October 2021. Objective 3. UV-C based control for CLS. A field trial was conducted to evaluate the efficacy and safety of five selected UV-C dosesat Cornell AgriTech, Geneva. To deliver the UV-C doses, a field wagon was designed and constructed in collaboration with the team from Mt. Sinai Lighting Research Center. The dose was varied according to the duration of the exposure to UV-C based on a sensor within the wagon. UV-C doses were applied (in the early evening) on eight different occasions following inoculation of the trial with C. beticola isolates from NY. Disease incidence and severity (and phytotoxicity) were evaluated on five different occasions. This trial will be harvested in late September 2021 to evaluate the effect of dose on yield components including root quality. Objective 4. Disseminate research fndings. In this reporting period, results were presented at two advisory group meetings, a vegetable extension meeting, and five different extension bulletins. Overall, we estimate a reach of approximately 250 growers and industry stakeholders. The results will be combined across years for preparation into scientific manuscripts to reach this audience as well. **Publications** - Type: Other Status: Published Year Published: 2021 Citation: Pethybridge, S. J., and McGrath, M. T. 2021. FIFRA 2(ee) recommendation for control of the unlabeled pest Cercospora leaf spot of table beets. Double Nickel LC. EPA Registration 70051-107. New York State Department of Environmental Conservation. Division of Materials Management Pesticide Product Registration. Accepted 12 March 2021. - Type: Journal Articles Status: Under Review Year Published: 2021 Citation: Sharma, S., Kikkert, J. R., Heck D. W., Branch, E. A., and Pethybridge, S. J. 2021. Cercospora leaf spot of table beet. Disease Lesson. The Plant Health Instructor Accepted with revisions 17 January 2021. R2 submitted 10 May 2021.

PROGRESS

2019/09 TO 2020/08 Target Audience:The target audiences for this research in this reporting period include organicorganic growers including table beet farmers across New York, and field and vegetable crop farmers in the Northeast and other regions with similar precipitation patterns. The research team has had regular engagement with the advisory group including table beet farmers, organic vegetable farmers, extension educators, andindustry stakeholders. This group met at project initiation (November 2019), March 2020, and will meet in December 2020 to discuss results from Year 1. The broader vegetable grower community has also been informed of the research and preliminary findings at annual research and extension commodity events in collaboration with Cornell Cooperative Extension with additional events planned for winter 2020/21. Results from these studies will also be communicated to the scientific community in presentations and scientific journal articles prepared in Year 2. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The Post Doctoral Research Associate employed partially on this project received advanced training in fungal identification, agronomy, planning and conducting field trials, phylogenetics, and plant pathology. They also gained experience in public presentation of their findings to a local scientific audience through a campus-wide seminar, and the distilling of information to appropriate target audiences through extension bulletins and extension presentations (see products listed). How have the results been disseminated to communities of interest?Selected organic table beet and broad-acre vegetable growerswere engaged through hearing of results and providing advice on treatments and direction, and practical aspects for implementation of results, at the six-monthly advisory group meetings held in 2019 and 2020. This included summaries of results that were presented to members of the advisory group. Initial results have also been highlighted at presentations at grower conferences in the Northeast region (NY and PA) which reached over 200 participants. A foliar disease guide was also published in the Cornell Cooperative Extension publication, VegEdge, which is distributed to over 200 growers weekly. What do you plan to do during the next reporting period to accomplish the goals?Objective 1a. Additional OMRI-approved table beet seed treatments are being refined over winter 2020/21 within in vitro and glasshouse trials to enable the selection of treatments for a small-plot replicated field trial and demonstration-style trial on organic farms in the 2021 cropping season (as planned). Objective 1b. Two replicated field trials will be conducted to evaluate the reproducibility of the OMRI-approved treatments identified as efficacious for PLS and CLS control in table beet (as planned). Objective 2. The field trial conducted in Year 1 evaluating cultivar susceptibliity to PLS and CLS will be repeated in Year 2. Moreover, these results are also being evaluated in greenhouse trials over winter 2020/21 (as planned). Objective 3. Our collaborators of the Lighting Research Center at Rensselaer Polytechnic Institute continue to build a tractor-mounted lighting array with specifications suited to broadacre table beet production capable of providing doses suitable for disease control and reducing potential phytotoxicity for deployment in field trials in 2021. Objective 4. We will continue to disseminate our research findings throughout the next reporting period including on-farm trials, an additional two research bulletins for organic growers and distributed through eOrganic, one field day in summer (if allowed by COVID-state regulations), at regional and local extension meetings, and the beet advisory committee for this project (held every six months; March and December 2021).The impact of the project will also be evaluated through formative and summative assessments.

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? Objective 1a: Efficacy of OMRI-approved seed treatments (Phoma betae).For the seed treatment research, asmall plot, replicated field trial wasconducted. The trials were conducted with two cultivar seedlots (cv. Ruby Queen and Pablo) and for each cultivar, two seedlots were used. One of the seedlots for each cultivar consisted of seed rejected for commercial sale due to a high incidence of P. betae. The other seedlot of each cultivar had no detectable P. betae. Treatments applied to the seed were different OMRI-approved boron and coppertreatments applied as either a seed soak or treatment.A nontreated control was also included for each cultivar within each trial. The incidence of P. betae and other fungi and seed germination in plate tests was evaluated within 10 days of treatment application and 22 to 30 days prior to planting. The trial was establishedwith a single row Jang JP-1 push seederat a within row spacing of 5.1 cm and 76 cm between rows. Supplemental irrigation by overhead sprinklers (5 mm/h) was provided to optimize crop growth as required. Plotsconsisted of a single 1.52 m long row separated by an unplanted 0.6 m between plots within rows. The randomized complete block experimental design in each of the trials was identical. Each seed treatment was replicated four times within each of the four cultivar/seedlots. Table beet plant populations were assessed by counting all plants within the entire plots at two occasions after emergence. The severity of PLS was also assessed at mid-season on two occasions.To confirm the association of PLS lesions with P. betae, 30 symptomatic leaves were randomly selected along a diagonal transect across the entire trial (15 from cv. Pablo and 15 from cv. Ruby Queen) on the same day as the disease severity evaluations were conducted in each year.The effect of treatment on table beet yield components was assessed by digging all plants within each plot. Plants were removed and separated into foliage and roots by hand. The weight of foliage was recorded after drying at 60ºC for 48 h. Roots were also counted, weighed and shoulder diameter using digital calipers.In addition, 20 roots were randomly selected from each plot and placed in a paper bag at 7.2°C following harvest. Roots will be removed in 4 weeks and evaluated for the presence of decay and boron deficiency, and isolations conducted. The effect of cultivar seedlot and seed treatment will be assessed as a two-way analysis of variance with replicate as a random effect. Least squares means (P = 0.05) will be used to separate significant treatments. Objective 1b: OMRI-approved foliar disease control (CLS and PLS). Two small-plot, replicated trials were conducted to evaluate the efficacy of OMRI-approved products for Cercospora leaf spot (CLS) and Phoma leaf spot (PLS).For CLS, the experiment was conducted at Cornell AgriTech,Geneva, New York. Treatments (n = 3) were arranged in a randomized complete block design with four replications, including a nontreated control andapplied using a CO2-pressurized backpack sprayer (16.8 gal/A), with three TeeJet 8002VS flat fan nozzles spaced 19 in. apart along a 38-in. boom. Fungicides were applied at 46, 56, 66, and 76 DAP. A backpack sprayer was used to apply an inoculum suspension (1.32 × 104 cfu/ml) at 48 DAP, containing a mixture of eight Cercospora beticola isolates representative of the New York genotypes. CLSseverity (%) was quantified by estimating the area of the leaf covered by disease compared to the entire leaf area on 20 arbitrarily selected leaves within each plot (10/row) at 41, 62, 68, 77, and 80 DAP, and used to calculate epidemic progress (area under the disease progress stairs; AUDPS). The effect of fungicides on average CLS severity at 80 DAP, AUDPS,and dry weight of foliage was analyzed using a generalized linear model. Means for each variable were separated by a Fisher\'s protected least significant difference test at P = 0.05 (Genstat Version 17.2). CLS severity in nontreated plots was high at 80 DAP with an average of 76%. All treatments significantly reduced CLS severity at 80 DAP and AUDPS. Final CLS severity and AUDPS were not significantly different between plots receiving the LifeGard, Cueva, and Double Nickel. These products were also tested for their efficacy to control PLS in a separate replicated trial. Inoculum (1,000 conidia/ml) of five selected P. betae isolates was used to inoculate the trial on the same day as for CLS. Disease assessments were made on the same days and in the same manneras that described above for CLS. PLS severity was significantly reduced by all three treatments (LifeGard, Cueva, and Double Nickel) and was not significantly different between them. Objective 2. Cultivar susceptibility to CLS and PLS. A replicated trial to evaluate the susceptibility of nine different table beet cultivars to PLS and CLS across three different planting dates was conducted on the farm of our co-operator, Bejo Seeds at Geneva, NY. Rows of each of the cultivars at each planting date were inoculated with liquid inoculum of each pathogen (Phoma betae and Cercospora beticola for PLS and CLS, respectively). Disease severity assessments were conducted 22 and 45 days after inoculation by evaluating ten arbitrarily selected leaves within each plot. There was significant variation in the susceptibility of cultivars to PLS and CLS which was consistent across the planting dates. For example, cultivar Pablo had significantly higher PLS and CLS than the other cultivars. One cultivar (Irazu) was identified that had significantly reduced PLS and CLS compared to the currently industry standard cultivars. Objective 3. UV-C based control for CLS. Several experiments were conducted to optimize and identify the UV-C dose for controlling CLS in table beet. In vitro experiments using conidial germination and mycelial growth consistently identified 600 J/m2 as optimal to prevent conidial germination with no significant differences in response across multiple and mixed C. beticola isolates. Experiments were also conducted to evaluate the phytotoxicity of a broad range of UV-C doseases across table beet cultivars. Plants of five cultivars (also used in Objective 2) were grown in the greenhouse (10 reps per cultivar). Ten replicate plants of each cultivar were exposed to the same range of UV-C doses (10 to 1000 J/m2) used for the in vitro experiments evaluating effects on conidial germination and mycelial growth. At the optimal dose identified for pathogen toxicity (600 J/m2) there was some phytotoxicity to table beet seedlings (4 to 8 true leaves; and 10 to 12 true leaves) identified in the form of necrosis on leaf edges. These plants are being evaluated to determine whether the phytotoxicity is lethal or plants are able to withstand the damage and continue growth without detriment. In preparation for field trials in 2021, our collaborators at the Lighting Research Center at Rensselaer Polytechnic Institute have been evaluating the practical aspects of broadacre table beet production to ensure the tractor-mouted lighting array due to be deployed in field trials fits the agronomic specifications of the farming system. Objective 4. Disseminate research findings. The goals and objectives of this project have been presented to our target audience over the first cropping season. Findings to date will continue to be disseminated through winter meetings over 2020/21 and future years within our vegetable extension meetings and extension newsletters, and direct discussions with our advisory group. In this reporting period, results were presented at two grower meetings (NY and PA), and published in two extension bulletins within the grower newsletter, Cornell VegEdge, distributed to over 400 growers weekly. Overall, through these venues, we have reached over 600 growers in this reporting period. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 No publications reported this period. ** **

↑ Return to Index

Improving Welfare and Disease Management on Organic Dairy Herds Through Fly Control

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Investigator(s)	Watson, D. W.; Ward, ST, HI.

NON-TECHNICAL SUMMARY

Diseases like mastitis and pink eye in dairy cattle are extremely problematic because of decreased cow health and comfort, but also because financial losses accumulate exponentially, especially in subclinical cases. In an organic system, where medications known to be successful at prevention or treatment may not be allowed, risk of loss to the farmer is often too great and is likely a barrier to transition to organic dairy production. Eliminating flies on the farm, through mechanical means, would greatly reduce the prevalence of diseases like mastitis and pink eye. Therefore, the short term goal(s) of this particular proposal is to gather experts in relevant disciplines and industries; to get stakeholder input into the issue of fly management; and to develop a full proposal to OREI. The long term goal will be to create solutions to known issues of fly management and reduced disease incidence on organic dairy farms, thus increasing sustainability and profitability of organic dairy farming. The team assembled here, along with the advisory board, will be able to develop educational programs and inform National Organic Program Standards relative to pesticide use and organic dairy production.

OBJECTIVES

Major Goals of this project are to:1) Facilitate the development and improvement of organic agriculture production, breeding, and processing methods, (50%).2) Conduct advanced on-farm research and development that emphasizes observation of, experimentation with, and innovation for working organic farms, including research related to production, marketing, food safety, socioeconomic conditions, and farm business management, (50%).To do this, we intend to bring together a strong team of producers, industry support, and academic and government researchers. In addition to the co-PIs initially identified in NC, TN, KY and NE. We will also invite cooperative representatives, pest management technical service representatives, and other support personnel to participate. We plan to develop a short survey to identify the needs of organic dairy producers, specific to fly control and disease management, and conduct focus groups that will provide insight into perceptions of barriers.Our Objectives are twofold:1)Survey of organic and conventional dairy farms to determine current management practices for fly control in the southern and midwestern regions including but not exclusive toNC, TN, KY, GA, NE.2) Conduct Planning meetings, Focus Groups, and Work Sessions

APPROACH

The initial group of collaborators established for this project represent experts in dairy production, mastitis management and animal health, and fly control and management1. Gather more information about barriers and limitation to adoption of fly control practices from organic dairy producers and industry support personnel. Survey of organic and conventional dairy farms to determine current management practices for fly control. A short survey will be developed using electronic tools (Qualtrics) and will be distributed through email listervs, social media, and other electronic means. The survey will include questions encompassing both economic and non-economic factors, such as individual and farm goals and sources of information that may influence decision-making and implementation. Questions regarding current management practices, effectiveness, and impact will also be included.2. Planning MeetingsThe initial planning meeting will focus on review of recent and current data from the PIs in the group and review of the survey responses. The primary focus of the initial planning meeting will be to: 1. Identify other project participants (co-PIs) and advisory board members 2. Review survey data and discuss project approach and budget 3. Recruit farmers for on-farm research projects 3. Focus Groups: Three focus groups will be held in different locations (NC/TN, GA, KY, NE), relative to the co-PIs on the project. Specific locations will be determined based on proximity to maximum number of dairy farms in a region. For example, a focus group may be held at the NC and TN state line to increase opportunity for producers from both states to attend. Farmers (both organic and conventional), extension agents, and industry support personnel will be invited to attend the focus groups. Interviews will be guided by a protocol requiring specific topics to be addressed (current fly management practices, perception of impact of flies on diseases, etc.) but still broad enough to allow flexibility for all relevant factors to be identified and explored. Progress 09/01/19 to 08/31/22 Outputs Target Audience:Dairy producers, veterinarians, animal scientists, entomologists.Two diseases of dairy cattle, mastitis and pink eye, are problematic because of decreased cow health and comfort, and the accumulated financial losses of subclinical infection. In organic systems, treatment and prevention options are limited and the risk of loss to the farmer is often too great and is likely a barrier to transition to organic dairy production. Pasture flies support and transmit the pathogens associated with mastitis and pink eye and their elimination would greatly reduce the prevalence of disease. Changes/Problems:Originally, this project included planning meetings, focus groups, and work sessions to prepare for a full OREI proposal submission. For example, a focus group would include farmers (both organic and conventional), extension agents, and industry support personnel. Interviews would guide specific topics broad enough to allow flexibility for relevant factors to be identified and explored. Using this input, research specialists were to develop OREI proposal to \"Improve welfare and disease management on organic dairy herds through fly control\". However the onset of the COVID-19 pandemic and the resulting restrictions associated with COVID-19 prevented travel and the focus group input from objective 2 was not performed. Using information from the survey we proceeded to submit a full proposal to OREI in 2020 and though not funded, the proposal was ranked in \"High Priority\" with only a few weaknesses pointed out by reviewers. We requested no cost extension to the grant and a revision to the existing budget (described below) to support activities supporting the suggested revisions and resubmission of a new proposal. OREI reviewer requests included: 1) develop data validating a scoring system to assess the impact of flies on mastitis (teat damage) and IBK (pinkeye) in cattle. 2) Further adapt the fly trap for pasture based organic operations by directly comparing passive and vacuum assisted walk-through fly traps, and 3) gather preliminary data on the efficacy of the fly trap impacts on teat damage. Revised Objective 2a. Develop methodology to evaluate the fly and disease relationship. On farm data collection from 60 Holstein and Jersey heifers included: Fly counts using digital images of the face, legs, and body of the animal. Defensive behaviors include; tail switch, head/ear shakes, leg stomps, and skin twitches.Fly densities were ranked and scored accordingly, (0 = no flies, 1 = < 5 flies, 2 = 5 to 15 flies, 3 = >15 flies) Teats were scored on a 0 to 4 scale with 0 = healthy no visible damage, 1 = evidence of feeding, 2 = feeding evidence and slight edema, 3 = lesion developing and moderate edema, 4 = severe damage and keratinization. For each score, if there was evidence that the skin was cracking or splitting a half point (0.5) was added to the score. The rationale for this was because cracked skin may be associated with mastitis. Similarly, an eye damage rubric was developed using the following scoring system: 0 = No abnormalities, 1 = Eye sensitivity to light, tearing, cornea has a slight cloudy appearance, 2 = Corneal ulceration and increased cloudy appearance and an evident pink hue to the eye tissues from vessel growth and inflammation. Excessive tearing and staining of the hair beneath the eye, 3 = Severe ulceration of the cornea, iris protrudes through the ulcer, pus exudate develops a yellow color. Revised Objective 2b. Comparitive fly trap efficacy using passive and vacuum assisted horn fly trapping technologies. We conducted a direct comparison of the vacuum assisted horn fly trap also known as the CowVacTM (Denning et al. 2014) to a passive walk through fly trap originally developed by Bruce (1938). The CowVac and the Bruce trap were placed on location at the NCDA Cherry Farm, Goldsboro, NC. The cattle were separated into three groups, approximately 50 animals each and housed on separate pastures. Horn fly numbers were estimated by a trained observer on 20 animals within each group weekly starting 2 weeks prior to using the traps and continuing for 6 weeks after the traps were activated for a total of 9 weeks of observations (weeks -2, -1, 0, 1, 2, 3, 4, 5, and 6). The cattle assigned to the trap treatments passed through the traps twice daily, the control group did not use the trap. The average number of flies on the control group on day 0 was 565, the Bruce trap was 512 and the CowVac was 424. By week 2, the horn fly numbers on the control group remained above 800 flies per animal but declined through week 6. This decline coincided with the removal of flies by the two trapping methods. Even though the untreated herd was on a separate pasture, the decline likely reflects an area wide depletion within the fly population. The reduction in the number of flies is calculated on a weekly basis using Abbott's formula where: percent (%) reduction = ((control count - treatment count)/ control count) x 100 (Abbott 1925). The traps were made operational on week zero. The pretreatment fly numbers for week -2 and -1 illustrate thatfly populations between the 3 treatment groups were similar. Relative to the control, the CowVac and Bruce traps had reduced the fly numbers by 32 and 21% after one week of use, respectively. By week 2, the number of flies in the CowVac group had decreased 76.2% and the Bruce trap 44.6%. Weekly percent reduction had increased to above 65% for the Bruce trap and above 90% for the CowVac during the last two weeks of the experiment. The total number of flies removed during the 6-week comparison was 698,648 for the CowVac (72.3% reduction), and 258,872 for the Bruce trap (51.5% reduction). Both traps reduced horn fly density compared with the control (p ≤ 0.001). The mean number of flies by treatment group was significant for the duration of the experiment; control mean 595 ± 26.5, Bruce trap 348 ± 26.6 , and the CowVac 232 ± 26.3 (df = 412, p≤ 0.001). Revised Objective 2c. Mitigating stressors of dairy cattle through the use of fly traps. In response to biting fly pressure, cattle exhibit four basic defensive behaviors, tail switch, head toss, skin twitch and foot stomp. We measured the defensive behaviors of three groups of dairy cattle assigned to the treatments outlined in 2b; an untreated control, Bruce fly trap, and the CowVac vacuum system. Unlike objective 2a, we used mature cattle in this experiment which are likely less susceptible to teat damage (Owens et al. 1998). Cattle were observed on weeks 1, 3, 4 and 5 after treatments were initiated. All defensive behaviors were recorded for a 2-minute period by two observers. The side of each animal observed was photographed to enumerate the number of flies at the time of the observation. Cow udders were examined for evidence of fly induced teat damage while in the milking parlor. Theresults demonstrated a strong positive relationship between fly score and annoyance behaviors in cattle. As fly scores increased, so did the frequency of defensive behaviors like head shakes, tail switching and skin twitching. There was no correlation between fly score and fly counts relative to eye or teat scores in this experiment. Although the fly traps reduced fly populations there was no observed reduction in teat damage scores by treatment. The age of the cattle in this study may have bearing on these observations. Previous studies linking teat damage to horn fly feeding on young cattle less than 2 years of age showed clear evidence of horn fly mediated damage and infection (Owens et al. 1998). Further study on the effects of fly trapping on teat damage and mastitis in older cattle is warranted. References Cited: Abbott, W.S. 1925. A method for computing the effectiveness of an insecticide. Journal of Economic Entomology 18: 265-267. Bruce, W.G., 1938. A practical trap for the control of horn flies on cattle.Journal of the Kansas Entomological Society,11(3), pp.88-93. Denning, S.S., Washburn, S.P. and Watson, D.W., 2014. Development of a novel walk-through fly trap for the control of horn flies and other pests on pastured dairy cows.Journal of dairy science,97(7), pp.4624-4631. Owens, W.E., Oliver, S.P., Gillespie, B.E., Ray, C.H. and Nickerson, S.C., 1998. Role of horn flies (Haematobia irritans) in Staphylococcus aureus-induced mastitis in dairy heifers.American journal of veterinary research,59(9), pp.1122-1124. What opportunities for training and professional development has the project provided?Extension publications are planned targeting producers. How have the results been disseminated to communities of interest?Results of the survey were shared with County Agricultural Agents and scientists with responsibilities in livestock. This event is hosted by the NCSU Department of Animal Science as an annual meeting to update county agents on relevant topics. Additional opportunities were occurred at the jointEntomological Society of America, Entomological Society of Canada, and the Entomological Society of British ColumbiaMeeting held in Vancouver British Columia, Canada. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? In 2019 and 2020, 1500 surveys were sent to US dairies listed with each State Department of Agriculture, resulting in 121 responses (8%). The location of the dairy was not included in the survey. The responses were compared and mean differences were evaluated using the t-test command in STATA (StataCorp 2022). Values were significant when P < 0.1. Farm Demographics: The highest response rate was 119 or 7.93% to the demographics questions. Of the respondents, 85.2% were owner/operators, 11.1% managers and 3.7% family members. Most respondents were aged 42-60 yrs (42.1%), followed by 28.0% aged 30-41 yrs and 20.6% above 60 yrs. Conventional dairy production systems predominated with 76% and organic dairies made up 17% of the respondents. Combined operations described 23.1%.No respondents considered themselves as transitioning into organic dairy farming. Herd makeup. Holstein cattle predominated the breed list with 59.6%, followed by Jersey (15.2%), crosses (10.1%) and herds with both Holstein plus Jersey or cross-bred cattle (10.1%). Other breeds making up about 1% each included Guernsey, Brown Swiss, Milking shorthorn and \"other\". Most conventional dairies in the survey maintained herds of 101-200 cows. Organic herds were smaller 51-100 cows. Responding dairies maintain herds of different aged animals comprised of lactating cows, dry cows, heifers and calves. Among the respondents, most (33%) had ≤ 50 cows in lactation. Similarly, 28.9% of the farms were milking between 51 and 100 cows. The majority of farms (86.3%) had ≤ 50 dry cows, heifers (57.7%) and calves (77.3%). Animal housing varied among the farms and animal category. Briefly, dairy housing was characterized as freestall, bedded pack, composted bedded pack, tie or stanchion, pasture, drylot, and hutch.Freestall housing is most common for lactating cows followed by pasture in conventional and grass/grazing systems, respectively. Dry cows and heifers reside on pastures, followed by bedded pack as the most frequent location. Hutch housing was used for calves until weaned and before moving to either bedded pack or pastures. Conventional, organic and grazing based operations use housing best suited to the operation. For example, freestall operations were most common to conventional dairies (52.4%) and pastures most amenable to organic (57.9%) and grazing (71.4%) operations. Bedded pack (31%)and composted bedded pack (21%) was most common in organic dairies. Few conventional or organic producers used stanchions/tie stall systems (11 and 15%, respectively). Similarly dry lots were most used by 10% of the organic producers. Animal Health and Welfare Concerns: Respondents to the survey were concerned with the health and wellbeing of their animals. Metrics for selection included; insect pests, heat stress, mastitis, animal comfort, teat damage/dry quarters and pink eye. Insect pests identified as common problem were relatively difficult to manage. About 10% of the farms experienced pink eye. Mastitis occurred with relative frequency on 12.9% of the farms and was more difficult to manage (22.2%). We queried the producers as to which of 10 pests that were most common problems on their farm. The horn fly and the face fly were of most concern, especially for organic producers, (T = -1.8889; df = 23.7762; P = 0.0712, and T = -2.9063; df = 22.3743; P = 0.0081, respectively) followed by house fly, stable fly and horse fly. Ticks, mites and lice were of concern for the organic producers. Fly and Pest Management Organic producers reported significantly higher levels of severity of pinkeye than conventional producers (T = -1.7723; df = 18.1726; P = 0.0931). In contrast, both organic and conventional producers perceived mastitis similarly (T = -0.1558; df = 20.8735; P = 08777). More producers responded 'yes' to flies being involved with pinkeye transmission compared to mastitis. Neither organic nor conventional producers report having effective options for preventing either disease but they do have effective means of treatment. Pesticide products available for conventional and organic dairies are significant. These include compounds that act on nerves and muscle; juvenile hormones and molting disruptors. Others are toxins originating in the microbial community included baculoviruses and Bacillus thuriengiensis. Lastly, are the insecticides with non-specific or unknown modes of action, such as boric acid, azadirachtin and sulfur. Producers with organic certification may use non-synthetic botanical pyrethrum with and without some restrictions, depending on the formulation (omri.org). Repellents of botanical origin are important products for organic producers. These may include botanical neem that contains azadirachtin, D-limonene, limonene, citronella and other essential oils. Conventional dairy farms were more likely to use ear tags, synthetic pour-on and sprays, and feed additives, including pyrethroid, organophosphate, and macrocyclic lactone pesticides. Organic producers use approved sprays containing botanicals and essential oils. Vaccines for pinkeye are available for conventional and organic uses. Walk-through fly traps passive and vacuum assisted are used by organic producers. Both conventional and organic producers practice cultural control by spreading manure to preventfly breeding. Furthermore, both use sticky traps to reduce adult flies and pasture rotation to minimize the negative effects of overgrazing. Composting manure is a favored practice by organic producers. Interestingly, the use of biological control agents, e.g. parastioids, are used at relatively low levels in our survey. In contrast, dung beetles are favored among the organic producers for their ability to help reduce pasture fly breeding resources. Dairy producers perceived direct, indirect and peripheral damage caused by flies to be clear. While all producers recognized that flies bother their cattle and cause discomfort, organic producers perceive this as problematic (T = -4.1312; df = 77.8305; P = 0.0001 and T = -3.0879; df = 62.2372; P = 0.0030, respectively). Dairy producers are concerned about the public perception of flies on the farm and recognize the defensive behaviors by cattle in response to flies. Organic producers care about how their operations are perceived (T = -1.8251; df = 24.3375; P = 0.0803). Producers also view the additional labor needed to address the fly situation on the farm as burdensome (T = -4.4207; df = 41.1033; P = 0.0001) and flies have a significant impact on the operation (T = -2.6204; df = 27.7554; P = 0.0141). The indirect impact of disease on milk quality and milk losses caused by flies has a financial impact(quality; T = -3.3537; df = 29.8405; P = 0.0022) and (yields; T = -2.6265; df = 29.4977; P = 0.0135). Producers were asked if the following were barriers limiting the adoption of organic practices or to continuing to operate an organic dairy operation; disease treatment options, fly management, cost of production, skilled labor, milk market or not interested. Of 63 respondents, the cost of production was considered the most limiting factor to adopting organic practices with 40 and 19% indicating a strong or extreme disincentive, respectively. Disease treatment options played a role in producer opinions on organic adoption with 27 and 24% viewing treatment options as a moderate to strong disincentive (T = -2.5319; df = 23.6422; P = 0.0184). Similarly 28 and 30% of the producers view fly management options available to organic producers as a moderate to strong concern. Most respondents were not concerned about finding skilled labor with 31 and 34% indicating labor as not a concern or only a slight concern. About 24% of 57 respondents viewed milk market as a strong concern, and was especially true for organic producers. Lastly, of 61 respondents, 29 indicated they were not interested in adopting organic dairy production, (29% strongly opposed and 18% extremely opposed). Publications Progress 09/01/20 to 08/31/21 Outputs Target Audience:Through extensive contacts with conventional and organic producers, extension workers, dairy cooperatives, veterinarians, animal scientists, entomologists Changes/Problems:Covid 19limited our ability to complete the project as originally planned and the focus group encounters were suspended due to travel restrictions and disease risk. Based on our early survey data, we redirected our efforts to proceed with a research and extension proposal presented in the accomplishments section entitled: \"Improving welfare and disease management on organic dairy herds through fly control\". Although the project was not funded the reviewers placed the proposal in the High Priority category. Positive Aspects of the Proposal The review panel considered the proposed topic very relevant, as fly populations have a significant detrimental impact in dairy systems and organic regulations limit the use of conventional commercial control products. The multidisciplinary nature of the team (entomologist, health specialists, economist, extension, computer engineer) is also attractive. The idea of developing a tool for burden and occurrence assessment of fly populations and the subsequent testing of control strategies is a good approach to capture the stakeholderinvolvement. The panel recognizes the benefit of previous interactions with stakeholders, as the research team has worked with producers in this topic by developing a survey and conducting focus groups as part of a previous planning grant. The presented objectives are well integrated, the approach is properly described, and the proposed timeline is appropriate. The budget seems adequate, with a good allocation of funds for graduate students. Negative Aspects of the Proposal There is some concern regarding the procedures for the assessment of health outcomes. The visual observation and scoring system are described; however, there are questions about the actual sensitivity and specificity of this approach for detecting disease, especially teat lesions.It is unclear why observation of these animals while in the milking parlor would not be preferable and a validation of this scoring system and approach is necessary. Other concerns included the number of co-PIs on the project and the in vitro tissue studies to evaluate pathogen reduction. No Cost Extension We requested and receiveda no cost extension and a rebudget to address the reviewers request to validate the visual observation and scoring sytems described. Furthermore we compared the vacuum assisted trapping system to a passive trap design. What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest?Aspects of this project have been presented to stakeholders and clients through the NCSU Veterinary Entomology Extension Program. What do you plan to do during the next reporting period to accomplish the goals?With the limited time remaining, we plan to address comments from the reveiw panel. Impacts What was accomplished under these goals? In 2019 and 2020, 1500 online and mail surveys were sent to US dairies listed with each State Department of Agriculture, resulting in 121 responses (8%). The location of the dairy was not included in the survey. Using data gathered in this project focused on dairy production and a focus group meeting held by team members at University of Tennessee, where dairy and beef producers were interviewed about their biggest on-farm challenges. Issues related to fly management, particularly regarding calves and heifers, were identified as a critical concern for producers. From thesurvey and a focus group meetingwe learnedthat 78% of producers considered insect pests to be a moderate to extreme problem on their farm. In order of severity, 74 and 71% of the respondents identified moderate to extreme problems with the face fly and horn fly, respectively. Of those surveyed, 23 and 50% had experienced moderate to serious issues with pink eye and mastitis, respectively. Producers responding to the survey reported having an average of 10.5 cases of pinkeye per year, impacting heifers mostly andflies were the suspected cause. For mastitis, producers averaged 3.4 cases per month, but did not suspect flies as the cause. Similarly, the average number of teat damage cases were 3.5 per month impacting cows most and producers were uncertain if flies were involved. Interviews conducted in a focus group of nine Tennessee dairy farmers revealed they are using a suite of methods- feed through larvicides, pour-ons/sprays/misted products, ear tags, fly sticky tape, fly bait, and environmental controls like mowing\--to manage fly populations across all their animal types. Because most are using feed-through insecticides containing insect growth and development regulators, most were unaware of their total costs for control for it was included in the feed costs. As a result most producers could estimate costs only for other fly control expenditures. Their primary consideration in adoption of practices is labor. Farmers indicated they routinely try the latest products in a desire to achieve better control or to decrease their labor invested in fly control. Fly control in heifers was indicated as an even greater challenge, because application of control methods to animals housed on pasture requires more labor compared to those housed inside or routinely worked for other reasons (i.e. lactating cows or calves). Farmers also stated that the effectiveness of existing products were diminishing and they are now applying products 2 and 3 times more frequently than 5 years ago. They also believe that current strains of pink eye that occur in their herds are less responsive to treatment and more damaging to the animal than the strains they encountered 5 years ago. Producers also were keenly aware that flies affect their profitability because cows standing and crowding and heifers experiencing mastitis and quarter-loss in their first lactation are causes of significant production and financial loss to them. In response to these preliminary results, we developed a proposal for submission to NIFA OREI entitled \"Improving welfare and disease management on organic dairy herds through fly control\". Collaborators on this submission included researchers at North Carolina State University, the University of Tennessee Knoxville, the University of Nebraska, the University of Kentucky, and the USDA Agricultural Research Service in Lincoln Nebraska. The long-term goal of this project is to provide management strategies that will reduce fly populations and associated disease incidence on organic dairy and beef farms. This will contribute to a reduction in preventable diseases like Infectious Bovine Keratoconjunctivitis (pink eye) and mastitis, which is a critical need for organic dairy farmers. An important goal of producing organic dairy and beef is the sound welfare, health, and productivity of cows. Limited organic treatments exist for pinkeye and mastitis, so prevention is critical. While good management can mitigate many of the potential sources of disease, fly control remains a challenge on all dairies. Fly control has multiple potential benefits, from reducing the irritation level of cattle on pastures to prevention of fly-transmitted pathogens.Most fly control products are synthetic insecticides. Organic producers are challenged because synthetic insecticides for fly control and antibiotics to treat infections transmitted by flies are prohibited in US organic dairy production. Our aim is to examine the impact of flies on cow health, well-being, and productivity on organic dairy and beef operations, and to demonstrate (and improve upon) proven repellent and trapping technologies for fly management. Our proposal objectives are: Objective 1 - Assess the health, well-being, and economic impact of flies and fly-related diseases on dairy farms. Develop an assessment tool that can quantify the losses associated with increased fly loads and subsequent decreases in animal health. We will work directly with organic farms to gather data relative to production and economic performance as well as gather observational data from on-farm visits.Data collected will include: fly samples and images of fly-infested animals, teat and face swabs, milk yield and components, ration information, herd level data, heifer growth data, and costs associated with fly management and health events. We will assess how digital imagingcould help predict how fly populations affect animal well-being and production performance. Objective 2- Evaluate and improve disease and fly management methods, including repellants and traps. Current strategies for controlling face and horn fly populations are relatively limited - especially on organically managed animal operations. Two practices that can be further developed to increase effectiveness and farmer adoption are 1) novel plant-based formulations that repel flies for extended periods and have a dual antimicrobial benefit and 2) modify the design of mechanical fly traps to improve fly removal when power is not available or limited. Application of fly repellents containing essential oils and free fatty acids obtained from naturally occurring compounds are effective at reducing fly populations. We will determine how variables like dose, concentration and frequency of application affect the efficacy of these compounds. Essential oils and fatty acids also have been demonstrated to have antimicrobial properties. We hypothesize that fly repellents will have a dual benefit by also limiting pathogen concentrations on the skin surface. Objective 3- Demonstrate the benefits and process of adoption of fly management practices. We aim to identify producer perception of fly management impacts on cow health, production, profitability, and labor management. We will also use results from Objectives 1 and 2 to provide novel and updated recommendations to producers across multiple regions. Barriers to adoption, as identified in interviews, will be used to improve fly management recommendations and encourage adoption.Success of this project will lead to fly management solutions for organic dairy and beef producers, resulting in improved animal health, well-being, and productivity as well as a reduction in barriers to adoption of organic practices. Publications Progress 09/01/19 to 08/31/20 Outputs Target Audience:Dairy producers and county extension agents. Initially these include conventional and organic producers in the southern mid Atlantic region but was expanded to a national audience. Changes/Problems:The Covid 19 pandemic and the subsequent limitations on travel and meetings prevented us from conducting the focus group sessions. We were able to circulate the survey to a wider audience and based on the responses, begin developing a proposal for submission to conduct further research once Covid 19 restrictions are lessened. What opportunities for training and professional development has the project provided?The development of the survey has provided the creators with opportunities to better understand how phrasing questions can cause significant variablity in the responses. 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?We plan to evaluate the responses to the initial circulation of the survey and depending on the responses if a second circulation is necessary. We further expectto begin focus group sessions. Impacts What was accomplished under these goals? We created a survey instrument in year one of the project to distribute to dairy producers.The survey included questions encompassing both economic and non-economic factors, such as individual and farm goals and sources of information that may influence decision-making and implementation. Questions covered three general categories 1) Farm Demographic, 2) Animal Health and Welfare Concerns, 3) Fly and Pest Management. Examples of the questions follow. A. Farm Demographics 1. What is your role on the farm: Owner/operator, Employee, Manager, Family member. 2. What age range in years best describes you: 18-29, 30-41, 42-60, >60. 3. How would you describe your operation: Conventional, Certified Organic, Transitioning Organic, Grazing based, Combined convention/grazing. 4. Please indicate the approximate number of each breed on your farm: Holstein, Jersey, Brown Swiss, Guernsey, Ayrshire, Milking shorthorn, Cross-bred, Other. 5. Please indicate your overall herd size and approximate number of each category of animals: 1-50, 51-100, 101-200, 201-500 >500. Categories were: Total herd size, Lactating cows, Dry cows, Heifers, Calves. 6. For each animal category identify the different housing types available on the farm and the number of animals for each. Animal categories were:Lactating cows, Dry cows, Heifers, Calves. Housing types were: Freestall, Bedded pack, Composted bedded pack, Stanchion/tie stall, Pasture, Dry lot, Hutches. 7. What is the number and proximity (miles or yards) of other animals on the farm? Choices were: Beef cattle, poultry, swine, goats, sheep, and horses. B. Animal Health and Welfare Concerns 8. Do you consider the following to be a problem on your farm? Choices were: Insect pests, Pink eye, Mastitis, Teat damage, Heat stress, and Animal comfort.Please rank each according to severity: None, Minor, Moderate, Serious, Extreme. Indicate the which problem (1)as most common and (1) most difficult to manage. 9. Which months of the year do you see these problems: Insect pests, Pink eye, Mastitis, Heat stress and Animal comfort. 10. Regarding pinkeye: Estimate the number of cases annually, which catagory of animals are most afflicted, do you suspect flies are involved, do you have effective preventatives and do you have an effective treatment option. 11. Regarding mastitis:Estimate the number of cases annually, which catagory of animals are most afflicted, do you suspect flies are involved, do you have effective preventatives and do you have an effective treatment option. 12. Is teat end/quarter damage aproblem on your farm:Estimate the number of cases annually, which catagory of animals are most afflicted, do you suspect flies are involved, do you have effective preventatives and do you have an effective treatment option. 13. The following 10 pests may be on your farm. Please indicte their severity, and rank the most common pests and most difficult to manage. Pest choices are: House fly, Face fly, Stable fly, Horn fly, Horse fly, Biting gnats, Mosquitoes, Cattle grubs, Lice, Ticks/mites. 14. Which month of the year do you consider flies to be a problem for each category of animals: Lactating cows, Dry cows, Heifers, Calves. C. Fly and Pest Management 15. How often (daily, weekly, monthly, yearly)do you practice cultural control: Clean the milk house, Clean the parlor, Remove filter socks, Scrape manure, Dispose of waste residue, Clean hutches. 16. How faris the proximity of your parlor, feeding area, or animal housing to the primary manure storage area? 17. How often (daily, weekly, monthly, yearly)do you move (change location), clean (remove old material) and refresh (add new material) in your pasture: Choices are Hay rings, Water troughs, Shade covers. 18. Where do you get information on pest control: Feed store, Veterinarian, Cooperative extension, Sales rep, Other farmers, Internet, Pest management professional, Popular press, Publications. 19. Do you attempt to control flies? Y/N 20. How do you determine when to start fly control? Choices are: Time of year, When flies are observed, When flies annoy people or animals, When others recommend it. 21. During peak fly season, where on the animal do you see the most flies? Choices are: Head/face, Back/withers, Sides/belly, Legs, Rump/udder. How would you rate the severity of each: None, Minor, Moderate, Serious, Extreme. 22. At peak fly densities, which picture best represents the number of flies you observe. This is a graphic showing low medium and high numbers of flies on the body, face and legs of a cow, representing predilection sites typical of horn fly, face fly and stable fly. 23. At what intensity do you consider flies to be a problem?This is a graphic showing low medium and high numbers of flies on the body, face and legs of a cow, representing predilection sites typical of horn fly, face fly and stable fly. Our intent here is to determine when the producers takes action. 24. Do you strongly disagree, somewhat disagree, neither agree or disagree, somewhat agree or strongly agree with the following statements: Flies bother my cows, Flies impose a significant impact on my operation, Flies potentially reduce milk yield and introduce financial uncertainty,Flies potentially reduce milk quality and introduce financial uncertainty,Flies potentially introduce disease (pinkeye/mastitis)and introduce financial uncertainty, Additinal labor needed to address pest problems is burdensome, Flies jeopardized cow comfort, I worry about the public perception of fly loads on my farm. 25. How do you determine if your cattle are bothered by flies?Choices are: Head toss, Foot stomp, Tail switch, Skin twitch, Snorting, Disease incidence. 26. Excluding labor, estimate your annual spending on fly control measures. 27. What control measures do you use for fly control?Chemical Controls include: Ear tags, Organic pour-on, Conventional pour-on, Organic spray, Conventional spray, Botanical/essential oils, Organic feed additive, Conventional feed additive, Injectable, Vaccine. Trapping methods include: Sticky traps, Fly vacuum, Passive walk-through trap, Other fly traps. Conventional control methods include: Spreading manure, Composting, Pasture rotation. Biological control methods include: Fly predators, Pathogenic fungi, Nematodes, Dung beetles, Pasture rotation with chickens. Producers were also asked if they were currently using these methods or have either discontinued or never used them. 28. How strongly do you feel the following concerns limit adoption of organic practices? Choices are none, slight, moderate, strong and extreme. Concerns were: Disease treatment options, Fly managment, Cost of production (feed), Skilled labor, Milk market, Not interested. ** **

↑ Return to Index

A Multifaceted Approach to Production Methods and Pest Management in Organic Sweet Potato Systems

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NON-TECHNICAL SUMMARY

Sweetpotato production is the economic and social backbone in rural communities that produce the crop. North Carolina and Mississippi rank number one and two, respectively, in planted sweetpotato acreage in the United States (USDA, 2017b). In 2016, an estimated 32,000 ha of marketable sweetpotato roots were harvested in North Carolina with an approximate value of \$342million marketed nationally (75%) and internationally (25%) (USDA, 2017b). In 2016,Mississippi producers planted 12,000 ha with a direct value of \$121.8 million (USDA, 2017b). In Mississippi alone, the sweetpotato industry supports 1,100 full-time-equivalent workers across 105farms and 26 packing lines (Morgan et al., 2012).Although organic sweetpotato acreage is a proportionately small part of sweetpotato production in the South, there is room for growth. Forty-four sweetpotato producers completed a survey expressly for conventional producers with an interest in growing organic. The greatest barrier to entry these growers identified was weed control, which was rated 4.11 on a scale of 1(less problematic in organic production systems) to 5 (more problematic) (Meyers et al., unpublished data). Addressing this production-related concern will benefit current organic producers immediately and potentially increase adoption of organic production among current conventional producers. The overall goal of this project is to address the need for well defined, research-based production and pest management techniques for organic sweetpotato producers. National organic sweetpotato hectarage doubled in the five-year span between 2011 to2016, from 1,760 ha to 3904 ha, half of which is located in the Southeast (USDA-NASS, 2017a).Research and outreach efforts in organic sweetpotato production systems have not kept pace with this growing market. Organic sweetpotato production practices differ greatly from conventional production practices; however, given the lack of organic-specific, research-based recommendations, producers have attempted to translate recommendations for conventional systems into organic production systems with varied success. In-depth research is necessary to develop robust production recommendations that address the needs of organic sweetpotato producers and maintain profitability and sustainability in the face of a changing landscape. Winter annual cover crops can benefit organic vegetable crops through improved soil health, reduced nitrate leaching, and weed suppression. With an interdisciplinary team, we will measure the benefits of novel suppression tactics for integrated pest management (weeds, insects and diseases) and sustainable soil fertility in a high value vegetable crop, organic sweetpotato. We will also examine the pest suppressive benefits of a new insect-resistant sweetpotato variety developed by the NC State Sweetpotato Breeding Program. This multi-pronged approach addresses intersecting production priorities for growers because cover crop use and variety selection may intensify insect pest issues and require adjustments to nitrogen application rates due to nitrogen immobilization/mineralization, but could also be an effective tool to control weeds. To address these different agronomic and Integrated Pest Management (IPM) priorities, we

propose to measure tradeoffs for cover crop use in organic sweetpotato by evaluating insect pressure, weed suppression, and soil nitrogen fertility in a series

OBJECTIVES

1. Identify sweetpotato clones that produce high yield and quality in organic sweetpotato production systems.2. Determine the impact of fall-planted cover crops on soil nitrogen availability, soil quality and insect pressure in organic sweetpotato.3. Determine if weeds, rotational crops, and cover crops found in organic sweetpotato systems serve as pathogen reservoirs.4. Identify cultural practices, weed-suppressive sweetpotato clones, and allelochemicals that decrease sweetpotato losses to weed interference.

APPROACH

Field studies will be conducted on certified organicsweetpotato farms in AR, MS, and NC as well as research stations with certified organic land inNC (Cherry Research Farm, Caswell Research Farm) located in areas of intensive sweetpotato production and on certified organic land at Purdue Agriculture Centers in IN. The commercial standard variety for field studies will be Covington (NC and IN) and Beauregard (MS and AR).Studies in MS and AR will also include Covington sweetpotato. To document sweetpotato establishment, stand counts in a specific area will be recorded approximately 2 WAT. Approximately 110 to 120 days after transplanting (DAT), sweetpotato foliage will be flail mowed, the center rows of each plot harvested, and sweetpotato storage roots graded into jumbo, no. 1,canner, and cull (USDA, 2005). In NC, storage roots will be graded by an Exeter optical sorter tocount number of sweetpotatoes, determine individual size, weight, and shape, length/width ratio;determine no. 1, jumbo, canner and cull grades. Sweetpotato accessions representing landraces, breeding lines, and cultivated varieties will be selected and obtained from the CIP (Lima, Peru), the NGR (Griffin, GA), and NCState\'s Micropropagation and Repository Unit in Raleigh, NC. Plants of each accession, as well as commercial standards Beauregard and Covington, will be phenotyped for weed-suppressive potential Ion four problematic weeds. Data will be analyzed with SAS or JMP. Where appropriate means will be separated with Fisher\'s protected LSD. Regression analysis will be conducted when appropriate to determine to what extend data collected can be used to predict relative yield loss. Progress 09/01/19 to 08/31/24 Outputs Target Audience:The goal of this proposal was to provide research results to a diverse range of individuals and organizations involved in agriculture including the following.Growers who focus on organic production systems and conventional growers. Farmers who produce vegetable and small fruit crops as well as growers that produce agronomic row crops. In addition, commodity groups or organizations that represent specific agricultural commodities working on behalf of producers to support market development, policy advocacy, and industry research, were educated about this project. Extension agents who work with farmers and the agricultural community to provide research, training, and practical guidance on farming practices and techniques were also given this information. Agrochemical company personnel, faculty at other institutions, and other members of the agricultural community were also educated on the research results of this project. In addition a large part of the target audience consisted of graduate students as graduate education is very important. It\'s critical to provide experiences and opportunities for the next generation of farmers, consultants, researchers, extension agents etc. This research allowed them to gain a critical skill set in the area of organic production. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Research results have been presented in agent trainings conducted in NC, MS and AR.In addition, many demonstrations and results have been presented at several sweetpotato and organic field days in NC, MS, AR, and IN.Research findings have alsobeen shared at various extension and research conferences, with information also available on the North Carolina Sweetpotato portal. Graduate students presented their research at extension and research conferences, participated in oral and poster contests, and developed valuable skills for agricultural industry careers. They also gained experience through student teaching, lab, and field research, expanding their knowledge of agricultural protocols. How have the results been disseminated to communities of interest?Research results have been published in the North Carolina Organic Commodities Production Guide Chapter 8: Crop Production Management in Sweetpotatoes. March 19, 2024. AG 660. In addition, many demonstrations and results have been presented at several sweetpotato and organic field days in NC, MS, AR, and IN. Research results have been presented at local, regional, and national extension and research conferences. Information is being posted on the North Carolina Sweetpotato portal. Many journal articles have been published and some will be published in the near future including the following. CD,Jennings, KM,MonksDW,BasingerNT,JordanDL,CahoonCW,BaronJJ,IppolitoSJ (2025)CD, Jennings, KM, MonksDW,BasingerNt, JordanDL,CahoonCW, BaronJJ, IppolitoSJ (2025)Effect of Weed Zapper Application Schedules on Palmer Amaranth (Amaranthus palmeri) Control and Crop Yield in Four North Carolina Crops. Weed Technology (in review) BlankenshipCD,Jennings, KM,MonksDW,BasingerNT,JordanDL,CahoonCW,BaronJJ,IppolitoSJ (2025)Efficacy of Electricity with and without Roller Crimping for Termination of a Sunn Hemp (Crotalaria juncea) Cover Crop. Weed Technology (in review) In addition, an extension publication on the use of the Weed Zapper is in draft form. Also research results from this project will be included in our new extension publication \'Weed Management in Sweetpotato\'. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? 1.Results of this researchindicate thatlegume cover crops: Austrian winter pea and crimson clover, contain a modest supply of nitrogen in the biomass, however, much of that N isreleased before sweetpotato istransplanted. This study also indicated that cereal rye is not an effective cover crop to utilize in sweetpotato production due to added labor required to properly terminate this cover crop to bed rows. The soil data indicated very little nitrogen released during the growth period of the sweetpotato. Using a nitrogen release calculator, it appeared that large portions ofthe cover crop nitrogen is released before planting occurs and certainly before significant N uptake happens. The traditional termination of a cover crop one to two weeks before planting to allow for water recharge normally recommended does not work at this time of the year. In late May and early June conditions are hot and wet, causing rapid decomposition of this material. This study showed that high applications of N consistently reduced sweetpotato yield. 2. Results showthat sweetpotato varietal resistance had a strong effect on the amount of wireworm damage observed. Across all studies, susceptible \'Covington\' sweetpotatohad more damage than resistant \'Monaco\' variety. The effect of cover crop was not found to be significant in any study. 3. Weeds including pigweed species, perennial nutsedge species, morningglory species, Jerusalem cherry, nightshade species, velvetleaf, wild mustard, sicklepod, carpetweed, and common purslanehave been determined to be RKN hosts. 4. Studies were conducted in North Carolina and Indiana to assess the impact of sweetpotato in-row spacing, two sweetpotato cultivars, and environments on sweetpotato yield and quality. Results indicate that Covington and Monaco sweetpotato cultivars do not differ in ability to produce sweetpotato yield under weedy conditions.While there is no evidence to suggest that varied spacings provide any competitive advantage against weeds for \'Covington\' and \'Monaco\' cultivars, future research should examine other parameters of production including between-row spacing and additional sweetpotato cultivars in order to determine whether potential weed-management benefits may be attained through the modification of planting practices. Covingtonand Monacocultivars do not differ in ability to produce sweetpotato yield under weedy conditions.Resutls strongly support the idea that delaying weedremoval during sweetpotato production significantly reduces yield.The longer weeds were allowed to exist in the crop, the morepronounced the reduction in yield became. Across the threecultivars studied, responses to weed interference in terms of yieldreduction varied. In both study years most sweetpotato varieties had similar yields to \'Covington\' sweetpotato, which is the NC standard cultivar. Yield increases were observed for some clones when harvest was delayed, with more clonesseeing this benefit in 2020 than 2021.In 2020,marketable yields were 16% higher for the horizontal orientation compared to verticalorientation, with intermediate yields with the sleeve attachment. However, in 2021, there wereno significant differences in marketable yield among planting orientations. In both years, No. 1yields were significantly higher when cuttings were planted horizontally compared to vertically,with an average increase of 18%. Results of this study indicate that delaying harvest until approximately 126days after planting is recommended to increase yields for \'Monaco,\' regardless of planting orientation. Thisstudy provides evidence that a horizontal planting orientation could increase crop yields andimprove land use efficiency for organic sweetpotatoes. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Blankenship CD, Jennings KM, Monks DW, Cahoon CC, Jordan DL, Basinger NT, Baron JJ, Ippolito SJ (2024) Effect of timing of the Weed Zapper on Palmer smaranth control and sweetpotato yield and quality. In Proceedings of SWSS annual meeting. San Antonio, TX Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Blankenship CD, Jennings KM, Monks DW, Cahoon CC, Jordan DL, Basinger NT, Baron JJ, Ippolito SJ (2024) Effect of timing of the Weed Zapper on Palmer amaranth control and sweetpotato yield and quality. In Proceedings of National Sweetpotato Collaborators Group (NSCG) New Orleans, LA Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Blankenship CD, Jennings KM, Moore LD, Jordan DL, Meyers SL, Monks DW, Schultheis JR, Suchoff DH (2023) Effect of Cultivation Regimes on Weed Control and Sweetpotato Cultivar Yield and Quality. In Proceedings of SWSS annual meeting. Baton Rouge, LA: SWSS Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Cooper EG, Meyers SL, Arana J, Jennings K, Adair A, Gibson KD, Johnson WG (2024) Evaluation of critical weed-free period for three sweetpotato (Ipomoea batatas) cultivars. Weed Science. 2024;72(3):267-274. doi:10.1017/wsc.2024.15 Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Woodard AJ, Schultheis JR, Jennings KM, Woodley AL, Suchoff DH (2024) Horizontal planting orientation can improve yield in organically grown sweetpotato. HortScience 59(1):36-42. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2023 Citation: Werle IS, Noguera MM, Karaikal SK, Carvalho-Moore P, Badou-Jeremie Kouame K, Bessa de Lima GH, Roberts TL (2023) Integrating weed-suppressive cultivar and cover crops for weed management in organic sweetpotato production. Weed Science 71(3):255-264. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2022 Citation: Werle IS, Noguera MM, Karaikal SK, Carvalho-Moore

P, Kouame KB-J, Tseng T-M and Roma-Burgos N (2022) Allelopathic potential and competitive traits of sweetpotato cultivars. Frontiers in Agronomy Type: Other Status: Published Year Published: 2025 Citation: https://ashs.org/news/691814/ Type: Theses/Dissertations Status: Published Year Published: 2022 Citation: WOODARD, ALYSSA JANE. Assessment of Sweetpotato Clones and Stem Cutting Planting Woodard AJ (2022) Orientations in Organic Sweetpotato Production. MS thesis. Raleigh, NC: North Carolina State University. 117 p Type: Theses/Dissertations Status: Published Year Published: 2022 Citation: Schlegel Werle, I. (2022). Evaluation, Characterization, and Utilization of Weed-Suppressive Sweetpotato Cultivars for Sustainable Weed Management. Graduate Theses and Dissertations Retrieved from https://scholarworks.uark.edu/etd/4453 Type: Theses/Dissertations Status: Published Year Published: 2024 Citation: Cooper, EG (2024). A multifaceted approach to weed management in organic sweetpotato systems. Purdue University Graduate School. Thesis. https://doi.org/10.25394/PGS.25647483.v1 Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Cooper E, Meyers SL, Jennings K, Adair A, Gibson KD, Johnson WG. Effect of in-row spacing on weed suppression and yield of Covington and Monaco sweetpotato. Weed Technology. 38:e59. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Cooper EG, Meyers SL, Arana J (2022) Evaluation of weed removal timing for three sweetpotato cultivars. Purdue University, West Lafayette, IN NCWSS Proceedings (66) Type: Peer Reviewed Journal Articles Status: Published Year Published: 2021 Citation: Pellegrino AM, Woodley AL, Huseth AS (2021) Understanding the relationship between aireworm (Coleoptera: Elateridae) damage, varietal resistance, and cover crop use in organic sweetpotato. Journal of Economic Entomology \Internet\. September 6, 2021;114(5):212734. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Thisproposal seeks to address concerns of organic production methods for sweetpotato including weed management, insect and disease contro by providingstakeholders with research-based information and guidance to improve production efficiency, profitability, and sustainability. Results from this proposal will be shared with stakeholders including growers, extension personnel, consultants, other researchers and members of the agricultural community. Graduate students will have the opportunity to learn new skills in organic production methods. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Graduate students played an integral role in conducting the research studies. They were responsible for transplanting sweetpotatoes, applying various treatments, and collecting weed control data. Additionally, they maintained the research plots, harvested the sweetpotatoes, and graded the storage roots. Afterward, the students analyzed the data, wrote detailed reports, and presented the research findings at professional conferences and extension meetings. This hands-on involvement allowed the students to participate in every phase of the study, from start to finish, providing them with valuable skills and experience throughout the process. How have the results been disseminated to communities of interest?The research results have been shared through various platforms, including field days, local and regional extension meetings, and peer-reviewed journals, ensuring broad dissemination to both the academic community and industry stakeholders. What do you plan to do during the next reporting period to accomplish the goals?A field study will beconducted in 2024 at the Horticultural Crops Research Station in Clinton, NCto determine the effect of Weed Zapper application frequency on Palmer amaranth control and crop yield in sweetpotato.further research is needed to improve the availability of options for cover crop termination in no-till systems. Therefore, studies will be conducted to determine the efficacy of electrical termination with and without roller crimping on sunn hemp cover crops. Impacts What was accomplished under these goals? Little information exists about the optimal application frequency schedule for use of the Weed Zapper and other electrical implements for control of Palmer amaranth in crops including sweetpotato. Thus, studies were conducted in 2023 to determine the impact of application frequency on Palmer amaranth control and crop yield. Field studies were conducted in 2023 at the Horticultural Crops Research Station in Clinton, NC to determine the effect of Weed Zapper application frequency on Palmer amaranth control and sweetpotato crop yield. All studies shared similar study designs and treatments. Treatments were applied in a 2 x 5 factorial split-plot arrangement in a randomized complete block design with four replications. The main plot factor (2 levels) consisted of the presence or absence of pre-emergence herbicide applied before or at planting/transplanting; the subplot factor (5 levels) consisted of Weed Zapper application frequency treatments including weekly, biweekly (every two weeks), monthly, hand-weeded check, and weedy check. Whole plots consisted of twenty rows 9.14 m long; subplots consisted of four rows, each 1.06 m wide by 9.14 m long. Weed Zapper schedule treatments were initiated when weeds reached an average height of 0.15 m over the sweetpotato canopy in each herbicide treatment. Treatments were typically initiated between 3 to 4 weeks after planting (WAP). Weed Zapper application treatment schedules were carried out for 5 weeks in order to ensure that the treatment schedules were fully applied; over this period, the weekly schedule received 5 treatments (7 days between treatments), the biweekly schedule received 3 treatments (14 days between treatments), and the monthly schedule received 2 treatments (28 days between treatments). The center two rows were used for data collection while the outside rows were border rows to prevent treatment interference from other plots. Each plot was separated vertically from other plots by an empty 4.6 m space. Weed Zapper treatments were applied using a Weed Zapper Annihilator 6R30 attached to a John Deere 6195R tractor. Tractor ground speed was set at 3.37 kph and power take-off RPM was set at 1070 for all treatments. The Weed Zapper was set to the first pass broadleaf setting for all treatments. Data collection included weekly Palmer amaranth control ratings using a scale of 0% (no control) to 100% (plant death). Visual crop injury was assessed on a scale of 0% (no injury) to 100% (crop death). Sweetpotato studies were harvested on October 2, 2023, and hand-graded into canner (≥ 2.5 cm but \< 4.4 cm in diam), no. 1 (≥ 4.4 cm but \< 8.9 cm), and jumbo (≥ 8.9 cm) grades (U.S Department of Agriculture 2005)before weighing. Marketable yield was calculated as the sum of no. 1 and jumbo grades. Total yield was calculated as the sum of canner, no. 1, and jumbo grades.Results will be included in the final report. In sweetpotato, limited research has been conducted to evaluate both between-row and in-row spacing as well as cultivar selection for weed management purposes. Cooper et al. (2024) reported that weed density was not affected by in-row crop spacing treatments. Information on the ability of sweetpotato cultivars to tolerate or reduce weed interference remains limited. Thus, studies were conducted in 2023 to assess the impact of three in-row spacings, two sweetpotato cultivars, and two competitive environments on sweetpotato yield and quality in order to evaluate their potential utility for use in integrated weed management systems. Field studies were conducted at the Horticultural Crops Research Station in Clinton, NC in 2023.Treatments were applied in a 3 x 2 x 2 full factorial split-split plot arrangement in a randomized complete block design with four replications. The treatments consisted of in-row spacing (main plot, 3 levels), cultivar (subplot, 2 levels), and competitive environment (sub-subplot, 2 levels). Sub-subplots consisted of two rows, with the first being a border row and the second being used for data collection. Subplots and main plots consisted of four and eight total rows, respectively; plot length was 6.1 m at all levels. In-row spacing treatments included three spacings: 20 cm, 30 cm, and 40 cm. Cultivar treatments included two cultivars with different canopy architectures: \'Covington\', a grower standard in North Carolina with a lateral growth habit, and \'Monaco\', an upright cultivar with a compact growth habit. Competitive environment treatments included two environments: weedy and weed-free. Weed-free plots were hand-weeded regularly to prevent weed competition; weeds in weedy plots were not removed throughout the growing season. No herbicides were applied for the duration of this study. Non-rooted sweetpotato cuttings were transplanted at study initiation into weed-free 1.07 m raised beds. Data collection included leaf counts at 2, 3, and 4 weeks after planting (WAP), visual estimates of sweetpotato canopy coverage at 4, 6, and 10 WAP, a stand count at 2 WAP, canopy heights at 2, 3, and 4 WAP, vine lengths at 4 WAP, and sweetpotato yield. Leaf counts were collected by counting fully open leaves on 3 representative plants per plot and then converted to leaves per linear meter of row in conjunction with stand counts. Canopy heights were collected by measuring the height of the tallest fully open leaf from the ground of five plants per plot. Vine lengths were collected by measuring the length of the longest lateral vine of three plants per plot. Visual sweetpotato canopy was assessed as an estimate of the total sweetpotato from row-middle to row-middle on a scale of 0% (no foliar coverage) to 100% (complete foliar coverage). Sweetpotato storage roots were harvested 107 days after planting, and hand-graded into canner (≥ 2.5 cm but \< 4.4 cm in diam), no. 1 (≥ 4.4 cm but \< 8.9 cm), and jumbo (≥ 8.9 cm) grades (U.S Department of Agriculture 2005) before weighing. Total yield was calculated as the sum of canner, no. 1, and jumbo grade yields. Standardized sweetpotato yield (% of weed-free yield) was a metric created by dividing weedy sweetpotato yield of each cultivar and spacing treatment by the weed-free yield of the corresponding treatment in order to assess the potential of each treatment to achieve its weed-free yield under weed competition. Results will be included in the final report. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Blankenship CD, Jennings KM, Moore LD, Jordan DL, Meyers SL, Monks DW, Schultheis JR, Suchoff DH (2023) Effect of Cultivation Regimes on Weed Control and Sweetpotato Cultivar Yield and Quality. In Proceedings of SWSS annual meeting 2023. Baton Rouge, LA: SWSS Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Oral Presentation. (2023) Effect of Timing of the Weed Zapper on Palmer Amaranth Control and Sweetpotato Yield and Quality. Southeast Vegetable & Fruit Expo. Myrtle Beach, SC. Type: Other Status: Other Year Published: 2023 Citation: Demonstration. (2023) Weed Zapper Demonstration and Presentation. 2023 North Carolina Sweetpotato Field Day. Clinton, NC. Type: Other Status: Other Year Published: 2023 Citation: Oral Presentation. (2023) Effect of Cultivation Regimes on Weed Control and Sweetpotato Cultivar Yield and Quality. Organic Commodities and Livestock Conference. Raleigh, NC. 4 Type: Peer Reviewed Journal Articles Status: Published Year Published: 2024 Citation: Woodard AJ, Schultheis JR, Jennings KM, Woodley AL, Suchoff DH (2024) Horizontal Planting Orientation Can Improve Yield in Organically Grown Sweetpotato. HortScience, 59(1), 36-42. Progress 09/01/21 to 08/31/22 Outputs Target Audience:Target audience included vegetable and small fruit growers (organic and conventional growers), agronomic crop farmers, extension agents, agrochemical personnel, crop consultants, and faculty and staff from other academic institutions. Report Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Students were given the opportunity to present their research results at field days including sweetpotato field days in NC and MS. They also shared results with stakeholders at local and regional sweetpotato production meetings. Additionally, results were shared with growrers at the organic commodities field day in NC. Graduate students were trained in the area of organic sweetpotato production systems including the use of the WeedZapper. . How have the results been disseminated to communities of interest?Results were shared with stakeholders at local and regional sweetpotato meetings. What do you plan to do during the next reporting period to accomplish the goals?In 2023, a study will be conducted in Indianato determinehow varying growth habits ofCovington sweetpotato with it\'s trailing growth habitand Monaco cultivar with it\'s semi-erect bunch type growth habit,will influence weed interference and sweetpotato yield under different in-row spacing. A similar study will be conducted in NC to assess the impact of three in-row spacings andtwo sweetpotato cultivarson sweetpotato yield and quality in order to evaluate their potential utility for use in integrated weed management systems. Another study planned for 2023 includes the use of buckwheat and silage tarps for controlling weeds in sweetpotato row middles. Little information exists about the optimal application frequency schedule for use of the Weed Zapper and other electrical implements for control of Palmer amaranth in crops including sweetpotato, cucumber, peanut, and cotton. Thus, studies will be conducted to determine the impact of application frequency on Palmer amaranth control and crop yield in cotton, cucumber, peanut, and sweetpotato. Impacts What was accomplished under these goals? Weed management is a significant challenge in sweetpotato production across the United States, particularly with Palmer amaranth, which is one of the most prevalent and problematic weeds in various cropping systems, especially in North Carolina and the southeastern U.S. Electrical weed management shows potential for controlling weeds like Palmer amaranth in a range of crops. However, limited research exists on the optimal frequency of electrical weed management applications across different cropping systems to effectively control weeds while maintaining crop yield and quality. To address this, field studies were conducted in sweetpotato, peanut, cucumber, and cotton to determine the ideal application frequency, both with and without preemergence herbicides. Additionally, using crop competition as a weed management tool offers a promising approach for improving sweetpotato weed control systems. In North Carolina, field studies assessed the effects of in-row spacing (3 levels), cultivar (2 levels), and competitive environment (2 levels). The in-row spacing treatments included 20 cm, 30 cm, and 40 cm. The cultivar treatments included \'Covington\' and \'Monaco,\' while the competitive environment treatments were either weedy or weed-free. Furthermore, a study conducted in Indiana explored how the differing growth habits of the \'Covington\' and \'Monaco\' sweetpotato cultivars might influence weed interference and yield under varying in-row spacings. Additionally in 2021, studies were conducted in grower fields to 1) evaluate yield of 13 sweetpotato clones grown under standard organic practices and harvested early and late in the season 2) compare growth habits of sweetpotato clones 3) evaluate changes in sweetpotato carbohydrates before and after curing, and throughout storage. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Blankenship CD, Jennings KM, Moore LD, Smith SC, Ippolito SJ, Sims KC, Jordan DL, Meyers SL, Monks D, Schultheis JR, Suchoff DD (2022) Effect of Cover Crops and Tillage on Weed Control in Four Sweetpotato Cultivars. Proc. National Sweetpotato Collaborators Group. Type: Other Status: Published Year Published: 2022 Citation: Southeastern Vegetable Extension Workers. Kemble J., Meadows I., Jennings K. M., and Walgenbach J. F., Eds. (2022) Southeastern US 2022 Vegetable Crop Handbook. Basil, cucurbits, hop, lettuce, endive, sweetpotato, and fungicide resistance tables (Quesada-Ocampo L. M. contributed 11 tables total). Type: Other Status: Published Year Published: 2022 Citation: Quesada-Ocampo L. M., Meadows I., and Gorny A. (2022) Disease control for commercial vegetables. North Carolina Agricultural and Chemicals Manual. Basil, cucurbits, hop, lettuce, endive, sweetpotato, and fungicide resistance tables (Quesada-Ocampo L. M. contributed 11 tables total). Type: Peer Reviewed Journal Articles Status: Published Year Published: 2021 Citation: Pellegrino AM, Woodley AL, Huseth AS. Understanding the Relationship Between Wireworm (Coleoptera: Elateridae) Damage, Varietal Resistance, and Cover Crop Use in Organic Sweetpotato. J Econ Entomol. 2021 Oct 13;114(5):2127-2134. doi: 10.1093/jee/toab118. PMID: 34487517. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Woodard, Alyssa J., et al. \"Evaluation of Sweetpotato Clones in an Organically Managed System in North Carolina.\" HORTSCIENCE. Vol. 57. No. 9. 113 S WEST ST, STE 200, ALEXANDRIA, VA 22314-2851 USA: AMER SOC HORTICULTURAL SCIENCE, 2022. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Moore, L. D., Jennings, K. M., Monks, D. W., Boyette, M. D., Leon, R. G., Jordan, D. L., \... & Chitr, F. N. U. (2022, September). Evaluating Electrical and Mechanical Methods for Palmer Amaranth Control in Sweetpotato. In HORTSCIENCE (Vol. 57, No. 9, pp. S285-S285). 113 S WEST ST, STE 200, ALEXANDRIA, VA 22314-2851 USA: AMER SOC HORTICULTURAL SCIENCE. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Blankenship, C., Jennings, K. M., Monks, D., Jordan, D., Meyers, S., Suchoff, D., & Schultheis, J. R. (2021, September). Weed Response to Cultivation Timing and Crop Architecture in Organic Sweetpotato Production Systems. In HORTSCIENCE (Vol. 56, No. 9, pp. S191-S191). 113 S WEST ST, STE 200, ALEXANDRIA, VA 22314-2851 USA: AMER SOC HORTICULTURAL SCIENCE. Progress 09/01/20 to 08/31/21 Outputs Target Audience:Target audience included vegetable and small fruit growers (organic and conventional growers), agronomic crop farmers, extension agents, agrochemical personnel, crop consultants, and faculty and staff from other academic institutions. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The annual meetings of the Southern Weed Science Society and the Weed Science Society of America provided numerous professional development opportunities for graduate students, technicians, faculty, agricultural chemical industry representatives, and weed scientists from other Land-Grant Institutions. During these events, several presentations focused on organic weed control in sweet potatoes. Additionally, regional sweet potato meetings offered training for farmers, consultants, extension agents, faculty, and graduate students from our program, as well as from other programs. How have the results been disseminated to communities of interest?Research results wereshared with growers, extension agents, crop consultants, faculty, graduate students, and staff at research stations at regional field days including the NC Sweetpotato Field Day in Clinton, NC. What do you plan to do during the next reporting period to accomplish the goals? Further studies will be carried out to validate the findings of previous research. For example, studies will be established to evaluate in-row spacing and number of cultivations in sweetpotato on weed control (objective 4f). Additionally, new studies will be initiated to ensure the successful achievement of all project objectives. Studies were also conducted to determine the effect of the Weed Zapper (electrical weed control) application frequency on Palmer amaranth control and crop yield for various North Carolina crops including sweetpotato. Impacts What was accomplished under these goals? Objective 1a. Field studies were conducted in North Carolina to 1)evaluate yield of 13 sweetpotato clones grown under standard organic practices and harvested early and late in the season, 2) compare growth habits of sweetpotato clones, and 3)evaluate changes in sweetpotato carbohydrates before and after curing, and throughout storage. Objective 2.Field studies were conducted to determine the impact of fall-planted cover crops on soil nitrogen availability, soil quality and insect pressure in organic sweetpotato. Objective 3. Black rot experiments and RKN experiments were conducted. Objective 4a. Field studies were conducted to identify the most competitive sweetpotato canopy architecture and to determine the minimum number of cultivatations for optimum weed control. The Indiana location was modified to a weed-free period study. The study will be conducted at two locations. Objectives 4c and 4d. Greenhouse studies were initiated toidentify weed-suppressive sweetpotato cultivars that would suppress growth of broadleaf and grasses. Field studies were conducted todetermine the tolerance of sweetpotato cultivars to full-season weed interference, andidentify the crop traits contributing to its competitive advantage against weeds. Objective 4f. The initial cover crop study was initiated in Fall 2021 to determine the impact of fall-planted cover crops on weed control and sweetpotato yield and quality. However, the cover crop stand was not adequate so the study was abandoned. In Fall 2022 cover crops will be planted and sweetpotato transplants (nonrooted cuttings) will be planted in the summer of 2022. This study will be replicated in Fall 2023 and Summer 2024. Publications Type: Peer Reviewed Journal Articles Status: Published Year Published: 2020 Citation: Stahr M.S, Butler S., Huerta A., Ritchie D., and Quesada-Ocampo, L. M. (2020) First report of bacterial root rot caused by Dickeya dadantii, on sweetpotato (Ipomoea batatas) in North Carolina. Plant Disease 104:2723. Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Stahr M. N. and Quesada-Ocampo, L. M. (2020) Evaluation of sweetpotato rotational crops and weeds as hosts of Ceratocystis fimbriata, causal agent of sweetpotato black rot. Phytopathology 110: S2.105. Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Ye W, Schwarz T., Davis E. L., Thiessen L. D., Quesada-Ocampo, L. M., and Gorny A. M. (2020) Occurrence of the root-knot nematode Meloidogyne enterolobii infecting sweetpotato in North Carolina, United States. Phytopathology 110: S1.2. Type: Other Status: Published Year Published: 2020 Citation: Quesada-Ocampo L. M., Meadows I., and Louws F. (2020) Disease control for commercial vegetables. North Carolina Agricultural and Chemicals Manual. Basil, cucurbits, hop, lettuce, endive, sweetpotato, and fungicide resistance tables (Quesada-Ocampo L. M. contributed 11 tables total). Type: Other Status: Published Year Published: 2020 Citation: Southeastern Vegetable Extension Workers. Kemble J., Meadows I., Jennings K. M., and Walgenbach J. F., Eds. (2020) Southeastern US 2020 Vegetable Crop Handbook. Basil, cucurbits, hop, lettuce, endive, sweetpotato, and fungicide resistance tables (Quesada-Ocampo L. M. contributed 11 tables total). 2019-20 progress report: Outputs Target Audience:Target audience includes growers, extension agents, crop advisors, and colleagues. 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?Results have been reported to sweetpotato growers at regional and national meetings and field days. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Currently, information to help growers make research-based decisions on cultural and pest management practices to optimize organic sweetpotato yield and quality, does not exist. Our expert team from multiple universities consists of weed scientists, an entomologist, a plant pathologist, a soil scientist, an extension production specialist, and an extension organic specialist. Our team is working closely with organic farmers to develop research-based, NOP-compliant recommendations for organic sweetpotato producers. We have conducted studies to improve organic sweetpotato production systems by identifying cultural practices that maximize sweetpotato yield and quality; addressing the need for weed-suppressive and insect-resistant sweetpotato clones; determining if weeds, rotational, and cover crops serve as pathogen reservoirs; and evaluating the impact of cover crops on weed control, nitrogen release, soil quality, and insect pressure. We have shared research-based findings with stakeholders and the greater scientific community via field days, production meetings, expos, conferences, and peer-reviewed journal publications. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Blankenship CD, Jennings KM, Moore LD, Smith SC, Ippolito SJ, Sims KC, Jordan DL, Meyers SL, Monks D, Schultheis JR, Suchoff DD (2022) Effect of Cover Crops and Tillage on Weed Control in Four Sweetpotato Cultivars. Proc. National Sweetpotato

Collaborators Group. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Blankenship CD, Jennings KM, Moore LD, Smith SC, Ippolito SJ, Sims KC, Jordan DL, Meyers SL, Monks D, Schultheis JR, Suchoff DD (2021) Weed Response to Cultivation Timing and Crop Architecture in Organic Sweetpotato Production Systems. Proc. Am. Soc. Hort. Sci. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Blankenship CD, Jennings KM, Moore LD, Smith SC, Ippolito SJ, Sims KC, Jordan DL, Meyers SL, Monks DW, Schultheis JR, Suchoff DD (2021) Effect of cultivation timing and crop canopy architecture on weed control in organically grown sweetpotato. Page 143 In Proceedings of the SWSS 74th annual meeting. Virtual: SWSS Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Blankenship CD (2021) Weed Management in Organic Sweetpotato Systems. Center for Environmental Farming Systems Organic Commodities Annual Meeting. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Blankenship CD (2021) Effect of cultivation timing and crop canopy architecture on weed control in organically produced sweetpotato. Organic Commodities and Livestock Conference. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Woodard AJ, Schultheis JR, Suchoff DH (2021) Sweetpotato variety trials: Results and recommendations. Organic Commodities and Livestock Conference. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Woodard AJ, Schultheis JR, Suchoff DH (2021) Evaluation of sweeetpotato varieties in an organically managed system in North Carolina. SR-ASHS Conference. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Woodard AJ, Schultheis JR, Suchoff DH (2022) Evaluation of alternative sweetpotato slip planting orientation. National Sweetpotato Collaborators Group Meeting. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Woodard AJ, Schultheis JR, Suchoff DH (2021) Effects of planting orientation of stem cuttings on yield in organically managed sweetpotato. ASA-CSSA-SSS conference. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Woodard AJ, Schultheis JR, Suchoff DH (2021) Planting orientation affects organically grown NC04-531 \'Monaco\'. Johnston County Grower Meeting. Type: Journal Articles Status: Published Year Published: 2021 Citation: Pelegrino A, Woodley A, Huseth A (2021) Understanding the relationship between wireworm (Coleoptera: Elateridae) damage, varietal resistance, and cover crop use in organic sweetpotato. Journal of Economic Entomology 114:2127-2134 Type: Journal Articles Status: Published Year Published: 2021 Citation: Pellegrino AM, Dorman SJ, Williams III L, Millar JG, Huseth AS (2021) Evaluation of 13-Tetradecenyl Acetate Pheromone for Melanotus communis (Coleoptera: Elateridae) Detection in North Carolina Row Crop Agroecosystems. Environmental Entomology Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Huseth A, Pellegrino A, Woodley A (2021) Documenting wireworm activity and management strategies in an organic sweetpotato agroecosystem. Organic and Crop Livestock Conference. Type: Other Status: Published Year Published: 2019 Citation: Stahr MN,Quesada-Ocampo LM Black rot of sweetpotato: A comprehensive diagnostic guide. Plant Health Progress Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Stahr MN, Bertone M, Huseth A, Quesada-Ocampo LM (2020) Evaluation of sweetpotato rotational crops and weeds as hosts of Ceratocystis fimbriata, causal agent of sweetpotato black rot. APS Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Quesada-Ocampo LM (2021) Translational strategies to improve management of re-emerging pathogens of vegetable crops. Australian Plant Pathology Society Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Stahr MN, Quesada-Ocampo LM (2021) Identifying inoculum reservoirs for Ceratocystis fimbriata in Sweetpotato production systems. Annual Conference on Soil-borne Plant P)athogens. Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Quesada-Ocampo LM (2021) Leveraging population genetics, epidemiology, and genomics to improve management of re-emerging pathogens of vegetable crops. Department of Plant Pathology Kansas State University Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Quesada-Ocampo, L. M.Population genetics and epidemiology approaches for management of re-emerging pathogens of vegetable crops. Department of Plant Pathology University of Minnesota. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Quesada-Ocampo LM (2020) From the field to the lab and back: translational strategies to improve disease control in vegetable crops. Plant Pathology Department Washington State University. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Quesada-Ocampo LM (2020) Management of re-emerging pathogens of vegetable crops through translational approaches. Department of Plant Pathology and Environmental Microbiology, Pennsylvania State University Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Stahr MN, Quesada-Ocampo LM Evaluation of sweetpotato rotational crops and weeds as hosts of Ceratocystis fimbriata, causal agent of sweetpotato black rot. Sweetpotato Virtual Field Day. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Gorny AM, Jeffreys B, Collins H, Quesada-Ocampo LM Nematode management in sweetpotato.North Carolina Vegetable Growers Association Ag Expo. Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Quesada-Ocampo LM (2021) Sweetpotato diseases: challenges and opportunities. Goodness Grows in the Carolinas Symposium. Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation:

Quesada-Ocampo, LM (2021) Expanding the disease management toolkit in sweetpotato. NC Sweetpotato Commission. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Quesada-Ocampo, L. M.Sweetpotato black rot management is no small fry (2020) Eastern NC Certified Crop Adviser Training. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Singh V, Werle I, Shankle MW, Meyers SL, Tseng T (2021) Allelopathy: An Alternative Weed Management Strategy to Control Palmer Amaranth. ASHS Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Varsha Singh, Isabel Werle, Mark W. Shankle, Stepen L. Meyers, Te-Ming Tseng (2022) Sweet potato allelopathy, a strategy for sustainable weed management under field conditions. Type: Conference Papers and Presentations Status: Other Year Published: 2022 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2022) Screening sweet potato varieties for their allelopathic effects on growth of different weed species under field conditions.Mississippi Academy of Science (MAS) annual meeting. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2022) Evaluating sweet potato varieties for their allelopathic effects on growth of different weed species under field conditions. National Sweetpotato Collaborators Meeting. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2022) Screening sweet potato varieties for their allelopathic effects on growth of different weed species under field conditions. Southern American Society of Agronomy Meeting. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2021) Allelopathic effects of sweet potato on yellow nutsedge, goosegrass, and Palmer amaranth. Southern American Society of Agronomy Meeting. Type: Journal Articles Status: Under Review Year Published: 2021 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2021) Allelopathy: An eco-friendly approach to control Palmer amaranth using allelopathic sweet potato.Frontiers in Agronomy, section Weed Management. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Varsha V, Werle I, Shankle MW, Tseng T (Allelopathic effects of sweetpotato varieties on Palmer amaranth growth. Proc. of SWSS. 74:17. Type: Conference Papers and Presentations Status: Published Year Published: 2021 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2021) Allelopathic management of Palmer Amaranth in sweetpotato. ASA-CSSA-SSSA Meeting. Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Varsha V, Werle I, Shankle MW, Meyers SL, Tseng T (2021) Effect of allelopathic sweet potato varieties on Palmer amaranth growth: A greenhouse study.Graduate research symposium at Mississippi State University.
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↑ Return to Index

Organic Dual-use Perennial Grain Crops: Pathways to Profitability and Soil Health

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Project No.	OHO03053-CG
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Project Type	OTHER GRANTS
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Performing Institution	OHIO STATE UNIVERSITY, 1680 MADISON AVENUE, WOOSTER, OHIO 44691

NON-TECHNICAL SUMMARY

Organic grain farmers have made great strides toward agricultural sustainability, but an over-reliance on tillage for weed control ultimately compromises the ability of soils to reach their full potential of fertility, soil structure and overall health. Perennial grain cropping systems could address a number of persistent challenges associated with organic field crop production. Specifically, organic farmers are interested in perennial grains because of their potential to improve soil health, suppress weeds, decrease labor requirements, and diversify production. Kernza (intermediate wheatgrass) and perennial cereal rye (PC-Rye) are two perennial crops that have been developed to produce specialty grain and high-quality forage. Leveraging on-going research with organic farmers and an existing network of researchers across the US, this proposal will address critical knowledge gaps and help alleviate market obstacles for perennial grains. We will work with organic farmers to conduct on-farm trials to test the effects of different soil and crop management practices on Kernza and PC-Rye performance. We will quantify soil health outcomes under perennial grain crops relative to annual crops and construct enterprise budgets to help determine the economic viability and profitability of these dual-purpose grain and forage systems. Stakeholder engagement is a central theme of this work, and we will expand our network of farmers, processors, local millers, bakers and maltsters to identify market opportunities and develop recommendations and guidelines from production to end-use. We will host yearly field days and winter meetings, develop a variety of digital outreach materials, and bring stakeholders together for peer-to-peer learning as part of a perennial grain conference. This project will advance the sustainability of organic agriculture by addressing key crop management constraints of dual-purpose perennial grain crops and subsequently developing new market opportunities for organic growers. Our ultimate goal is to diversify organic farming rotations with perennial grain crops that significantly enhance organic agricultural sustainability and farmer profitability.

OBJECTIVES

The goal for this proposal is to alleviate key production, economic, and market constraints of two promising perennial grain crops, Kernza and PC-Rye, when managed to produce both grain and forage. Specific project objectives include: Establish management recommendations to optimize organic dual-use grain and forage production of Kernza and PC-Rye. Quantify improvements that perennial grain crops have on soil health relative to annual grain crops. Construct enterprise budgets for each region to compare annual and perennial system production economics and identify price points that could increase or limit adoption. Integrate research activities and farmer networks into existing perennial grain commercialization efforts

APPROACH

Objective 1: Establish management recommendations to optimize organic dual-use grain and forage production of Kernza and PC-Rye. Small-plot research trials will be established on land that is certified organic or in transition at experiment stations in Ohio, Minnesota, New York, and Kansas (4 total sites). Ohio, Minnesota, and New York have identified certified organic land, and Kansas is in the process of converting a newly acquired farm to certified organic production. Kernza and PC-Rye will be planted in two adjacent trials in a randomized complete block design with 4 replications. The experimental design will consist of four treatments with increasing degrees of forage harvest. All treatments will include a grain harvest in the summer, followed immediately by a summer forage harvest. Treatments include: Summer forage harvest; Summer + Spring forage harvest; Summer + Fall forage harvest; Summer + Spring + Fall forage harvest. Forage biomass will be harvested mechanically and samples collected to determine dry matter yield and forage quality. At each site, we will take the following measurements: Baseline soil characterization (see Table 2 below); Grain yield and quality (protein, starch, dietary fiber, gluten index); Total aboveground biomass at grain harvest; Weed density, biomass, and community composition at grain harvest; Forage yield and quality (crude protein, acid detergent fiber, neutral detergent fiber, neutral detergent fiber digestibility, relative feed quality, in vitro dry matter digestibility) at each cutting. Number of seed heads per area, average plant height, relative lodging scores. Daily weather data (max and min temp, precipitation). The second activity will be an on-farm participatory investigation of haying and grazing management with Kernza. Certified organic livestock graziers (beef, dairy, sheep) and grain farmers will be given Kernza seed with general guidelines for planting and managing as a dual-use crop. We will focus on three regions with a robust forage and grazing landscape: Eastern Ohio (Wayne, Holmes, and Athens Counties), Minnesota (West and Northwest regions including Rock and Roseau Counties) and the Finger Lakes Region in Upstate New York (Cayuga, Tompkins, and Yates Counties). We will strive to have no less than 15 on-farm trials across the regions. Growers from each region will be invited to a summer field day in Ohio, Minnesota and New York in Year 1 to get introduced to the study objectives, see the crop in the field and learn about some past and current research results. Growers will be given seed and general management guidelines about planting and maintaining perennial grain stands. Grower goals will be discussed and management strategies will be developed on an individual basis. Farmers will plant the seed in the late summer/early fall and test agronomic and/or grazing management practices over the course of each year. These practices will manifest as a direct manipulation to compare various dual-use forage harvest practices. Research questions will be driven by farmer and regional interests, but farmers will be encouraged to examine manipulations that focus on the timing or frequency haying or grazing of Kernza. Objective 2: Quantify impacts that Kernza has on soil health indicators relative to annual grain crops. We will establish approximately 25 paired comparisons of perennial grain crops planted adjacent to annual grain crops. We will take advantage of our on-station and on-farm sites (Obj 1) where possible, but also identify other farmers and sites in our network that have already planted or will soon plant Kernza. Baseline soil samples will be collected prior to experiment establishment, and vetted to ensure the adjacent fields will make for valid comparisons. Fields will be sampled to a depth of 1 meter in 3 intervals (0-20 cm, 20-40 cm, 40-100 cm) and analyzed for nutrient analysis, soil texture and total C and N. Differences less than 10% between fields will be considered similar. Vetted and selected fields be sampled every year for three or four years, depending on establishment year. Sampling times will be targeted as either fall or spring when a crop is not vigorously growing. At each site, we will sample to a depth of 1 meter in 3 above-mentioned depth intervals. Multiple cores will be taken and compiled for each crop-depth combination and immediately shipped overnight to the Culman lab for processing and comprehensive soil health analyses. We will analyze these data as paired comparisons through time to track any observed changes in measured properties. We will also analyze our results in Year 4 as a percent change from Year 1. In particular, we are interested in quantifying on a multi-regional and region-specific scale, the impact of perennial grains on soil health. We will construct a set of key criteria pertaining to agronomic and production inputs and yields at each site. Site-specific management information will be gathered from farmers and farm managers. These inputs will feed into our enterprise budgets (Obj 3) and help constrain realistic yields and inputs associated with each site and each region. Objective 3: Construct enterprise budgets for each region to compare annual and perennial system production economics and identify price points that could increase or limit adoption. Economic enterprise budgets will be developed for both Kernza and PC-Rye production for each region to provide farmers with realistic costs of production, returns on sold products and overall profitability. Agronomic production information from all paired, annual-perennial comparison trials in Obj 2 will inform and parameterize these enterprise budgets. For example, the amount of seed planted, quantities of organic fertilizer, and other inputs will be included in the compiled budgets. The specific combinations of inputs and prices will be presented as well as current and projected prices of outputs and inputs. In addition, farmers will be able to compare budgets of perennial grain crops with organic annual grain crops and organic forage systems to estimate overall profitability between the various systems. These enterprise budgets will be compiled as downloadable Excel Spreadsheets that contain macros for ease of use. Users can input their own production and price levels to calculate their own numbers. Detailed footnotes will be included to help explain methodologies used to obtain the budget numbers. Budgets will also be made available as an online web tool. Objective 4: Integrate research activities and farmer networks into existing perennial grain commercialization efforts. Consumer and commercial demand for Kernza and PC-Rye far exceed the supply of these grains currently being produced. As with any newly emerging market, there are many reasons for this imbalance, many of which can be attributed to lack of knowledge and information. These include: 1) agronomic production constraints, 2) environmental conservation outcomes, 3) economic viability, 4) post-harvest processing, such as cleaning, milling and malting, 5) optimal end-use opportunities, and 6) supply chain purchasers. This final objective aims to link these elements together by integrating research findings into existing commercialization efforts (Figure 5). Objectives 1-3 address primary farmer constraints on the supply side. However, we recognize the large role end-use opportunities have had, and will continue to play in creating market demand for perennial grain. Objective 4 intends to leverage this work by facilitating engagement of the producers with end-use commercialization efforts. We believe this holistic approach will be highly synergistic and be the most effective way to expand organic perennial grain acreage in the near future. Progress 09/01/19 to 08/31/24 Outputs Target Audience:The target audience for this project included organic producers, organic agricultural service providers, researchers, and end users of perennial grains, such as bakers and brewers, as well as the general public. The project provided technical assistance, outreach materials, and online educational events to engage these audiences and promoted the adoption and commercialization of perennial grains. The project also collaborated with existing networks and organizations, such as The Ohio State University, Washington State University, University of Minnesota, Cornell University, McGill University (Canada), The Land Institute, Agraria Center for Regenerative Practice, and the Ohio Ecological Food and Farming Association, to reach a wider and more diverse audience. The project aimed to address the needs and interests of the target audience by providing relevant and timely information and guidance on organic perennial grain production, management, and marketing. Changes/Problems:The project faced challenges and changes due to the COVID-19 pandemic, which limited the ability to conduct on-farm trials and in-person events, as well as the transition of the previous PI to a new institution. The project also faced difficulties in establishing field trials due to seed availability and environmental factors. To overcome these challenges, the project requested a no-cost extension, hired a new PI, planted new field trials, and adapted to virtual modes of communication and dissemination. The COVID-19 pandemic posed significant challenges for the project, especially in the first three years (2020 to 2022), when travel restrictions and social distancing measures prevented or limited the ability to conduct on-farm trials and in-person events. The project had to scale back on-farm work because these perennial grains require more time in the field (multiple years) compared to annual crops. The project also had to cancel field days and switch to virtual platforms for outreach and education. The project adapted to these challenges by expanding the use of digital media and online tools, such as webinars and seminars, to reach and engage the target audience. The project also leveraged the existing networks and partnerships with other organizations and stakeholders to disseminate information and resources on organic perennial grain systems. The project also experienced a major change in the leadership, as the previous PI, Dr. Steve Culman, accepted a new position at Washington State University in 2022. A new PI, Dr. Leo Deiss, was hired as a Visiting Assistant Professor at the Ohio State University to take over the project lead. The transition was successful with the new PI being fully integrated into the project and working to accomplish the proposed deliverables. Dr. Steve Culman provided valuable and continued assistance to the project during the transition and is still involved in the project. The project also faced challenges in hiring a postdoctoral scholar to assist with the project, due to the availability of competitive candidates and the transition of the PI. The project found and hired a suitable candidate, Dr. Samaneh Tajik, for a 9-month post doctorate between 2023 and 2024. The project also faced difficulties in establishing some field trials due to seed availability and environmental factors. The project initially proposed to evaluate perennial rye along with Kernza, however due to the shortage of perennial rye seed availability, the project decided to work with another perennial crop instead, perennial wheat, which has potential to be a major perennial grain crop in organic systems. The project planted the organic perennial wheat trials in Fall 2022 in four states and harvested for the second year in 2024. The project also had an unsuccessful establishment of the Kernza-legume intercrop trials in three out of four states, due to poor germination and weed pressure. The project re-planted these trials in Fall 2020 in Ohio, and in Fall 2021 in Kansas and New York to test the effect of manure and intercropping with legumes. The project ran these trials for at least two years to generate sufficient data on perennial grain crop cycle for analysis and dissemination. The last year\'s data (2024) from these trials will be part of manuscripts being prepared for publication to be submitted in late 2024 and 2025. To overcome these challenges and ensure the completion of the project goals, the project requested a no-cost extension for one year, from August 2023 to August 2024. What opportunities for training and professional development has the project provided?The project trained and mentored undergraduate students (5), visiting scholars (2), a postdoctoral scholar (1), and research technicians

(4) who were involved in the project. The project provided them with opportunities to conduct field and laboratory research, analyze and interpret data, write and publish scientific papers, present research results at conferences and workshops, and interact and network with other researchers and stakeholders. The project provided technical assistance and guidance to farmers who expressed interest in organic perennial grain production. The project donated free-of-charge seeds and planting instructions to farmers, and collected feedback on their experience and challenges with organic perennial grain production, and developed and disseminated management recommendations for organic growers. Collaborators to this project participated in activities targeting education to farmers and extension agents on how to establish and manage organic perennial grain systems, how to assess and improve soil health in organic systems, and how to use the online extension enterprise budget tool and interpret the results. The project also provided training and guidance on how to use perennial grains and address their needs and interests. The project promoted opportunities for networking and collaboration with other researchers, growers, service providers, and end users of perennial grains, such as bakers and brewers, through participating in regional and national conferences and workshops, hosting virtual and in-person field days and winter meetings, and donating Kernza grains and flour to local millers and bakers. Project members participated in regional and national conferences and workshops, to present the research results and outreach activities to a wide and diverse audience of researchers, growers, students, and other stakeholders, described as follows: Dr. Steve Culman (previous PI) presented in virtual events promoted as seminar or training including a presentation on the \'Potential for Perennial Grains and Grasses\' to the National Academies of Sciences\' Workshop: Reducing the Health Impacts of the Nitrogen Problem (February 11, 2021), the Ohio State University\'s Soil Health Seminar Series (2021), and a webinar hosted by the Ohio Ecological Food and Farming Association (2021). These presentations hosted stakeholders to showcase the field experiments and demonstrate organic perennial grain production and management practices. Dr. Matt Ryan and his team at Cornell University hosted two winter Perennial Grains Meetings (Jan 21, 2019 & Feb 22, 2021) for farmers, researchers, and stakeholders. The 2019 meeting had 13 attendees and included topics on disease in perennial grains, intercropping, and post-harvest handling/processing. The 2021 meeting had 34 attendees and included perennial grains research in France, renovating old stands, weed management during establishment, and a farmer panel. Dr. Matt Ryan and his team at Cornell University presented the \'Reducing Tillage in Organic Grain Systems: No-Till and Perennial Grains\' at the Empire Farm Days. Pompey, NY. Aug. 5, 2021. Mrs. Sandra Wayman and Dr. Eugene Law presented \'Perennial grains in sustainable cropping systems\' at the 2020 Winter Conference Northeast Organic Farming Association of New York. Syracuse, NY. Jan. 18, 2020. Dr. Matt Ryan and his team at Cornell University presented \'Evaluating Kernza: the first perennial grain\' at the 2019 Aurora Farm Field Day. Musgrave Research Farm, Aurora NY. July 11, 2019. Dr. Eugene Law et al., a PhD student at Cornell University, gave a presentation on \'An energy comparison of annual and perennial small grain cropping systems\' at the 19th Annual Meeting of the American Ecological Engineering Society held in Asheville, North Carolina. Dr. Eugene Law et al., a PhD student at Cornell University, gave a presentation on \'Exploring the impacts of weeds in perennial grain crops\' at the 2020 Joint Meeting of the Weed Science Society of America and Western Society of Weed Science. Maui, HI. Dr. Eugene Law et al., a PhD student at Cornell University, gave a presentation on \'Interseeding medium red clover with perennial and annual cereal crops under organic management: three years of grain and forage yields\' at the 2020 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held as a Virtual Event. Dr. Eugene Law et al., a PhD student at Cornell University, gave a presentation on \'Evaluating environmental impact of intermediate wheatgrass cropping systems using the Farm Energy Analysis Tool and emergy synthesis\' at the 2021 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held in Salt Lake City, UT, USA, 2021. Dr. Priscila Pinto et al., a postdoc at University of Wisconsin-Madison, gave a presentation on \'Dual-use Kernza intermediate wheatgrass seasonal forage yield and nutritional value across North America\' at the 2021 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held in Salt Lake City, UT, USA, 2021. Dr. Deiss participated in the 2023 Kernza Conference, in Minnesota, and presented preliminary results from the OREI project. The Kernza Conference occurred in the Twin Cities, on June 21-23, 2023, with three days of research talks, field trips, and plenty of Kernza food. The successful event brought together over 120 researchers, growers, students, and other perennial grain enthusiasts from 18 states, two Canadian provinces, Denmark, and Sweden. Dr. Deiss participated in the 2024 Ohio Organic Grains Conference, Oregon, OH and presented preliminary results from the OREI project. The 2024 Ohio Organic Grains Conference occurred in Oregon, OH, Jan 3rd-5th, and had 241 attendees. Among the attendees, the average organic farm size (certified acres) was 522 acres. Attendees\' data showed 146 self-identified farmers from 108 operations, 8 states and 2 Canadian provinces. Gathered data indicated that there were \~ 50,000 certified organic acres represented in the room, including 5,000 transition acres and \~25,000 conventional acres were also represented. Ms. Berenice Montano et al., a Visiting Scholar at Ohio State University presented a poster on \'Soil Aggregate Stability in Perennial Grain Systems\' at the 2023 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held in Saint Louis, USA. Dr. Deiss participated in the United

States Department of Agriculture - Organic Agriculture Research and Extension Initiative\'s Project Directors Meeting (USDA-OREI) in Orlando, Florida, 2024, April 24-45th 2024. Dr Deiss presented the project \'Organic Dual-Use Perennial Grain Crops: Pathways to Profitability and Soil Health\'. Mr. Ben Robinson et al., a Research Associate at Ohio State University, will present a poster on \'Organic dual-use kernza: impact of defoliation intensity on grain and forage yield\' at the 2024 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held in San Antonio, USA. Dr. Samaneh Tajik et al., a Postdoctoral Researcher at Ohio State University, will present a Virtual Presentation on \'Enterprise budgets for organic dual-use Kernza intermediate wheatgrass grain and forage production in Ohio\', as part of the 2024 American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting, held in San Antonio, USA. How have the results been disseminated to communities of interest?The project disseminated the results to communities of interest through the following means: It has developed scientific materials for organic perennial grain management and production in the form of publications to be disseminated with the broader scientific community. It published peer-reviewed papers in prestigious journals with scope in the areas of agronomy, soil science, and agroecology, as described in the following: Culman, S, P Pinto, J Pugliese, T Crews, L DeHaan, J Jungers, J Larsen, MR Ryan, M Schipanski, M Sulc, S Wayman, M Wiedenhoeft, D Stoltenberg, V Picasso. 2023 Forage harvest management impacts \"Kernza\" intermediate wheatgrass productivity across North America. Agronomy Journal 2023;115:2424-2438. Menalled, UD, CJ Pelzer, A DiTommaso, and MR Ryan. 2023. Effect of multi-tactic weed management on weed suppression and yield in the establishment year of intermediate wheatgrass. Agrosystems, Geosciences & Environment 6, e20426. Law, EP, S Wayman, CJ Pelzer, SW Culman, MI Gómez, A DiTommaso, and MR Ryan. 2022. Multi-criteria assessment of the economic and environmental sustainability characteristics of intermediate wheatgrass grown as a dual-purpose grain and forage crop. Sustainability 14: 3548. Law, EP, S Wayman, CJ Pelzer, A DiTommaso, and MR Ryan. 2022. Intercropping red clover with intermediate wheatgrass suppresses weeds without reducing grain yield. Agronomy Journal 114:700-716. Heineck, GC, B Schlautman, E Law, J Zimbric, MR Ryan, VD Picasso Risso, D Stoltenberg, C Sheaffer, and JM Jungers. 2022. Intermediate wheatgrass seed size and moisture dynamics inform grain harvest timing. Crop Science 62:410-424. Fulcher, MR., EP Law, S Wayman, MR Ryan, GC Bergstrom. 2022. Fungal plant pathogens observed on perennial cereal crops in New York during 2017-2018. Renewable Agriculture and Food Systems. 37:279-291. Other manuscripts are currently in preparation focused on agronomy and soil science. Five manuscripts are being prepared for publication to be submitted in late 2024 and 2025, as outlined below: KODU - Kernza organic dual-use experiment: 1. Samaneh Tajik (OSU) et al. Organic kernza-dual use grain and biomass production in the Midwest USA. Intended journal: Field Crop Research. 2. Alexa Smychkovich (MSU) et al. Nematodes and soil microbial community in organic dual-use kernza production systems: Intended journal: Soil Science Society of America Journal. 3. Steve Culman et al (WSU) et al. Soil health in dual-use organic perennial grain and forage production systems: Intended journal: PLOS One. KLI - Kernza legume intercropping and manure experiment: 4. Leo Deiss (OSU) et al. Manure rates and legume intercropping on organic kernza dual-use for grain and forage production. Intended journal: Agronomy Journal. 5. Jessica Nicksy (McGill - Canada) et al. Legume nitrogen fixation and transfer to intercropped kernza. Intended journal: Applied Soil Ecology. The project developed enterprise budgets for organic dual-use Kernza production systems. These materials covered topics such as the benefits and challenges of organic perennial grain systems, the best management practices for organic perennial grain production, and the market opportunities and economic analysis of organic perennial grain systems. Main characteristics taken in consideration on enterprise budgets were the dual-use nature of this crop to produce both grain and forage production, multiple forage harvest events across seasons (fall, summer, and spring), organic management, land/ and other fixed costs, and government assistance programs. These materials were made available online through the Ohio State University Budget Enterprise (2024) platform (https://farmoffice.osu.edu/farm-management/enterprise-budgets), as well as through the partners\' networks channels. The project developed and maintained a website to share the project updates, research results, outreach activities, and educational materials with the target audience and the general public. The website also provided links to other relevant resources and networks on organic perennial grain research and outreach. More info can be found in the following link: https://soilfertility.osu.edu/our-research/perennial-grains As part of the efforts to integrate research activities and farmer networks into existing perennial grain commercialization efforts, the project provided technical assistance to farmers interested in testing organic Kernza. It provided free-of-charge seeds (up to 1-acre fields) and technical training covering topics such as planting depth, seeding rates, fertilization regimes, and crop management. The project donated Kernza grains and flour to local miller, baker, and brewer, including Stutzman Farms and Mill (Millersburg, OH), Avalanche Pizza (Athens, OH), Local Millers (Carroll, OH), and Yellow Springs Brewery (Yellow Springs, OH), to promote the use and consumption of perennial grain products. The project collaborated with these partners to develop and market Kernza-based products, such as stone-milled flour, bread, pizza, and beer. The project also facilitated the connection between these partners and other stakeholders, such as consumers, retailers, and media outlets, to increase the awareness and demand for perennial grain products. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Objective 1: The project established and evaluated three field experiments across four states (Ohio, New York, Minnesota, and Kansas) to test different management practices for organic dual-use grain and forage production of Kernza and perennial wheat. Our findings demonstrated that perennial grain system management has significant impacts on the performance and sustainability of organic perennial grain systems. TheKernza Organic Dual-Use (KODU) experiment. Key findings from the KODU experiment revealed that the age of Kernza stands significantly influenced both grain and forage yields, with productivity generally declining over time, particularly for grain production. The decision to maintain Kernza beyond the third year or to renew it after the second year hinges on whether the primary goal is to maximize grain yield or forage production. Additionally, management practices for forage harvesting had a substantial impact on yields; the treatment involving two forage harvests in summer and fall (2x-SuFa) yielded the highest grain and forage outputs, while spring forage harvests had the most detrimental effect on grain yield. This demonstrates that harvesting Kernza for both grain and forage in a dual-use system is complementary and advantageous in organic systems. Environmental conditions and management practices also affected forage quality, which generally improved over time, especially for the variables crude protein and digestibility, although the degree of improvement varied by site. Furthermore, weed biomass increased over the four years in most sites, showing an inverse relationship with Kernza yield parameters and negatively impacting spike density, grain yield, and forage yield, with grain yield being particularly susceptible to weed pressure. In conclusion, the findings emphasize the need for careful management and strategic decision-making to optimize the productivity and sustainability of Kernza grain and forage systems, considering factors such as stand age, harvest timing, and weed control to achieve the best outcomes. TheKernza-Legume Intercrop (KLI) experiment. The KLI experiment provided valuable insights into the effective combinations of legume species and their planting times to maximize the yield and quality of Kernza grain and forage. The experiment also demonstrated a common struggle that organic farmers experience in trying to establish and maintain mixed stands of legume and grasses\--the research team had to re-establish the KLI experiment in multiple locations to enable legumes to be successfully established. The research also demonstrated that varying the amounts of manure applied (0.5x, 1x, 2x of the recommended rates) had a profound effect on soil health, boosting nutrient availability and enhancing crop performance. The experiment revealed that specific intercropping strategies and manure application rates significantly influence Kernza grain productivity. These results underscore the importance of tailored agronomic practices, particularly the strategic use of manure, for the sustainable and efficient production of organic perennial grain systems. By optimizing manure application, farmers can significantly improve both grain and forage outputs, contributing to more resilient agricultural practices. TheOrganic Perennial Wheat (OPW) experiment.The main takeaway from the Organic Perennial Wheat (OPW) experiment is that despite the initial promise shown by several perennial wheat varieties, most of the tested lines did not robustly survive beyond the first year of grain harvest. This highlights the challenge of achieving sustainable perenniality in organic systems. Evaluated across four states, the experiment revealed significant variability in crop performance by both variety and sites. The findings underscore the need for continued plant breeding and development to identify robust perennial wheat lines capable of thriving in diverse environmental conditions and under varying management practices. Objective 2: The project compared the soil health outcomes under different Kernza forage harvest strategies to quantify the effects of removing aboveground biomass on soil health. The project sampled and analyzed soils in the fourth and final year of the Kernza Organic Dual-Use (KODU) experiment across five sites. Soil and roots were sampledand root biomass was quantified along with a suite of soil health properties, including pH, extractable nutrients, texture, C and N pools, and soil microbial communities characterized with PLFA and nematode speciation. We found that Kernza forage harvest strategies across all five sites had no impact on soil properties, and we concluded that forage harvests do not have deleterious impacts on the soil food webs, soil C or N pools, or nutrient cycling. These findings corroborate previous work in non-organic Kernza systems. The main takeaway from this objective is that perennial grain crops, such as Kernza, can be harvested for forage without compromising soil health benefits. This makes Kernza a viable option for organic systems aiming to enhance soil health while producing both grain and forage. Our research underscores the importance of considering management practices that do not adversely affect soil properties, thereby supporting the sustainability and resilience of organic farming systems. Objective 3:The project compiled and assembled data from the field experiments and other sources to populate the enterprise budgets for organic dual-use Kernza production systems. The project developed an online extension tool that estimates economic metrics, such as net returns, breakeven prices, and return on investment, in scenarios considering dual-use Kernza production systems and organic sources of soil amendments. The project found that perennial grain systems were economically viable depending on the duration of cycle (in years), and profitable under certain conditions, such as high grain and forage prices, low input costs, and government assistance. The project disseminated the enterprise budgets and the online extension tool to farmers and extension agents through the Ohio State University Enterprise Budget website. This objective highlighted the critical role that enterprise budgets play in informing and guiding farmers and stakeholders. By providing detailed and accurate economic assessments, these budgets help farmers make informed decisions about adopting perennial grain systems. They demonstrate the financial viability and potential profitability of dual-use Kernza production, thus supporting the broader goal of achieving sustainable agriculture. For stakeholders, these enterprise budgets offer valuable insights into the economic dynamics of organic farming practices, enabling better planning, policy-making, and investment in resilient agricultural systems. In essence, the enterprise budgets are instrumental in bridging the gap between agronomic research and practical, profitable farming practices. Objective 4:The project integrated research activities and farmer networks into existing perennial grain commercialization efforts by providing organic Kernza seeds and technical training to interested farmers, donating Kernza grains and flour to local miller, baker and brewer, participating in regional and national conferences and workshops, and developing and providing materials for organic perennial grain management and production. The project provided significant professional development for farmers, environmental professionals, and extension agents, equipping them with the necessary skills and knowledge to implement and sustain organic perennial grain systems. This project made significant strides in promoting the adoption and commercialization of perennial grains by stakeholders engaged with the project. Publications Type: Peer Reviewed Journal Articles Status: Published Year Published: 2023 Citation: Culman, S, P Pinto, J Pugliese, T Crews, L DeHaan, J Jungers, J Larsen, MR Ryan, M Schipanski, M Sulc, S Wayman, M Wiedenhoeft, D Stoltenberg, V Picasso. 2023 Forage harvest management impacts Kernza intermediate wheatgrass productivity across North America. Agronomy Journal 2023;115:24242438. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2023 Citation: Menalled, UD, CJ Pelzer, A DiTommaso, and MR Ryan. 2023. Effect of multi-tactic weed management on weed suppression and yield in the establishment year of intermediate wheatgrass. Agrosystems, Geosciences & Environment 6, e20426. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2022 Citation: Law, EP, S Wayman, CJ Pelzer, SW Culman, MI G�mez, A DiTommaso, and MR Ryan. 2022. Multi-criteria assessment of the economic and environmental sustainability characteristics of intermediate wheatgrass grown as a dual-purpose grain and forage crop. Sustainability 14: 3548. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2022 Citation: Law, EP, S Wayman, CJ Pelzer, A DiTommaso, and MR Ryan. 2022. Intercropping red clover with intermediate wheatgrass suppresses weeds without reducing grain yield. Agronomy Journal 114:700-716. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2022 Citation: Heineck, GC, B Schlautman, E Law, J Zimbric, MR Ryan, VD Picasso Risso, D Stoltenberg, C Sheaffer, and JM Jungers. 2022. Intermediate wheatgrass seed size and moisture dynamics inform grain harvest timing. Crop Science 62:410-424. Type: Peer Reviewed Journal Articles Status: Published Year Published: 2022 Citation: Fulcher, MR., EP Law, S Wayman, MR Ryan, GC Bergstrom. 2022. Fungal plant pathogens observed on perennial cereal crops in New York during 2017-2018. Renewable Agriculture and Food Systems. 37:279-291. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Primarily, the target audience for this project includes organic producers, organic agricultural service providers, researchers and end users of perennial grains, such as bakers and brewers. We will continue to meaningfully engage the general public with this project, to diffuse information about the importance of perennial crops to achieve sustainable development goals. Due to sustained COVID-19 restrictions in 2020 that extended into 2021 and 2022, our traditional avenues of outreach and extension were limited, with many field days being canceled and most programs gone virtual. We have recorded video footage of Kernza in the field and outreach videos are being edited to provide information about Kernza, perennial grains, and dual-use forage and grain systems. This content will be made available to the general public as part of an online extension portal hosted by OSU\'s Soil Fertility Lab.? Changes/Problems:The previous PI, Dr. Steve Culman, in 2022, accepted a new position at Washington State University, and a new PI, Dr. Leo Deiss, has taken the project lead as Visiting Assistant Professor at the Ohio State University. The transition was successful with the new PI being currently fully integrated in the project and working to accomplish the proposed deliverables. Dr. Steve Culman provided valuable and continued assistance to the project during the transition and is still involved in the project. The previous efforts to hire a postdoc were not successful (described in the previous reports), mostly due to the availability of competitive candidates as well as transition of the late PI to a new institution. In 2023, we went through the process of interviewing and offering the position to a candidate, after receiving more than 30 applications and conducting interviews of top candidates. Unfortunately, the candidate who initially accepted the position, had to decline the position due to an Asylum-Seeking petition application.We are going to continue the efforts to find and hire a postdoc to help conclude proposed goals of this project. A position is currently re-posted online for a broad national search. We are also working with the current team of researchers to address the deliverables of this project. The continued challenges of COVID-19 in previous years have limited our ability to fully engage with the proposed on-farm components of this project. As restrictions have eased, we are re-investing efforts to achieve the proposed deliverables of this project. Given the limitations imposed by the COVID-19 pandemic in the first years of this project, we have made an early decision as a team to make this a 5-year project (see previous annual reports), by requesting a no-cost extension in the 4th year, from Aug 2023 to Aug 2024. We have completed the request of the first one-year no-cost extension. However, in addition to the already requested extension, we foresee the need to request an additional 6 months of no-cost extension, from Aug 2024 to Feb 2025, to enable the completion of second harvest in re-established field trials, to generate at least two-years of perennial grain crops data across all trials, to help meet the proposed deliverables of this project. To safeguard against the shortcomings of trial establishment failures, we planted a new set of field experiments (in late 2022), to address two important questions of organic perennial crop production, related to nitrogen management (Kernza Legume Intercrop trials) and testing a new perennial crop (Organic Perennial Wheat trials). Given that part of the experiments are still in the first grain harvest in 2023, we plan to run the experiment for at least one more year during the growing season of 2024, to achieve the targeted goal of at least two years of data for field trials evaluating perennial grain systems. What opportunities for training and professional development has the project provided?We have provided intensive training to the new PI of the project, Dr. Leo Deiss, as he got integrated into the ongoing activities in June 2022. Adding to that, as described in the accomplishments of Objective 4, we provided training to farmers that were interested in testing Kernza in their fields. This training included technical instructions on how to establish and maintain organic Kernza fields. We will continue to supplement training to all personnel involved in the project through in person meetings and field visits as well as a series of videos on organic Kernza production. Due to COVID-19, our professional training and development activities have been institutionally-limited in the previous years of the project. How have the results been disseminated to communities of interest?Given the described challenges experienced in previous years related to unsuccessful attempts to establish field trials, COVID-19 restrictions, and change of project PI, we are still collecting results to share and disseminate to communities of interest. Notably, Dr. Steve Culman (previous PI) gave a presentation on the \'Potential for Perennial Grains and Grasses\' to the National Academies of Sciences\' Workshop: Reducing the Health Impacts of the Nitrogen Problem (February 11, 2021). We have also provided outreach activities through webinars of Ohio Ecological Food and Farming Association (Feb 14, 2021). Moreover, we hosted virtual events (Ohio State University, Soil Health Seminar Series) that showcased perennial grains as a potential new crop for organic producers (Winter 2021). The team has provided one-to-one training to farmers that were interested in testing Kernza in their fields (Fall 2022). Dr. Deiss participated in the 2023 Kernza Conference, in Minnesota, and presented preliminary results from the OREI project to an audience of more than 120 participantsincluding researchers, growers, students, and other stakeholders. Ms. Berenice Montano, a Visiting Scholar from El Salvador that is working with the OREI project, will be presenting preliminary results on soil aggregate stability from the Kernza Dual-Use experiment, in the form of poster presentation, at the tri-societies meeting of the Soil Science Society of America, American Society of Agronomy, and Crop Science Society of America, to take place in Saint Louis, USA, October 2023. What do you plan to do during the next reporting period to accomplish the goals?1. We will continue to evaluate field experiments and collect data in two experimental protocols (Kernza-Legume Intercrop and Organic Perennial Wheat trials) testing management recommendations to optimize production systems of perennial grain crops. The Kernza-Legume Intercrop experiment was designed to compare the response of organically managed Kernza to nitrogen rates, sourced as manure, or legume-intercropping. The Organic Perennial Wheat experiment is evaluating perenniality (survival) of perennial wheat lines in organic systems. We plan to continue to collect and analyze plant and soil samples from the Kernza-Legume Intercrop and Organic Perennial Wheat experiments, for at least one more year in 2024. With the Kernza Dual-Use experiment being harvested for the fourth and last time in 2023, we will prioritize finishing soil and plant analysis as well as writing peer-reviewed and extension publications coming out of the Kernza Dual-Use experiment. 2. We will continue to process and analyze soil samples to quantify improvements that perennial grain crops have on soil health. Soils were sampled at the end of the Kernza Dual-Use experiment, and we are conducting a comprehensive soil health assessment on the four-year impact of plant defoliation treatments. Initial results will be presented at the tri-societies meeting (Soil Science Society of America, American Society of Agronomy, and Crop Science Society of America) in Saint Louis, MO, Oct 2023. A more comprehensive analysis of results will be reported in manuscripts currently being prepared for submission to be published in prestigious peer-reviewed journals in the areas of agronomy and soil science. 3. We will continue the development of enterprise budgets for perennial cropping systems, continue to populate budget data, and test the enterprise approach.The enterprise budgets will be made available to the general public as an online extension tool that estimates economic metrics in scenarios considering dual-use (forage and grain) Kernzaproduction systemsas well as organic sources of soil amendments. 4. We will continue with the efforts to integrate research activities and farmer networks into existing perennial grain commercialization efforts. We are working to expand engagement with stakeholders to provide real-world experience of producing organic perennial grain systems. Finally, we will continue to participate in extension stakeholder meetings, and create written and audio-visual extension materials considering management aspects in organic perennial grain production. Impacts What was accomplished under these goals? 1. As part of the accomplishments related to the first goal, we describe in the following the current state and distribution of field sites of the three experimental protocols that are part of this objective. 1.1 Kernza Dual-Use (KODU) experiment: we established KODU experiments at five research stations, in early Fall 2019. Trials are in Ohio (2 sites), New York, Minnesota, and Kansas, using the first commercially available variety of Kernza, namely, Clearwater Kernza (1504). These trials aim to evaluate organic dual-use grain and forage production of Kernza. The trial design is a RCBD with 4 replicates, and includes four defoliation treatments: i. Summer only after grain, ii. Spring+Summer, iii. Fall+Summer, iv. Spring+Summer+Fall.These trials were successfully harvested for grain and forage for the fourth year in 2023, including both forage and grain harvestable products. We also conducted an end-of-experiment soil sampling, four years after the start of experiment in all locations. Soil are currently being analyzed for a variety of soil health measures including routine nutrient analysis, active carbon (POXC, Respiration, and Protein), inorganic Nitrogen (nitrate and ammonium), and soil total C and N.This experiment will end after the last forage harvest to be conducted in the fall 2023. Kernza-Legume Intercrop (KLI) experiment: we successfully established this experiment in four states, including Minnesota (2021), Ohio (2022), Kansas (2023), New York (2023). This experiment is on track to be evaluated for at least two growing seasons in all sites. The objectives of this experiment are to A) determine what combination of legume species and legume planting time/approach maximize Kernza grain yield, forage yield and forage quality, B) determine a reasonable rate/range for manure use in organic systems. The experiment is a RCBD with 4 replicates and include 10 treatments: i. Kernza (control), ii. Kernza + red clover (at plant), iii. Kernza + red clover (frost seed), iv. Kernza + red clover (after harvest), v. Kernza + alfalfa (at plant), vi. Kernza + alfalfa (frost seed), vii. Kernza + alfalfa (after harvest), viii. Kernza + manure 0.5x, ix. Kernza + manure 1x, and x. Kernza + manure 2x.These trials were successfully harvested for grain and forage in 2023, in all four locations. Plant biomass was harvested and separated to determine vegetation composition (kernza, legumes and weeds). Plant tissue subsamples are being analyzed in the lab to determine forage nutritional quality. We plan to conduct at least one more year of grain and forage harvest in 2024 across all trials. Organic Perennial Wheat (OPW) experiment: Perennial wheat has potential to be a major perennial grain crop in organic systems due to its high interspecific competition ability. The main goal of this experiment is to evaluate the production capacity after the first grain harvest (perenniality) of perennial wheat lines, and its agronomic performance to produce both grain and forage. We planned and established the Organic Perennial Wheat experiments in four states (Ohio, New York, Minnesota, and Kansas). The experimental design is a RCBD with 4 replicates and includes four perennial wheat varieties developed by The Land Institute.These trials were successfully harvested for the first year in 2023, in all four locations, to determine grain and forage productivity. The evaluation of perennial wheat lines will continue, with measurements of overwinter survival in early 2024, and provided the survival rates are reasonable, these trials will continue aiming to evaluate grain and forage productive performance during at least two growing seasons (until 2024). 2. Aiming to quantify the impact of perennial crops on soil health, we: Have conducted an end-of-experiment soil sampling on the Kernza Dual-Use (KODU) experiment, four years after the start of experiment in all locations. Soils are currently being analyzed for a variety of soil health measures including routine nutrient analysis, active carbon (POXC, Respiration, and Protein), inorganic Nitrogen (nitrate and ammonium), and soil total C and N. Have sampled baseline soils (0-20 cm depth) on the two other trials, namely Kernza-Legume Intercrop (KLI)and Organic Perennial Wheat (OPW) experiments described for Objective 1. We plan to resample soils at the end of each trial to compare the effect of different management practices of perennial grain systems on soils health. Those soils will be analyzed for a complete soil health analysis including biological, chemical, and physical indicators. 3. Enterprise budgets frameworks are being developed and we expect to apply those frameworks once the duration of each trial is concluded, and field data collection is finalized and processed. We have started the process of compiling and assembling data from both theKernza Dual-Use experiment andKernza-Legume Intercropexperiment to be used as input for enterprise budgets, and this process will continue for the duration of the field trials. 4. Aiming to continue to integrate research activities and farmer networks into existing perennial crop commercialization efforts: Kernza seeds produced in certified organic areas were made available to interested farmers in Ohio, to plant up to one-acre areas, to test Kernza performance in their fields. These activities are being promoted with support of OSU Extension agents. Moreover, harvested grains milled into flour by an organic grain mill (Stutzman Farms and Mill, Millersburg -Ohio) were donated to a baker (Avalanche Pizza, Athens - OH) as part of the efforts to integrate and promote commercialization networks of perennial grain crops. We are continuously looking for partners interested in perennial grain products, sharing knowledge and creating opportunities for new markets, and we will continue these efforts for the duration of the project and beyond. Dr. Deiss participated in the 2023 Kernza Conference, in Minnesota, and presented preliminary results from the OREI project. The Kernza Conference happened in the Twin Cities, on June 21-23, 2023, with three days of research talks, field trips, and plenty of Kernza food. The successful event brought together over 120 researchers, growers, students, and other perennial grain enthusiasts from 18 states, two Canadian provinces, Denmark, and Sweden. Publications **Progress** 09/01/21 to 08/31/22 **Outputs** Target Audience:Primarily, the target audience for this project includes organic producers, organic agricultural service providers, researchers and end users of perennial grains, such as bakers and brewers. We also hope to meaningfully engage the general public in the later years of this project to diffuse information about the importance of perennial crops to achieve sustainable development goals. Due to sustained COVID-19 restrictions in 2020 that extended into 2021, our traditional avenues of outreach and extension were limited, with many field days being canceled and most programs gone virtual. We have recorded video footage of Kernza in the field and outreach videos are currently being edited to provide introductory information about Kernza, perennial grains, and dual-use forage and grain systems. Changes/Problems:The previous PI, Dr. Steve Culman, accepted a new position at Washington State University, and a new PI has taken the project lead, Dr. Leo Deiss, Visiting Assistant Professor at the Ohio State University. The transition was successful with the new PI being currently fully integrated in the project and working towards accomplishing the proposed deliverables. Dr. Steve Culman provided valuable and continued assistance to the project during the transition and is still involved in the project. The efforts to hire a postdoc in 2022 (described in the previous report) were not successful, mostly due to the availability of competitive candidates as well as transition of the late PI to a new institution. We are going to continue the efforts to hire a postdoc. A position will be posted in early 2023 for a broad national search. The selected candidate will be dedicating at least 50% of their time to this OREI project. The continued challenges of COVID-19 in previous years have limited our ability to fully engage with the proposed on-farm components of this project. As restrictions have eased, we are re-investing efforts to achieve the proposed deliverables of this project. To safeguard against the shortcomings of trial establishment failures, we planted a new set of field experiments, to address two important components of organic perennial crop production, including nitrogen management (Kernza Legume Intercrop trials) and testing a new perennial crop (Organic Perennial Wheat trials). Finally, a reminder that we have made a team decision to make this a 5-year project, so we will be requesting a no-cost extension in the 4th year. What opportunities for training and professional development has the project provided?We have provided intensive training to the new PI of the project, Dr. Leo Deiss, as he got integrated into the ongoing activities in June 2022. Adding to that, as described in the accomplishments of Objective 4, we provided training to farmers that were interested in testing Kernza in their fields. This training included technical instructions on how to establish and maintain organic Kernza fields. We will continue to supplement training to all personnel involved in the project through in person meetings and field visits as well as a series of videos on organic Kernza production. Due to COVID-19, our professional training and development activities have been institutionally-limited in the previous years of the project. How have the results been disseminated to communities of interest?Given the described challenges experienced in previous years related to unsuccessful attempts to establish field trials, COVID-19 restrictions, and change of project PI, we only had preliminary results to share and disseminate to communities of interest. Notably, Dr. Steve Culman (previous PI) gave a presentation on the 'Potential for Perennial Grains and Grasses' to the National Academies of Sciences' Workshop: Reducing the Health Impacts of the Nitrogen Problem (February 11, 2021). We have also provided outreach activities through webinars of Ohio Ecological Food and Farming Association (Feb 14, 2021). Moreover, we hosted virtual events (Ohio State University, Soil Health Seminar Series) that showcased perennial grains as a potential new crop for organic producers (Winter 2021). Finally, we provided one-to-one training to farmers that were interested in testing Kernza in their fields (Fall 2022). What do you plan to do during the next reporting period to accomplish the goals?1. We will maintain and continue to collect data in the three established experimental protocols to establish management recommendations to production of perennial crops. We will begin to collect data on both the re-established Kernza-Legume Intercrop trials and newly established Organic Perennial Wheat trials, to better understand nitrogen availability in organically managed Kernza cropping systems as well as evaluate a new perennial crop (perennial wheat) in organic systems. We will continue to sample and analyze plant and soil data from trials and start preparing peer-reviewed publications with initial emphasis on the Kernza Dual-Use experiment. 2. We will continue to process and analyze soil samples to quantify improvements that perennial grain crops have on soil health. 3. We will finalize the development of enterprise budgets for perennial crop systems, continue to populate budget data, and test the enterprise approach with preliminary data already available from previous years. 4. We will expand efforts to integrate research activities and farmer networks into existing perennial grain commercialization efforts. We will work to expand our on-farm trials with growers that will provide real-world experience of planting, harvesting, and managing organic Kernza. Finally, we will make inroads in developing and providing materials (written and video) for organic perennial grain management and production. **Impacts** What was accomplished under these goals? 1. The current state and distribution across sites of the three experimental protocols that are part of this objective are described as follows. Kernza Dual-Use (KODU) experiment: we planned and established the Kernza Dual-Use experiments at five research stations in early Fall 2019. Trials were planted in Ohio (2 sites), New York, Minnesota, and Kansas, using the first commercially available variety of Kernza, namely, Clearwater Kernza (1504). These trials aim to evaluate organic dual-use grain and forage production of Kernza. The trial design is a RCBD with 4 replicates, and includes four defoliation treatments: i. Summer only after grain, ii. Spring+Summer, iii. Fall+Summer, iv. Spring+Summer+Fall. These trials were successfully harvested for the third year in 2022, including both forage and grains, in all five locations. The Kernza-Legume Intercrop (KLI) experiment: we had an unsuccessful establishment of these trials in three out of four states, including Ohio, Kansas, and New York states, except Minnesota where the trial establishment was successful and has been maintained since 2021. Those unsuccessful trials were re-planted in 2022 in the three mentioned states (Ohio, Kansas, and New York) and are on track to be evaluated for at least two growing seasons (2023 and 2024). The objectives of this experiment are to A) determine what combination of legume species and legume planting time/approach maximize Kernza grain yield, forage yield and forage quality, B) determine a reasonable rate/range for manure use in organic systems. The experiment is a RCBD with 4 replicates and include 10 treatments: i. Kernza (control), ii. Kernza + red clover (at plant), iii. Kernza + red clover (frost seed), iv. Kernza + red clover (after harvest), v. Kernza + alfalfa (at plant), vi. Kernza + alfalfa (frost seed), vii. Kernza + alfalfa (after harvest), viii. Kernza + manure 0.5x, ix. Kernza +

manure 1x, and x. Kernza + manure 2x. Organic Perennial Wheat (OPW) experiment: we initially proposed evaluation of the perennial rye crop along with Kernza. Unfortunately, those efforts were compromised due to shortages of perennial rye seed availability. Consequently, the team decided to work with another perennial crop instead. Perennial wheat was selected given the potential of this crop to be a major perennial grain crop in organic systems due to its high interspecific competition ability (preliminary unpublished results from The Land Institute) as well as seed availability. We planned and established the Organic Perennial Wheat experiments in all participating states (Ohio, New York, Minnesota, and Kansas). The experimental design is a RCBD with 4 replicates and includes four perennial wheat varieties developed by The Land Institute. These four varieties will initially be evaluated for overwinter survival in early 2023, and provided the survival rates are reasonable, the trials will continue aiming to evaluate performance during at least two growing seasons (2023 and 2024). Crop performance measures will include stand, height, above-ground biomass, yield, and seed size. Additional (optional) measures will include anthesis date and disease resistance/susceptibility. 2\. Aiming to quantify the impact of perennial crops on soil health, we have sampled baseline soils (0-20 cm depth) on all three outlined trials described for Objective 1. These also include the re-established trials Kernza Legume Intercrop trials and newly established Organic Perennial Wheat trials.We plan to resample soils at the end of each trial to compare the effect of different management practices of perennial grain systems on soils health. Those soils will be analyzed for a complete soil health analysis including biological, chemical, and physical indicators. 3\. Enterprise budgets frameworks are being finalized and we expect to apply those frameworks once the duration of each trial is concluded, and field data collection is finalized and processed. We have begun the process of compiling and assembling data for this effort which will continue into the following years. 4\. Due to COVID-19 restrictions and cancellation of summer field days in previous years, this objective to integrate commercialization efforts will be increasingly more relevant in the remaining years of the project. In 2022, we harvested Kernza seeds from certified organic areas and made those seeds available to interested farmers in Ohio, to plant up to one-acre areas, to test Kernza performance in their fields. These activities were promoted with support from OSU Extension agents. Unfortunately, only two producers followed up and acquired the seeds in the year 2022. We provided technical assistance to those farmers on how to establish areas with those organic seeds, in terms of planting depth, seeding rates, fertilization regimes, and crop management. We are still monitoring if they were successful in establishing those crops. Those producers compromised to provide grain yield estimates if those fields ended up being harvested and give feedback on crop performance and management. We expect to expand those efforts in the following years. Moreover, 400 lbs. of harvested grains of season 2022 were donated to a baker (Avalanche Pizza, Athens - OH) and an organic grain mill (Stutzman Farms and Mill, Millersburg -Ohio) as part of the initial efforts to integrate and promote commercialization networks of perennial grain crops. **Publications** **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience: Primarily, the target audience for this project includes organic producers, organic agricultural service providers, researchers and end users of perennial grains, such as bakers and brewers. We also hope to meaningfully engage the general public in the later years of this project. Due to sustained COVID restrictions in 2020 that extended into 2021,our traditional avenues of outreach and extension remained limited, with many field days being canceled and most programming gone virtual.We hosted some limited virtual events (e.g., Ohio State Univeristy, Soil Health Seminar Series) that showcased Kernza as a potential new crop for organic producers.In addition, there are several field days scheduled for organic grower engagement this spring. We have recorded a large amount of video footage of Kernza in the field and outreach videos are currently being edited to provide introductory information about Kernza, perennial grains and dual-use forage and grain systems. Changes/Problems: There are a few changes/ problems to report to this project. First, the continued challenges of COVID-19 have limited our ability to fully engage with the proposed on-farm components of this project. We have mailed growers seed and provided them planting instructions so some of this work has been initiated. To safeguard against this short-coming we decided to plant another set of trials to address an important component of organic Kernza production - nitrogen availability. Second, a reminder that as a team, we have already made a decision as a team to make this a 5-year project so we will be requesting a no-cost extension in the 4th year. Finally, we request that you change the sponsored programs contact on this award from Traci Aquara to: Ginette A Busque Sr. Sponsored Program Officer The Ohio State University Office of Sponsored Programs 1960 Kenny Road Columbus, Ohio 43210 614-292-0956? What opportunities for training and professional development has the project provided? We have provided training to a several research technians and undergraduate students. We are bringing a post-doctoral scholar onto the project in the Spring of 2022. We have also provided outreach activities through webinars (Ohio Ecological Food and Farming Association, Feb 14, 2021). Due to COVID our professional training and develop activities have been instituationally-restricted. We do have some additional training webinars scheduled for this spring and we intend to supplement training through a series of videos on organic Kernza production. How have the results been disseminated to communities of interest?Since this is only the 2nd year of the project, we only have preliminary results to share and disseminate to communities of interest. Notably, Steve Culman (PI) presented the justification of Kernza and perennial grains to theNational Academiesof SciencesWorkshop: Reducing the Health Impacts of the Nitrogen Problem. The talk, 'Potential for Perennial Grains and

Grasses' was presented on February 11, 2021. What do you plan to do during the next reporting period to accomplish the goals? In the next reporting period, we will work to expand our on-farm trials with growers that will provide real-world experience planting, harvesting, grazing and managing organic Kernza. We will being to collect data on our newly established Kernza-legume intercrop trials to better understand nitrogen availability in organically managed Kernza cropping systems. We will continue to analyze plants and soils from trials and start preparing peer-reviewed publications from these trials. We will finalize our framework for enterprise budgets and continue to populate the budgets with data. Finally we will make inroads in developing and providing materials (written and video) for organic Kernza management and production. **Impacts** What was accomplished under these goals? 1. We maintained our five research farm trials (planted in Fall 2019; 2 in Ohio, 1 in New York, 1 in Minnesota, 1 in Kansas, using the first commercially-available variety, Clearwater Kernza (1504). The trials have 4 forage harvest treatments (i. Summer only after grain, ii. Spring+Summer, iii. Fall+Summer, iv. Spring+Summer+Fall). In Year 2, we implemented the forage harvest treatments as outlined above and collected samples similar to in Year 1. We have compiled all data and have started the process of data analysis with the intention of writing up the first 3 years of data. We also established a limited number of on-farm trials in Fall 2021 (1 in OH, 2 in MN). We had to scale back on-farm work due to travel restrictions due to COVID-19. We anticipate planting several more on-farm trials in Fall 2022. Due to the uncertainty surrounding COVID-19 and our ability to successfully complete on-farm research goals, the team decided to establish an additional set of trials focused on another highly relevant issue for organic grain producers - nitrogen availability. The objectives of the experiment are to: 1) determine which legume species and legume planting time/approach maximize Kernza grain yield, forage yield and forage quality (or a combination of these three properties), 2) determine a reasonable rate/range for manure use in organic systems. The experiment is a RCBD with 4 replications and the following treatments: 1) Kernza (control) 2) Kernza + red clover (at plant) 3) Kernza + red clover (frost seed) 4) Kernza + red clover (after harvest) 5) Kernza + alfalfa (at plant) 6) Kernza + alfalfa (frost seed) 7) Kernza + alfalfa (after harvest) 8) Kernza + manure 0.5x 9) Kernza + manure 1x 10) Kernza + manure 2x Trials have been established at all sites, although the Kansas site is suffering from poor establishment and will be re-evaluated in spring of 2022. We are working on developing consistent data sampling methods and protocols. 2. We are working through baseline soils (both on-farm and on-station) and performing analyses to compare these values with soils to be sampled at the end of the project. 3. We have continued conversations for setting up enterprise budgets frameworks. We have begun the process of compiling and assembling data for this effort which will continue into year 4. 4. Due to COVID restrictions and cancellation of summer field days, minimal effort has been made on this front to integrate commercialization efforts at this point. This objective will become increasingly more important in the later years of this award. **Publications**

PROGRESS

2019/09 TO 2020/08 Target Audience: The target audience for this project includes organic producers, organic agricultural service providers, researchers and end users of perennial grains, such as bakers and brewers and the general public. Due to COVID restrictions in 2020 and this being the first year of the project, work on outreach and education was limited. However, there are several events schedule for organic grower engagement this winter. We have recorded a large amount of video footage of Kernza in the field and outreach videos are currently being edited to provide introductory information about Kernza, perennial grains and dual-use forage and grain systems. Changes/Problems:There are no major changes or problems to report here, but a couple points to mention. First, we have already made a decision as a team to make this a 5-year project so we will be requesting a no-cost extension in the 4th year. Second, we anticipate COVID-related instiutional travel bans will not be implemented in summer 2021, which will alllow us to expand this work as initially proposed. We appreciate NIFA\'s patience through this process. Finally, we request that you change the sponsored programs contact on this award from Traci Aquara to: Josh Gates Sponsored Program Officer 614-688-4626 (Office) gates.346@osu.edu What opportunities for training and professional development has the project provided?We have provided training to a limited number of research technians and undergraduate students. A PhD student will be brought on in 2021 for in-depth training. Due to COVID our professional training and develop activities have been instituationally-restricted. We do have some training webinars scheduled for this winter and we intend to supplement training through a series of videos on organic Kernza production. How have the results been disseminated to communities of interest?Given this is the first year, there are no real results that have emerged, only preliminary results that are being compiled and analyzed. What do you plan to do during the next reporting period to accomplish the goals?In the next reporting period, we will significantly expand our on-farm trials with growers that will provide real-world experience planting, harvesting, grazing and managing organic Kernza. We will also, given sufficient seed available, to plant a dual-use perennial cereal rye trial to complement the ongoing work with Kernza. We will continue to analyze plants and soils from trials annually. We will finalize our framework for enterprise budgets and continue to populate the budgets with data. Finally we will make inroads in developing and providing materials (written and video) for organic Kernza management and production.

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? 1. We planned and established Kernza research trials on both research and grower\'s farms. Five research farm trials were planted in early Fall 2019 (2 in Ohio, 1 in New York, 1 in Minnesota, 1 in Kansas) using the first commercially-available variety, Clearwater Kernza (1504). The trials have 4 defoliation treatments (i. Summer only after grain, ii. Spring+Summer, iii. Fall+Summer, iv. Spring+Summer+Fall). We unified sampling protocols and implemented the defoliation treatments and harvested for both grain and forage. We consider the first field season to be successful with quality data generated. We also established a limited number of on-farm trials in Fall 2020 (2 in OH, 1 in NY, 3 in MN). We had to scale back on-farm work because of travel restrictions due to COVID-19. We anticipate planting several more on-farm trials in Fall 2021. 2. We have sampled baseline soils for all of the above outlined trials. Those soils will be analyzed this winter for a complete soil health analysis and serve as a starting point for future comparisons. 3. We have had initial conversations, documented goals and sketched out a preliminary framework for enterprise budgets. This work will be finalized this winter and efforts are on-going to collect data to help realistically parameterize these budgets. 4. Due to COVID restrictions and cancellation of summer field days, minimal effort has been made on this front to integrate commericalization efforts at this point. This objective will become increasingly more important in the later years of this award. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 No publications reported this period. ** **

↑ Return to Index

Planning Proposal: Exploiting Brewery Waste for Soil Management in Organic Agriculture

Accession No.	1020431
Project No.	OHOW-2019-03047
Agency	NIFA OHOW\
Project Type	OTHER GRANTS
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Proposal No.	2019-03047
Start Date	01 SEP 2019
Term Date	31 AUG 2020
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Grant Year	2019
Investigator(s)	Davis, S. C.; Miller, KI.
Performing Institution	OHIO UNIVERSITY, 286 UNDLEY HALL, ATHENS, OHIO 45701

NON-TECHNICAL SUMMARY

Organic agriculture and the microbrewery industry are both expanding in rural America. This planning project outlines technology that could be employed to exploit brewery waste for organic soil management, thereby incurring economic and health benefits for rural regions where both the microbrewery production and organic farming are increasing. This project addresses FY 2019 OREI legislatively defined goals of \"Conducting advanced on-farm research and development that emphasizes observation of, experimentation with, and innovation for working organic farms, including research relating to production, marketing, food safety, socioeconomic conditions, and farm business management\" and \"Facilitating the development and improvement of organic agriculture production\...\" Socieconomic conditions are ripe for leveraging brewery waste as an organic soil amendment because this waste is a growing resources that poses a challenge for business owners to manage. While this waste stream is distinctly suited to organic application if processed through anaerobic digestion, there are no clear guidelines for applying of this technology in the National Organic Program standards. Stakeholder needs as identified by collaborating local extension educators include easing the cost and clarifying the regulatory steps for organic certification. Organic agriculture is increasingly practiced by small farmers, but many are not officially certified as organic producers. Stakeholders characterize both the certification process and soil management as time-intensive, requiring training and practice. The education goals of this project develop a curriculum plan for training agricultural professionals with the tools to maintain USDA organic certification and advance organic practices using emerging soil management strategies.

OBJECTIVES

This project will identify technology that can be employed to exploit brewery wastes for organic soil management. Input gathered from practitioners in the brewery industry and organic agriculture will inform the development of a multi-year plan for research and curriculum development that meets specific needs for advancing organic production. A diverse group of stakeholders, including farmers, brewery owners, university and extension educators, and researchers, will engage in workshops designed to resolve the potential for processed brewery waste to be used as a soil amendment in organic agriculture. Outcomes of the workshops will identify gaps in knowledge about the effect of brewery waste application to soils, and curricular needs for training the next generation workforce for organic agriculture. Specific objectives are to: Identify stakeholder interest in developing closed-loop systems for brewery waste management that meets organic certification standards. Identify farmers that already use organic practices in the region that would pursue certification if subsidized (financially and/or with regulatory consultation).Summarize reports from group meetings and apply outcomes to a multi-year plan based on the potential of brewery waste and digestate for organic agriculture, the gaps in knowledge that must be filled to advance practices that exploit this potential, and curricular gaps that must be filled to meet training needs of the organic agriculture workforce.

APPROACH

Planning activities will launch with a workshop to share preliminary data and identify gaps in knowledge, continue with a meeting focused on developing a research plan, a meeting focused on curriculum development, and culminate with work on a white paper detailing priority research areas to address and a full proposal to advance technologies and education for organic agriculture management with brewery wastes. After the initial workshop, another set of meetings will allow for detailing on farm research needs, assessing feasibility and scale of brewery AD, and curriculum development. The first meeting will be organized with relevant team members to coordinate soil sampling at the Barrel Ridge Farm (part of closed-loop model), Green Edge Gardens (certified organic farm), and student gardens at Ohio University. It is expected that initial soil tests will be accomplished during the planning grant cycle to assess baseline soil conditions at the different locations where brewery-derived soil amendments will be tested. The soil conditions at the successfully operating organic farm will be used to establish benchmark conditions for the test sites that will be treated with brewery-derived soil amendments. A second meeting will be designed specifically to amass data to inform quantitative estimates of the scale of soil amendment that is likely to be produced from (i) the model brewery-brewbpub-farm business and (ii) brewery operations across the region. Input will be provided from AD business managers, microbrewery operators, regulatory experts, and extension personnel (some of which are listed in the stakeholders list and support letters are attached).A curriculum planning meeting will be designed to specifically outline curricula that meet the needs of the next generation workforce required to support organic agriculture. Extension educators, university instructors, organic farmers, and prospective organic farmers will be included in this discussion to develop a curricular framework that supports the target student body. Based on prior certificate programs in Environmental Studies, we expect to support annual enrollment in a carefully designed curriculum of 15-25 professionals and graduate students. There is a Student Farm on campus at Ohio University that will be used to give students hands on training in organic practices before they engage directly with working organic farms. **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:This project engaged stakeholders with different backgrounds: organic farmers, prospective organic farmers (landowners growing vegetables or meat that are not yet certified), brewery operators, wastewater treatment managers, a biogas industry representative, agricultural extension educators, and organic certifying agents in addition to university-affiliated researchers/educators. Approximately 45 participants attended a workshop, which included short seminars on organic practices, NOP standards, soil management, biogas production, and digestate amendments to soils. The seminar series was followed by breakout group discussions on (1) soil and plant nutrient management; (2) brewery waste management; and (3) education and workforce training needs for organic agriculture. Severeal farm owners, a brewery and restaurant owner, extension educators, organic certifiers, waste managers, and legal professionals have all agreed to participate in the next phase of this project to develop innovative solutions for waste processing that meet the needs of organic farmers while also meeting the standards for organic certification. Both undergraduate and graduate students were also engaged with this project. This funding supported hands-on training experiences with anaerobic digestion of brewery waste and direct engagement with farm and brewery operations. These experiences are essential for training a new generation of organic farmers. The project activities took place in the Appalachian region of southeast Ohio where the population is economically disadvantaged and traditionally underserved in innovative farm science. Changes/Problems:Due to COVID-19, we held small group outdoor meetings with farmers and brewers instead of a larger group meeting to share the outcomes of the workshop and details of the multi-year plan that resulted. What opportunities for training and professional development has the project provided?The workshop supported by this planning grant provided a seminar series that included training by Organic Certifying agents, practicing farmers, biogas operators, and professional lawyers. The multi-discplinary perspectives provides professional development for everyone involved. How have the results been disseminated to communities of interest?Small group meetings occured with farmers and brewery owners to provide a summary of the workshop outcomes. A copy of the full multi-year plan that was developed and submitted as part of a recent application for funding was shared with the workshop stakeholders that expressed interest in participating. We hoped to continue this work with new funding from USDA that has not yet been approved. What do you plan to do during the next reporting period to accomplish the goals?This is a final report for the planning grant. The plan for future work requires additional funding, and the full proposal that was prepared this year will be revised according to reviewer comments and resubmitted next year. **Impacts** What was accomplished under these goals? Objective 1: Identify stakeholder interest in developing closed-loop systems for brewery waste management that meets organic certification standards. There is substantial interest in waste management issues among farmers in the region, but it is clear that there is limited awareness about the growing brewery waste stream. Wastewater treatment plant managers on the other hand are very aware of the increased volume of brewery waste, and the limited options for sludge disposal after treatment. Spent grain waste from Jackie O's brewery is already repurposed as feed for cattle and as an ingredient for foods in their brewpub (tortillas, breads, etc.). There are, however, challenges for storage of this material because it spoils quickly; local breweries are not currently able to safely store and use all of the spent grains produced. Objective 2: Identify farmers that already use organic practices in the region that would pursue certification if subsidized (financially and/or with regulatory consultation). There are at least 18 commercial farms in the local region that claim to use organically certifiable practices or that claim no industrial chemical applications are used as pesticides, herbicides, or fertilizer. Of these, only one is actually USDA certified organic. This indicates that there is strong interest in organic agriculture, and there is a need for greater resources and education to support achieving certification. Several farmers cited the high costs and time commitment as deterrents for pursuing certification. Most were familiar with the regional certifying agent, OEFFA, but were not fully aware of the reimbursements and support that is available to offset costs of organic certification. Objective 3: Summarize group meetings and apply to multi-year plan based on (a) the potential of brewery waste and digestate for organic agriculture, (b) the gaps in knowledge that must be filled to advance practices that exploit this potential, and (c) curricular gaps that could meet training needs for the organic agriculture workforce. (a) Most of the growth in the brewing industry is expected to occur in small to midsize breweries, and not in large-scale commercial breweries. As such, there is a lot of potential for developing technologies that address the growing waste management needs in rural municipalities with growing microbrewery sectors. The ingredients and processing technologies in microbreweries are well-suited to yield wastes that can be applied in organic soil management. (b) There is a gap in knowledge about how brewery waste should be handled (when stored, transported, applied to soil) for use in organic agriculture. There is also a lack of clear guidance in the NOP standards about the use of brewery waste. None of the stakeholders at the aforementioned workshop, except the PDs, were familiar with the potential applications of the trub portion of the brewery waste. The chemical composition of trub is similar to that of spent grain, but the slurry consistency makes it less feasible for livestock feed. The limited research on the use of trub as feedstock for biogas production and as a fertilizer is reviewed in a subsequent section of this document. It is clear that there is a gap in knowledge about the potential benefits of exploiting this growing waste resource for agricultural applications. (c) Farmers indicate an aging workforce in the farming community, and difficulty finding laborers that are knowledgeable in soil management. Application to muli-year plan: A multi-year was developed and a full proposal was submitted to the USDA OREI program in response to the Fiscal Year 2020 Request for Applications. **Publications** - Type: Theses/Dissertations Status: Accepted Year Published: 2019 Citation: Optimizing Feedstock Mixtures for Anaerobic Digestion of Food Waste, Brewery Waste, and Crop Residues - Type: Conference Papers and Presentations Status: Published Year Published: 2020 Citation: Davis SC. Science x people: perspectives from best practices in agriculture. Inspire Session: Addressing the Challenges of Ecologys Human Dimensions. Ecological Society of America Annual Meeting. August 3-6, 2020. Virtual Meeting Platform. (invited) - Type: Journal Articles Status: Under Review Year Published: 2021 Citation: Miller KE, Herman T, Philipinanto DA, Davis SC. Anaerobic digestion of food waste, brewery waste, and agricultural residues in an off-grid continuous reactor. Energies. submitted for review and still under review.

↑ Return to Index

Developing the Next Generation of Organic Agricultural Researchers: Student Article Competitions and Oral Sessions

Accession No.	1020589
Project No.	ORE00335
Agency	NIFA ORE\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30251
Proposal No.	2019-03038
Start Date	01 SEP 2019
Term Date	31 AUG 2020
Grant Amount	$41,955
Grant Year	2019
Investigator(s)	Formiga, A. K.; Fernandez-Salvador, JA, AN.

NON-TECHNICAL SUMMARY

This conference proposal would fund eOrganic, which is the Organic Agriculture Community of eXtension.org based at Oregon State University, to conduct two student article competitions and organize two oral sessions on organic agricultural research at professional society conferences in 2020: one at the American Society for Horticultural Science (ASHS) Conference, and the other at the Tri-Societies Conference. Five student article competition winners will receive sufficient funding to attend each and present their articles at the oral sessions, and learn about the eOrganic community and its science-based information resources on organic farming and research. Following the conference, the student articles would be published online by eOrganic, made publicly available and publicized to a wide audience of organic farmers, researchers, extension educators and agricultural professionals (Priority 2). The proposal would make the results of more organic farming research projects available in language that is accessible to the general public, since the competition instructions would emphasize, provide tips on and prioritize effective written communication for a farmer audience. Article entries can include soil health and nutrient management, cover crops, weed, insect and disease management, plant breeding and seed production, vegetable and grain production, technology and tools, marketing and economics. (Goals 1,2,6,7,8, Priorities 1,4,5,6,7). The result would be to enable 10 students to attend professional society meetings, share information on current organic research projects with other researchers and students, meet colleagues in their disciplines, and produce 10 publicly available articles that would transmit practical, science-based information on organic farming research and practice to end-users.

OBJECTIVES

The major goals of this project are to increase the amount of publicly available, current, science-based organic farming research; to further the professional development of student organic agricultural researchers; and to Improve the communication of organic research findings to public audiences. We will do this by organizing student article competitions and oral sessions at 2 professional society conferences (Tri-Societies and the American Society for Horticultural Science). Ten student winners willgain valuable experience and further their career prospects by presenting their research at national professional society conferences, where they will meet other researchers and students engaged in organic research, and learn about communicating research to farmer audiences. They would also learn about eOrganic and its many science- and experience-based information resources. Their articles, on current organic agricultural research, will be peer-refereed, checked for organic certification compliance, published, and made publicly available by eOrganic.

APPROACH

The methods listed in the timeline were successfully completed for the 2018 ASHS conference, so we are confident that they will work well in 2020. They engage members of the professional societies as well as eOrganic members and students in producing research-based information for farmers. eOrganic would put out a call for proposals between 2 and 3 months before the abstract deadlines of the respective conferences and it would also be sent to all Tri-Societies and ASHS members. Student competitors would write an article about their research in a style that is suitable for a general audience of farmers, extension agents, and other agricultural educators and professionals. Submissions would be judged by a committee from the respective organic interest group at the professional societies. eOrganic would notify the winners and submit the winning abstracts, and place the articles into review by eOrganic members. The five winning students would attend the conference and present their articles at an oral session organized by eOrganic. 1-2 eOrganic members would also give a presentation about the eOrganic community, its resources and how to get involved. After the conference, the students would be reimbursed for their expenses (registration, hotel, food, U.S. travel up to \$1500). The articles would be published by eOrganic and publicized in the eOrganic newsletter. **Progress** 09/01/19 to 08/31/21 **Outputs** Target Audience:The target audience for the article competition was students who are conducting agricultural research in organic systems. The articles they wrote for the competition had as their target audience producers, agricultural researchers, educators, service providers and professionals, organic certifiers and inspectors, and students. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The 4-webinar course at https://eorganic.org/node/33929 provided training on writing science for an audience of producers, how to find reliable information on organic management, writing for diverse audiences, and the peer-review process. Additional feedback was provided to students in the course of the review and editing of their articles, and students received professional development training and career information at the professional society conferences they attended. How have the results been disseminated to communities of interest?Articles were published on the eOrganic website at https://eorganic.org and publicized in the eOrganic newsletter which reaches over 12,000 subscribers. Abstracts and pre-recorded videos were uploaded to the ASHS and Tri-Societies virtual conference platforms for all attendees. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **Impacts** What was accomplished under these goals? This award supported the publication of a publicly available 4-webinar course on writing articles on organic agricultural science for producers, 9 publicly available peer-refereed student articles on eOrganic research at land grant universities across the U.S., 9 conference abstracts, 1 oral session at the ASHS conference, 1 oral session at the Tri-Societies conference, 4 additional articles in press. Ten students attended and presented at professional society conferences in 2020. Three students attended the ASHS conference in person in 2021, and one student will attend the Tri-Societies conference in November, 2021. Graduate student competition winners reported benefits from attending the conferences, including meeting students and researchers, learning about water-efficient irrigation and where to start in advising farmers about designing these systems, learning about methods that would assist them in their data analysis, getting ideas for careers after completing their education. Another learned that she could pursue a broader range of career possibilities than she initially assumed. One student article on plant disease management was among the top 20 most-read eOrganic articles in summer 2021, and the author was inspired to submit a second article to eOrganic which is in review. One of the student articles was translated into Spanish and published on eOrganic, and 8 more article translations are in progress. One of the published student articles led to a collaboration between farmers and researchers on a successful NIFA OREI proposal in 2021. **Publications** - Type: Other Status: Published Year Published: 2020 Citation: Alam, T. & Rustgi, S. Organic Management of Bacterial Wilt of Tomato and Potato Caused by Ralstonia solanacearum. eOrganic article. Available at https://eorganic.org/node/34193 - Type: Other Status: Published Year Published: 2020 Citation: Archer, L., 2020. Olive Mill By-products for Organic Verticillium Wilt and Weed Management - Type: Other Status: Published Year Published: 2021 Citation: Barker, T., Fernandez-Salvador, J., Bell, N., Stoven, H. 2021..Initial Considerations for Establishing Small-Scale Organic Olive Orchards in the Pacific Northwest West of the Cascades. eOrganic article. Available at https://eorganic.org/node/34189 - Type: Other Status: Published Year Published: 2020 Citation: Candelaria, N., Grossman, J. Pfeiffer, A., Fernandez, A. , Rogers, M. 2020. Summer Cover Crop Options for Organic Vegetable Farms in the Upper Midwest. eOrganic article. Available at https://eorganic.org/node/34375 - Type: Other Status: Published Year Published: 2021 Citation: Candelaria, N. , Grossman, J. Pfeiffer, A., Fernandez, A. , Rogers, M. 2021. Opciones de abonos verdes en tiempos de verano para fincas org�nicas de hortalizas en la parte superior del Medio Oeste. eOrganic article. Available at https://eorganic.org/node/35006 - Type: Other Status: Published Year Published: 2021 Citation: Dean, C. Pena Mosca, F., Ray, T., Heins, B., Pinedo, P., Machado, V., Caixeta, L., Noyes, N. 2021. What is the microbiome and why is it important for organic livestock production? eOrganic article. Available at https://eorganic.org/node/34373 - Type: Other Status: Published Year Published: 2019 Citation: Formiga, A., Stone, A., Wzselaki, A. & Fernandez-Salvador, J. 2019. How to write an eOrganic article course: writing scientific information for farmers and the general public. eOrganic course. Available at https://eorganic.org/node/33929 - Type: Other Status: Published Year Published: 2020 Citation: Kubesch, J. O.C. 2020. Forage Species Selections to Minimize Weeds in Transitioning Organic Programs. eOrganic article. Available at https://eorganic.org/node/34377 - Type: Other Status: Published Year Published: 2020 Citation: Loria, K. 2020. Understanding and Managing Seedborne Pathogens in Organic Dry Bean Systems. eOrganic article. Available at http://eorganic.org/node/34369 - Type: Other Status: Published Year Published: 2021 Citation: Merscher, P. & Stone, A. 2021. Adjuvants for Organic Pest and Disease Management. eOrganic article. Available at http://eorganic.org/node/34967 - Type: Other Status: Published Year Published: 2020 Citation: Puka-Beals, J. & Gramig, G. 2020. Hydromulching in Carrot: An Organic Weed Control Tool for Direct Seeded Crops. eOrganic article. Available at https://eorganic.org/node/34194 **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:The target audience for the article competition was students who are conducting agricultural research in organic systems. The articles they wrote for the competition had as their target audience producers, agricultural researchers, educators, service providers and professionals, organic certifiers and inspectors, and students. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? The 4-webinar course at <https://eorganic.org/node/33929> provided training on writing science for an audience of producers, how to find reliable information on organic management, writing for diverse audiences, and the peer-review process. Additional feedback was provided to students in the course of the review and editing of their articles, and students received professional development training and career information at the professional society conferences they attended. How have the results been disseminated to communities of interest?Articles were published on the eOrganic website at https://eorganic.org and publicized in the eOrganic newsletter which reaches over 12,000 subscribers. Abstracts and pre-recorded videos were uploaded to the ASHS and Tri-Societies virtual conference platforms for all attendees. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **Impacts** What was accomplished under these goals? This award supported the publication of a publicly available 4-webinar course on writing articles on organic agricultural science for producers, 9 publicly available peer-refereed student articles on eOrganic research at land grant universities across the U.S., 9 conference abstracts, 1 oral session at the ASHS conference, 1 oral session at the Tri-Societies conference, 4 additional articles in press. Ten students attended and presented at professional society conferences in 2020. Three students attended the ASHS conference in person in 2021, and one student will attend the Tri-Societies conference in November, 2021. Graduate student competition winners reported benefits from attending the conferences, including meeting students and researchers, learning about water-efficient irrigation and where to start in advising farmers about designing these systems, learning about methods that would assist them in their data analysis, getting ideas for careers after completing their education. Another learned that she could pursue a broader range of career possibilities than she initially assumed. One student article on plant disease management was among the top 20 most-read eOrganic articles in summer 2021, and the author was inspired to submit a second article to eOrganic which is in review. One of the student articles was translated into Spanish and published on eOrganic, and 8 more article translations are in progress. One of the published student articles led to a collaboration between farmers and researchers on a successful NIFA OREI proposal in 2021. **Publications** - Type: Other Status: Published Year Published: 2020 Citation: Alam, T. & Rustgi, S. Organic Management of Bacterial Wilt of Tomato and Potato Caused by Ralstonia solanacearum. eOrganic article. Available at <https://eorganic.org/node/34193>. - Type: Other Status: Published Year Published: 2020 Citation: Archer, L., 2020. Olive Mill By-products for Organic Verticillium Wilt and Weed Management - Type: Other Status: Published Year Published: 2021 Citation: Barker, T., Fernandez-Salvador, J., Bell, N., Stoven, H. 2021..Initial Considerations for Establishing Small-Scale Organic Olive Orchards in the Pacific Northwest West of the Cascades. eOrganic article. Available at <https://eorganic.org/node/34189>. - Type: Other Status: Published Year Published: 2020 Citation: Candelaria, N., Grossman, J. Pfeiffer, A., Fernandez, A. , Rogers, M. 2020. Summer Cover Crop Options for Organic Vegetable Farms in the Upper Midwest. eOrganic article. Available at <https://eorganic.org/node/34375>. - Type: Other Status: Published Year Published: 2021 Citation: \" Candelaria, N. , Grossman, J. Pfeiffer, A., Fernandez, A. , Rogers, M. 2021. Opciones de abonos verdes en tiempos de verano para fincas org�nicas de hortalizas en la parte superior del Medio Oeste. eOrganic article. Available at <https://eorganic.org/node/35006>. - Type: Other Status: Published Year Published: 2021 Citation: Dean, C. Pena Mosca, F., Ray, T., Heins, B., Pinedo, P., Machado, V., Caixeta, L., Noyes, N. 2021. What is the microbiome and why is it important for organic livestock production? eOrganic article. Available at <https://eorganic.org/node/34373>. - Type: Other Status: Published Year Published: 2019 Citation: Formiga, A., Stone, A., Wzselaki, A. & Fernandez-Salvador, J. 2019. How to write an eOrganic article course: writing scientific information for farmers and the general public. eOrganic course. Available at <https://eorganic.org/node/33929>. - Type: Other Status: Published Year Published: 2020 Citation: Kubesch, J. O.C. 2020. Forage Species Selections to Minimize Weeds in Transitioning Organic Programs. eOrganic article. Available at <https://eorganic.org/node/34377>. - Type: Other Status: Published Year Published:

2020 Citation: Loria, K. 2020. Understanding and Managing Seedborne Pathogens in Organic Dry Bean Systems. eOrganic article. Available at <http://eorganic.org/node/34369>. - Type: Other Status: Published Year Published: 2021 Citation: Merscher, P. & Stone, A. 2021. Adjuvants for Organic Pest and Disease Management. eOrganic article. Available at <http://eorganic.org/node/34967>. - Type: Other Status: Published Year Published: 2020 Citation: Puka-Beals, J. & Gramig, G. 2020. Hydromulching in Carrot: An Organic Weed Control Tool for Direct Seeded Crops. eOrganic article. Available at <https://eorganic.org/node/34194>. **Progress** 09/01/19 to 08/31/20 **Outputs** Target Audience:This project funds 2 student article competitions, and the winners will attend either the ASHS Conference in August, 2020, or the Tri-Societies Conference in November, 2020. The articles were to be Extension style articles for publication on the eOrganic public website at http://eorganic.org, and should address an organic farming or research topic in language which would be accessible to farmers and the general public. So the target audience was students who are engaged in organic research or who would be able to synthesize research and practical information and would like to advance their careers by attending a professional society meeting.Calls for articles for both competitions were widely distributed, to the eOrganic mailing list, which reaches over 12,000 subscribers including university researchers who investigate organic agriculture topics and supervise students. The notice was also sent to relevant departments at Land Grant Universitiesand universities with organic agriculture farms and research programs listed on the USDA Sustainable Agriculture database, as well asto the Organic Farming Research Foundation.Along with the competition announcement, students were invited to attend a free 4-webinar class on how to write up their research for an eOrganic article, The class was conducted in October and November, 2019, and the webinar recordings were archived to the eOrganic YouTube channel where they received views from many more people than had attended the class in person. Changes/Problems:We were orginally planning to award five students to attend each of the competitions for a total of ten, but only four of the entries met our requirements to win the ASHS competition. We added a presentation to the session by the CO-PI which we thought would be useful to students in attendance which will discuss his experience mentoring students for Extension careers with a focus on applied research. Therefore, if we have remaining funds, we will hold a competition in 2021 with the goal of sending a student to the ASHS conference and publishing his or her article in 2021. What opportunities for training and professional development has the project provided?Several of the student winners had attended the 4-webinar class offered by eOrganic on how to write an eOrganic or Extension style article in the fall of 2019. After the winners were chosen, feedback from the judges was sent to the competition winners, as well as those who were not chosen, so that the articles could be prepared for peer-review. Articles are now being sent into peer review by two blind reviewers and will then be checked for organic certification compliance and copy edited before being published on the eOrganic websites following the respective conferences, where the students will present their work. We expect that the feedback and experience of the review, as well as students' attendance at the conference, whether or not they take place in person or online due to COVID-19, will provide them with an educational and beneficial experience. How have the results been disseminated to communities of interest?The competition winners will be announced in the eOrganic newsletter, and their articles will be published on the eOrganic public website at http://eorganic.org. The presentations from our class on how to write an eOrganic or Extension style article and find science- and practice-based information on organic agriculture have been publicly archived on the eOrganic YouTube channel. What do you plan to do during the next reporting period to accomplish the goals?eOrganic requested and received a no-cost extension because the second conference takes place after the original end of the reporting period. During the next period, both conferences will be held, the students will present at the conferences, and the articles will be reviewed, checked for certification compliance, copy-edited, and published on the eOrganic public website. **Impacts** What was accomplished under these goals? In the fall of 2019, eOrganic announced the competition widely, and conducted a 4-webinar class for students on how to write an eOrganic (Extension style) article. In February through May, 2020,sStudents submitted entries to both competitions, and the entries were judged by committees which included members from eOrganic as well as the organic management groups of the respective professional societies, the American Society for Horticultural Science, and the American Society of Agronomy. By the end of May, four winners were chosen for the ASHS competition, and five were chosen for the Tri-Soceities Conference. Conference sessions have been set up and all abstracts have been submitted to the conferences. **Publications** - Type: Conference Papers and Presentations Status: Submitted Year Published: 2020 Citation: ASHS Conference Abstracts Submitted Formiga, A., Stone, A. 2020. Eorganic Outreach and Communication for Organic Research Projects. Fernandez-Salvador, J. 2020. Mentoring Undergraduate and Graduate Students for Careers in Extension with a Focus on Applied Research. Barker, T.A. 2020. Establishing Small-Scale Organic Olive Orchards in the Pacific Northwest. Hydromulching: A New Approach for Weed Management in Organic Agriculture . J. Puka-Beals Archer, L. 2020. Olive Mill By-Products for Organic Soil Management. Alam, T. 2020. Organic Management of Bacterial Wilt in Tomato Caused By Ralstonia Solanacearum. Tri Societies Conference Abstracts Submitted Candelaria, N.2020.Summer Cover Crop Options for Organic Vegetable Farms in the Upper Midwest. Loria, K.2020.Evaluation and Improvement of Dry Beans (Phaseolus vulgaris) for Regional Staple Crop Production in the Northeastern United States. Kubesch, J. Forage Species Selections to Minimize Weeds in Transitioning

Organic Programs. Dean, C. 2020. What Is the Microbiome, and Why Is It Important for Organic Livestock Production? Ghimire, B. 2020. Biologically Based Indicators of Soil Quality: Their Interpretation and Application in Organic Farming Systems Formiga, A. 2020. Outreach for Organic Research Projects Through eOrganic and Student Article Competitions. ** **

↑ Return to Index

From Compost Carryover to Compost Legacy: Intercropping and Compost Effects on Yield, Quality, and Soil Health in Organic Dryland Wheat

Accession No.	1020449
Project No.	UTA-01502
Agency	NIFA UTA\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30476
Proposal No.	2019-03079
Start Date	01 SEP 2019
Term Date	31 AUG 2023
Grant Amount	$1,919,855
Grant Year	2019
Investigator(s)	Reeve, J. R.; Carr, PA, MA.; Norton, JA, B.; Jacobson, AS, RO.; Norton, UR.; Burke, IA, CR.; Kim, MA.; Curtis, KY.; Larsen, RY.; Yost, MA.; Fortenbery, T., RA.; Creech, JO, EA.; Eberle, CA, AN.

NON-TECHNICAL SUMMARY

A large percentage of the organic wheat acreage in the United States is grown in the West. However, declining wheat yields and poor quality caused by lack of soil fertility and weed pressure threaten the economic and environmental sustainability of these farms. The long-term goal of this project is to foster the development of economically viable and environmentally sustainable farming systems to address the low fertility and growing weed pressure facing dryland organic wheat producers in the western U.S. To meet this goal, we have three main objectives. The first is to monitor long-term on-farm research sites devoted to testing and showcasing compost carryover effects of single applications for increased water use efficiency, soil health, wheat yield and quality, and economic viability for dryland organic wheat growers. Second, to test and demonstrate intercropping strategies and new varieties for increased weed management, soil health, wheat yield and quality, and economic viability. The third is to continue to build an innovative Extension program to promote communication among producers, processors, marketers, researchers, Extension personnel, and professional crop advisors by building an interactive, multi-state communication network to enhance the economic viability and environmental sustainability of organic wheat production systems. Outreach efforts, guided by input from our Advisory Council, will target producers, Cooperative Extension personnel, and agricultural professionals who advise producers on organic practices through in -person events (on-farm trials, field tours, winter meetings), printed materials (Extension publications and analysis tools), and digital resources (webinars, webpages, and web-based videos).

OBJECTIVES

The overall, long-term goals of this project are to: 1) continue to monitor and develop long-term on-farm research sites devoted to testing and showcasing organic dryland wheat management strategies for increased water use efficiency, soil health, wheat yield and quality, weed dynamics, and economic viability in the western U.S., and 2) work with county Extension personnel, agronomists, growers, and federal agency personnel to enhance the ability of agricultural producers to grow productive, high quality, sustainable, and profitable dryland organic wheat. We will work towards these goals through the following specific objectives: A. Determine the legacy effects of compost on wheat yield and soil health up to 28 yrs after initial application to dryland soils and further understanding of soil and site characteristics responsible for sustained compost response. B. Measure yield, weed dynamics and grain quality of organic dryland wheat using variety selection, compost and legume intercropping strategies. C. Increase adoption and sustainability of organic wheat production through education and outreach programs including tools to aid decision making by growers on the economic viability of applying compost to organic dryland wheat systems.

APPROACH

Objective A: Long-term replicated field experiments will occur on university research and grower farms. Treatments are arranged in a randomized complete block split-split plot design, with compost rate (0, 12.5, 25, and 50 Mg/ha) as the whole plot, year of compost application (2011, 2012, 2015, 2016, 2019 and 2020) as the split plot, and intercrop (winter pea + wheat or winter wheat + clover and fallow control) as the split-split plot. Treatments will be replicated four times. Wheat will be grown every other year in a wheat-fallow rotation. Plots will be harvested with a small plot combine in July or Aug. of the following year. Winter pea will be intercropped with wheat in alternate rows; the pea crop component will either winter-kill or be removed at 75% canopy closure using an inter-row sweep mounted with an Acura Trak guidance hitch, or be allowed to mature for grain harvest. Clover intercrops will be broadcast seeded onto frozen ground at a rate of 20 kg/ha. Grower Demonstration Trials: Unreplicated demonstration trials on grower farms will be monitored for wheat yield and soil effects. Each site is approximately one ha in size. Compost was applied in June 2014 in UT at four rates (0, 12, 25, 50 Mg/ha). In addition, a replicated trial (3 reps) where compost was applied once in 1994 at 0 and 50 Mg/ha. Soil Health and Fertility: Soil quality will be assessed in all treatments over time and compared to current practices. All standard soil tests will be completed using methods described in Soil and Plant Reference Methods for the Western Region. Sites will be sampled in April during the wheat phase of the rotation and analyzed for nitrate and ammonium, Olsen P, dissolved organic C and N measured in in water extracts, and TOC and N. In addition, readily mineralizable C, basal respiration and microbial biomass, dehydrogenase and phosphatase enzyme activities and aggregate stability will be measured. The following soil tests will be conducted in the final wheat crop of each phase of the rotation (third and fourth year of the project) only: Olsen K, DTPA-extractable elements (Fe, Zn, Cu, Mn); EC; and pH. Soil Moisture and Temperature: To determine crop and cover crop water use, profile soil moisture will be measured at planting and on a monthly basis from May through June of each wheat /wheat intercrop at all sites. Topsoil moisture, temperature and electrical conductivity will be measured daily during the growing season with true TDR-315 probes. Probes will be installed at three depths (2.5, 5, and 15 cm) in all four replicates of two treatments (0 and 50 Mg/ha compost).Soil Fractions and FTIR analysis: In order to assess the potential for C storage over the short term, changes in SOM functional groups will be investigated by ATR-FTIR. Soil micro- and macroaggregates will be physically fractionated. The soil fractions will be analyzed before and after removal of SOC by oxidation with sodium hypochlorite. The soil mineral spectra (post oxidation) will be subtracted from the whole soil spectra to enhance peaks associated with SOM. Samples of the compost amendments and wheat straw residues will be dried, ground to a powder and also analyzed by ATR-FTIR. The resulting spectra will be compared to identify any modifications associated with the different treatments. Untangling the effects of soil type vs. compost type on wheat and soil response: Different types of compost (e.g. manure based compost, yard waste compost and dried stacked manure) will be evaluated in separate trials. Each compost type will be applied at 50 Mg/ha in Sept 2020 with three replicates. Compost will be analyzed using a standard manure characterization. In addition, the composts, manure, wheat straw residues and select soil samples will be analyzed for total, acid soluble and acid insoluble lignin, and lignin monolignols (i.e., guaiacyl, syringyl, and p-hydroxyphenyl).Economic Analysis: A quality requirements assessment will be conducted with organic wheat buyers to determine desired quality attributes, as well as organic wheat demand components. Data will be collected through in-person survey and interviews and will be analyzed with econometric techniques. This will be coupled with an in-depth consumer analysis of the end product characteristics desired and effective communication and promotional messages. This data will be collected through lab and in-store behavioral experiments. The long-term return on investment to compost applications across the study area will also be assessed. This will entail completing multi-year cost and return studies to determine the long-term financial effects of investments in compost . **Objective B**: Weed, Wheat and Intercrop Growth: Plots in Objective A will be evaluated for weed and intercrop growth in May/June of each year. The plant canopy will be assessed using a ceptometer to measure photosynthetically active radiation (PAR) at three locations in each plot. Weed, wheat and intercrop densities will be measured by counting plant numbers in three, randomly placed 0.25- to 1.0-m2 quadrats per plot. Biomass data will be collected in June by harvesting a 1.0-m2 area from each plot, separating weeds, intercrop and wheat and, recording the fresh weight of each and drying a small sub-sample to use in calculating dry weight. Wheat Yield and Quality: Wheat growth in plots in Objective A will be determined by measuring tillers per plant on 10 randomly selected plants per plot, heads per plant for those 10 plants, seeds per head (two per plant), and 1000 kernel weight immediately prior to harvest. Wheat yields will be determined by harvesting each plot with a plot combine. Quality measurements for each plot will include test weight, protein, 2 g mixograph, and lactic acid sedimentation. Multi-State Variety Trials: Twenty cultivars and advanced breeding lines will be tested at two sites each in years two and four. The experimental design will be a randomized complete block split-plot with compost as the whole plot (0 and 50 Mg/ha) and cultivar as the subplot. Phenotypic measurements will include stand establishment and winter survival, height, heading date, plot yield and previously mentioned end-use quality tests. Economic Analysis: The economic analysis will include a risk and return analysis for various intercropping strategies utilizing stochastic simulation methods. A cost-benefit analysis of all wheat varieties under trial will be completed, which will include creating partial cost and return studies for each variety. This analysis will provide valuable information on the overall economic feasibility of each variety in terms of its production costs and impact on revenues associated with yield and quality. **Objective C**: A centerpiece of this project will be the development of an innovative Extension program on dryland organic wheat production. Our model for reaching agricultural producers and professionals is based on using research and demonstration trials as centers of dissemination. This program will integrate traditional outreach efforts with electronic media, and will be guided throughout by input from the Advisory Council. **Progress** 09/01/22 to 08/31/23 **Outputs** Target Audience:Growers, scientists and stakeholders interested in organic dryland production systems and soil health. Changes/Problems:Continuing problems were encountered due to the ongoing 1000 year drought affecting the Intermountain and Pacific Northwest regions. Unusually dry conditions at planting resulted in delayed wheat emergence resulting in poor competition with weeds in the spring. All research sites in Utah, one in Wyoming and one in Montana had to be terminated prematurely to prevent weeds from going to seed. In Utah, record breaking snow fall resulted in heavy spring runoff and flooding at our Snowville field sites which had to be subsequently terminated. Conditions such as this have not been experienced since the first trials were initiated in Snowville in 1994 or our grower cooperator first became certified organic in the early 1980s. Note also that FTEs do not reflect the time committed by all individuals on this project. Five professors associated with the project did not submit their data even after multiple requests. What opportunities for training and professional development has the project provided?Three PhD (Brad Davis at USU and Hannah Rodgers and Christina Helseth at UW) and two MS (Preston Christensen at USU and Iliak Harmsen) students continued their work on the project with Christina and Iliak both defending. In addition, two postdoctoral researchers (Idowu Atoloye and Tatiana Drugova, USU) four research technicians (Nate DuCasse, UT, Leanna Hayes UT, Maya Garby UT, McKenna Brown MT and Holly Lane WA), fifteen undergraduate research assistants (Anna Billings, Bridger Cary, Kayla Hancey, Annie Lawer, Abigail Lazier, Ayla Meek, Caleb Ostvig, Emily Samuels, Cassidy Sawden, and in UT, and Caz, Sophie, Dillon, Cortney, Sarah and Josue in UW) were hired and trained in field maintenance and laboratory protocols. How have the results been disseminated to communities of interest?Two presentations were given to the University of Wyoming Sustainable Agriculture Research and Extension Center Field Day on August 9th, 2023. One journal article was published and six journal articles were submitted. Four presentations were given at the Tri-Society annual meeting. One International conference presentation given to the RETASTE conference in Athens, Greece. One PhD defense presentation. One MS defense presentation The 12 Extension fact sheets published from this project and the prior project have 1,411 total downloads (USU digital commons only). The PhD dissertation and the MS thesis from the previous project have 758 total downloads. The journal articles so far published have been cited 86 times. A webpage for all publications, including Extension and outreach materials for this project with regards to marketing and producer adoption components can be found at: https://extension.usu.edu/apec/organicwheatmarketing. This website had 182 visitors in 2023. What do you plan to do during the next reporting period to accomplish the goals?Objective A:Soil will be sampled, and soil properties determined across all research sites in the wheat phase of the rotation in May 2024. Soil moisture and temperature will be monitored. Backlogs of soil samples incurred during the pandemic will be cleared and the effects of compost on lignin chemistry and soil chemical functional groups will be completed. MS student Preston Christensen will complete his degree on the effects of compost on soil health in dryland wheat. At least four manuscripts will be submitted for publication. Objective B:Given the drought induced problems affecting the wheat and intercrops at most sites,a no cost extension was requested on the project in the hope of obtaining a final year of quality yield data. Fall planted trials will be harvested in Snowville, UT, Wyoming, Montana and Washington. Two cultivar trials will be harvested in Blue Creek and Monticello, UT. Sweet yellow clover will be inter-seeded into existing stands of winter or spring wheat at research sites in MT. PhD student Brad Davis will complete his dissertation on the agronomic and cultivar trials in UT. Objective C: A journal article on policy implications for producer adoption of organic wheat will be completed. At least two fact sheets will also be completed. The economic analysis will be completed by Drs. Larsen and Kim. Journal Articles - Working Curtis, K., and T. Drugova. \"Producer Adoption of Organic Wheat: Policy Implications.\" Working paper. Extension Publications - Working There are two, but titles have not yet been determined. **Impacts** What was accomplished under these goals? Objective A: Soil samples were collected during the wheat phase of the project from three experimental sites in Snowville and Blue Creek, Utah, one in WA, one in MT and one in WY. UT and MT soil samples from the 0-10 cm depth were analyzed for bulk density, gravimetric moisture content, aggregate stability, mineralizable carbon, basal respiration, microbial biomass and dehydrogenase enzyme activity. Ammonium, nitrate, Olsen P and dissolved and total organic carbon and nitrogen and DTAP extractable elements on samples collected to 90 cm soil depth in 30-cm increments are still in progress. Total lignin contents and FTIR spectra were collected on soils and composts all UT sites, the characterization of individual lignin species is in progress. In WA, soil samples were collected at 0-15, 15-30, 30-60 and 60-90cm and analyzed for a suite of nutrients and carbon. Soil samples collected in WY are still being analyzed for nutrients. Moisture sensors were installed in three replicates of the 0 Mg/ha and 50 Mg/ha wheat plots in UT, WY and MT at depths of 7.5, 15, and 22 inches. The sensors sent moisture readings to the cloud every 15 minutes. Water infiltration and penetrometer data were collected on two Snowville sites using the Cornell Sprinkle Infiltrometer and FieldScout penetrometer in early spring. Aggregate stability was measured on two Snowville and one Blue Creek site. A journal article on the continued presence of significant soil health benefits nearly three decades after application was submitted. In depth measurements on soil carbon in Utah show compost induced biochemical changes in soil organic matter at Snowville but not Blue Creek suggesting that compost degradation is affected by site characteristics. Moreover, residue and or compost type affected soil organic carbon and total lignin contents. Two presentations on this work were given at the SSSA annual meeting in November and one at the RETASTE conference in Athens, Greece. In Wyoming, PhD student Christina Helseth defended her dissertation on the project. Results showed no synergy between compost and cover crops but these two practices affected soils and crop yield in different ways. The 45 Mg ha-1 of compost elevated soil organic carbon (SOC), total nitrogen (N), and available phosphorus (AP). Elevated soil labile N and no increases in nitrous oxide emissions point to efficient soil labile N conservation. Cover crops reduced soil water content during growth but did not affect the following wheat crop. However, cover crops reduced weed biomass and diversity as well as increased methane assimilation. A second PhD student Hannah Rogers presented a poster at the SAREC field day and submitted a paper to Soil Biology and Biochemistry on compost effects on soil microbiological properties. In Washington, soil nutrients were highest in 50 Mg ha-1 DW compost treatment. Soil moisture was also increased in treatments with compost, especially the highest compost rate treatment in winter wheat/fallow/winter pea/fallow rotation. No such effects in soil moisture were observed in winter wheat/fallow rotation for this year. There were no significant differences in soil organic matter in Washington, likely due to the deeper sampling depth, however, the highest compost treatment showed numerically highest soil organic matter levels in both the crop rotations. The data was used to assess the efficacy of common greenhouse gas accounting tools and published in the Journal of Cleaner Production and a presentation given at the SSSA annual meeting. Objective B: Wheat was planted at all sites in the fall of 2022. The Snowville and Blue Creek sites in UT, the Deakin site in MT and SAREC site in WY were all terminated prematurely due to drought and or flood induced crop failure. At CARC MT, yellow-flowered sweetclover was planted into targeted wheat plots on 16 May 16, 2023. In MT, an Accupar LP80 PAR meter was used to determine Leaf Area Index in all plots. Fallowed plots were cultivated as needed to suppress weeds. Crop and weed biomass samples were collected on 05 July to determine DM production in each plot. What grain was harvested from selected plots on 10 August. Greater amounts of above-ground wheat dry matter (8195 kg/ha) were produced in plots that had received an application of 50 Mg/ha of composted manure compared with plots receiving an application of 12.5 Mg/ha (2412 kg/ha) or only urea fertilizer (2184 kg/ha; P \< 0.05). Similar trends were detected for wheat grain with greatest amounts produced in plots where 50 Mg/ha composted manure was applied in 2020 (3266 kg/ha) compared with 12.5 Mg/ha of composted manure or urea fertilizer (2043 kg/ha). Wheat yield was lower in plots following sweetclover the previous year (1176 kg/ha) compared with summer fallow (3629 kg/ha), probably because weed pressure was lower in summer fallowed plots. Wheat yield was also highest in the 50 Mg /Ha compost rate in WA, showing that compost application improves dryland productivity over conventional fertilizers in most years even in the highly productive soils of the Palouse region. Previous cultivar trials (20 cultivars with and without compost in 2021 and 2022) in WY were analyzed and a MS student presented a poster at the SAREC field day and defended his thesis on this work. Unlike results from UT and MT where Pronghorn and Wolf were the top performers, the top performing cultivars in WY were Bobcat, Breck, Curlew and WB 4462. Objective C: A survey of wheat growers in the US west was administered in 2022. We are currently analyzing results and expect at least one journal article and two Extension fact sheets will be submitted for review in 2024. A survey of US consumers on preferences and WTP for organic bakery products was conducted in the fall of 2021. Based upon the results four journal articles have been drafted, three are under review, and one was published in a conference proceedings paper in March 2023. Three Extension fact sheets were published in 2023. The 12 Extension fact sheets published from this project and the prior project have 1,411 total downloads (USU digital commons only). The PhD dissertation and the MS thesis from the previous project have 758 total downloads. The journal articles so far published have been cited 52 times. A webpage for all publications, including Extension and outreach materials for this project with regards to marketing and producer adoption components can be found at: https://extension.usu.edu/apec/organicwheatmarketing. This website had 182 visitors in 2023. **Publications** - Type: Other Status: Published Year Published: 2023 Citation: Other: At, I., Creech, J. E., Reeve, J., & Jacobson, A. (2023). Molecular-Level Composition of Soil Organic Matter in Response to Compost Application in Dryland Winter Wheat Systems. Soil Science Society of America **Progress** 09/01/21 to 08/31/22 **Outputs** Target Audience:Growers, industry, government agencies, scientists and extension scientists in the fields of organic wheat and dryland soils. Changes/Problems: The problems encountered this year were a result of the ongoing 1000 year drought affecting the Intermountain and Pacific Northwest regions. At some locations wheat emergence has been poor resulting in poor competition with weeds. Grower cooperators had to terminate their crops prematurely to prevent weeds from going to seed in large numbers and the decision was made at two of the research farm locations to save the trials by spraying herbicide and restarting the transition to organic. These decisions were not taken lightly and were made in an effort to save long-term research trials in the face of unprecedented climate stressors. What opportunities for training and professional development has the project provided? Three PhD (Brad Davis and Preston Christensen at USU and Hannah Rodgers at UW) and two MS (Tina and Iliak) students continued their work on the project. A fourth PhD student defended their PhD on the project. In addition, a postdoctoral researcher (Tatiana Drugova, USU) four research technicians (Greg VanDas UT, Leanna Hayes UT, McKenna Brown MT and Holly Lane WA), eight undergraduate research assistants (Mark Kindred, Daniel Rigby, Brady Christensen and KaSandra Nordgren UT, and three unnamed) have been hired and trained in field maintenance and lab work protocols. How have the results been disseminated to communities of interest? In February 2022, the long-term project in Utah was discussed at an extension outreach meeting for San Juan County crop school in Blanding, UT. Approximately 60-70 people were present. Two presentations were given to the University of Wyoming Sustainable Agriculture Research and Extension Center Field Day on August 21st, 2022. A presentation was also given at the organic crops field day in Moccasin, MT. An article on the effects of compost and cover crops on soil health in organic wheat was also published in the University of Wyoming Field Day Bulletin. The nine Extension fact sheets published from this project and the prior project have 979 total downloads. The PhD dissertation and the MS thesis from the previous project have 643 total downloads. The four journal articles so far published have been cited approx. 31 times. What do you plan to do during the next reporting period to accomplish the goals?Objective A:Soil will be sampled, and soil properties determined across all research sites in the wheat phase of the rotation in May 2023. Soil moisture and temperature will be monitored. A soil incubation study will be completed to evaluate effects of compost type on nutrient cycling and trace gas emissions. Compost samples will be analyzed for lignin chemistry and the effects of compost on soil chemical functional groups determined using FTIR. At least two manuscripts will be submitted for publication. Objective B:fall planted wheat was not planted at Deakin or CARC MT due to the need to take a year out to manage weeds. Sweet yellow clover will be inter-seeded into existing stands of winter or spring wheat at research sites in UT, WY and MT. WA will assess the effect of pea intercrops. Weed, intercrop and wheat species and biomass will be collected. Yield of winter wheat will be determined at harvest. Side trials designed to assess a variety of different intercropping strategies will be initiated. Wheat variety trials will be established in UT, WY and MT. Objective C: Research and analysis for the marketing component of this project has been completed. Two fully drafted journal articles will be submitted for review in early 2023. Another journal article is currently being drafted and will be submitted for review in 2023. Two Extension fact sheets will be submitted for review in 2023 and two additional fact sheets drafted. The economic analysis to be completed by Drs. Larsen and Kim will begin in the spring of 2023 **Impacts** What was accomplished under these goals? Objective A: Determine the legacy effects of compost on wheat yield and soil health up to twenty-eight years after initial application to dryland soils and further our understanding of the soil and site characteristics responsible for sustained compost response. Soil samples were collected during the wheat phase of the project from three experimental sites in Snowville, Utah, one in WA, two in MT and one in WY. UT, MT and WY soil samples from the 0-10 cm depth were analyzed for bulk density, gravimetric moisture content, aggregate stability, mineralizable carbon, basal respiration, microbial biomass and dehydrogenase enzyme activity. Ammonium, nitrate (in progress), Olsen P and dissolved organic carbon and nitrogen were analyzed to 90 cm soil depth in 30-cm increments. DTAP extractable elements, total organic carbon and nitrogen are still in progress. WA cleared a backlog of soil analyses that had accrued in 2020 and 2021 over the pandemic. Water infiltration and penetrometer data were collected on two Snowville sites using the Cornell Sprinkle Infiltrometer and FieldScout penetrometer in early spring. Aggregate stability was measured on three Snowville sites. Surface TDR soil moisture and temperature were measured in the wheat phase at all sites (0 and 50 Mg ha-1 DW). Trace gasses, soil C, N and water content were measured every two weeks in compost amended plots in WY. Labile C and N was measured in deep soil profiles four times over the growing season. Compost sourced from different states was mixed with the WY soil and is under a 10-week incubation. Preliminary results from UT show increased aggregate stability in plots that received compost in 2015 but not in 2019. Samples collected in 2022 support this trend and suggest aggregate stability is initially reduced by compost but then increases with time. In addition, compost reduced soil resistance and increased water infiltration. A journal article was published showing that compost has a positive effect on soil carbon fractions up to 90cm depth in dryland soils in UT. Similar deep soil carbon accrual was observed at the WA site. These changes are attributed to an increase in root growth. Three papers were submitted on soil health assessment, soil mineral and organic matter associated phosphorus and greenhouse gasses after one-time compost applications and cover crops in dryland soils. Four presentations were given at the Tri-Society annual meeting. One PhD defense presentation. Objective B: Measure yield, weed dynamics and grain quality of organic dryland wheat using variety selection, compost and legume intercropping strategies. Wheat was planted and harvested at all sites except

Deakin MT. The Deakin site was terminated prematurely due to crop failure. The measurements included chlorophyll concentration (µmol m-2) at heading and kernel grain fill, tiller count; m2, spike length; cm plant height; cm weed type and population; m2, harvest index, yield kg ha-1. In addition to the measurements taken throughout the growing season, grain quality analysis was also determined. These measurements include protein, moisture, and test weight. Yields were relatively low overall due to the ongoing drought and intense weed pressure although a strong compost response was still seen at most sites with the exception of CARC where stands were highly variable due to weeds and pests. In UT, the highest compost rate (50 Mg ha-1) for 2015 and 2019 application dates provided the highest yield response over all other application rates confirming the presence of significant legacy effects to compost. The sweet clover intercrop decreased wheat yield and biomass by 50% at CARC likely due to increased competition due to poor wheat stands. Intercrops failed to establish in UT due to a really cold spell after emergence. Cultivar trials (20 cultivars with and without compost) were harvested in two locations in UT Monticello and USU Blue Creek in the Pocatello valley area, and one location in MT and WY. In MT, one site had to be terminated prematurely due to weed and pest pressure, at the second site wheat grown with compost performed worse than without compost, likely caused by a combination of reduced stands and increased weed pressure. Data collected at each location included spike length, height, tiller count, harvest index, yield, and grain quality analysis. Data collected at the Blue Creek farm due to the proximity of the trial included heading date and chlorophyll concentration at heading and kernel grain fill. The SY wolf variety had the highest yield at the Blue Creek location, and the Pronghorn variety was the best performer at Monticello. SY Wolf was also the top performer in MT. There was no significant interaction between compost application (none; 25 Mg ha-1) and variety at the UT or MT sites. The data from WY is still being analyzed. A journal article was published describing the results from the early phase of the work in WY. An invited symposium presentation and poster on wheat yield response to compost in UT was presented at the ASA CSSA & SSSA annual meetings. Objective C: Increase adoption and sustainability of organic wheat production through education and outreach programs including tools to aid decision making by growers on the economic viability of applying compost to organic dryland wheat systems. A wheat quality needs assessment was conducted with organic wheat buyers (millers and bakeries) using two separate online surveys. One journal article was published based upon these results. A survey of wheat growers (both organic and non-organic) was developed and administered in 2021/2022. We are currently analyzing results and expect at least one journal article and two Extension fact sheets will be submitted for review in 2023. A survey of US consumers on preferences and WTP for organic bakery products was conducted in the fall of 2021. Based upon the results three journal articles have been drafted, one is under review, and the two others will be submitted in January 2023. Two Extension fact sheets were written and will be submitted for review in 2023. One paper was presented at an academic conference in October 2022 and a corresponding conference proceedings paper will be published in March 2023. A webpage for all publications, including Extension and outreach materials for this project with regards to marketing and producer adoption components can be found at: <https://extension.usu.edu/apec/organicwheatmarketing>. This website had approx. 55 visitors in 2022. The economic analysis will begin in late 2022 due to delays in data collection. Dr. Larsen has started to develop the enterprise budgets that will be used to assist Dr. Kim in the economic analysis of varying intercropping strategies. Drs Larsen and Kim will finish the economic analysis by spring 2023. **Publications** - Type: Journal Articles Status: Published Year Published: 2022 Citation: Atoloye, I. I., Jacobson, A., Creech, J. E., & Reeve, J. (2022, July). Soil organic carbon pools and soil quality indicators 3 and 24 years after a one-time compost application in organic dryland wheat systems. Soil and Tillage Research, 224. - Type: Other Status: Published Year Published: 2022 Citation: Christensen, P., Jacobson, A., Creech, J. E., & Reeve, J. (2022). Amendment type influences aspects of soil physical health in dryland organic wheat systems. American Society of Agronomy. **Progress** 09/01/20 to 08/31/21 **Outputs** Target Audience:Growers and industry representatives in the organic wheat industry. Researchers in the fields of soil science, agronomy, economics and marketing. Changes/Problems:Follow on impacts of the Covid19 pandemic resulted in a number of delays to our plan of work for 2021. A backlog of samples is still being worked through due to delays incurred by the covid19 pandemic. Two soil microbial datasets (from Blue Creek UT and CARC MT) were lost due to mishandling of samples by an undergraduate student worker. A particularly harsh drought throughout the Pacific and Intermountain west negatively impacted wheat and intercrop establishment and reduced yields. In person meetings were delayed and or cancelled due to ongoing pandemic restrictions. What opportunities for training and professional development has the project provided? Two new graduate students (Tina and Iliak) were recruited and hired at UW and a new PhD student Brad Davis was hired at USU. Two PhD students continued their work on the project Preston Christensen at USU and Hannah Rodgers at UW. These two students are leading plot management and soil analysis efforts at the UT and WY sites respectively. One student at USU (Michael Deakin) finalized his thesis for completion of his MS degree in Plant Science. In addition, a postdoctoral researcher (Tatiana Drugova, USU) three research technicians (Keenen Crummitt UT, Leanna Hayes UT, McKenna Brown MT), four undergraduate research assistants (KaSandra Nordgren, Brady Christensen and two unnamed) have been hired and trained in field maintenance and lab work protocols. How have the results been disseminated to communities of interest?A presentation was given to the NRCS workshop Working Effectively with Organic Producers - Utah. Two presentations were given to the University of Wyoming Sustainable Agriculture Research and Extension Center Field Day on August 23rd, 2021. An article on the effects of compost and cover crops on soil health in organic wheat was also published in the University of Wyoming Field Day Bulletin. Thus far, nine Extension fact sheets have been published from this project and the prior project with 697 total downloads. The PhD dissertation and the MS thesis from the previous project have had 535 total downloads. The four journal articles so far published have been cited approx. 16 times as of this report. What do you plan to do during the next reporting period to accomplish the goals? Objective A: Determine the legacy effects of compost on wheat yield and soil health up to twenty-eight years after initial application to dryland soils and further our understanding of the soil and site characteristics responsible for sustained compost response. Soil will be sampled, and soil properties determined across all research sites in the wheat phase of the rotation in May 2022. Soil moisture and temperature will be monitored. A soil incubation study will be completed to evaluate interaction effects between compost type and soil type on nutrient cycling and trace gas emissions. Compost samples will be analyzed for lignin chemistry and the effects of compost on soil chemical functional groups determined using FTIR. At least two manuscripts will be submitted for publication. Objective B: Measure yield, weed dynamics and grain quality of organic dryland wheat using variety selection, compost and legume intercropping strategies. Sweet yellow clover will be inter-seeded into existing stands of winter or spring wheat at research sites in UT, WY and MT. WA will assess the effect of pea intercrops. Weed, intercrop and wheat species and biomass will be collected. Yield of winter wheat will be determined at harvest. Side trials designed to assess a variety of different intercropping strategies will be initiated. Wheat variety trials will be established in UT, WY and MT. Objective C: Increase adoption and sustainability of organic wheat production through education and outreach programs including tools to aid decision making by growers on the economic viability of applying compost to organic dryland wheat systems. A grower advisory committee meeting will be held in UT and online in February. A second grower advisory and project participant meeting will be held in WY in June in conjunction with a summer field day. Wheat grower survey data is currently being analyzed and expect at least one journal article and two Extension fact sheets will be written and submitted in 2022. We may also do phone-based grower interviews to supplement survey results. Consumer survey data is currently being analyzed and we expect at least three journal articles, and 4-5 Extension fact sheets will be written and submitted in 2022. The expect to have the journal article under submission published or at least forthcoming in 2022 and a current working paper submitted in early 2022. The economic analysis to be completed by Drs. Larsen and Kim will begin in the spring of 2022. **Impacts** What was accomplished under these goals? Objective A: Determine the legacy effects of compost on wheat yield and soil health up to twenty-eight years after initial application to dryland soils and further our understanding of the soil and site characteristics responsible for sustained compost response. Compost was applied to unamended plots in the main trials in MT and WY and to a grower cooperator farm in MT. A new trial was established in Snowville Utah to test the effect of compost that varied in lignin type with and without additional nitrogen (eight treatments with four replicates). TDR soil moisture and temperature was measured in the wheat phase at Snowville, Blue Creek and CAREC during the 2021 growing season and new sensors were installed at all sites shortly after planting (0 and 50 Mg ha-1 DW) at 3, 6 and 9 inches depth in the fall of 2021. Data collected: Soil samples were collected during the wheat phase of the project from two experimental sites in Utah Snowville and Blue Creek, two in WA, two in MT and one in WY. UT, MT and WY soil samples from the 0-10 cm depth were analyzed for bulk density, gravimetric moisture content, aggregate stability, mineralizable carbon, basal respiration, microbial biomass, dehydrogenase, phosphatase enzyme activities (Blue Creek and Montana still in progress). Organic C and total N measurements on that depth are also still in progress. Also, pH and electrical conductivity were measured on the 0-30 cm samples. Ammonium, nitrate, and dissolved organic carbon and nitrogen were analyzed to 90 cm soil depth in 30-cm increments. Olsen P and total organic carbon and nitrogen are still in progress. Water infiltration and penetrometer data were collected on Snowville plots using the Cornell Sprinkle Infiltrometer and FieldScout penetrometer in early spring of 2021. A methods comparison for aggregate stability was conducted on Snowville soils in an effort to test which method was most sensitive at determining stability in unstable soils. The methods used were; wet aggregate stability (Kemper and Rosenau), Slakes smart phone application, and dry sieving. Further testing will include the Cornell Sprinkle Infiltrometer for wet aggregate stability. WA soil samples were collected and frozen and or airdried as appropriate and stored for future analysis due to an ongoing backlog due to covid19 lab access restrictions. WY measured trace gasses from plots that received compost in 2016. Summary of results: Preliminary results from UT show an increase in aggregate stability in plots that received compost in 2015 but not in 2019. In addition, penetrometer data and water infiltration data suggest compost improves soil physical health. Two journal articles were published describing the results from the early phase of the work at Blue Creek and the short and long-term effects of compost on soil phosphorus dynamics. A third paper was published on the effects of semiarid wheat management practices on soil microbial properties. A journal article was submitted showing that compost has a positive effect on soil carbon fractions up to 90cm in depth in dryland soils, likely due to enhanced root growth. Four presentation was given at the Tri-Society annual meeting. Objective B: Measure yield, weed dynamics and grain quality of organic dryland wheat using variety selection, compost and legume intercropping strategies.

Wheat was planted and harvested at all sites except Snowville UT and Deakin MT, which were terminated prematurely by the growers due to crop failure caused by the drought. Yields were relatively low overall, although at CARC MT, yields in the 50 mg/ha compost treatment were almost twice that of the urea fertilizer control. Similar benefits of compost under drought conditions were observed in WA. Intercrops failed to establish in UT and WA due to a lack of soil moisture. Cultivar trials (20 cultivars with and without compost) were also established in two locations in MT and UT and one location in WY. A poster on wheat yield response to compost in UT was presented at the 2020 ASA CSSA & SSSA annual meetings. Objective C: Increase adoption and sustainability of organic wheat production through education and outreach programs including tools to aid decision making by growers on the economic viability of applying compost to organic dryland wheat systems. A virtual grower advisory meeting with members participating from all four states was held on February 24th, 2021. Two presentations were given to the University of Wyoming Sustainable Agriculture Research and Extension Center Field Day on August 23rd, 2021. An article on the effects of compost and cover crops on soil health in organic wheat was also published in the University of Wyoming Field Day Bulletin. A wheat quality needs assessment was conducted with organic wheat buyers (millers and bakeries) using two separate online surveys. Results were presented at the project advisory meeting in February 2021. Two Extension fact sheets and one journal article were written based upon study results. The fact sheets were published in June 2021 and the journal article is under review. The in-person interviews planned could not be conducted due to COVID-19 based restrictions IRB has in place that prohibit in-person data collection. Phone interviews were conducted with two bakers and three wheat millers for input and testing of the survey instruments. A survey of wheat growers (both organic and non-organic) was developed and administered in summer/fall of 2021. Again, in-person interviews weren't possible due to COVID based IRB restrictions. We are currently analyzing results and expect at least one journal article and two Extension fact sheets will be written and reviewed in 2022. A survey of US consumers on preferences and WTP for organic bakery products was conducted in the fall of 2021 with 659 consumers responding. In-person based economic experiments were not allowed due to COVID based IRB restrictions. We are currently analyzing results and expect at least three journal articles and 4-5 Extension fact sheets will be written and reviewed in 2022. Three journal articles have been outlined and literature review completed. A webpage for all publications, including Extension and outreach materials for this project with regards to marketing and producer adoption components was completed and can be found at: https://extension.usu.edu/apec/organicwheatmarketing. This website had approx. 40 visitors in 2021 so far. **Publications** - Type: Journal Articles Status: Published Year Published: 2021 Citation: Adeleke, K., Atoloye, I., Creech, J. E., Dai, X., & Reeve, J. (2021, June). Nutritive and non-nutritive effects of compost on organic dryland wheat in Utah. Agronomy Journal, 113, 3518-3531. - Type: Journal Articles Status: Published Year Published: 2021 Citation: Atoloye, I. A., Jacobson, A., Creech, J. E., & Reeve, J. (2021, May). Variable impact of compost on phosphorus dynamics in organic dryland soils following a one-time application. Soil Science Society of America Journal. - Type: Other Status: Published Year Published: 2021 Citation: Christensen, P., Jacobson, A., Creech, J. E., & Reeve, J. (2021). Compost Effects on Physical Aspects of Soil Health in Dryland Organic Wheat Systems. American Society of Agronomy. - Type: Other Status: Published Year Published: 2021 Citation: Christianson, B., Christensen, P., Jacobson, A., & Reeve, J. (2021). Methods comparison for determining wet aggregate stability in organic, compost-treated, semi-arid, calcareous soils. American Society of Agronomy. - Type: Other Status: Published Year Published: 2021 Citation: Reeve, J., Atoloye, I., Adeleke, K., Jacobson, A., & Creech, J. E. (2021). Compost effects on particulate organic matter, mineral associated organic matter and soil health in surface and sub-soils of organic dryland wheat. American Society of Agronomy. - Type: Conference Papers and Presentations Status: Other Year Published: 2021 Citation: Presentations Reeve, J., Creech, J. E., Working Effectively with Organic Producers, \"Soil health in organic orchards and dryland wheat systems.,\" NRCS workshop. (April 2021 - April 23, 2021)

PROGRESS

2019/09 TO 2020/08 Target Audience:Growers, industry stakeholders, researchers and extension personnel in crop, soil and business management of dryland grain production. Changes/Problems:Covid19 pandemic restrictions resulted in a number of delays to our plan of work for 2020. In person field days were cancelled and the implementation of wheat variety and compost type trials were delayed until 2021. In WA soil samples were taken but had to be stored for future analysis. The establishment of the two new sites in Montana were delayed until spring of 2021 due to unseasonably dry field conditions that precluded the planting of winter wheat at those locations before the arrival of snow. What opportunities for training and professional development has the project provided?Two new PhD students were recruited and hired, Preston Christensen at USU and Hannah Rodgers at UW. These two students are leading plot management and soil analysis efforts at the UT and WY sites respectively. In addition, a postdoctoral researcher (Tatiana Drugova, USU), two research associates (Idowu Atoloye USU, Carol McFarland WA) and four research technicians (Preston Christensen UT, Keenen Crummitt UT, Leanna Hayes UT, Heather Fryer MT, Sally Dahlhausen MT), two undergraduate research assistants

(KaSandra Nordgren and Erin Mortensen) and a program assistant (Taylor Thompson) have been hired and trained in field maintenance and lab work protocols. How have the results been disseminated to communities of interest?A presentation and a poster on the project were given at the High Plains Organic Conference in Wyoming Organic Association winter meeting on February 27th, 2020 to 106 participants and three presentations were made to the USU Extension Crops Virtual Field Day on July 28th 2020. Topics included compost for dryland organic wheat, cover crops for dryland wheat and cover crop and compost impacts on soil health in organic dryland wheat. Each of these presentations attracted 80 participants. Youtube videos of the presentations have received 177, 140 and 75 views respectively to date. What do you plan to do during the next reporting period to accomplish the goals?Objective A:Soil will be sampled and soil properties determined across all research sites in the wheat phase of the rotation in May 2021. Baseline soil samples will be taken in early spring, prior to establishment of treatments at both locations in Montana. Installation of soil moisture and temperature sensors will be completed and measurements taken. New plots will be established in Montana. A new trial to assess the importance of compost/manure type/composition will be established. At least two manuscripts will be submitted for publication. Objective B:Sweet yellow clover will be inter-seeded into existing stands of winter or spring wheat at research sites in Utah, Wyoming and Montana. WA will assess the effect of pea intercrops. Weed, intercrop and wheat species and biomass will be collected. Yield of winter wheat will be determined at harvest. Side trials designed to assess a variety of different intercropping strategies will be initiated. Wheat variety trials will be established in Utah, Wyoming and Montana. Objective C:A grower advisory committee meeting will be held in Utah in February. A second grower advisory and project participant meeting will be held in Wyoming in June in conjunction with a summer field day (Covid 19 restrictions permitting). The analysis for the two surveys described in objective C under accomplishments will be completed by summer 2021 and academic and outreach materials will be outlined at that time. Submissions for winter and spring 2022 conferences will be completed in summer and fall 2021. A consumer preference and behavioral change experiments for organic wheat products will be conducted using the experimental economics lab and in-store taste tests coupled with a survey, hopefully, in the late spring or early summer of 2021 when the COVID based restrictions end. Assuming the experiments take place in spring/summer 2021, the analysis will be done by December 2021 and academic and outreach plans will be outlined at that time. Submissions for spring and summer 2022 conferences will be completed in the winter of 2022. The economic analysis to be completed by Drs. Larsen and Kim will begin in the spring of 2021. An article will be prepared for publication in a trade journal and work on developing a website dedicated to organic dryland wheat production will commence.

IMPACT

2019/09 TO 2020/08 What was accomplished under these goals? Objective A: Compost was applied to unamended plots at Snowville and Blue Creek, in UT, WY and WA. TDR soil moisture and temperature sensors were installed at UT sites shortly after planting in plots that received compost (0 and 50 Mg ha-1 DW) in 2011 (Blue Creek) and 2015 (Snowville) at 3, 6 and 9 inches depth. New sites in Montana were prepared for establishment of plots. Manure was sourced and supplies acquired for the establishment of manure treatments. Data collected: Soil samples were collected during the wheat and fallow phase of the project from three experimental sites at Snowville UT, two in WA and one in WY. In UT, soil samples from the 0-10 cm depth were analyzed for bulk density, gravimetric moisture content, aggregate stability, mineralizable carbon, basal respiration, microbial biomass, dehydrogenase, phosphatase enzyme activities, total organic carbon, and nitrogen. Also, pH and electrical conductivity were measured on the 0-30 cm samples. Olsen P, ammonium, nitrate, total organic carbon and nitrogen, and dissolved organic carbon and nitrogen were analyzed to 90 cm soil depth in 30-cm increments. Soil moisture was measured on a fortnightly basis from May through June as deep as possible. WA soil samples were frozen and or airdried as appropriate and stored for future analysis due to covid19 lab access restrictions. WY collected soil samples from each fallow plot on September 18, 2020, and analyzed for SOM components, including labile C and N pools on fresh field moist samples. Results are being compiled. Summary of results: At the UT site established in 1994, a significant compost carryover effect was still observable 26 years later. The available soil phosphorus, P, acid phosphates and dehydrogenase enzyme activities were significantly higher in plots that received compost compared with the control plots. In the plots established in 2015 at Snowville, compost significantly increased soil dehydrogenase activity, and acid and alkaline phosphatase enzyme activities. Readily mineralizable carbon and microbial biomass were significantly higher in amended plots. Likewise, the soil available P was higher in amended plots compared with control plots. In Washington, the medium and high rates of compost continue to yield wheat crops in excess of 100 bu/acre. The positive effect of including pea in the rotation is starting to become evident, particularly at the low compost rate. Two journal articles were submitted describing the results from the early phase of the work at Blue Creek and the short and long-term effects of compost on soil phosphorus dynamics. Two presentation was given at the Soil Science Society annual meeting. Objective B: Winter wheat was planted on research sites in Utah, Wyoming and Washington State. Organic seed (winter wheat and sweetclover) was purchased, however plot establishment and planting in Montana was delayed due to adverse weather. Two new graduate students were recruited to work on this objective in Utah and Wyoming. In Wyoming, preliminary screening trials for new cover crop treatments were initiated on August 24, 2020, including: 1) winter-hardy mix of vetch, lentil, and triticale planted into fallow after wheat harvest to be terminated in late spring 20201; and 2) a cold-sensitive mix of safflower, crimson clover, phacelia, and nitro radish planted into fallow ground three weeks before wheat planting. Two more screening treatments will be planted in March, 2021, including: 1) fast-growing mix planted in fallow, terminated in May; 2) intercropping yellow-blossom sweet clover (winter-hardy biennial) into wheat, terminated in May, 2022; and 3) intercropping a cold sensitive summer annual into wheat. We will evaluate these treatments in spring and summer 2021 and decide which to continue and combine with compost treatments. A poster was presented at the 2020 ASA CSSA & SSSA annual meetings: Objective C: University restrictions in place because of covid19 prevented face-to-face and other interactions with stakeholders starting in March of 2020. Public access to research sites in Montana was prohibited until mid-summer and was restricted thereafter. One in person presentation and a poster were given to 106 participants at the 2020 High Plains Organic Conference and three presentations were given at the Utah Field Crops Virtual Field Day with attendance of 80 individuals at each. A wheat quality needs assessment is currently being conducted with organic wheat buyers (millers and bakeries) using two online surveys. The surveys were developed and are being distributed by two industry organizations. USU staff are also calling and emailing mills and bakeries to complete the surveys. The in-person surveys and interviews planned could not be conducted due to COVID-19 based restrictions IRB has in place that prohibit in-person data collection. A separate survey for wheat growers (both organic and non-organic) has been developed and will be administered in January 2021. Again, in-person interviews won\'t be possible due to COVID based IRB restrictions. We are currently considering phone interviews. This research will build upon that done on this topic in the previous grant. We hope to secure additional input and observations. Two journal articles and two extension factsheets were published. **PUBLICATIONS (not previously reported):** 2019/09 TO 2020/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Presentations Atoloye, I. A. (Presenter & Author), Reeve, J. (Author Only), Jacobson, A. (Author Only), Creech, J. E. (Author Only), Soil Science Society of America Annual Meeting, \"Effects of cover crops and a one-time compost application on soil health in organic dryland winter wheat-fallow systems.\" (November 9, 2020 - November 12, 2020) 2. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Presentations Reeve, J., High Planes Organic Conference, \"Soil building practices in driest dryland wheat production,\" Cheyenne, WY. (February 27, 2020) 3. Type: Conference Papers and Presentations Status: Other Year Published: 2020 Citation: Presentations Reeve, J., Soil Health Water Conservation Training, \"Soil health building in dryland, pastures, forages and orchards,\" Utah State University Extension. (February 20, 2020) 4. Type: Other Status: Published Year Published: 2020 Citation: Atoloye, I. A., Reeve, J., Jacobson, A., & Creech, J. E. (2020). Effects of cover crops and a one-time compost application on soil health in organic dryland winter wheat-fallow systems. Soil Science Society of America.

↑ Return to Index

Organic Alternatives to Conventional Celery Powder as a Meat Curing Agent

Accession No.	1020528
Project No.	WIS03027
Agency	NIFA WIS\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2019-51300-30243
Proposal No.	2019-03095
Start Date	01 SEP 2019
Term Date	31 AUG 2023
Grant Amount	$1,999,999
Grant Year	2019
Investigator(s)	SILVA, E. M.; MITCHELL, PA, D.; Zhao, XI.; SINDELAR, JE, J.; Shade, JE.
Performing Institution	UNIV OF WISCONSIN, 21 N PARK ST STE 6401, MADISON, WISCONSIN 53715-1218

NON-TECHNICAL SUMMARY

We will address current and future needs of the organic processed meat industry, particularly in the development of systems allowing for the increased production of organically grown celery powder and/or other crop alternatives that will benefit both the biology and economics of the organic crop rotations being used by farmers across the U.S. This addresses a critical and imminent issue facing the organic cured meat industry: the lack of availability of organic vegetable curing powder, which could impede further growth and potentially erode market shares. We propose to conduct vital research and extension activities to address these barriers facing the organic cured meat industry, bringing together a multiregional team of researchers, extension personnel, and industry stakeholders to establish a Working Group comprised of a \"consortium of expertise\" in organic horticultural and agronomic production, economics, and meat processing. Long-term Project Goal: The long-term goal is to help establish fully organic sources of curing powders to expand markets for organic cured meat. Mid-term goals include 1) increasing availability of organic vegetable curing powder by developing best management practices that result in adequate vegetable nitrate concentrations; and 2) confirming the efficacy of organic vegetable curing powders in commercial cured organic meat products, ensuring adequate quality and food safety. Through project activities, we will develop strategies across the supply chain to ensure an adequate quantity of curing powders from organically produced crops to meet the needs of the expanding organic processed meat industry without comprising system sustainability and environmental or human health.

OBJECTIVES

Our team will conduct agronomic, meat science/processing, and economic research responding to the key issues that had been identified throughout our planning grant activities to ensure an adequate supply of organic vegetable curing agent. The complexity of the issues related to developing a supply of organic curing powder will necessitate a research and outreach approach that integrates crop genetics, crop management, yield of raw and extracted product, and economics, and accounts for the needs of farmers and processors. The activities will also adhere to the letter and spirit of the NOP regulation and maintain land stewardship as a guiding principle. The objectives are: Objective 1-Assessment of impacts of nitrogen (N) fertility, variety selections, and environment on nitrate levels in organic celery, chard, and beets. Objective 2- Quality and safety assessment of cured meat products using organic vegetable powder. Objective 3- Economic and market assessment of organic celery powder and cured meat. Objective 4- Extension and outreach of project results

APPROACH

Assessment of impacts of nitrogen (N) fertility, variety selection, and environment on nitrate levels in organic celery, chard, and beets, Methods: Transplants of four cultivars of organic celery (\"Calypso\", \"Tall Utah\", \"Conquistador\", \"Mission\", the top four varieties emerging from preliminary testing) will be started using organic production methods in February 2020. In mid-May, 8-week old certified organic transplants will be set out in the fields. The whole-plot factor will include three cover crop treatments (red clover (summer planted at rate of 12 lbs/ac) and winter field peas and chickling vetch (spring planted at 50 lbs/ac). The split-plot factor will include fertilizer application, with treatments including a single application of CPM and feathermeal (depending on field NPK needs, to prevent excess phosphorus accumulation in the soil) at a rate of 200 lbs/ac (as per the standard recommendation for the FL conventional celery industry) and the second as an initial application of CPM and feathermeal at a rate of 120 lbs per ac as a sidedress treatment, with an equivalent rate 10 lbs/ac applied weekly from weeks 5-12. The split-split plot factor will include celery variety. Plots for each variety will be 15 ft long, with 6 rows wide set 30\" apart. Plants will be spaced at 10\" apart, with a 10\" buffer at beginning and end of plot (making for a 20\" aisle between plots). Soils will be sampled before fertilizer applications and at harvest for nitrate-nitrogen, ammonium, and total N, with samples analyzed at the UW Soil and Plant Analysis Laboratory. Celery cultivars will be sampled at two maturity dates (early versus late, 80 and 110 after transplanting) to compare nitrate concentrations in the whole plant. At harvest, entire plants (leaves and petioles) from the middle rows of each subplot treatment will be cut at the soil line (approximately fifteen lbs. fresh weight of material). Individual plant samples will be bulked from each subplot, with any decayed material discarded. A subset of the material will be set aside to measure both plant wet and dry weight (drying at 60 C for 24-48 hours or until constant weight) in order to determine yield. Plants will be processed for nitrate analysis as per industry protocol standards (Kerry Food, personal communication). Plants will be held at 45 F in storage prior to processing. Within three days of harvest, whole plants will be blanched in boiling DI water for three minutes to deactivate enzymatic activity. After 3 minutes, plants will be removed from the pot and cooled. Blanched material will then be chopped using a food processor for 30-60 sec or until pureed. Vegetable puree will then be frozen at -20 C until nitrate analysis is performed. Initial evaluation of nitrate concentrations will be conducted at UW-Madison using a dedicated high-performance liquid chromatography HPLC instrument (ENO-20 NOx analyzer, EiCom USA, San Diego, CA).Quality and safety assessment of cured meat products using organic vegetable powder. Samples of each of the vegetables tested which meet the desired industry standards (stable nitrate levels exceeding a 1200 ppm threshold with good nitrate:nitrite conversion efficiency) will be used for efficacy testing in commercially produced organic meat and poultry products after each field season. The ingredient samples will first be converted from nitrate-to-nitrite by Kerry Ingredients and sent to the University of Wisconsin Meat Science and Muscle Biology Laboratory for subsequent testing. Physiochemical and sensory testing will be conducted on products in which the ingredients are incorporated to determine the impact they may have on important quality and consumer acceptability properties of organic processed meat and poultry products. Quality Assessment:Boneless ham and frankfurters are well known in the meat and poultry industries to yield cured color development and consistency challenges as a result of alternative curing (Kerry Ingredients, personal communication, 2016). Deli-style turkey breast will include both quality and sensory evaluations as color and flavor impacts are commonly observed by the meat and poultry industries (personal communication, 2016). All experiments will be designed so results can be comparative and relatable to previously completed conventional celery juice powder work. Past quality research in our lab investigating purified and natural (non-organic) sources of nitrate and nitrite will be used to develop experiments minimizing unnecessary overlap as well as to allow the most value results to be generated. Boneless ham and frankfurters treatments (11.34 kg batches) will be formulated with varying concentrations (n=\<3; e.g. 50, 75, 100 mg/kg) of organic nitrite to investigate the impact organic sources of nitrite have on important product quality attributes including color, color pigment, pH, lipid oxidation, and residual nitrite. Due to the importance nitrite has on product quality shelf life, the quality measurements mentioned will be taken over a 90-day storage time. Food Safety Assessment: To address the impact that the inclusion of these ingredients has on the food safety of organic processed meat products, the same/similar approach used for the quality assessment will take place with experiments focusing on Part II products (evaluation on smaller number of ingredients). Efficacy of the organic sources of nitrate and nitrite to control Listeria monocytogenes and Clostridium perfringens will be developed to confirm the same efficacy is present to control these pathogenic bacteria as for purified and natural sources inclusion. Microbiological methods (including inocula preparation, inoculation, and sampling) will closely mimic procedures conducted for previous studies completed at the University Wisconsin-Madison in partnership with the Food Research Institute. Economic and market assessment of organic celery powder and cured meat. Celery cost estimates will be based on enterprise budgets built for each region. The first step will be to build a draft enterprise budget for organic celery production based on available budgets and general knowledge from having developed the Veggie Compass Tool (http://www.veggiecompass.com/) (Silva et al. 2014). For example, UC-Davis Department of Agricultural and Resource Economics has several vegetable cost and returns studies available online, including one for celery: (<http://coststudies.ucdavis.edu/current/>). University of Florida has a similar budget system for celery (<http://ufdc.ufl.edu/IR00004163/00001>), and Michigan State University for Midwestern production (<https://msu.edu/user/blackj/>). These budgets will be updated for current prices and converted to organic production as a first draft. Next, we will \"ground truth\" budgets by working with growers in each region. Working with co-PIs and/or industry partners in each region, extension specialists and industry contacts, grower focus groups will be recruited from each region. This process was successfully used to develop and refine the Veggie Compass Tool for Midwestern small vegetable producers (Silva et al. 2014) and will be replicated again for this project. Participants will receive draft budgets, including initial cost and yield estimates, in advance and be asked to provide feedback, either in person, by writing or via teleconferences. In-person meetings will be \"piggy-backed\" on existing meetings if possible, by hosting short sessions at farmer extension meetings or conferences (e.g., MOSES Organic Farming Conference, EcoFarm Conference). Based on this feedback, enterprise budgets for each region will be finalized, including expected cost and yield, giving expected cost to produce organic celery as \$ per acre and \$ per pound of celery. Progress 09/01/19 to 08/31/24 Outputs Target Audience:Our target audiences included the following: 1) farmers producing organic celery for processing 2) Industry partners producing organic cured meats 3) other organic researchers and students with overlapping interests 4) consumers and the broader public interested in organic products. This outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science and the International Congress of Meat Science and Technology, and at presentations at Natural Products Expo West. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?UW-Madison: This project involved three graduate students, one in plant sciences, and one in meat sciences. These students have had opportunities to present their research at both farmer and professional society conferences. Results on the residual nitrite and nitrate in processed meats were presented at the American Meat Science Association\'s Annual Reciprocal Meat Conference (Oklahoma City). In addition, these results were included in a two-page paper and a poster presented at the 70th International Congress of Meat Science and Technology held in Brazil. Conference Presentations/Abstracts/Short Papers Washam, O. and E. Silva. 2022. Organic Alternatives to Conventional Celery Powder As a Meat Curing Agent. American Society of Horticultural Science Annual Conference, Chicago, IL. Aug 2022. Sheng, S., Sindelar, J.J., Silva, E.M., Claus, J.R. 2024. Survey of residual nitrite and nitrate in processed meats from small processors and in meat analogues at retail in the United States. 70th International Congress of Meat Science and Technology Conference, Foz do Iguacu, Brazil. August 18-23. Short Paper ID 329 Sheng, S., Sindelar, J.J., Silva, E.M., Claus, J.R. 2024. Survey of residual nitrite and nitrate in processed meats from small processors and in meat analogues at retail in the United States. American Meat Science Association. 77th Reciprocal Meat Conference. Oklahoma City. June 17-19. Abstract and E-poster #153 U of FL: This project has provided ample opportunities for the Ph.D. student to lead research trials and developing multifaceted skills in experimental design and implementation, sampling, field instrumentation, lab work, data analysis and interpretation, and scientific writing. The graduate student has gained a comprehensive understanding of organic production systems, soil fertility and soil health management, plant available N dynamics, N assimilation and accumulation, and food quality. In addition, the graduate student has been actively involved in regular project meetings and dissemination of research findings through professional conferences and field days. The postdoctoral researcher and biological scientists who assisted with certain research activities also had the opportunity to strengthen their research skills as well as teamwork and communication skills. The undergraduate assistants received various training in research throughout the project period by working with the graduate student to complete field experiments and lab assays. The extension agent working with us to organize field days was able to learn more about organic celery production and nutrient management and since then has become an outreach collaborator on other organic cropping systems projects. Conference Presentations Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2024. Exploring plant-available nitrogen dynamics under integrated organic nutrient management. Florida State Horticultural Society Annual Meeting, Orlando, FL. Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2024. Integrating compost and sunn hemp cover crop residue in an organic celery production system. Florida State Horticultural Society Annual Meeting, Orlando, FL. Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Effects of organic fertilizer source and nitrogen application rate on growth, quality, and tissue nitrogen dynamics in organic celery. American Society for Horticultural Science Annual Conference, Orlando, FL. Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Evaluating integrated nitrogen fertilization programs for organic celery production. American Society for Horticultural Science Annual Conference, Orlando, FL. Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2023. Tackling nitrogen fertilization for improving organic celery production: fertilizer source, preplant fertilization, and in-season fertigation. Florida State Horticultural Society Annual Meeting, Daytona Beach, FL. Ray, Z.T., L. Zotarelli, and X. Zhao. 2022. Comparing two types of granular organic fertilizers in organic celery production. Florida State Horticultural Society Annual Meeting, Sarasota, FL.

Ray, Z.T. and X. Zhao. 2022. Yield and quality attributes of organic celery as affected by cultivar selection and harvest scheduling. American Society for Horticultural Science Annual Conference, Chicago, IL. Abstracts Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Evaluating integrated nitrogen fertilization programs for organic celery production. HortScience 58:S262. Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Effects of organic fertilizer source and nitrogen application rate on growth, quality, and tissue nitrogen dynamics in organic celery. HortScience 58:S45. Ray, Z.T. and X. Zhao. 2022. Yield and quality attributes of organic celery as affected by cultivar selection and harvest scheduling. HortScience 57:S96-S97. Conference Proceedings Articles Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2023. Tackling nitrogen fertilization for improving organic celery production: fertilizer source, preplant fertilization, and in-season fertigation. Proceedings of the Florida State Horticultural Society. Proceedings of the Florida State Horticultural Society 136:124. Ray, Z.T., L. Zotarelli, and X. Zhao. 2022. Comparing two types of granular organic fertilizers for preplant application with different in-season nitrogen rates for organic celery production. Proceedings of the Florida State Horticultural Society 135:110-113. Extension Articles Ray, Z.T., I. Vincent, N. Xu, L. Anrecio, G. Maltais-Landry, and X. Zhao. 2024. Nutrient management in organic crop production systems: An overview of common inputs and major challenges. UF/IFAS Extension EDIS publication (to be submitted in December). Refereed Scientific Journal Articles Ray, Z.T., X. Zhao, et al. 2024. Celery cultivars exhibit yield, quality, and nitrogen accumulation differences in organic production systems. HortScience. (to be submitted in December). Ray, Z.T., X. Zhao, et al. 2024. Monitoring nitrogen mineralization from organic fertilizer, leguminous cover crop residue, and composts in sandy soils. (in preparation) Ray, Z.T., X. Zhao, et al. 2024. Integrated soil and nutrient management practices to enhance organic celery yield and nitrogen use efficiency in sandy soils. (in preparation) Ray, Z.T., X. Zhao, et al. 2024. Optimizing nitrogen application timing regimens toward enhancing nitrogen use efficiency in organic celery. (in preparation) Ray, Z.T., X. Zhao, et al. 2024. Evaluation of nitrogen application rates and granular and liquid organic fertilizer sources for organic celery production. (in preparation) How have the results been disseminated to communities of interest?Outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presentations at Natural Products Expo West. Results were also presented at organic farming conferences. Additionally, the organic celery work was featured at an organic vegetable production research field day held at the University of Florida Plant Science Research and Education Unit in Citra, FL in Dec 2022. General information and research findings related to nitrogen mineralization from organic fertilizers and enhancing N use efficiency in organic celery production were discussed. Participants also visited the ongoing organic celery field research trials to observe different soil and nutrient management treatments. Another organic vegetable production research field day was held in Jan 2024 to present key research findings on cover cropping, compost application, and N application scheduling. In addition, project results have been presented at the American Society for Horticultural Science Annual Conference (2022 and 2023) and the Florida State Horticultural Society Annual Meeting (2022, 2023, and 2024). We are currently working on a number of research and extension manuscripts for publication to further disseminate project findings. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Objective 1: Field trials were conducted at the UW West Madison Agricultural Research Station in Madison, WI. Organic celery yield averaged over all treatments and seasons was 26820 kg per hectare. Increased N fertilizer resulted in higher biomass, with responses seen at fertilizer application levels of 201.75 kg·ha-1 and above. There was no observed main effect from the cover crop treatment ($p = 0.881$), or an interaction effect between cover crop and N fertilizer treatment ($p = 0.327$). Fertilizer N rate impacted tissue nitrate concentrations between and within years, with higher levels of tissue nitrate observed at nitrogen fertilizer application rates of 201.75 kg·ha-1 and above during both years (p\<0.001). The highest tissue nitrate concentrations across the treatments where fertilizer was applied occurred at harvest 1 (30 DAP), with tissue nitrate concentrations dropping and plateauing at harvests 2 (60 DAP) and 3 (90 DAP) in 2021, and continually dropping in 2022 at all harvests. For the treatment where no fertility product was applied, the highest tissue nitrate concentrations occurred at harvest 1, and then steadily dropped through harvests 2 and 3 for both seasons. Similar trials were conducted in FL. In both Spring and Fall trials, the UW team consistently observed increasing nitrate accumulation in celery tissue as the production season progressed, coinciding with biomass and total N accumulation. In the Fall trial, despite similar total N accumulation among cultivars, significant differences in nitrate accumulation suggest divergence in nitrate uptake and assimilation capacities. \'Tall Utah\' and \'Pink Plume\' were high-yielding and robust cultivars that performed well in the challenging Spring production environment, though in the Fall, cultivars like \'Merengo\' and \'TZ6200\' emerged as productive cultivars. Results of nitrogen application rate studies showed that lant tissue nitrate content at final harvest was not significantly affected by N application rate or fertilizer source in the Fall trial, whereas overall nitrate accumulation was increased at the highest rate of 308 kg N ha-1 compared to all other application rates. In the Spring trial, similar results in nitrate accumulation were observed, where celery fertilized with the highest total N rate of 336 kg N ha-1 exhibited higher nitrate accumulation compared to all rates except the 252 kg N ha-1. Objective 2: The objective of the food quality portion was to assess plant source nitrite as a curing agent in three different cured meat systems (deli-style turkey, boneless ham, and frankfurter) through physiochemical and sensory testing. Four different plant source nitrite ingredients (conventional celery, organic celery, conventional Swiss chard, and organic Swiss chard) were assessed for their nitrite concentration and volatile compounds profile. Plant source nitrite (pre-converted vegetable powder): All alternative vegetable-based cures used met the requirement of stable nitrate levels exceeding a 2000 ppm threshold with good nitrate:nitrite conversion efficiency. Nitrite (NO2) concentration was tested using a reverse phase high performance liquid chromatography coupled with UV-VIS detector. NO2- content was determined to be 22487 ,17262, 24531, and 27711 ppm in pre-converted conventional celery, organic celery, conventional Swiss chard and organic Swiss chard powder, respectively. Ready-to-Eat boneless ham was manufactured using fresh pork biceps femoris muscles formulated with selected curing ingredients used to deliver 200 ppm nitrite. Cure ingredient treatments included: sodium nitrite (control), conventional and organic celery (deodorized), and conventional and organic Swiss chard. Ready-to-Eat frankfurter (85% lean trim beef and 50% lean trim pork blend) were formulated with various curing agent including sodium nitrite (control), conventional and organic celery, and conventional and organic Swiss chard. All treatments and control displayed good color stability over the course of the shelf-life study with no significant difference. An Conventional Swiss chard frankfurters had a significantly lower non-meat aftertaste compared with other treatments and the control. Conventional Swiss chard treatment was rated (p\<0.05) the most liked (6.76, 9-point hedonic scale) followed by conventional celery (6.49), organic Swiss chard (6.21), organic celery (5.92), and sodium nitrite (5.76) by the consumer panelists. It should be noted that commercially available alternative cures often include salts (e.g. sodium chloride) which may impact the consumer\'s taste preferences. Ready-to-Eat deli turkey was manufactured using boneless, skinless turkey breast with various curing agent including sodium nitrite (control), conventional and organic celery (deodorized), and conventional and organic Swiss chard. In general for the three different processed meats evaluated, all vegetable powder treatment displayed similar curing efficacy and color stability. Sodium nitrite contributed to a better cured meats color than all vegetable powder treatments. Some consumer sensory flavor characteristics were affected by the source of the alternative cure ingredients. Conventional Swiss chard was rated overall liked the most by consumer panels in the three distinctly different Ready-to-Eat processed meats. The objective of the food safety portion of this grant was to determine the efficacy of four natural sources of nitrite on inhibiting Clostridium perfringens growth on a turkey deli product. The turkey deli product was prepared with four natural sources of nitrite: organic celery, conventional celery, organic Swiss chard, and conventional Swiss chard. The organic celery treatment had slight growth during hour 5 and 15, with a log reduction of -0.31 at hour 10. The most effective nitrite sources at inhibiting C. perfringens growth on turkey deli product were the conventional sodium erythorbate and sodium nitrite treatment and the conventional celery-sourced nitrite treatment. As each nitrite source prevented C. perfringens outgrowth to the USDA limit of 1 log, each nitrite source was considered effective. The objective of the second food safety study was to determine the effects of naturally sourced nitrite products on inhibiting Listeria monocytogenes growth during shelf storage after cooling in turkey deli products. The conventional celery, conventional Swiss chard, and Organic Swiss chard cured products exceeded 2-log growth by week 3. The organic celery cured product, however, did not exceed the 2-log growth limit during the 4-week study, with 1.84-log growth by week 4. Therefore, the organic celery cured product was the only product that successfully inhibiting L. monocytogenes growth during the 4-week period, according to the USDA limit. Objective 3: Organic processing celery enterprise budgets were created. Net revenue was projected at \$335 per acre. Market assessment found that growth rate of this industry sector over the next decade was project to be approximately 6%. Objective 4 accomplishments are listed under outreach. Publications Type: Theses/Dissertations Status: Submitted Year Published: 2023 Citation: Washam, O. 2023. ORGANIC CELERY PRODUCTION AS A NATURAL CURING AGENT FOR THE ORGANIC MEAT PROCESSING INDUSTRY. Master\'s Thesis, University of Wisconsin-Madison. Type: Peer Reviewed Journal Articles Status: Under Review Year Published: 2024 Citation: 1. Sheng, S. E.M. Silva, R. Tart�, and J.R. Claus. 202X. Residual Nitrite and Nitrate in Processed Meats and Meat Analogues in the United States: Composition, Processing, Geographical Influence Factors. Under review in Scientific Reports. Preprint available online. Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Evaluating integrated nitrogen fertilization programs for organic celery production. HortScience 58:S262. Type: Conference Papers and Presentations Status: Accepted Year Published: 2023 Citation: Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Effects of organic fertilizer source and nitrogen application rate on growth, quality, and tissue nitrogen dynamics in organic celery. HortScience 58:S45. Type: Conference Papers and Presentations Status: Accepted Year Published: 2022 Citation: Ray, Z.T. and X. Zhao. 2022. Yield and quality attributes of organic celery as affected by cultivar selection and harvest scheduling. HortScience 57:S96-S97. Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2024. Exploring plant-available nitrogen dynamics under integrated organic nutrient management. Florida State Horticultural Society Annual Meeting, Orlando, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2024. Integrating compost and sunn hemp cover crop residue in an organic celery production system. Florida State Horticultural Society Annual Meeting, Orlando, FL. Type: Conference Papers and Presentations Status: Other

Year Published: 2023 Citation: Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Effects of organic fertilizer source and nitrogen application rate on growth, quality, and tissue nitrogen dynamics in organic celery. American Society for Horticultural Science Annual Conference, Orlando, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Ray, Z.T., L. Zotarelli, and X. Zhao. 2023. Evaluating integrated nitrogen fertilization programs for organic celery production. American Society for Horticultural Science Annual Conference, Orlando, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: Ray, Z.T., L. Zotarelli, G. Maltais-Landry, and X. Zhao. 2023. Tackling nitrogen fertilization for improving organic celery production: fertilizer source, preplant fertilization, and in-season fertigation. Florida State Horticultural Society Annual Meeting, Daytona Beach, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2022 Citation: Ray, Z.T., L. Zotarelli, and X. Zhao. 2022. Comparing two types of granular organic fertilizers in organic celery production. Florida State Horticultural Society Annual Meeting, Sarasota, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2022 Citation: Ray, Z.T. and X. Zhao. 2022. Yield and quality attributes of organic celery as affected by cultivar selection and harvest scheduling. American Society for Horticultural Science Annual Conference, Chicago, IL. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Our target audiences included the following: 1) farmers producing organic celery for processing 2) Industry partners producing organic cured meats 3) other organic researchers and students with overlapping interests 4) consumers and the broader public interested in organic products. This outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presentations at Natural Products Expo West. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project involved three graduate students, two in plant sciences, and one in meat sciences. These students have had opportunities to present their research at both farmer and professional society conferences. Steven Sheng (Ph.D. candidate) was provided with the opportunity to learn how to use GC-Mass Spec instrumentation to assess flavor volatiles in processed meats. This also entailed learning how to distill and concentrate the aromatics for analysis. How have the results been disseminated to communities of interest?Outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presentations at Natural Products Expo West. Results were also presented at organic farming conferences. What do you plan to do during the next reporting period to accomplish the goals?Further field trials will be conducted at the University of FL. Meat product testing and food safety testing will be conducted during the next project period. Market assessment and enterprise budgets will be completed during the next project period. Impacts What was accomplished under these goals? UW-Madison meat science research: Working with our industry partner Kerry Foods, raw celery juice from our research trials were converted to organic celery powder. These will be used for testing the production of organic hot dogs in 2023. In the meantime, we used commercially available organic curing powders from Diana Foods to test meat quality (deli turkey) using the organic powders. Measurements of residual nitrites after curing, as well as sensory characteristics, were collected. University of FL field research: Cultivar evaluation: Two field trials focused on celery cultivar evaluation were conducted in Spring (Mar - Jun 2021) and Fall (Nov 2021 - Mar 2023) seasons. In the Spring season, \'Conquistador\', \'Kelvin\', \'Merengo\', \'Pink Plume\', \'Tall Utah\', \'Tango\', \'TZ6200\', and \'Victoria\' were assessed, while \'Balada\' and \'Command\' were added in the Fall season. In both seasons, celery was transplanted into double-rows on plastic-mulched raised beds (1.2 m between-bed spacing and 30 cm plant spacing). Representative whole plant samples were collected biweekly in the Spring and every 21 days in the Fall, with six total harvests from 26 to 96 days after transplanting (DAT) in the Spring and three harvests from 70 to 112 DAT in the Fall. At each harvest, samples were weighed to monitor biomass accumulation, and either juiced (Spring) or homogenized (Fall) to analyze soluble solids content and nitrate content. Nitrate content was analyzed using the nitration of salicylic acid method. In both Spring and Fall trials, we consistently observed increasing nitrate accumulation in celery tissue as the production season progressed, coinciding with biomass and total N accumulation. In the Fall trial, despite similar total N accumulation among cultivars, significant differences in nitrate accumulation suggest divergence in nitrate uptake and assimilation capacities. \'Tall Utah\' and \'Pink Plume\' were high-yielding and robust cultivars that performed well in the challenging Spring production environment, though in the Fall, cultivars like \'Merengo\' and \'TZ6200\' emerged as productive cultivars. Nitrogen application rate studies: Two field trials aimed at optimizing total N application rates and sources for organic celery grown on plastic-mulched beds in Florida\'s sandy soils were conducted in Fall (Nov 2021 - Mar 2023) and Spring (Feb - May 2023) seasons using \'Tango\'. In the Fall trial, the total N application rates included 0 (control), 140, 224, and 308 kg ha-1, while five N rates including 0, 84, 168, 252, and 336 kg ha-1 were assessed in the Spring trial. In both experiments, 35% of each total N application rate was supplied at preplant and the remainder was applied through in-season fertigation. Liquid fish fertilizer was used for in-season fertigation in the Fall trial, and Chilean nitrate was added as a comparison in the Spring trial. Both experiments also aimed to compare two commonly used organic fertilizer products for preplant application, i.e., Nature Safe 10-2-8 vs. Everlizer 3-3-3 in terms of soil N availability, crop yield, N uptake and N use efficiency, and tissue nitrate content. Plants were sampled at 69 and 101 DAT in the Fall trial, and 72 and 94

DAT in the Spring trial. Preplant and in-season N regime trials: A field trials focused on the further optimization of N management were conducted in Fall 2022 (Nov 2022 - Mar 2023) season using \'Tall Utah\'. These field trials included a continuous range of preplant fertilization rates at 0%, 20%, 40%, 60%, 80%, and 100% of the total N application rate of 280 kg ha-1 using either Nature Safe 10-2-8 or Everlizer 3-3-3, with the corresponding rates of in-season fertigation using liquid fish fertilizer. Celery was harvested at 82 and 110 DAT in the Fall 2022 trial, and 83 and 111 DAT in the Fall 2023 trial, where yield and nitrate content were determined. Tissue N content was analyzed at each harvest to identify differences in N uptake and utilization. Biometric parameters including relative chlorophyll content and normalized difference vegetation index (NDVI) were assessed throughout production in both trials to further quantify the impacts of N application timing on crop performance. In both 2022 and 2023 trials, celery yield at final harvest was maximized with a 20% preplant application, significantly greater than 80% and 100% preplant fertilization treatments. In the Fall 2023 trial, Everlizer significantly improved final season yields compared to Nature Safe across preplant application rates. Nitrogen accumulation in celery tissue was maintained at maximal levels from 0-60% preplant fertilization, while significant declines between 60% to 80%, and 80% to 100% preplant fertilization were observed reflecting a diminished N uptake efficiency with excessive preplant fertilization. Soil CO2 fluxes were measured using a LI-6800 soil respiration chamber at final harvest in the Fall 2022 trial, where 100% preplant fertilization showed diminished CO2 fluxes compared to all other preplant application rates. Integrated nutrient management trials: A field studies involving rotation with a leguminous summer cover crop and application of various compost products were conducted in Fall 2022 (Aug 2022 - Mar 2023). In Aug 2022 and 2023, sunn hemp cover crop was seeded at a rate of 45 kg ha-1 and terminated after approximately 70 days, prior to celery planting. Sunn hemp crop residues were incorporated into the soil about one week before the application of composts and organic fertilizer and the installation of plastic mulch and drip irrigation for transplanting organic celery \'Tall Utah\'. The field trials compared weedy fallow residues vs. sunn hemp residues, and applications of yardwaste compost (22.4 MT ha-1), vermicompost (11.2 MT ha-1), and a 1:1 gravimetric mix of yardwaste compost and vermicompost (22.4 MT ha-1) with a no-compost control. Preplant organic fertilizer was applied alongside the compost products using Nature Safe 10-2-8 at a rate of 100 kg N ha-1. Weekly applications of liquid fish fertilizer were conducted to reach a total N application rate at 280 kg ha-1. Organic celery was harvested at 84 and 112 DAT in the Fall 2022 study, and 83 and 111 DAT in the Fall 2023 study. Samples were processed to determine aboveground biomass, nitrate content, and total N content. In the Fall 2022 study, there were no significant impacts of cover crop residues or composts on tissue nitrate content, while in the Fall 2023 experiment, sunn hemp significantly increased nitrate content and accumulation in organic celery compared to the weedy fallow. Interestingly, the mixed compost treatment in the Fall 2023 study resulted in significantly higher tissue nitrate accumulation, with no differences in total N content or accumulation. These results suggest that both composts and leguminous cover crops may impact tissue N dynamics and nitrate assimilation, while highlighting the benefits in yield that can be obtained following integrated soil and nutrient management practices. Publications Progress 09/01/21 to 08/31/22 Outputs Target Audience:Our target audiences included the following: 1) farmers producing organic celery for processing 2) Industry partners producing organic cured meats 3) other organic researchers and students with overlapping interests 4) consumers and the broader public interested in organic products. This outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presenations at Natural Products Expo West. Changes/Problems:We had no unexpected challenges, beyond the general pest pressure experienced in organic celery production. We are one year behind in progress with field work due to COVID. What opportunities for training and professional development has the project provided?This project involved three graduate students, two in plant sciences, and one in meat sciences. These students have had opportunities to present their research at both farmer and professional society conferences. How have the results been disseminated to communities of interest?Outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presentations at Natural Products Expo West. Results were also presented at organic farming conferences. What do you plan to do during the next reporting period to accomplish the goals?We will continue with the field research, focusing still on fertility management as well as alternative vegetables such as Swiss chard. We will continue meat product testing. We will also conduct a more extensive economic analysis using the production recommendations arising from the first two seasons of field trials. Impacts What was accomplished under these goals? Field research - UW-Madison: A second year of field trials were conducted at the UW West Madison Agricultural Research Station. This included the investigation of 5 levels of nitrogen fertility, with and without a preceding cover crop, over three harvest dates. Data analysis was accomplished for both years. Organic celery yield averaged over all treatments and seasons was 26820 kg per hectare. Within 2021, N fertilizer rate did not impact fresh celery biomass yield (p=0.312). However, within 2022, increased N fertilizer apparently resulted in higher biomass, with responses seen at fertilizer application levels of 201.75 kg·ha-1 and above (p = 0.006). There was no observed main effect from the cover crop treatment (p = 0.881), or an interaction effect between cover crop and N fertilizer treatment (p = 0.327). Significant between year differences of nitrate concentrations averaged over harvests and replications were observed (p=0.025) (Table 3). Within each year, periodic harvests were different over time (p\< 0.001). Fertilizer N rate impacted tissue nitrate concentrations between and within years, with higher levels of tissue nitrate observed at nitrogen fertilizer application rates of 201.75 kg·ha-1 and above during both years (p\<0.001); however, no differences in tissue nitrate concentrations over the range of fertilizer application rates applied were observed (p=0.793). Cover crop treatments had no effect on tissue nitrate concentrations (p=0.434). No N fertilizer × cover crop interaction affecting nitrate concentration was observed (p=0.949). When comparing nitrate concentration means within 2021 and 2022, averaged over cover crops, celery tissue nitrate concentrations varied across harvest intervals. The highest tissue nitrate concentrations across the treatments where fertilizer was applied occurred at harvest 1 (30 DAP), with tissue nitrate concentrations dropping and plateauing at harvests 2 (60 DAP) and 3 (90 DAP) in 2021, and continually dropping in 2022 at all harvests. For the treatment where no fertility product was applied, the highest tissue nitrate concentrations occurred at harvest 1, and then steadily dropped through harvests 2 and 3 for both seasons. UW-Madison meat science research: Working with our industry partner Kerry Foods, raw celery juice from our research trials were converted to organic celery powder. These will be used for testing the production of organic hot dogs in 2023. In the meantime, we used commercially available organic curing powders from Diana Foods to test meat quality (deli turkey) using the organic powders. Measurements of residual nitrites after curing, as well as sensory characteristics, were collected. University of FL field research: Field trials addressing various aspects of this objective have been conducted on certified organic land at the University of Florida Plant Science Research and Education Unit (PSREU) in Citra, FL. To date, two cultivar evaluation studies and two fertility management trials focusing on total rate and source of N have been conducted between March 2021 and March 2022. Additional trials focusing on preplant fertilization and in-season fertigation rates, leguminous cover cropping, and various composts are underway with further plans for replication in Fall of 2023. Cultivar Evaluations: In Spring 2021 (March - June 2021), a selection of 8 commercially available celery cultivars (\'Balena\', \'Conquistador\', \'Kelvin F1\', \'Merengo\', \'Pink Plume\', \'TZ6200\', \'Tall Utah\', \'Tango\', \'Victoria\') were selected for field evaluation, and were transplanted into double-rows onto plastic-mulched raised beds (4 ft between-bed spacing and 1 ft plant spacing). Representative whole plant samples were harvested biweekly, weighed to monitor biomass accumulation, and juiced to analyze soluble solids content and nitrate accumulation until the final harvest at 96 days after transplanting. Nitrate from celery juice was analyzed colorimetrically, using the nitration of salicylic acid approach. Another cultivar evaluation trial was conducted in Fall 2021 (November 2021 - March 2022) but expanded to include 10 cultivars (\'Tango\', \'Command\', \'Balada\', \'Victoria\', \'Merengo\', \'Conquistador\', \'Tall Utah\', \'TZ6200\', \'Pink Plume\', and \'Kelvin\'). In the spring 2021 trial, we observed a tendency for NO3-N to accumulate in celery tissue in the later season. There was a significant increase in NO3-N accumulation between 68 and 82 days after transplanting, which corresponds to a period of rapid growth and biomass accumulation. At 96 days after transplanting, significant differences in NO3-N accumulation were observed among treatments. \'Tall Utah\' stood out as a top performer in Florida\'s conditions, showing good disease resistance, accumulating substantial biomass, and exceeding other cultivars such as \'Victoria\' and \'Tango\' in terms of accumulated NO3-N. Preliminary results from the fall 2021 trial suggest similar findings in terms of yield and NO3-N accumulation patterns. Fertility Management Trials: In fall 2021 (November 2021 - March 2022), an experiment aimed at optimizing total Nitrogen (N) application rate for organic celery grown on plastic-mulched beds in Florida\'s sandy soils was initiated. Total N application rates included a zero N control, 140 kg ha-1, 224 kg ha-1, and 308 kg ha-1, with 35% of the total rate supplied as a preplant fertilizer and the remainder supplied through in-season fertigation using liquid fish fertilizer. This experiment also aimed to compare two common organic fertilizer formulations (Nature Safe 10-2-8 vs. Everlizer 3-3-3) in terms of soil N availability, crop yield and N uptake, and NO3-N accumulation. Field set-up and sample analysis was similar to the cultivar evaluation study, but celery plants were sampled at a mid- and final season time point on 69 and 101 days after transplanting, respectively. This experiment was expanded in Spring 2022 (February - May 2022) with a wider range of total N application rates and the inclusion of an additional factor comparing in-season fertigation with either liquid fish fertilizer or Chilean Nitrate as a positive control. In fall 2021, Soil N dynamics were also closely monitored for the first six weeks after preplant fertilization using traditional soil testing to determine NO3-N concentration and deploying anion exchange membranes (AEMs) for a more dynamic measurement of NO3-N flux. There were distinct patterns of N release from the two organic fertilizers with the use of Nature Safe 10-2-8 resulting in an earlier and higher peak in NO3-N. Traditional soil testing showed similar differences in fertilizer release, and these results were consistent into the expanded Spring 2022 trial. Although nitrate analyses are still underway for plant tissue, the soil N dynamics will help to contextualize potential differences in tissue nitrate accumulation and will help to build more targeted nutrient management programs with the goals of increasing tissue nitrate accumulation in organic celery, promoting overall yield performance, and optimizing overall N use efficiency. Economics and market assessment: We continued discussions with industry partners as to the economic barriers to production. Labor costs of domestic production of celery appear to be one of the biggest challenges. We will continue to build out this objective as we enter the second half of the project. Extension and outreach of results: Outreach was done through the website and press releases put out by the Organic Center, presentations at scientific conferences such as the American Society for Horticultural Science, and at presentations at Natural Products Expo West. Publications Progress 09/01/20 to 08/31/21 Outputs Target Audience:The target audience reached included: Organic farmers, Commodity groups serving organic farmers, Industry stakeholders, Organic consumers. This communication was achieved through one-on-one conversations as well as broader press releases. Changes/Problems: As reported in the last progress report, the first-year experienced delays due to the COVID pandemic. However, no significant delays or changes were experienced this reporting period. What opportunities for training and professional development has the project provided? The primary training has been through the three graduate students employed through this project. How have the results been disseminated to communities of interest? We have been having one-on-one meetings with various stakeholders (farmers, cured meat processors, vegetable powder processors) to ensure that they are aware of project progress and continually provide feedback. Additionally, the Organic Center has been generating press releases and managing a project website. What do you plan to do during the next reporting period to accomplish the goals?We will begin meat quality assessments in Fall 2021. Additionally, we will be repeating the celery field experiments in 2022, including expanding the work into additional crops (beets and chard). Impacts What was accomplished under these goals? Objective 1-Assessment of impacts of nitrogen (N) fertility, variety selections, and environment on nitrate levels in organic celery, chard, and beets In Wisconsin, two experiments were conducted - a greenhouse experiment in the Winter 2021, and a field experiment during the summer 2021. The greenhouse experiment assessed different levels of N applications using different organically approved N sources, including different cultivars of celery. The field experiment assessed different levels of N applications using different organically approved N sources, including cover crops. Data collected includes: celery yield, nitrate levels throughout the growing season, and insect/disease pressure throughout the growing season. Data analysis is still ongoing. In Florida, similar experiments were conducted and data collected, which again is still being analyzed. Objective 2- Quality and safety assessment of cured meat products using organic vegetable powder With the celery harvested in Fall 2021, we are working with Kerry Foods to generate curing powder to begin work on this objective. We are also working with Diana Foods to obtain other organic vegetable powders to conduct quality and safety assessments. Objective 3- Economic and market assessment of organic celery powder and cured meat Throughout winter and spring 2021, we met with a series of stakeholders to begin mapping out the economic and market assessment related to the production of organic celery powder and cured meat. Objective 4- Extension and outreach of project results As per the proposed timeline, this objective is yet to begin in earnest. Publications Progress 09/01/19 to 08/31/20 Outputs Target Audience:The target audience reached included: Organic farmers Commodity groups serving organic farmers Industry stakeholders Organic consumers This communication was achieved through one-on-one conversations as well as broader press releases. Changes/Problems:Due to COVID-19, we were not able to initiate field work in 2020 at either the Wisconsin or Florida sites. We plan to resume this work in 2021, with a full suite of greenhouse experiments occurring in Fall 2020/Winter 2021. What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest?Although results have not yet been generated, the objectives of the project were communicated through a press release from the Organic Center. What do you plan to do during the next reporting period to accomplish the goals?With COVID-19 protocols in place, we will initiate field experiments in both Wisconsin and Florida. Graduate students have been brought onto the project to oversee this work. We will continue to meet regularly with stakeholders to ensure the relevance of our approach and facilitate adoption of our results. The project team has been and will continue to meet monthly to ensure that benchmarks to reach our goals are being met and to ensure communication and coordination of our work. Impacts What was accomplished under these goals? Objective 1: Because of the situation precipitated by COVID-19, field experiments were not conducted during the 2020 production season. However, greenhouse experiments were initiated in Fall 2020, after more stringent COVID-19 protocols allowed work to resume. These experiments will include assessments of fertilizer source/type on nitrate concentrations in celery plants and will guide 2021 field experiments. Objective 3: To begin work on Objective 3, the project team initiated discussions with key stakeholder groups in Wisconsin and Florida, including the Wisconsin Potato and Vegetable Growers' Association and the Midwest Processing Vegetable Growers' Association. These meetings helped assess the feasibility of adding celery in the processing vegetable rotation. Objective 4: The Organic Center generated a press release communicating the project objectives to a broader audience. Publications Organic Transitions Program

↑ Return to Index