ORG Project Details

Award Year 2022

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PROJECT INDEX

How Regenerative Management Affects the Transition to Organic for Cropping Systems of the Southeast

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Investigator(s)	Maltais Landry, G.; Treadwell, DA, D.; Athearn, KE, R..; Dittmar, PE, J.; Paret, MA, .; Liao, HU, .; Grabau, ZA, .
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NON-TECHNICAL SUMMARY

Strategies to improve agroecosystem sustainability include optimizing the use of external inputs, crop rotation, and tillage, which fall into the realm of regenerative agricultural practices. While implementing crop rotations to minimize pest and disease pressure is common in organic systems, optimizing the use of fertilizers/pesticides and reducing tillage while minimizing trade-offs and ensuring profitability remains a substantial challenge. These challenges are exacerbated in the Southeastern US, where coarse-textured soils and a hot and humid climate favor leaching losses and pests. This project will quantify the effects of transitioning to organic systems for carrot, grain corn, peanut, and cabbage production in the Southeastern US, with and without regenerative management. We will establish a 3-year experiment in two sites of North Florida to compare regenerative to traditional management during the transition to organic systems. In all systems, we will measure crop yield and quality, biological, physical, and chemical indicators of soil health and microbial communities, pest damage and weeds, and economic costs, returns and risks. Grower feedback and interactive co-learning will occur at all experimental stages through field days, traditional extension documents, webinars, and social media posts. Extension agents will also be trained during a professional training workshop. Our holistic approach to evaluate these farming systems will directly quantify synergies and tradeoffs and identify barriers to adoption. These results will be generalizable to many other farming systems of the Southeastern US that experience similarly challenging climatic and edaphic conditions.

OBJECTIVES

The overall goal is to identify the effects of transitioning to organic systems, with and without regenerative management, on yields, crop quality, soil fertility and health, soil biology, pest damage and profitability relative to conventional production, by completing these objectives:1. Quantify how the transition to organic, with and without regenerative management, affects cropyield and quality, soil fertility and health, microbially-driven carbon and nutrient cycling, andeconomic costs, returns and risks compared to conventional systems.2. Determine the effects of transitioning to organic systems, with and without regenerativemanagement, on weeds, diseases, and nematodes, relative to conventional systems.3. Increase the capacity for producers to make complex, system-level decisions that maintainprofitability, build soil health, facilitate conservation, and enhance sustainability.

APPROACH

Field experiment for objectives 1 and 2We will establish a systems comparison that will be used for objectives 1 and 2, where the main systemsare defined as:- Conventional system: synthetic fertilizers and pesticides used; other practices defined bytraditional management (see below).- Organic system: fertility managed with poultry manure and livestock waste products, OMRI approvedpest management, other practices defined by management approach. Two management approaches will be compared in the organic system, where regenerative management is based on early carrot planting that should reduce pest pressure and pesticide inputs, and the use of winter cover crops that removes the cabbage cash crop.1. Traditional management: corn-carrot-peanut-cabbage rotation (more cash crops but samerotation length) with late carrot planting, no cover crops, and conventional tillage for all crops.2. Regenerative management: corn-carrot-peanut-cover crop rotation with early carrot planting,legume-grass cover crops included in the rotation, reduced tillage for cover crops and corn. The experimental design will consist of a completely randomized block design, with four plots (50 ft x 100 ft)on conventional land and eight plots on certified organic land.Allconventional plots will be located on non-certified fields adjacent to organic plots. The experiment will be replicated at two sites: the North Florida Researchand Education Center-Suwanee Valley in Live Oak and the Plant Science Researchand Education Unit in Citra.Varieties will be identical in all systems and selected for their pest resistance and reliable yieldand quality. Fertilization will be conducted according to N recommendations - 240 lb ac-1 N (corn),175 lb ac-1 N (carrot, cabbage), 30 lb ac-1 N (peanut) -, and according to soil tests for P and K. Synthetic fertilizers will be used in the conventional system,and compliant animal-based and mined nutrients (e.g., poultry litter, potassium) in the organicsystem. Synthetic fungicides and nematicides will be used in conventional plots vs. compliantproducts in organic plots if cultural controls are ineffective.Methods for objective 1A capacitance sensor will be installed in onerepresentative plot per location to inform irrigation decisions; data will be used in extension activities as well. Accumulated heatunits will becalculated per each crop\'s base temperature and combined with in-field assessmentsto gauge crop development and assess harvest readiness.Cash crop yields will be measured using harvesting machinery, and a subsample will be usedfrom each plot to quantify crop quality as well as nutrient content. Cover cropbiomass will be sampled at termination, and samples will besorted by species.Crops will be dried, ground, and nutrient concentrations will be determined.Soils will be sampled at a variable frequency depending on the variables ofinterest. Soil will be sampled by pooling 15 cores (0-15 cm) collected randomlyfrom the whole area of each plot. Soils will be separated in three subsamples: preserved at -80Cfor microbial analyses, kept refrigerated for some soilindicators and pests, or air-driedand sieved at 2 mm. At the beginning and end of the experiment, three deep soil cores perplot will be taken, split by depth, and analyzed for soil fertility andhealth variables.We will use fresh soil to measure N cycling (2M KCl), resin-extractable P, and microbialP (resin-extractable P on fumigated soils).Air-dried and sieved subsampleswill beanalyzed by an external laboratory for macro- and micronutrients (Mehlich 3), soil pH in water, and soil cation exchange capacity.Soilhealth indicators will also be quantified, including permanganate-oxidizable C and mineralizable C, in addition toautoclave-citrate extractable protein. Soil total C and total N will be measured at the onset of the experimentand annually thereafter. At the beginning and end of the experiment, we will quantify soil textureand aggregation in addition to saturated hydraulic conductivity on intact soil cores.Soils preserved at -80Cwill be processed for soil enzyme activity at the same frequency assoil health indicators, using MUB-labeled substrates. We will also quantify the absolute abundance and community compositionof microbes. Soil DNA extraction, PCR library constructiontargeting fungal ITS and bacterial 16S rRNA, and Next-Generation Sequencing (NGS) dataanalysis will be performed.After data compilation, nutrient budgets and NUE will be computed, and ANOVAs using a complete randomized block design will be used. Data analysisfor microbial communities will be processed by integrating data collected from qPCR and NGS,usingthe QIIME2 pipeline, and using statistical tests (e.g.,one-way ANOVAs, PERMANOVA).Correlations among indicators and between cropyields/quality and other indicatorswill be used.We will also perform multi-dimensionalstatisticsto determine theoverall effect of the three systems.We will establish a recordkeeping system to track material costs, labor hours, use ofequipment and durable supplies, and marketable yields for all systems. We will also collect marketprice data for the cash crops. These data will be used to create partial budgets comparing costs and returnsfor all systems, usingstochasticsimulation modeling through the \@Risk software.Methods for objective 2We will record weed abundance and biomass prior to each weed removal/control event duringeach cash crop growing season - weeds will be identified to species, sorted, and dried.After each cash or cover cropping phase, we will use a fresh soil subsample collected for objecitve 1 for nematodeanalyses. Nematodes will be extracted using the sucrose-centrifugation techniqueand the whole community of nematodes will be identified and quantified based on morphology. Root damage by root-knot nematodes will be assessed byevaluating root galling after harvest in each cash crop.Pathogens affecting carrots will be diagnosed weekly duringthe growing season, usinginfected plant parts andfungal structures, viatraditional microscopy or pure culturingin media plates; we will validate diagnostics through DNA isolation and PCR. Disease severity will be evaluated weekly using the Horsfall-Barratt scale,mid-point averages, andthe calculation of Area Under DiseaseProgress Curve (AUDPC).Multi-spectral mapping with a drone will be used twice toevaluatecrop health during the carrot growing season.After data compilation, ANOVAs using a complete randomized block design will be used to analyze these data. Correlations andmultivariate analyses will also be used.Methods for objective 3We will conduct the following activities:-Round tables to discuss our progress with key stakeholders will be heldtwice during theproject (after the first carrot crop and and after the first full crop cycle).- Workshops for crop producers will emphasize equipment demonstrations,visual assessment of treatments, and a discussion of how individual management actions haveinfluenced systems holistically, for benefit or risk.- An in-service trainingwillinclude advanced agroecology training and tools to apply key findings to specialty and agronomicrow crop producers.- Advanced online trainings & webinars will be developed for each of the four disciplines of thisproposal. Narrated presentations will drill down what we did, why we did it, how wedid it and most importantly, answer the \"So what?\" question.- Team members will also share informationat annual field days, presentations atconferences, academic meetings, and regional meetings with substantial farmer attendance; social media will also be used.- Learning and behavioral objectives will be identified in year 1, revisited annually togauge progress towards goals, and amended if necessary.Measurable knowledge gain and changes in attitudes, skills, and aspirations will bedetermined through formal evaluation procedures. Progress 09/01/23 to 08/31/24 Outputs Target Audience:The target audience has not changed. It remains organic growers and those considering a transition to organic managementand professionalsin Florida and the Southeast US - this audience will be reached mainly via extension and outreach activities.Students are another target audience of this project, as graduate students will be a key part in conducting the research - this audience will be reached primarily during research activities, group meetings, and lab meetings. Students attending classes are the third main audience for this project - they will beexposed to the research outcomes via educational materials (e.g., lectures, problem-based learning activities) used to teach at the University of Florida. Changes/Problems:As with the previous reporting period, maintaining the organic certification has been a challenge, given the close proximity of the two fields at both locations. Thanks to good support and attention to detail by farm crews, we have remained compliant with the certification. For both the carrot and peanut trials, weed management has been a challenge for organic plots, and a hand-weeding event had to be included. This is not ideal, as commercial producers may not have the capacity to perform a weeding event of that kind. Nevertheless, we recorded the labor required and will factor this in our economic analyses. The carrot trial at Live Oak was damaged by deer browsing, resulting in crop damage, low yields, and lower-quality data. Luckily, a new fence was installed at the station, and hopefully this will prevent future crop damage at Live Oak; carrot production was also very good at Citra, providing robust data for one of two sites. The termination of millet was not complete at both locations, most likely due to its immaturity, and weed pressure was high for peanuts at both locations, even in the conventional systems. As a result, data for peanut might be less representative of farmer practices than for other crops, with lower yields in the conventional systems compared to nearby commercial farms. In the case of Citra, this was exacerbated by sandhill crane damage to the crop after germination, which reduced plant densities in both organic and conventional plots. Finally, reduced tillage in the organic system has been harder to implement than expected, due to very high weed pressure, and the two systems are more similar than originally thought. They are still differentiated by other practices, but the difference between traditional vs. regenerative management has been clearer for the conventional plots. We hope that cover crop biomass production will be sufficient prior to the next corn crop, allowing to separate the two organic systems more clearly based on cover crop termination and tillage methods (e.g., rolling-crimping vs. mowing and disking). What opportunities for training and professional development has the project provided?Field and lab activities provided training for several graduate students (three PhD students have at least one dissertation chapter focusing on this work), while undergraduate students were also involved in field and/or lab activities, receiving training in how to collect data and obtain robust results in the lab. Several research technicians were also involved in the project, helping to train students and perform other activities (e.g., develop spray programs). Two postdoctoral associates are also participating in this project (part-time) and provided several mentoring opportunities, as they were instrumental in helping students and technicians during the collection and processing of samples. Similarly, graduate students gained mentoring experience, as they worked with undergraduate students during sample collection and processing. The PD and all co-PDs provided mentoring to students and staff, whether formally or informally, on key research aspects of the proposal, while mentoring for extension and outreach activities will become more important as those activities ramp up. How have the results been disseminated to communities of interest?As the 3-year field experiment is less than halfway done, with sample processing and data analysis ongoing for all cropping phases completed so far, results and outcomes have not been disseminated to a large extent. As results and outcomes become clearer in the next reporting period, and outreach/extension activities become more important, we will increase the dissemination of key results and outcomes. What do you plan to do during the next reporting period to accomplish the goals?In the next reporting period, we will complete peanut harvest, then we will plant and harvest a fall brassica cash crop. After the cash crop harvest, we will plant and terminate a winter-spring cover crop in all systems but the conventional traditional, which will be followed by planting and harvesting the second corn cash crop. Once we plant the corn, we will enter the final year of the field experiment, and the most critical phase of data collection. Plant and soil sample collection will continue, using a similar sampling approach as for previous cropping phases, and samples will be processed using the same methods. As we accumulate more data, data analysis beyond preliminary analyses will take place, and data dissemination will become more important. The dissemination of key results and outcomes will take place through presentations at scientific conferences and extension/outreach activities. Impacts What was accomplished under these goals? In the last reporting period, the field experiment continued, several plant and soil samples were collected, and sample processing followed. Preliminary data analysis was also conducted for some variables. Objective 1 The four systems (organic traditional, organic regenerative, conventional traditional, conventional organic) established during the last reporting period were maintained at two locations in Florida (Live Oak and Citra). This reporting period started after corn was harvested, and before carrots were planted. Carrots were planted in October 2023 (same variety, no seed treatment in all plots) and harvested in March 2024 at both locations. Multiple management events were conducted during the carrot growing season: fertilization, herbicide sprays or cultivation, fungicide sprays. After carrots were harvested, cover crops were planted in three systems (all but conventional traditional), with a difference in mixture: pure pearl millet in organic traditional and conventional regenerative, and a mixture of millet, sunn hemp and buckwheat in organic regenerative. Cover crops were planted in late March 2024 and terminated in mid-April 2024, resulting in a short cover cropping season. Peanut were seeded in all plots (late April in Citra, early May in Live Oak), using the same variety in organic and conventional, but with fungicide coating for the latter. The peanut growing season is ongoing, with a planned harvest in September 2024. It involved several fertilization events (including gypsum application), in addition to herbicide sprays or cultivation, and fungicide sprays. Eight capacitance soil probes (measuring soil moisture at 9 depths up to 86 cm deep) were installed during the carrot and peanut growing seasons, i.e., one soil moisture sensor per system at each location. For each cash crop, plant growth variables were collected during the growing season, and yield was sampled at harvest, via manual and mechanical harvest. Crop quality was measured for carrots (e.g., Brix). For cover crops, biomass was sampled at termination, using quadrats. Tissue samples weredried and ground, and they will be analyzed for nutrient concentrations by an external lab. At the harvest of each cash crop, we collected soil samples from the surface (0-15 cm) for nutrients and soil microbes. Soil samples were air-dried and sent to an external lab for soil fertility measurements, using Mehlich 3 extractions and ICP. Subsamples for soil microbes were frozen (-80 C), then extracted for DNA; these samples will be analyzed for amplicon sequencing at an external facility in the next reporting period. These samples were also analyzed for qPCR, to establish the dominant soil microbial taxa and the abundance of functional genes related to C, N, and P cycling. A subsample of frozen soils will be analyzed for soil enzyme activity subsequently, using fluorometric assays. Additional soil surface samples were collected during the growing season to measure nitrogen cycling, using short-term incubations; samples were also collected at cover crop termination for the same purpose. At cover crop termination, deep cores (0-15 cm, 15-30 cm, 30-60 cm) were collected in each plot, to measure soil health indicators on air-dried soils (i.e., POXC, ACE protein, mineralizable C, SOM, total C and N). We used a recordkeeping system to track material costs, labor hours, use of equipment and durable supplies, and marketable yields for all systems, for use in future economic work. Objective 2 During the growing season, weed counts were performed at a regular interval, and weeds were classified by main group. Weed counts and biomass measurements were also conducted for the cover cropping phase. Alternaria leaf blight (ALB) was scouted weekly during the carrot season and it was diagnosed with traditional microscopy or via pure culturing in media plates, with diagnostic validated by PCR. Disease severity was evaluated weekly using the Horsfall-Barratt scale, mid-point averages, and the calculation of Area Under Disease Progress Curve (AUDPC). Multi-spectral mapping was performed with a drone to evaluate crop health during the carrot growing season. The same surface soil samples collected for soil microbes (i.e., after each cash crop) were also used to extract nematodes, and all nematode samples have been counted and identified. Data analysis will be conducted once more data points are available. Objective 3 There were few extension activities planned for this reporting period, as the project is still in its early stages, but we have started planningthe first carrot round table. Activities (e.g., round tables with stakeholders, participating in field days and other activities) will continue to ramp up in the next reporting cycle. Publications Progress 09/01/22 to 08/31/23 Outputs Target Audience:The target audience has not changed. It remains organic growers (and those considering the conversion to organic management) and professionals (e.g., crop consultants, extension agents) in Florida and the Southeast US. The research results obtained during this project will help quantify the effects of regenerative management during the transition period on several indicators of agroecosystem sustainability. Regardless of the outcome (i.e., if regenerative management helps, worsens or is neutral regarding challenges experienced during transition), results from this project will help inform growers and other stakeholders. Extension and outreach activities (e.g., field days, extension fact sheets) will be critical to disseminate key results to this audience. Students are another target audience of this proposal, as graduate students will be a key part in conducting the research. These students will also be exposed to the research via lab meetings and other similar activities where they will learn about other disciplines involved in the project. In addition, key research results will be integrated in educational materials (e.g., lectures, problem-based learning activities) used to teach at the University of Florida. Changes/Problems:The main change conducted to the experimental design was to add a regenerative management sub-system to the conventional systems, to have a balanced design that will be more useful for statistical analyses. Stakeholders will likely be interested in that comparison as well. This made the number of plots increase by a third, so we reduced the size of plots slightly to maintain expenses at a similar level. Maintaining organic certification was also a challenge, given the very close proximity of our organic and conventional plots, and the use of GM varieties on the conventional side. Luckily, our certification agency has been open to this work, and we have implemented several practices to ensure compliance with the organic certification. Finally, a postdoc was supposed to be recruited part-time for this project, but immigration delays made that impossible. Luckily, other personnel stepped up to the task, and the recruitment of PhD students on the project will help. What opportunities for training and professional development has the project provided?Two undergraduate students and a postdoc have been trained on field and lab protocols for this project so far. Two graduate students are joining the project as of August 2023, and they will be trained extensively during the project\'s duration. How have the results been disseminated to communities of interest?As the project just got underway, with one cropping cycle barely finished (and data not thoroughly validated and analyzed), information has not been disseminated extensively yet. That should start to change in the next reporting cycle. What do you plan to do during the next reporting period to accomplish the goals?In the next reporting period, we will move to the second crop (carrots) that will be grown from October until following spring, followed by a peanut crop (which will be planted but not harvested in the next reporting cycle). For both crops, we will manage them according to differences in systems; conduct pre-season, in-season, and post-season sampling for crops and soils; conduct harvesting operations and measurements; and collect data for economic analyses. As more data get collected and analyzed, we will ramp up the rhythm of extension activities in the next reporting cycle. Impacts What was accomplished under these goals? The field experiment started in March 2023, and this last year was focused on refining the experimental design, implementing the first crop cycle, and collecting data for the first crop. Several PIs have also assigned personnel, although this is still ongoing. Objectives 1 and 2 We established a systems comparison that will be used for 3 years for objectives 1 and 2. In March 2023, we established four systems (organic traditional, organic regenerative, conventional traditional, conventional organic) at two Florida locations: North Florida Research and Education Center-Suwanee Valley in Live Oak and the Plant Science Research and Education Unit in Citra. We established long-term plots at each of these locations, with all conventional plots located on non-certified fields adjacent to organic plots. Maintaining organic certification has been very important given the close proximity between the conventional and organic. This has been mitigated with multiple standard operating procedures to ensure unallowed substances do not enter the certified organic plots. PI Treadwell has been the main responsible for maintaining organic certification compliance. For each long-term plot, we took initial surface soil samples (0-15cm) for nutrients, soil health indicators, nematodes, and microbes. Deep cores (0-15 cm, 15-30 cm, 30-50 cm) were also collected in each plot for future analyses. Soil were either extracted fresh for N cycling, air-dried and sieved prior to analyses of other nutrients and soil health indicators, extracted fresh and counted for nematodes, or stored at -80?C until further analyses for soil microbes. Basal fertilization was applied in mid-March to each plot, according to system: a high rate of heat-treated manure for organic traditional, an intermediate rate of heat-treated manure for organic regenerative, a liquid fertilization at planting for conventional traditional, and a blend of liquid fertilization and low rate of heat-treated manure in conventional regenerative. Corn was planted in both locations in late March, using the same hybrid in both organic and conventional systems, but with additional GM traits (and nematicide applied in furrow) in the conventional system. A pre-emergence herbicide was added to all conventional plots. Eight capacitance soil probes (measuring soil moisture at 9 depths up to 86 cm deep) were added in total, i.e., one soil moisture sensor per system at each location. In-season fertilization consisted in granular applications followed by fertigation in the pivot for conventional systems (with a lower rate of granular fertilizer for the regenerative to account for manure inputs) or a one-time side-dressing with NatureSafe fertilizer (a mixture of feather meal, blood meal, etc.) in the organic regenerative. Glyphosate was applied for weed control in the conventional side (the grain variety was glyphosate-resistant) whereas cultivation was used on the organic side. Applications of insecticides and fungicides were made on the conventional and organic side. Irrigation was applied as needed based on experience of the farm crew and the soil sensor data. In-season data collection included soil sampling after side-dressing to quantify nutrient cycling, weed counts, in addition to measurements of crop growth and health. For the latter, measurements were started two weeks after planting and continued until harvest, focusing on plant stage/number, stem diameter below cob, number of tassels/green leaves, cob fresh weight/length/damage (herbivory, mold), and cob drooping. We established a recordkeeping system to track material costs, labor hours, use of equipment and durable supplies, and marketable yields for all systems, for use in future economic work. Before corn harvest, a subsample of corn was sampled for biomass allocation and nutrient concentrations, using one linear meter to remove all plants, measure fresh weights of different plant parts, and dry the material (grinding will follow). Surface soil samples were also collected for soil nematodes (extracted but not counted), microbes, and nutrients. Soil moisture sensors were removed before harvest. Corn was then mechanically harvested from each plot using a two-row small plot combine (2 rows of 50 ft per plot), to get a yield estimate and moisture concentration that would match what growers might obtain with their equipment. A sub-sample from each plot was collected to confirm test weight, moisture, and grading according to US standards for corn. Following corn harvest, fields were mowed and/or disked (depending on system) and field preparation will continue until carrots are planted in October 2023, in the next reporting cycle. Sampling occurring at that time will also be reported in the next cycle. Objective 3 As the project just got underway, limited progress has been made for extension objectives, but activities (e.g., round tables with stakeholders, participating in field days and other activities) will ramp up in the next reporting cycle. Publications

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Breaking New Ground: Reducing Perennial Weeds and Improving Soil Fertility for Southern Farmers Transitioning to Organic Production

Accession No.	1029062
Project No.	GEOW-2022-04695
Agency	NIFA GEOW\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2022-51106-38011
Proposal No.	2022-04695
Start Date	01 SEP 2022
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Investigator(s)	Cassity-Duffey, K. B.; Coolong, TI, W..; Basinger, NI, TU.
Performing Institution	UNIVERSITY OF GEORGIA, 200 D.W. BROOKS DR, ATHENS, GEORGIA 30602-5016

NON-TECHNICAL SUMMARY

In 2019, Georgia had 102 certified organic farms and currently represents only 0.6% of the nation\'s organic farms in Georgia (USDA-NASS, 2019). In contrast, for conventional fresh vegetable production, GA ranks number four in the nation and has a \$1.2 billion farm gate value (CAED, 2022). Given the large conventional vegetable industry, Georgia is not capitalizing on increased consumer demand for organically grown produce. Nelson et al. (2015) determined in a survey of Georgia farmers, that the perception and potential for lower crop yields and a lack of demonstrated success were the top influences that prohibited the adoption of organic certification or practices. In the 2022 National Organic Farmer Survey conducted by the Organic Farming and Research Foundation (OFRF), farmers ranked controlling weeds (67% of respondents) and nutrient management (43% of respondents) as two of the top four production challenges. Further, the OFRF recommend research for integrated weed management that is farmer collaborative, \"fine tunes\" current methods (tillage and tarping), and for research and develop strategies that manage weeds and restore soil health during transition production (Snyder et al., 2022). Addressing weed management, soil fertility, and organic matter are of critical need to encourage more organic vegetable producers and increasing the scale of organic production in the Southeast U.S. It is difficult for organic small to mid-sized farmers to acquire land given current land costs. In Georgia, The Conservation Fund\'s Working Farm Fund is working directly with Georgia Farmers to acquire land, conserve farmland, and scale up organic production for the wholesale market with a goal of reaching 200 farmers. However, available land is often unmanaged farmland that was previously in old pastures. This derelict land comes with the potential for compaction, residual herbicides, poor soil fertility, and persistent weeds, especially Bermuda grass. These issues represent further challenges to organic producers and can cause significant lags in their time to profitable production. Cover crops have been shown to decrease weed populations, increase soil carbon, increase soil N fertility, decrease soil bulk density, and increase yield in following cash crops. While tarping (silage or black plastic) land slated for production has shown to be effective on weed control, this method is not always affordable or practical for farmers in mid-size farms and does not improve the soil fertility or organic matter. Based on methods for no-till drilling forages into Bermuda pasture in the South we propose a method for no-till drilling cover crops directly into derelict land and will create on-farm tests for farmers to measure weed pressure and potential for residual herbicides. Through on-farm field studies and studies conducted at the

University of Georgia research farm, we will determine how different cover crops and different cover crop entry time (Fall versus Spring) can impact weed species and following vegetable crop production. Through these studies, we will address how different competition mechanisms of weed suppression we can outcompete and deplete perennial weeds (through shading) in this land while simultaneously improving soil fertility and quality for the following cash crops. Through developed tools, on-farm demonstrations, online and written Extension outreach, and through collaboration with non-profits and farmer-collaborators, we will share this information with farmers, Extension, agricultural professional, and the scientific community. Providing farmers with more access to research (based on their needs), we can address issues in organic production in the Southeast and help aid in farmer profits and availability of organic produce. REFERENCESCAED: University of Georgia Center for Agribusiness and Economic Development. Ag Snapshots 2022. Available at: https://caed.uga.edu/content/dam/caes-subsite/caed/publications/ag-snapshots/20 22CAEDAgSnapshotsWeb.pdf (Accessed 11 April 2022).Nelson, M.C., E. Styles, N. Pattanaik, X. Liu, and J. Brown. 2015. Georgia farmers\' perceptions of production barrier in organic vegetable and fruit agriculture. Presented at the Southern Agriculture Exonomics Assocaition\'s2015 Annual meeting Atlanta, GA. Jan 31-Feb 3 2015.Snyder, L., M . Schonbeck, and T. Velez. 2022. Outcomes and recommendations from the 2020 National Organic and Transitioning Farmer Surveys and Focus Groups. Organic Farming Research Foundation. Santa Cruz, CA. Available at: https://ofrf.org/wpcontent/uploads/2022/03/OFRF National-Organic-Research-Agend a-NORA 2022.pdf. (Accessed 5 Apr. 2022). USDA-National Agricultural Statistics Survey. 2019. Organic Survey. Available at: https://www.nass.usda.gov/Publications/AgCensus/2017/Online Resources/Organics/ index.php (accessed 11 April 2022).

OBJECTIVES

Breaking new ground is a difficult task for any farmer. New organic farmers and farmers transitioning to organic vegetable production often purchase or expand on land that has previously been in pasture or is derelict farmland (land that has been previously farmed but not recently managed). In the Southeast U.S., this land is usually the most affordable and commonly available land for new farmers and has the added benefit that it can rapidly undergo organic certification due to having previously laid fallow. However, breaking new ground and turning this land into productive cropland can be time consuming, laborious, and expensive. This land is commonly in need of heavy fertility inputs and is dominated by perennial weed species, especially Bermuda grass which can be incredibly difficult to kill and persistent in the South. Our long-term goals are to create research-based management strategies focused on farmer needs that will lead to reduced inputs and time, increase the number of organic certified acres, incentivize the switch to organic vegetable production, and encourage more sustainable practices in Georgia and the Southeast. Our project directly addresses farmer identified needs for alternative and rapid approaches to combat perennial weeds and poor soil fertility on derelict farmland primarily composed of old pasture. Through the use of no-till drilled cover crops directly into derelict land and Bermuda grass pastures, farmers can decrease weeds and hasten soil fertility as they transition this land to organic cash crop production. Additionally, through a state-wide survey, we will identify common weed and fertility issues encountered by farmers that purchase this type of land. Using this information, we will create on-farm tools that address weeds and residual herbicides. By doing so, we help farmers identify issues and aid in land-use decisions that often lead to the lag in profitable production for organic farmers on new land. Specific objectives of this grant are to:Survey land commonly available for organic transition in the Southeastern U.S. and evaluate weed community composition, residual herbicide carryover, soil fertility, and soil organic matter.Develop two on-farm diagnostic tools: 1) the Germinable Seed Bank Assay and 2) the Residual Herbicide Assay in Southern Soils for use by farmers and Extension.Reduce weeds and improve soil fertility and quality in derelict land/pasture through no-till drill cover crops by determining the effect of management practices on weed suppression, cover crop quality, soil N fertility, soil organic matter, and vegetable cash crop yield and health compared to traditional tillage techniques and silage tarping. Management practices under investigation will include: a) no-till drill cover crop entry time (planting fall or spring), b) cover crop species, and c) the addition of poultry litter at cover crop planting.Ensure timely research-based information through outreach and education to help farmers, agricultural professionals (Extension Agents, NRCS, FSA, Consultants), and students make the best decisions possible when transitioning new land to organic production.

APPROACH

Objective 1:Collaborating with The Working Farm Fund, Georgia Organics, and UGA County Extension Agents, 25 locations representative of land typically available to transitioning organic farmers will be sampled across the state of Georgia in Year 1 from October 2022 to Feb 2023. Points will be surveyed for initial plant communities and weed biomass and evaluated for abundance, distribution, diversity and community analysis. Soil compaction will be determined in 10 locations. To determine initial soil fertility, aminopyralid concentrations, and germinable weed seed banks, 30 samples per location/site will be taken. Soils will also be analyzed for soil physical, chemical and biological characteristics (texture, pH, water release curves, routine analysis, CEC, total N, total C, loss on ignition carbon, organic matter fractionation, inorganic N, CO2 microbial flush, and rapid N indicators). Soil will be analyzed in replicates of three for this survey (with the exception of herbicide analysis in replicates of two) and germinable weed seed banks measurements will be taken 5 and 7 weeks after assay initiation with three replications per site. Objective 2:The Germinable Seed Bank Assay will be created using data collected in the soil survey from Objective 1. The Residual Herbicide Assay created in this project will build on work done by Washington State University (http://whatcom.wsu.edu/ag/aminopyralid/ Bioassay2011.pdf) and Fauci et al. (2002). Five soils will be selected from the Objective 1 survey that represent a range of chemical, physical, and biological characteristics. Soils will be brought to 60% field capacity and then spiked with 5 treatments of aminopyralid to supply concentrations of 0.1, 1, 5, and 10 µg kg-1. Soils will be placed in 0.5 L pots and Pea (Pisum Sativa) will be planted four per pot with four replications per soil x aminopyralid treatment (Fauci et al., 2002). Plants will be monitored for germination rates and scored based on visual injury from 0-100 (dead) on a weekly basis for 6 weeks. Two weeks after planting, soil samples will be taken from each replication to determine the aminopyralid concentration. Objective 3: This study will be conducted on certified organic land at the UGA Organic Research Farm (Watkinsville, GA) and the Love is Love Cooperative Farm (Mansfield, GA). There will be two different cover crop entry points (Fall and Spring) with following tomato and broccoli cash crops (respectively) to determine the effects of timing on weed suppression, soil fertility, and system success. For each cover crop entry point, we will determine the effect of cover type (two cover crops, silage tarp, or no-cover) and the effect of the addition of poultry litter on at cover crop planting on weeds, soil fertility, soil organic matter, and cash crop yield. Plots will be organized in a randomized complete block design with the cover type as main effect and the addition of poultry litter applications as split plots within each main treatment. Prior to planting, soils will be analyzed for soil physical, chemical and biological characteristics and germinable weed seed bank analysis. Initial weed biomass and species population will be determined and plots will be mowed. Poultry litter (routine analysis performed at the UGA AESL) will be surface-applied (equivalent to 6000 kg ha-1) to appropriate plots just prior to planting. Cover crops will be direct drilled into the pasture using a compact no-till grain drill with a small seed box (Fall entry point: crimson clover and rye; Spring entry point: Sudan grass and cowpea) and watered overhead to ensure adequate germination. Silage tarps will be laid at cover crop planting. During the cover crop growing season, cover crop and weed biomass/speciation will be determined 2-3 months after planting. At cover crop termination, cover crop biomass, total weed biomass, and weed speciation will be determined. Cover crops will be analyzed for lignin, hemicellulose, carbohydrates, total C, and total N and mineralizable N. Soils will be sampled for total N, total C, organic matter, and inorganic N. Four weeks after cover crop termination beds will be prepped for cash crop planting using chisel plowing followed by harrowing. Soils will analyzed and the germinable weed seed bank for each plot will be determined. Two rows spaced 6-ft (1.8 m) center to center will be planted in each plot. Tomatoes (c.v Defiant) and broccoli (c.v. Emerald Crown) will be hand-planted at 50 and 20 cm in-row spacing respectively. Pest management will be done in accordance with UGA Extension recommendations for organic production. Three times during the growing season and at harvest, inorganic N in the soil will be determined. Cash crop N uptake will be determined twice during vegetative growth and biomass and N uptake will be determined at harvest for the fruit and plant. Weed pressure will be determined on a bi-weekly basis. Weed biomass and speciation will be determined just prior to whole plot weeding. Cash crops will be harvest and rated for quality and yield. Weather data will be collected for each farm using the UGA Automated Environmental Monitoring Network (AEMN) weather stations. Data Analysis: All data collected in objectives 1, 2, and 3 will be analyzed using linear mixed techniques implemented in SAS PROC GLIMMIX (SAS/STAT 14.2; SAS Institute Inc., Cary, NC) to determine significant differences in treatment effects on soil characteristics, weed populations, and plant yield parameters. N mineralization data and plant uptake data will be used to determine plant uptake and N availability and the N balance for each treatment and plot. Objective 4:Data, tools, and publications will be shared with farmers, Extension, professionals, and the scientific community. Our advisory panel will help with evaluation during the project and specific efforts will evaluated individually. Effort 1: Deliver new knowledge on weeds, weed species, potential herbicide issues, and soil fertility issues for farmers on new/derelict land. Evaluation 1: Development of Germinable Weed Seed Bank and Residual Herbicide Assay for farmer and Extension use. Creation of web-based publications for use by Extension and producers (2), Webinars (1) and peer-review articles (2). Effort 2: Deliver new knowledge for farmers looking to use cover crops that are no-tilled drilled into derelict land and determine the immediate effects on weed management (particularly Bermuda), germinable weed seed banks, soil N fertility, and soil organic matter. Evaluation 2: Demonstrate and measure findings with UGA and on-farm field studies using organic vegetable cash crops. Generate a management program for best practices for decreasing weeds and increasing soil fertility. Create Extension publications (1), Webinars (1), and peer-review articles (2) Effort 3: Increase student understanding of weeds, cover crops, and N fertility in organic production systems through hands-on class projects and case studies. Evaluation 3: Evaluations of student knowledge from class room and field learning sessions with students through interactive whole class studies and graded assignments. Effort 4: Increase in Extension agent\'s knowledge and skills in organic transitions and organic production systems and their capacity to provide technical support for sustainable agriculture practices. Evaluation 4: Pre and post evaluations of agent knowledge after in-service trainings (3). Effort 5: Increase in farmers knowledge and skills in organic transition, N and weed management, cover crop planting in organic production systems, and of services and research provided by UGA. Evaluation 5: Post evaluations of farmer knowledge after conference presentations, workshops and webinars. Farmer/Researcher collaborative fields days (2) and workshops for new farmer outreach. Progress 09/01/23 to 08/31/24 Outputs Target Audience:• Local organic growers and certified naturally grown growers in Georgia • Extension agents • Graduate/undergraduate students • General/agriculture public through news stories • Reserachers and Scientists Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project will have a field day October 21, 2024 for both farmers and Extension agents. How have the results been disseminated to communities of interest?Data has been presented to the scientific community through a presentation at Southern Region ASHS with farmer and Extension dissemination soon. What do you plan to do during the next reporting period to accomplish the goals?During the next reporting period, we will complete our field trials at the UGA Organic Farm (Dec 2024) and Love is Love Farm (Aug 2025). We will analyze the soils and plants and perform statistical analysis on the data to prepare for publication and presentation. Based on farmer and researcher needs,we wil do another field study at Love is Love October 2024 with May 2025 tomatoes. The remaining sites for the survey will be collected by September 2024 and final germinable seed banks performed. Soils will be analyzed forfor texture, potentially mineralizable N, organic matter, total C and N, soil routine analysis, and aminopyralid (winter 2025) and data prepared for publication and presentations.We will prepare Extension publications and videos for the herbicide and seed bank assays to dissiminate to the public and agents. An on-farm field day will be conducted October 2024 and July 2025 with data presented at the Southeast Fruit and Vegetable Conference with Farmer Collaborators and Auburn on Organic transitions. Coolong, Basinger, and Cassity-Duffey will present at scientific meetings with graduate students (ASHS, SSSA,WSSA). We have submitted with our farmer collaborators to present at a regional organic meeting in February 2025. Impacts What was accomplished under these goals? Objective 1: The masters student working on the survey began (Charles Smith) in Summer of 2023 and during that time has collected 15 of the 20 proposed sites have been sampled in objective 1. These samples represent pasture and derelict lafrom Clarke, Oconee, Madison, Banks, and White counties. Sites have been analyzed for weed communities, weed biomass, and soil samples collected for weed and soil analysis. The germinable seed bank has beenconducted on 12 (rest to begin in Sept 2024) and soil samples will be analyzed for texture, potentially mineralizable N, organic matter, total C and N, soil routine analysis, and aminopyralid this winter 2024. Objective 2: We have been working on our germinable seed bank protocol to ensure it is ready for the assay protocol as well as the aminopyralid analysis protocol which will be performed with a collaborator here at UGA. We have been working with our County Extension Agents and farmers on our advisory board, to ensure that the protocols for the assay are appropriate for Extension and farmer use. Instructions/Outreach for assays will be developed Fall 2024/Winter 2024 with Extension publication planned for Spring 2025. The heribice assay has been complete in the greenhouse trials with both squash and green beans. Initial trials with winter pea, showed better sensitivity with the green beans and we wanted to select multiple crops for growers to try. Soils will be analyzed forfor texture, potentially mineralizable N, organic matter, total C and N, soil routine analysis, and aminopyralid this winter 2024. Objective 3: Field studies proposed in the grant have been conducted on schedule. In October 2022, the first field study was planted at the UGA Organic Farm with winter cover crops, tarps, and control plots. Data was collected on the soil and the cover crops and weed biomass. The plot was then tilled and planted with tomato cash crops in May of 2023. Data was collected on weeds, soil health, tomato yield, and plant uptake. In May of 2023, the second field study was started and planted with summer cover crops. Data was collected as above and the plot was planted with broccoli in late August 2023. In October 2023, the thirdfield study was planted at the UGA Organic Farm and the first field study at Love is Love Farm (farmer collaborator)with winter cover crops, tarps, and control plots. Data was collected on the soil and the cover crops and weed biomass. The plot was then tilled and planted with tomato cash crops in May of 2024. Data was collected on weeds, soil health, tomato yield, and plant update during the 2024 summer growing season. In May 2024 summer cover crops were planted at the UGA Organic Farm and incorporated August 1, broccoli will be planted late August 2024.Data is still being analyzed on weeds, soil health, and plant health.Germinable weed banks have been done on 2022/2023 data and initial soil and plant nutrient uptake. Many samples have been collected and we have begun analysis of the cover crop, weed biomass, plant uptake, and soils. Graduate students in the program (James Pulliam and Zachary Hirsch-Santiaga) and student workers have been assisting in this project and soil analysis will begin this Fall. Objective 4: Results from objectives 1, 2 and 3 are still under analysis but we have had significant outreach to the public about the ORG grant. Through interviews with Vegetable Growers News this reporting period we have highlighted the goals of the project, nonprofit collaborators, our farmer collaborators, and discussed some of the difficulties in organic transition and acquiring new land. Data was presented at the Southern Region Americal Society for Horticutlure Science.We had a full advisory committee meeting Feb 2024 with one planned this fall.

we have been meeting every week with farmer collaborators (on their farm) and discussing results with outadvisory panels members. A on-farm field day is planned for October 2021 and results will presented at mulitple conferences this fall. Publications Progress 09/01/22 to 08/31/23 Outputs Target Audience:During this first reporting period, we shared the intent of the grant and have worked with/given preliminary results to: Local organic growers and certified naturally grown growers in Georgia Extension agents Graduate/undergraduate students General/agriculture public through news stories Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project is still in beginning phases, but was highlighted in our UGA Extension On-farm Farmer Workshop in March 2023 (20 Farmers). We have been working closely with Extension agents (specifically Ashely Best) who have been helping with sampling and overall project implementation. How have the results been disseminated to communities of interest?This has been highlighted in our UGA Extension On-farm Farmer Workshop in March 2023 (20 Farmers). We have had significant outreach to the public through about the purpose of the grant through general and also agriculture-specific media outlets. We have been giving real-time updates (to obtain feedback) with our collaborating farmers and farmers in the region. Both undergraduate and graduate students have exposed to this project. Graduate studnets in the Cassity-Duffey and Basinger lab (directly related to this grant but also other lab members) have been working and learning about this project. Cassity-Duffey has added the use of no-till drilling cover crops into her Hort 4125/6125 Organic Ag Systems course cirriculum. Students have seen no-till drill demonstartions and experimental plots. What do you plan to do during the next reporting period to accomplish the goals?During the next reporting period, we will continue our field studies, begin our herbicide analysis and assay experiments, work on plant/soil and data analysis, and continue our outreach efforts. The remaining sites for Objective 1 will be sampled May of 2024 and analyzed as described previously above. The residual herbicidal work will be started next spring (concentration/soil study) in preparation for the creation of the residual herbicide assay. We will continue with data collection from our field studies in Objective 3 with studies continuing at both the UGA Organic Farm and Love is Love Cooperative Farm through summer of 2024. Sample analysis has begun with samples being sent to the UGA AESL for cover crop, plant and soil analysis and in-house samples will begin analysis winter of 2024. In 2024, we will have an on-farm field day at the UGA Organic Farm and the Love is Love Cooperative farm in collaboration with our participating Extension agents. Coolong, Basinger, and Cassity-Duffey (and/or) will present at scientific meetings (ASHS, WSSA). We are working with our farmer collaborators to determine best conferences to present at together. Impacts What was accomplished under these goals? Objective 1: The masters student working on the survey began (Charles Smith) in Summer of 2023 and during that time has collected 9 of the 20 proposed sites have been sampled in objective 1. These samples represent pasture and derelict land from Clarke, Oconee, Madison, Banks, and White counties. Sites have been analyzed for weed communities, weed biomass, and soil samples collected for weed and soil analysis. The germinable seed bank is currently being conducted and soil samples will be analyzed for texture, potentially mineralizable N, organic matter, total C and N, soil routine analysis, and aminopyralid this winter 2024. Objective 2: We have been working on our germinable seed bank protocol to ensure it is ready for the assay protocol as well as the aminopyralid analysis protocol which will be performed with a collaborator here at UGA. We have been working with our County Extension Agents and farmers on our advisory board, to ensure that the protocols for the assay are appropriate for Extension and farmer use. Instructions/Outreach for assays will be developed Fall 2024. Objective 3: Field studies proposed in the grant have been conducted on schedule. In October 2022, the first field study was planted at the UGA Organic Farm with winter cover crops, tarps, and control plots. Data was collected on the soil and the cover crops and weed biomass. The plot was then tilled and planted with tomato cash crops in May of 2023. Data was collected on weeds, soil health, tomato yield, and plant update during the 2024 summer growing season. In May of 2023, the second field study was started and planted with summer cover crops. Data was collected as above and the plot was planted with broccoli in late August 2023. Data is still being collected on weeds, soil health, and plant health. Harvest is expected in the next few weeks. Germinable weed banks are currently being run to determine weed seed banks in each plot/season. In October 2023, the third field study (replicate of field study 1) was planted and the first experiment was planted on-farm at Love is Love Cooperative Farm with the help of the farmers and the Newton County Extension Agent. Many samples have been collected and we have begun analysis of the cover crop, weed biomass, plant uptake, and soils. Graduate students in the program (James Pulliam) and student workers have been assisting in this project and an enthusiastic student has been working as a student worker on this project and will begin as a masters student next Spring (Zachary Hirsch-Santiaga). Objective 4: Results from objectives 1, 2 and 3 are still under analysis but we have had significant outreach to the public about the ORG grant. Through interviews with Scripps Network (https://scrippsnews.com/stories/new-study-seeks-to-help-traditional-farms-transition-to-organic/), GPB Fresh Air, UGA Communications , and various other news organizations, it has been estimated that we have reached over 106 million people about this grant and organic production (UGA CAES Communications Staff Analysis). Through this media outreach, we have highlighted the goals of the project, nonprofit collaborators, our farmer collaborators, and discussed some of the difficulties in organic transition and acquiring new land. We had a full advisory committee meeting December 2022, and have been meeting every 2-3 months with farmer collaborators (on their farm) and advisory panels members. Our next full adivisory meeting is scheduled November 2023. We presented preliminary results and showed the plots with cover crops with an on-farm tour hosted by UGA Extension in March of 2023 (20 farmer/educator participants). We are working with our farmer collaborators to identify the best conferences for farmer/researcher presentations in 2024. Publications

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Being Particular About Organic Matter

Accession No.	1028988
Project No.	ILLU-875-647
Agency	NIFA ILLU\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2022-51106-37924
Proposal No.	2022-04683
Start Date	01 SEP 2022
Term Date	31 AUG 2025
Grant Amount	$749,899
Grant Year	2022
Investigator(s)	Wander, M. M.; Grift, TO, E.; Ugarte, CA, M..
Performing Institution	UNIVERSITY OF ILLINOIS, 2001 S. Lincoln Ave., URBANA, ILLINOIS 61801

NON-TECHNICAL SUMMARY

This integrated research projectwill develop effective modeling tools and soil health metrics to increase organic grain farmers\' ability to manage plant-soil feedbacks to maintain adequate N for heavy feeding crops like corn without excessive N applications. On-station and on-farm research will develop particulate organic matter (POM) as a direct test for soil health andfor use in on-farm applications of process models used to estimate carbon sequestration and greenhouse gas (GHG) emissions. By helping us document C inputs to soils and decay rates, POM will help us accurately predict carbon sequestration rates which are underestimated on organic farms because crop yields can be lower than achieved on conventional farms. It will also help with estimates of GHG emissions, which will focus on nitrous oxides, which can be significant from agricultural soils. Education and outreach efforts will seek to increase usability of research results by farmers, soil testing and consulting services, certifiers and verifiers as well as increase public confidence in estimates of ecosystem services (productivity, C sequestration, and greenhouse gas emissions).

OBJECTIVES

1 Document and understand the effects of organic practices on soil health and fertility andgreenhouse gas mitigation.2: Develop improved technologies, methods, models, and metrics to document, describe, and optimize the ecosystem services and the climate variability adaptation and mitigation capacity of agriculture.3: Overcome infrastructure (decision support) and marketplace (verification) challenges.

APPROACH

Research activities will be conducted at the University of Illinois organic systems trial \"Illinois Organic\", the facilities of the College of Agricultural and Consumer and Environmental Sciences and Beckman Institute imaging facilities and at on-farm locations across the state.These will include:1. Develop Particulate Organic Matter (POM) as a diagnostic tool by:A. Developing rapid testing methods (imaging)B. Establishing relationships between POM, crop N use efficiency and greenhouse gas emission2. Use POM to initialize the biogeochemical model (pCentury which is a parameterized version of Century/DayCent) which underpins widely used for greenhouse gas accounting protocolsA. Use Monte Carlo methods to calibrate pCentury C-submodel using POM and SOC results from past effortsB. Use results from Objective 1 and bayesian inference to estimate SOC and

GHG emissions and associated model error3. Evaluate performance of POM and model on farms using zone-management to optimize manure N application ratesA. Establish management zones in three case study farms (with and without livestock integration) and quantify POM using standard methods and imagingB. Measure and model SOC and N2O emissions on case study farms to validate model performance. Progress 09/01/23 to 08/31/24 Outputs Target Audience:Audience includes farmers, scientists and technical service providers including soil testing and advising communities. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Grad student and undergrads are actively engaged in laband field research. A highlight of this year\'s efforts was a session at our organic field day that featured a jepardy game designed and hosted by the students to engage farmers and other ag-technical service providers in a discussion of soil health indicators, plant roots, and soil structure. How have the results been disseminated to communities of interest?We hosted workshops at the Land Connection\'s annual eventand a field day on soil measurments and nutrient management at our organic systems trial. We have also engaged in one on one discussions with collaborating farmers to help us align efforts with farmer\'s struggles to maintain plant and soil health without over use of fertilizers or tillage. What do you plan to do during the next reporting period to accomplish the goals?Collect measures on farm fields and calibrate model for estimation of N loss through N2O and leaching and SOC change to help farmers with nitrogen management and organic matter management. Gather detailed information about farms we have and will sample through farmer interviews Conduct workshops and demonstration at farmer facing conferences Author outreach articles for eOrganic Publish results Impacts What was accomplished under these goals? Objective 1. Measurments of nitrous oxide emissions and covariates that will be used to initialize the modelwere taken in UofI\'s replicated organic systems trial. This organically certified experiment compares manure application rates and cover-crops within three and four year cash grain rotations. Measures of nitrous oxide emissions, soil organic matter, particulate organic matter, plant available N and dissolved organic matter were taken along with measures of bulk density, soil temperature and moisture for use in modeling efforts. Objective 2. Sampling and analysis of particulate organic matter (POM) fromfarm fields sampled over the past three decadeswas completed. Samples have been used to develop imaging protocols that compare POM determined using sieving (\>53 micron) with image-based estimates. We are working on modeling code for the parameterized centure soil organic matter model (PCSOM model). Efforts have focused on optimization of the C submodel by comparing estimates of SOM and POM change based on traditional spin up methods with model estimates produced using POM as a proxy for the \'slow\' pool that changes within decades. Protocol for POM quantification was completed after optimization of sample handling, sample holders, wetting proceedures were refined to support high-throughput applications. We are illuminating samples with high intensity LEDs and an NIR camera mounted above a movable stage that permits assay of multiple samples that are larger than typically used by wet-lab methods. Objective 3. We have held discussions about use of POM as a key metric of soil stewardship with representatives of AOAC which works to bring government, industry and academia together to develop standard methods for food and the environment. Publications Progress 09/01/22 to 08/31/23 Outputs Target Audience:Target audience includes farmers, scientists, and technical service providers. Changes/Problems:We have had a difficult time finding a post-doc with the skill set we need. While several students have contributed to field and analysis, agraduate student devoted to the modeling effort will finally engage this fall. What opportunities for training and professional development has the project provided?Training of undergrads and graduate students in our lab has familiarized them with proceedures. Inclusion of grad students and professionals in field days and small group discussions has provided a two-way exchange that is helping us understand how to make POM quantification methods both practical and useful. How have the results been disseminated to communities of interest?Information has been disseminated through a field day co-sponsored with the Land Connection, a non-profit organization that caters to the organic and regenerative farming community in Illinois. What do you plan to do during the next reporting period to accomplish the goals?We will validate and publish results on our imaging and modeling protocols, complete discussions with farmers and technical service providers about POM applications, and publish outreach materials about use of modeling tools and POM to manage and assess organic matter quality and quantity and understand climate implications (greenhous gas emissions and C sequestration) and soilN supply. Impacts What was accomplished under these goals? Objective 1 and 3 were addressed through interactions with farmers and technical service providers at a field day and through interactions with industry folks in one on one discussions. Objective 2 was addressed through on farm sampling of POM and SOC in sites previously sampled, sampling if POM, SOC and other variables including nitrous oxide in the certified Illinois Organic farming systems triial located on campus. Advances in POM imaging were made by set up of an imaging platform and optimization of sampler and sample pretreatment methods. Publications

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Expanding Organic Systems to Reduce Water Demand and Increase Agricultural Resilience in the Southwest

Accession No.	1029072
Project No.	NMFernald-22G-04686
Agency	NIFA NM.\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2022-51106-38025
Proposal No.	2022-04686
Start Date	01 SEP 2022
Term Date	31 AUG 2026
Grant Amount	$750,000
Grant Year	2022
Investigator(s)	Fernald, A. G.; Lillywhite, JA, M..; Lombard, KE, .; Guzman, IV, .; Maxwell, CO, M..; Heyduck, RO, F.
Performing Institution	NEW MEXICO STATE UNIVERSITY, 1620 STANDLEY DR ACADEMIC RESH A RM 110, LAS CRUCES, NEW MEXICO 88003-1239

NON-TECHNICAL SUMMARY

Water scarcity is one of the largest challenges to agricultural resilience in the increasingly arid Southwest. An important question is if expanding organic systems can support small farms to achieve the water demand reductions needed to preserve cultivation across agricultural valleys while also achieving overall agricultural resilience. Organic systems could be critical for water resilience, but small farmers need additional knowledge and science-based tools. Our approach brings together field studies of drought tolerant and high value organic crops addressing water demand and agricultural livlihoods with water budget analysis to integrate resilient water and agriculture futures.Our goal is to identify pathways to agricultural and water resilience for arid and semi-arid small farms, and synthesize these understandings into an organic system planning toolkit. Our team\'s integrated Research (R) and Extension (E) objectives in three regions of New Mexico with diverse water and climate conditions are to: E1) build regional learning communities through expanding existing working groups to collect traditional and local knowledge, co-produce tools, and share innovative strategies using an interactive website for producers, policy-makers, and the public; R2) identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes through analyses of attributes, markets, and costs, and paired field and water budget studies that assess yields, water use, and farmer needs as compared to non-organic approaches; and RE3) identify combinations of strategies that can achieve regional resilience through adapting existing decision-support models that assess water, agro-ecological, and socio-economic system dynamics. This project will address ORG priorities of using a systems approach to collaboratively develop improved strategies, models, and metrics that optimize ecosystem services and the climate variability adaptation ability of organic systems.

OBJECTIVES

Our transdisciplinary team\'s goal is to identify pathways to agricultural and water resilience for small farm communities in the increasingly arid Southwest, and use this understanding to develop an organic system planning protocol and toolkit for effective targets and innovative strategies. The study question is what combination of organic systems can support small farming communities to achieve the water demand reductions needed to preserve cultivation across agricultural valleys while also achieving overall agricultural resilience. The Agricultural and Water Resilience Organic Systems Planning (AgWaRes OSP) protocol and toolkit will consider the farm-to-market system, including site, climate projections, water availability projections, water delivery approaches, producer needs, and markets. The AgWaRes OSP protocol structure will assist farmers in areas of high water scarcity throughout the Southwest to develop an organic system plan that meets the requirements for the organic certification program. Our team\'s interrelated Extension (Ext) and Research (Res) objectives and corresponding approaches are shown in Fig. 4, and are to:Objective E1) is to build regional learning communities and outreach strategies. Our approach will be to:Further develop existing regional working groups in regions of New Mexico (Fig. 1) with diverse climates and water conditions convening in annual workshops to collect local and traditional knowledge and identify stakeholder-driven strategies of organic crops, practices, and support programs for agricultural and water resilience. We will additionally affiliate the team and establish an Organic Systems and Agricultural and Water Resilience focus area at NMSU\'s Center of Excellence in Sustainable Food and Agricultural Systems (CESFAS).Co-develop the AgWaRes OSP protocol and toolkit and conduct bilingual (English and Spanish) trainings of early drafts at the paired field and water budget sites to refine the tool.Provide outreach of farmers\' challenges, project findings of synthesized critical indicators in the toolkit, and technical assistance programs for producers, policy makers, and the public of the farm and regional scale benefits for transitioning to these approaches on an interactive website housed at CESFAS.Objective R2) is to identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes. Our approach will be to:Conduct research on key crop and practice attributes for agricultural and water resilience.Conduct market and cost analyses of crops and practices that are found to be suited for the changing climate conditions and are of interest to stakeholders.Co-design and implement with working groups paired field and water budget studies in the three climatic regions to assess the interactions between promising crops, practices, and water and develop resilience indicators. We will assess yields, water use, and farmer needs. These studies will measure the key ecosystem service indicators that can inform resilient organic transitions and management.Objective RE3) is to identify combinations of strategies that can achieve regional resilience. Our approach will be to:Collaboratively further develop and adapt existing decision-support models for the southern and northern New Mexico Rio Grande regions that assess water, agro-ecological, and socio-economic system dynamics to conduct a comparative analysis and predict the key ecosystem service regional effects of implementing various combinations of strategies in two climatic regions. These models will be called Agricultural and Water Resilience System Dynamics Decision-Support Models (AgWaRes System Models).Present the benefits and tradeoffs of combinations of strategies from the AgWaRes System Models results to the San Juan River working group to assess refine the tool to increase the generalizability of the results and transferability the tool.Synthesize the results into a bilingual AgWaRes OSP protocol and toolkit for developing organic system plansThis project will address ORG goals, objectives, and priorities of using a systems approach to collaboratively address Priority 2, Develop improved technologies, methods, models, and metrics to document, describe, and optimize ecosystem services and the climate variability adaptation ability of organic crop production systems, including developing innovative practices. This will be synthesized in our AgWaRes OSP protocol, which also addresses Priority 4, Overcome barriers to organic transition.

APPROACH

Regional and Policy Working Groups and CESFAS affiliationThe regional working groups will be further developed from existing working groups composed of collaborators primarily engaged in land and water management such as farmers, acequia and irrigation system managers, and land manager in the three regions of New Mexico, the Northern New Mexico Rio Grande region, the Southern New Mexico Rio Grande region, and the San Juan River region. The policy working group will collaborate with the regional working groups to develop and review policy strategies. Representatives from the regional working groups will serve to summarize and convey important perspectives of their groups. The group begins with collaborators for the development of this project and will recommend and recruit other critical members.Interactive websiteThe team will collaborate with the working groups and advisory board to solicit input as to what will serve the stakeholders, how they may engage with the site, and monitor for evidence of use. To maximize accessibility, the approach will employ multiple media formats to weave the story of the producers using simple and clear messages and providing areas that dig in deeper for technical information and data from results.Protocol and toolkit for developing Agricultural and Water Resilience Organic Systems Plans (AgWaRes OSP)For the AgWaRes OSP Protocol and toolkit, we will synthesize the critical water, crop, economic, and producer factors that support the long-term resilience of the agricultural socio-environmental systems. Our analysis will examine both the potential site-specific effects for farmers in the identified regions, as well as the potential effects of the practices and crop selections on critical environmental, resource, and socio-economic regional factors if adopted on a significant scale.Three main protocols will be developed, a crop and practices selection protocol, monitoring methods and tools protocol, and a water budget protocol. The crop and practices selection protocol will consider current and potential climate change effects, including changes in timing of water availability and growing aridity, and review the protocol with stakeholder working groups both for desirable crops, practices, and strategies and usability of the protocol. The monitoring protocol will provide descriptions of how the crops and practices meet organic goals and improve natural resources with a focus upon water quantity and quality conservation. The protocol will be tested in the paired field and water budget studies, and reviewed with the stakeholder working groups for practicality of use, relevance to regional needs, and meeting OSP requirements. The water budget protocol will outline the outline the evidence provided by this project from the results of the Paired Field and Water Budget Studies and the Regional AgWaSystem Models to help guide community strategies and provide indicators for farmers to monitor for goals, as well as the methodology for producing regional water budget models. As individual farmers do not have access to regional information, an understanding of water budgets, the accounting of water movement and storage change into and out of a defined region according to the underlying hydrologic processes, provides a foundation and sound science for effective water-resource and environmental planning and management. As well, predictive scenarios are criticalto estimate effects of strategies intended to address projected climate challenges to understand trade-offs of current and differing approaches.Market analysis of crops and cost analysis of practicesBoth analyses will initially employ literature reviews of previous studies. Survey questionnaires will be reviewed with working groups and mailed to producers, consumers, and practitioners for crop preferences used and discrete choice analysis will be used to model the probability that a person chooses a particular alternative. For practices, where costs are not available, schematic plans will be developed and estimated.Paired Field and Water Budget StudiesThe study sites for this project will be in the three regions, two in each region for a total of six, to determine what ranges of crop water consumption can be expected and the corresponding crop yields. Organic crops and practices will be compared to non-organic in a range from conventional to qualified for certification with interest for transition. In the Northern New Mexico Rio Grande Basin region, one set of sites will be at NMSU\'s Sustainable Agriculture Science Center at Alcalde, the other with local neighboring farmers. In the Southern New Mexico Rio Grande Basin region, one site will be on the NMSU Organic Farm and the other at the NMSU Fabian Garcia Science Center. The data for comparison with conventional approaches from several sites in the region will be provided by the other USDA NIFA project team led by the lead PI of this project, which is described in section A.4. In the San Juan River region, two sets of sites will be at the NMSU\'s Science Center at Farmington organic fields (currently in the process of certification) and conventional fields.Agricultural and Water Resilience System Dynamics Decision-Support Models (AgWaRes System Models)We use a system dynamics (SD) approach to estimate the comparative effects of differing combinations of strategies on the ability to achieve both agricultural and water resilience. Our study question as it relates to the model is which actions within modeled scenarios constitute pathways to system transformation to both farm-scale and regional resiliency? And in our analysis of results, can we identify thresholds of critical ecosystem services that inform management targets and key performance indicators? Our modeling approach is stakeholder-driven in both project definition and focus, and a participatory assessment of resilience.The purpose of the regional SD models are to first to describe the interplay of dynamics that has led each site to their current state and then to collaborate with stakeholders to identify socially acceptable paths to improved agricultural and water resilience. The system dynamics model will act as the means to capture and reflect the understanding of the researchers, stakeholders including water and land managers and water users, and policy-makers in the study regions. Our iterative engagement of stakeholders in developing the model, suggesting possible alternative scenarios for evaluation, and finally identifying which alternatives represent socially-acceptable pathways to sustainability follows the principles of participatory modeling. For the purposes of this study, a \"sustainable pathway\" is defined as a governance or resource management alternative that ensures availability and sustainable management of water for all, including water for humans and ecosystems and is acceptable or preferable to stakeholders. Stakeholders will be able to use the model\'s results to determine the tradeoffs of these different strategies on water availability and long-term livelihood of their communities and decide which work best for them. The model simulation will generate time series (trends) of outputs for all the indices, predicting dynamics to the end of the century. Progress 09/01/23 to 08/31/24 Outputs Target Audience:Land and water managers, including farmers, ranchers, Acequia, and other irrigation district community members, as well as federal, state, county, and local agency staff. Changes/Problems:We updated the IRB protocol to include our in-depth market interviews. What opportunities for training and professional development has the project provided?Farmer training of the planning, development, and implementation considerations of organic and water conservation practices in collaboration with our team, and graduate and undergraduate student professional development on project activities detailed in other sections of this report. How have the results been disseminated to communities of interest?The accomplishments/preliminary results have been disseminated in interviews, focus groups, site visits, and conferences. What do you plan to do during the next reporting period to accomplish the goals?In relation to our goals, study questions, and objectives, find below our planned accomplishments in year 3. 1) Personnel plan and expenditures: Our team has plans to utilize the budgeted funds for this project, find the following of note: 1.a) Our economics team has completed plans to expand the research, with a focus on in-depth interviews as detailed in this section 5.c. 1.b) Our farmer consultant, Santa

Cruz Farm and Greenhouses, will utilize the budgeted funds to conduct an herb trial at fields at Northern NM College, in a riparian floodplain along the Santa Cruz River, and in the floodplains of the upland dry river beds (arroyos) contributing to the Santa Cruz River. 2) Goal: To identify pathways to agricultural and water resilience for small farm communities in the increasingly arid Southwest, and use this understanding to develop an organic system planning protocol and toolkit for effective targets and innovative strategies. 1.a) The southern NM input models, analyzed results data, synthesis SD model, and scenarios for testing will be completed and visualizations of results prepared for stakeholder review. We will test and validate the model and scenarios with stakeholders in interactive model exercises; the model will be revised with feedback and data, recalibrated and revalidated. 1.b) The organic system planning toolkit will input preliminary results and information provided by the organic certification workshop, which will be held approximately February 2025. 1.c) Research questions include: 1.c.i) What are the essential strategies for preserving cultivation and irrigation/surface water spreading in agricultural valleys to also preserve community and ecological resilience and what is the role of the organic and holistic approach in these strategies? 1.c.ii) What are the essential dynamics to inform policies that support collaborative networks of locally-led adaptive management to achieve the organic holistic approach on regional scales? 3) Study question: A central question of this work is what combination of organic systems can support small farming communities to achieve the water demand reductions needed to preserve cultivation across agricultural valleys while also achieving overall agricultural resilience. The research and publication plan to break this question down into their constituent parts in the next reporting period is included in the following hypothesis and our plans to address objectives. 3.a) Hypothesis: the holistic strategy of a high-value, low input organic practices and management approach can result in lowering water demand across the farm system, resulting in lowered water demand on a regional scale. This would provide evidence supporting that organic approaches optimize water supplies and facilitate better water management. 4) Objective E1) is to build regional learning communities and outreach strategies. 4.a) We will further develop collaboration networks, learning communities, and outreach strategies with a focus on developing resilience strategies including: 4.a.i) Our team consultant ALI will focus on stakeholder driven development of pilot projects for agricultural resiliency in the San Juan River basin as well as development of website content including addition of content from case study assessments and further planning, and interviews of team members. The bi-lingual informative website with the additions of current interviews and updated plans will go live. 4.b) Research questions include: 4.b.i) How can stakeholder strategies interconnect to strengthen the building of resilience? 5) Objective R2) is to identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes. 5.a) Field trials. 5.a.1) We will analyze the first year\'s crop and water budget data and collect and analyze the second year\'s data. 5.a.2) We will in collaboration with our farmer consultant, Santa Cruz Farm and Greenhouses, conduct an herb trial at fields at Northern NM College, in a riparian floodplain along the Santa Cruz River, and in the floodplains of the upland dry river beds (arroyos) contributing to the Santa Cruz River. 5.b) We plan to feature the low-water medicinal plant trial on our field day tour in all three regions, and as part of other related workshops. 5.c) We will publish a book chapter (detailed in section Other Products 4.2), 3 manuscripts (detailed in Accomplishments 5.c.i and 5.d). 5.d) (1) The draft manuscript describing consumer preferences for Lycium cream should be submitted in the next several months. The draft three-statement financial model (detailed in section Accomplishments 5 5.d.iii) will be completed by the end of the calendar year. The model will be used to explore financial returns from various New Mexico grown herbs as they are identified by the research team. An additional manuscript will be developed exploring the consumer preferences for Ginseng tea, a popular herbal tea made out of Ginseng root. 5.e) Research questions for results include: 5.e.1) What are the optimal irrigation requirements and water budget for high value crops in arid and semi-arid regions of NM to maximize yield and water use efficiency? 5.e.2) Is there any significant difference on water budget using deficit and extreme deficit irrigation treatment on 3 different arid and semi-arid regions? 5.e.3) How do conservation practices, such as deficit irrigation and soil moisture management, affect water use efficiency and crop yield for medicinal herbs and shrubs? 5.e.4.) What is the potential of fallow land for cultivating medicinal herbs and shrubs in terms of water use efficiency, adaptability, and overall contribution to sustainable agriculture in arid regions? 5.e.5) What are the projected impacts on water demand, crop productivity, and resource sustainability when progressively diversifying 10%, 20%, 30%, and eventually all farming land to medicinal crops? 5.e.6) How will the phased diversification to medicinal crops and conservation practices influence the regional water budget, and what are the broader implications for agricultural sustainability in water-scarce regions? 5.f) Research questions for synthesis analysis include: 5.f.1) How low in water use can a farmer go in the three regions of New Mexico with trials and achieve a high value return, as measured by post-harvest physiology, quality, yield, and market assessments? 5.f.2) What are findings of the key regional characteristics in the three regions that affect crop choice and yields? 5.f.3) We will continue market and cost analysis on crops and practices of high interest, including in-depth interviews with purchasers of crops of interest. We will share the herb processing facility economic feasibility analysis with potential sponsors for such a project (particularly the ¡La Sostenga! program at Northern NM College) and publish a manuscript article. 6) Objective RE3) is to identify combinations of strategies that can achieve regional resilience See the overall goal (this section, section 2) for a comprehensive description of next year\'s plans on this objective. Impacts What was accomplished under these goals? Our goals, study questions, and objectives are found below with year 2 reporting 1) Personnel: - PIs contributed time planned (many utilized their standard salary to support the effort to plan for upcoming research and field staff needs) - 4 graduate and 1 undergraduate student (a miscoding for the economics student is being corrected); - Consultants: Santa Cruz Farm and Greenhouses - 0.01 FTE (plan for budget expenditures are focused on a year 3 herb trial in the landscape); Alamosa Land Institute - 0.06 FTE 2) Goal: To identify pathways to agricultural and water resilience for small farm communities in the increasingly arid Southwest, and use this understanding to develop an organic system planning protocol and toolkit for effective targets and innovative strategies. The toolkit includes the following main elements and progress: 2.a) The development of strategies (further detailed in objective E.1) 2.b) For the system dynamics (SD) synthesis model to test strategies, we developed the model using crop data and org project information, including the following progress: - We a) further developed the causal loop diagram for the model, b) identified challenges with characterizing surface flow from storm events and groundwater recharge, and to overcome those, we initiated changes in the structure of the model, began a submodel to characterize recharge (MODFLOW), and began calibration efforts using an additional model (RGTIHM), and c) finished calibration of the model with observed flow data - For the SD analysis of alternative organic crops on regional scale, we further developed the plan to input the field trials results and the regional implications of crop changes 2.c) For the development of the organic system planning protocol, we finalized our plan for incorporating results into the protocol, and planned an organic certification workshop for Feb. \'25. 3) Study question: A central question of this work is what combination of organic systems can support small farming communities to achieve the water demand reductions needed to preserve cultivation across agricultural valleys while also achieving overall agricultural resilience. - We further developed our research and publication plan - As identified in the Other Products section, the students developed their research into presentations and posters, and team members submitted a book chapter and further developed planned manuscripts. 4) Objective E1) is to build regional learning communities and outreach strategies. We closely collaborated with our networks and learning communities to develop resilience strategies. Our team consultant ALI co-developed multiple innovative landscape- and watershed-scale agricultural resilience planning strategies in the Northern and Lower Rio Grande basin study areas which identify potential opportunities for alternative agricultural production, flood mitigation and managed aquifer recharge, including: - Co-developed plans focusing on restoring watershed health to mitigate downstream flooding and improve water quality through reduction in sediment transport, reduction in flood energy and upland revegetation, and along riparian corridors in the agricultural valleys, aquifer recharge through increased overbank flooding, removal of invasive species and accumulated fuel reduction, and planting of native species including wild gathered traditional food crops. - Completion of 3 videos of interviews with individual stakeholders, farmers, and producers, and documentation from community workshops, which have been added to a preliminary structure for the informative website. 5) Objective R2) is to identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes. 5.a) We incorporated input from farmers in workshops and market research into our farmer selection criterion for organic crops and practices framework, developed a crop list of promising organic herb and medicinal crops for NM farmers and presented it at the conference identified in the Other Products section 2.1, and recommended crops for the paired field and water budget studies. 5.b) We installed the experiments for the crops and water budget equipment for the paired field and water budget studies in the northern and southern NM regions, as described following: - In Las Cruces, NM, 9 different annuals/perennial herbaceous plants and 3 perennial shrubs were transplanted at the Fabian Garcia Research Center. These crops are all considered high value due to their medicinal or horticultural use. Drip lines were installed per the water budget study, and all crops and establishment data is done being taken to monitor survivability after transplanting. Three crops, calendula, spilanthes and marshmallow had the best establishment. Calendula and spilanthes high value flowers were harvested and biomass data was collected over the multiple harvests. - At the Alcalde site, two replicated trials were established, both using drip irrigation. First, we established a trial of five native shrub species in hedgerow/windbreak configuration. The second trial consisted of nine low-water-use medicinal plant species under three different irrigation treatments. In this trial, survival of clary sage and marshmallow was 100%, while survival of spilanthes, calendula, and evening primrose was 93%. Survival of Mexican arnica was 0%. We were able to harvest three species\--marshmallow, spilanthes, and calendula in our first year. Annuals like spilanthes and tepary beans are now lost to frost, and we will monitor the perennials for survival in the spring. - Installation of the water budget study equipment including soil moisture probes and pressure transducers measuring groundwater levels in two of the three research sites is completed (Fabian Garcia and Alcalde) 5.c) We secured additional IRB approval for the market analysis consisting of in-depth interviews with businesses that would purchase these crops. Our developed crop list supports questions of production, demand, preferences, recommendations, customer purchase quantities, product forms and series of market in depth questions to inform production. 5.d) We developed a plan to synthesize the first year protocol and crop and water budget study results including our literature review findings into an article on cultivation of medicinal plants in aridlands into a special Issue of Horticulturae, entitled \"Strategies of Producing Horticultural Crops under Climate Change\" 5.e) Our economics team analyzed previously collected survey data related to public use and acceptance of complementary and alternative medicines, with a focus on Chinese medicinal herbs, and presented results at the ICSB oxford botanical conference 2024. The data, analysis and resulting manuscript will help frame the larger question associated with the project relating to public/consumer use and preference for organically grown low water use herbs and other plants. - The survey included a discrete choice experiment question related to lyceum cream, Lycium Barbarum. The experiment included product-specific attributes of price, growing conditions (wild, cultivated), location (U.S., International), Scent (scented, unscented), and production type (organic, non-organic). This analysis has been done using an N-logit methodology and a manuscript is in preparation. - A three-statement financial model was developed (draft complete) to explore the financial feasibility of processing herbs into essential oils. The model will allow users to estimate the financial returns from value-added herb production, based on user-specified variables, e.g., labor, equipment, and energy requirements and costs. Additionally, users can explore potential impacts of various marketing strategies, e.g., direct-to-consumer marketing via farmers\' markets. 6) Objective RE3) is to identify combinations of strategies that can achieve regional resilience. See goal for progress description Publications Progress 09/01/22 to 08/31/23 Outputs Target Audience:Land and water managers, including Farmers, Ranchers, Acequia and other irrigation district community members, and Federal, State, County, and Local agency staff. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Farmer training of organic and water conservation practices in workshops, and graduate student professional development on project activities. How have the results been disseminated to communities of interest?The accomplishments/preliminary results have been disseminated in workshops, focus groups, and conferences. What do you plan to do during the next reporting period to accomplish the goals?In relation to our goals, study questions, and objectives, find below our planned accomplishments in year 2. 1) Goal: To identify pathways to agricultural and water resilience for arid and semi-arid small farms, and synthesize these understandings into an organic system planning toolkit. 1.a) Installation and monitoring protocols for field studies will be developed and tested, further data on crops and practices collected for inputs into regional scenario modeling assessment. 1.b) The model approach will be further developed collaboratively with the target audience, particularly farmers. 2) Study question: A central question of this work is if expanding organic and traditional systems can support small farms to achieve the water demand reductions needed for preserving cultivation across agricultural valleys while also achieving overall agricultural resilience. The research and publication plan to break this question down into their constituent parts in the next reporting period is included in the following hypothesis and plans to address objectives. 2.a) Hypothesis: the holistic strategy of a high-value, low input organic practices and management approach can result in lowering water demand across the farm system, resulting in lowered water demand on a regional scale. This would provide evidence supporting that organic approaches optimize water supplies and facilitate better water management. 3) Objective 1: Build regional learning communities to collect knowledge on holistic systems that align with organic approaches (organic and traditional local knowledge), co-produce tools, and share innovative strategies using an interactive website for producers, policy-makers, and the public 3.a) We will continue to convene the regional learning communities in workshops, working groups, and focus groups. 3.b) We will review ecosystem service indicators for efficacy of planning; review model experiments 3.c) We will continue to capture stories from producers to create narrative of challenges faced, potential solutions, and ecosystem benefits of agriculture; we will describe the project. 3.d) We will create the user website interface and go live with the website. 3.e) Research questions for manuscript development: 3.e.i) What is the role of local knowledge in achieving a full understanding and implementing a holistic organic approach functions on a regional scale? 3.e.ii) How can stakeholder strategies interconnect to strengthen the building of resilience? 4) Objective 2: Identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes through analyses of attributes, markets, and costs, and paired field and water budget studies that assess yields, water use, and farmer needs as compared to non-organic approaches 4.a) We will install studies in field, collect data, and conduct initial analysis on extreme drought tolerant/low water use/high value organic crops and their corresponding water budgets. Research questions for manuscript development: 4.a.i) How low in water use can a farmer go in the three regions of New Mexico with trials and achieve a high value return, as measured by post-harvest physiology, quality, yield, and market assessments? 4.a.ii) What are findings of the key regional characteristics in the three regions that affect crop choice and yields? 4.b) We will continue market and cost analysis on crops and practices of high interest, including in-depth interviews with purchasers of crops of interest. We will share the herb processing facility economic feasibilty analysis with potential sponsors for such a project (particularly the ¡La Sostenga! program at Northern NM College) and publish a manuscript article. Research questions for manuscript development: 4.b.i) What crops show promise in their marketability to be currently reliable, and what indicators should farmers track to assess crop marketability over time? 4.c) We will complete and submit for publication manuscripts on the crop selection criterion and ranking analysis, the survey analysis results on complementary and alternative medicines, and the results with a focus on Chinese medicinal herbs. We will present these results at the International Conference on the Science of Botanicals and the 7th World Congress on Medicinal and Aromatic Plants in MS on April 15th-18th, 2024. 5) Objective 3: Identify combinations of strategies that can achieve regional resilience through decision-support models that assess water, agroecological, and socio-economic system dynamics 5.a) We will continue in all three regions to identify and develop key strategies collaboratively with farmers that can be replicated on a landscape scale to increase regional resilience. We will continue to develop examples as pilot projects to allow us to continue the collaboration to develop the strategies to be feasible, effective, and ready for implementation. Research questions for manuscript development: 5.a.i) What are the essential strategies for preserving cultivation and irrigation/surface water spreading in agricultural valleys to also preserve community and ecological resilience? 5.a.ii) What is the role of the organic and holistic approach in these strategies? 5.b) We will test and validate the model and scenarios with stakeholders in interactive model exercises; the model will be revised with feedback and data, recalibrated and revalidated. Overall system analysis through system dynamics modeling research questions for manuscript development: 5.b.i) What are the regional water implications? ii) What outside support and policies would facilitate implementing resilience strategies on scale to preserve holistic organic agricultural approaches? iii) With this analysis, we will then identify essential elements to inform policies that support collaborative networks of locally-led adaptive management to achieve the organic holistic approach on regional scales. 6) The results will enable us to continue to leverage this project for additional funded achievements: 6.a) Significant interest from agencies and private foundations exists to support executing the pilot projects designed in this project, which will lead to additional collaboration and collection of local knowledge. 6.b) Significant interest from universities, mentors, and practitioners exists to support the development of educational programs, community liaisons, and a network of mentor educators to develop the next generation of community organic/holistic agricultural stewards while executing the pilot projects, which will lead to additional dissemination and training of the knowledge collected and developed. Collaboration is occurring in particular with Northern NM College on several initiatives, also in particular their ¡La Sostenga program!, with the New Mexico Acequia Association on their mentor programs, and with Reclamation on developing educational programs at NMSU to address needs in the southern NM region. Impacts What was accomplished under these goals? In relation to our personnel plan, goals, central study question, and objectives, find below the accomplishments in year 1 1) Personnel plan and expenditures: 1.a) PIs: the planned time expenditures have been completed and all team members have contributed the time previously estimated to support the project. Many of the staff were able to utilize their standard salary to support the effort, and thus expenditures are lower, with a plan to convert the budgeted amounts to field staff support in subsequent years. 1.a.i) Sam Fernald (0.02 cal mo. yr. 1) 1.a.ii) Connie Maxwell (0.07 cal mo. yr. 1) 1.a.iii) Kevin Lombard (0.01 cal mo. yr. 1) (PES) 1.a.iv) Ivette Guzman - 12 month salary supports this effort, salary not needed (PES) 1.a.v) Jay Lillywhite (0.02 cal mo. yr. 1) (AG ECON) 1.a.vi) Rob Heyduck (0.04 cal mo. yr. 1) (Alcalde Science Center) 1.b) Graduate students 1.b.i) Three graduate students were hired and a job opening posted for a combined fourth position (originally 5 graduate students), one began the Fall semester 2023, and two are confirmed to begin the Spring semester 2024, and the final combined fourth position is anticipated to begin also spring 2024. 1.b.ii) For the economics graduate student, the graduate student assistant was hired later than originally planned due to difficulties in identifying a student with project-related interests and abilities. 1.c) Consultants (invoices under process) 1.c.i) Santa Cruz Farm and Greenhouses - 0.025 FTE 1.c.ii) Alamosa Land Institute - 0.05 FTE 2) Goal: To identify pathways to agricultural and water resilience for arid and semi-arid small farms, and synthesize these understandings into an organic system planning toolkit. 2.a) We completed a draft of the main structure of the handbook/toolkit and distributed it at the first year workshops 2.b) We made substantial progress in refining the synthesis system dynamics model (part of the toolkit) for the southern NM Rio Grande region 3) Study question: A central question of this work is if expanding organic and traditional systems can support small farms to achieve the water demand reductions needed for preserving cultivation across agricultural valleys while also achieving overall agricultural resilience. 3.a) We have completed a research and publication plan to break this question down into their constituent parts (see plans for next reporting period). 4) Objective 1: Build regional learning communities to collect traditional and local knowledge, co-produce tools, and share innovative strategies using an interactive website for producers, policy-makers, and the public 4.a) We developed collaboration networks establishing the beginnings of the learning communities and conducted workshops and farmer focus groups in all regions 5) Objective 2: Identify farmer selection criterion for organic crops and practices that can excel in current and projected climate changes through analyses of attributes, markets, and costs, and paired field and water budget studies that assess yields, water use, and farmer needs as compared to non-organic approaches 5.a) From a literature review and input from farmers in workshops and market research, we completed a framework for crop analysis and selection. The framework is categorized by region and location and then ranking by 19 indicators of marketability / community economic well-being, agroecological functions, agronomic suitability, and food sovereignty / community health. 5.b) We then identified the crops and practices for the paired field and water budget studies. We anticipate continuing with a comprehensive crop analysis with the framework and publishing these results in year two. 5.c) The framework has informed questions for a market analysis consisting of in-depth interviews with businesses that would purchase these crops to gain a deeper understanding of market dynamics in year 2. 5.d) Dr. Lillywhite analyzed previously collected survey data related to public use and acceptance of complementary and alternative medicines, with a focus on Chinese medicinal herbs. The data, analysis and resulting manuscript will help frame the larger question associated with the project relating to public/consumer use and preference for organically grown low water use herbs and other plants. 5.e) The team also developed a project for students to design, cost and estimate the benefits of an organic herb processing facility in an economic development feasibility class taught by Dr. Lillywhite. 6) Objective 3: Identify combinations of strategies that can achieve regional resilience through decision-support models that assess water, agroecological, and socio-economic system dynamics 6.a) We have collected substantial input from farmers and other land and water managers in all regions on resilience strategies 6.b) We have identified and developed key strategies collaboratively with farmers that can be replicated on a landscape scale to increase regional resilience. Our team developed example pilot projects, which allow us to continue the collaboration to develop the strategies to be feasible, effective, and ready for implementation. We began in year one with the northern New Mexico Rio Grande region. 6.c) Ecosystem service drivers for resiliency have been collaboratively hypothesized; model structure, causal relationships, and feedbacks initially adapted; initial tests of stakeholder strategies have been conducted; initial model calibration has been conducted. Publications

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Bridging Traditional Agriculture and Climate-adaptive Organic Agriculture in the Southwest

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Project No.	NMPratt-22G
Agency	NIFA NM.\
Project Type	OTHER GRANTS
Project Status	NEW
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Proposal No.	2022-04692
Start Date	01 SEP 2022
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Investigator(s)	Pratt, R. C.; Patrick, MI, .; Schutte, BR, .; Lombard, KE, .; Djaman, KO, .
Performing Institution	NEW MEXICO STATE UNIVERSITY, 1620 STANDLEY DR ACADEMIC RESH A RM 110, LAS CRUCES, NEW MEXICO 88003-1239

NON-TECHNICAL SUMMARY

Vastly expanded agricultural production and rapid urban development have been the hallmarks of the growing economy in the western United States. The American West has been experiencing a \"megadrought\" and recent modeling studies predict that alongside climatic changes, socio-economic changes will exacerbate water shortages and impact crop yields. The Southwest is essentially ground zero for the future impact of climate change. Many small farmers in the southwestern United States do not have access to technologies or programs that address the growing scarcity of water for irrigation. Organic agriculture can increase system resiliency, but many small farmers in the Southwest are hesitant about pursuing organic certification. Our project will address this hesitancy by exploring the commonalities between organic principles and traditional agricultural methods. Our Research program will use participatory research to identify \"non-thirsty\" summer cover crop species and blends that provide ecosystem services and contribute to farm income with limited water resources. We will also determine the abilities of regionally adapted cover crops to produce seeds during the monsoon season with modest supplemental irrigation. Our Extension program will enable farmers and a regional organic seed supplier to decide if they want to produce seeds of cover crops well suited for organic transition in the Southwest. Our Extension program also will initiate organic transition on cooperators\' farms, and at community and educational demonstration farms. Our Education program will exercise cultural sensitivity in predominantly minority ethnic communities (Hispanic and Native American) and address language barriers to increase knowledge of organic transition requirements, and promote knowledge of the benefits and limitations of cover crops in the Southwest.This project builds on a foundation of previous work that identified heirloom crops and winter cover crops that add economic value and ecosystem services. Thecross-commodity, and plant (cropping) systems goalsof this project arealigned withUSDA strategic goal no. 1.1 \"Use Climate-Smart Management and Sound Science to Enhance the Health and Productivity of Agricultural Lands.\"

OBJECTIVES

Major goals: 1) Identify primary constraints to small farmers in the southwestern United States which prevent their adoption of regenerative, organic farming practices and organic certification 2)Determine traditional farming practices that are compatible with organic principlesin order toincrease system resiliency and farmer interest in organic certification 3)Assist farmers with initiation oforganic transition on their farms by producing and distributing educational materials in various media and host workshops to increase farmer knowledge of organic transition and certification requirements 4) Promote knowledge of the benefits and limitations of cover crops in the Southwest 5) Identify summer-planted cover crop species and blends that provide ecosystem services and contribute to farm income under limited irrigation 6) Determine the abilities of regionally adapted cover crops to produce seeds with modest irrigation 7) Establish seed processing facilities and networks that willenable farmers to produce seeds of cover crops well suited for organic transition in the Southwest. 8) Develop market opportunities for regionally adapted cover crop seed, leading to income streams for producers.Education Objective 1. Address farmer hesitancy to pursue organic certification by improving knowledge and awareness of the compatibility of organic methods with traditional agricultural systems, and of the expanded market opportunities and agroecological benefits that result from organic certification.Education Objective 2. Improve knowledge and awareness of procedures and requirements for organic certification.Education Objective 3. Provide training to farmers who wish to become contract seed producers of selected cover crops in both Spanish and English languages.Research Objective 1. Through participatory research, compare the ability of \"candidate\" cover crop species and mixtures to provide ecosystem services during organic transition with limited irrigation.Research Objective 2. Compare the ability of \"finalist\" cover crop species to produce a high-quality seed crop with modest irrigation input.Extension Objective 1. Through participatory research, establish a network of farmers to produce seeds for drought tolerant, regionally adapted cover crops.

APPROACH

Efforts:Education Objective 1 methods:At pre-season collaborator meetings, ask farmers to describe their traditional farming methods and crops they grow. Present overview or organic practices and opportunities for production of less water-thirsty cash and cover crops. Discuss how organic principles are aligned with the cultural values of different farmers.Discuss farmer perspectives, review their current farm plans, and discuss what the potential outcomes of the cover-crop selections might be, and in what ways they are likely to contribute to ecosystem services on their farms.Provide educational materials that will include technical note sheets, protocols for limited irrigation, plot management, and access to videos posted on the web.Organize farmer-to-farmer meetings at on-farm visits, with invitations extended to all interested parties.Education Objective 2 methods:We will present the certification plan for the NMSU Student Research and Education Gardens and discuss how each plan is unique for the particular farm operation. Farmers will be able to ask questions and interact with Rodale Institute staff and a consultant (farm advisor) who has twenty years of experience as an organic vegetable grower. An overview sheet will be provided so that growers can easily access relevant information.Education Objective 3 methods:In year three, a presentation will be made by a regional organic seed company owner who will discuss contract seed production for seed companies.A follow-up webinar will be hosted to allow interested parties to learn of these kinds of opportunities from national seed companies offering diverse organic seeds.Working with the Student Chapter of the National Agri-Marketing Association\--develop a marketing strategy for the benefit of our producer/collaborators.Research Objective 1 methods:Convene pre-season collaborator meetings to review the goals and objectives of the project.Discuss farmer perspectives, review their current farm plans, and allow them to make their cover-crop selections.Provide technical assistance where needed to ensure proper planting of field plots and application of limited irrigation treatments.Provide needed guidance, assistance, and materials to program assistants and students to secure a. weed suppression data, b. soil quality and moisture measurements, c. canopy cover and biomass data from research plots and on-farm trials. a. 1. Determine, with grower input, which weeds are the most problematic, and scout fields and determine weed abundance prior to planting.b. i. Soil moisture probes will be installed so that irrigation applications can be provided in a consistent manner. ii. Student and program assistants will obtain soil samples for analysis. c. 1. The date when canopies close in each treatment will be recorded. ii. Plant tissue samples will be obtained by student and program assistants to determine nutritional and anti-nutritional parameters.Research Objective 2 methods:In years three and four, plant \"finalist\" annual cover crop species and provide sufficient irrigation to allow seed maturation. Harvest plots to determine yields and seed quality. a. Seed quality traits to be determined are: 100-seed weight, seed viability with tetrazolium staining, standard germination tests,accelerated aging tests, leachate assays for mechanical integrityExtension Objective 1 methods:The \"finalist\" cover crops that will be examined for their seed production potential will have been identified during the first two years of the project.Seed yield and quality of the tested cover crops will be determined following moderate irrigation treatments.Seed producers will be able to thresh and clean seed at any one of the three \"hubs.\"A seed company representative will provide training on proper processing of seed.A video will be produced and posted on the web so that other interested parties can obtain access.Evaluation:Implement \"pre-then-post\" tests to measure changes in farmer knowledge regarding organic transition and certification requirements, organic farm management practices, cover crop ecosystem services,andseed production practices following educational workshops and meetings.Solicit \"self-evaluations\" and employ questionnaires in meetings with farmer-cooperators to determine a. their degree of adoption of organic, regenerative managementpractices b. whether or not they have obtainedaccess to new marketsA research protocol using secondary data, focus groups and targeted consumer surveys will be employed to determine the current and future demand in regional and established markets for the project\'s \"finalist\" cover crop species. Evaluation of potential strategies or modelsfor supplying the seed will be conducted by collaborators and external reviewers who will be solicited to act in an advisory capacity.Indicators of success will include:The identification of well-adapted, weed-suppressive \"non-thirsty\" summer cover crops and methods for assuring their ability to provide ecosystem services.The identification of summer cover crops that will be candidates for seed production.The adoption of more regenerative, organicpractices on farms.The adoption of better irrigation and soil moisture management practices on farms.Organic certification of some or all of the cooperating farmers operations.increased access to market opportunities for farmers\'cash crops or new seed crops.Research findings that improve our state of knowledge regarding the adaptation of summer cover crops in semi-arid regions.Research findings that improve our state of knowledge regarding weed suppression during the organic transition period. Progress 09/01/23 to 08/31/24 Outputs Target Audience:Experiential learning (field plot research) internshipand special topics courses - undergraduate minority students (3 Hispanic). Conduct ongoing research through on-farm visits (approximately one dozen) and one-on-one consulting to assist New Mexico, small farmers, including those representing minority groups (Hispanic, Native-American, i.e. Isleta Pueblo, Navajo Nation). Support growers with farm management decisions and cover crop trials, Support from university scientists, andprofessional farm consultants associated with Southwest Grain Cooperative and Rodale Institute. An educational presentation on cover crop research by a graduate student to the public at Fabian Science Center field day Las Cruces, NM 10/10/23). Educational and organizational grower-cooperator meeting (Albuquerque New Mexico, 10/20/23) includes an educational presentation on cover crop research by graduate students to researchers and farmers/cooperators. Experiential learning opportunities for growers through farmer-to-farmer visits (Isleta Pueblo, Belen, NM, 10/21/23). Dr. Pratt (PD) and a graduate student attended the WSARE \"Building Relationships\" summit meeting in December 12-13, 2023, in Phoenix, Arizona. Graduate student made an oral presentation on first-year results from cover crop field research. Educational presentation to hay growers by a graduate student entitled \"Using Cover Crops in Transitioning from Traditional Agriculture to Climate-Adaptive Organic Farming in the Southwestern US.\" New Mexico Crop Production Association 2024 Conference held in Ruidoso, NM on January 29-30, 2024. An educational presentation on cover crop research to the public by NMSU scientist (K. Djaman) and Rodale Consultant (S. Hilborn-Naluai) to public at Farmington Ag Science Center Field Day(June 27, 2024). Changes/Problems:Some farmer collaborators failed to plant cover crop trials due to personal reasons or circumstances beyond their control. It may be necessary to recruit additonal collaborators. What opportunities for training and professional development has the project provided?In-person meeting (Fall 2023) with farmers and researchers in attendance. Our graduate student, Mr. Aminou Saibou, made a powerpoint presentation on his research findings, and farmers discussed their experiences with the candidate cover crops during the 2023 season. Discussions about cover crops and soil health ensued during the in-person meeting. We also had farm visits following the meeting at three farms (two at Isleta Pueblo and one near Los Lunas, NM - the Moya Farm.) We have continued individualized instruction and mentoring throughout the year. These have entailed in depth conversations about problem solving, daily management, longer term crop rotation and soil husbandry planning. Student interns have gained valuable practical experience in planning and management of field crops. One intern completed the LEADING Hispanics to Federal Agency Employment program (2023/2024). The graduate student has gained valuable experience in the conduct of cover crop fieldresearch. The graduate student has realized professional development by making educational presentations to other researchers, farmer/cooperators and the public at the Western SARE meeting in Phoenix (2023), at the New Mexico Crop Production Association 2024 Conference, and at the College of Agriculture Consumer Science Open House. How have the results been disseminated to communities of interest?The public was reached at a field day in Las Cruces (Fabian Garcia Science Center October 11, 2023) and the public (including the Navajo Nation) was reached at a field day at the Farmington Ag Science Center on 27th June, 2024. Presentation \"Developing Region-Specific Guidelines for Cover Crops in New Mexico.\" What do you plan to do during the next reporting period to accomplish the goals?Continue ongoing outreach and consulting to assist New Mexico small farmers. Support growers with farm management decisions and cover crop trials, Support from university scientists, and professional farm consultants associated with Southwest Grain Cooperative and Rodale Institute. Ongoing conversations with farmers will reveal if there are specific traditional farming practices that are compatible with organic principles. We are in the process of developing \"in-house\" educational articles for future distribution. Further elaborate soil moisture usage/retention by different cover crops and different planting densities. Examine the potential of open-pollinated varieties of sorghum and millet to replace sorghum-sudangrass hybrids as candidate summer cover crop species for seed production. Conduct more systematic research on the optimal configuration of promising cover crop blends e.g. time of planting respective components of blends, relative contribution of components (grass v. legume) to final biomass. Facilitate consideration of farmers forming a Cooperative through assistance from the Rocky Mountain Farmers Union. Zoom meeting planned in December 2024 with Dan Hobbs, RMFU Cooperative Specialist. We will also be presenting at the

Organic Seed Alliance Conference in Corvallis, Oregon, in February 2025. The title of our panel presentation is: \"Grown by Southwest Farmers for Southwest Farmers: Trials and Pipeline for Regionally Adapted, Certified Organic Cover Crop Seed\". Impacts What was accomplished under these goals? Major Goal 1) Identify constraints to adoption of organic farming practices - Through interviews, site visits, and group meetings, we ascertained the following: Primary constraints on small farmers preventing adoption of regenerative organic practices include: the cost of certification fees and time spent on paperwork finding and/or creating new market opportunities additional knowledge about cover crops in the southwestern environment is needed concern about the cost of cover crop seed (primarily because of added shipping costs to our region) lack of planting, harvesting, and processing equipment when presented with a new crop opportunity Risks associated with transitioning to a new cropping system often inhibit farmers from doing so. Building and maintaining soil health takes time, and learning new skills and knowledge can be a challenging process. We learned that familiarity with organic management techniques per se is not a primary constraint in deciding to undertake organic certification. Many farmers have already been using some organic management practices. In addition to the above-mentioned obstacles, barrierstoadoption of organic certification tend to be farm-specific or case specific. Major Goal 2) - Determine compatibility of traditional and organic system, increase system resiliency and farmer interest in organic certification We have emphasized participatory research during the first two years of our project by conducting research in both (university) cover crop field experiments and in on-farm trials. We have made progress in introducing cover crops to farmers and connecting a clear relationship between their utility in both traditional and organic systems. Native/Indigenous farmers have told us that they are averse to using agricultural chemicals, even though they have been encouraged to do so by conventional extension educators over the years. Understanding that the soil is a living ecosystem helps farmers remember traditional values of sound land stewardship for the benefit of future generations. THe opportunity to seesoil moisture data has also given farmers more confidence that a limited irrigation strategy can still result inecosystem services from a variety of summer cover crops. Increased grower knowledge and awareness of procedures and requirements for organic certification was also achieved. Major Goal 3) Assist farmers with initiation of organic transition on their farms by producing and distributing educational materials in various media and host workshops to increase farmer knowledge of organic transition and certification requirements We continued making use of educational materials from California Certified Organic Farmers (CCOF), which will be our certifying agency, and the Rodale Institute. Ongoing support from our collaborators (Dr. Tim Vos, and Ms. Samantha Hilborn-Naluai) has shown the importance of cover crops as both a management tool and \"soil builder\" in the development of Organic System Plans. Farmer participation in field trials of cover crops gave them first-hand experience and observations to share with the entire group. The fall meeting in Albuquerque also focused on SeedLinked as a tool for farmers to use to report and share data. The co-founder of SeedLinked, Dr. Nicolas Enjalbert, joined us through video-link during the fall meeting. Growers improved their ability to conduct on-farm variety trials and how to use SeedLInked. Their understanding of trial rating systems and shared results improved. Growers have increasingly realized that organic certification is not merely a bureaucratic necessity. One farmer collaborator has completed the organic certification process. Another has submitted their application, undergone inspection, and should receive final certification next month. Major Goal 4) Promote knowledge and benefits of cover crops - Cover crops in the Southwest have not been as widely used as they should be. We shared knowledge about the benefits of cover cropping as a foundational practice for building soil health and fertility.Farmers realized the benefits of cover crops, but growing them under current mega-drought conditions is challenging. Growers learned that water conservation can be achieved by selecting drought and heat tolerant cover crops, and withholding irrigation longer than originally thought possible.Through research and educational efforts we are demonstrating the importance of cover cropping for soil water-holding capacity, which then would lead to a more resilient cropping system in the context of future climate change uncertainties. Farmers gained direct experience with the planting of summer cover crops that wasintegral to their knowledge base of cover cropping. Benefits and limitations realized included: • Successful cover crop planting with both grain drills and by broadcasting • Certain cover crops weremore or less competitive with weeds • Some cover crops weremore resilient under stress and producedseed heads/pods even during shorter seasons • Farmers learned timing of planting and irrigation is important to success of cover crops Major goal 5) Identify summer-planted cover crop species and blends that provide ecosystem services and contribute to farm income under limited irrigation We now have results from trials of the candidate grass and legume species across two seasons at two locations. Data from one 2024location is still being analyzed but some trends are coming into focus: 1) all candidate cover crops do well at one or more of the multiple eco-system services desired, but none of them appear to be \"super plants\" capable of high performance for theecosystem services measured \-- biomass production, weed suppression, forage quality and water conservation. Sorghum-sudan grass hybrids make the most biomass and appear to have the best weed-supressive ability. 2) The legume species do not produce as much biomass as the best performing grasses, but they have very good forage quality. Some specific observations are also becoming more apparent: 1) there appears to be some preferential adaptation across elevations\...e.g. foxtailmillet appears to be more adapted to higher elevation sites.2) Sunn hemp biomass production appears to be highly variable across environments. 3)

Tepary bean hashigh forage quality. Performance of the grass/legume blends requires further study. Major goal 6) Determine the abilities of regionally adapted cover crops to produce seeds with modest irrigation We started performing observations this year. At some sites, it appears that birds may be a problem for sorghum and millet seed crops. A trial harvest of foxtailmillet showed that some weed species with similar seed size will have to be more efficiently removed from the harvested seed. No results to report at this time. Major goals 7 and 8 have been initiated. Nothing to report at this time. Publications Type: Conference Papers and Presentations Status: Accepted Year Published: 2024 Citation: Saibou, A., Schutte, B., Djaman, K., Pratt, R. & Idowu, J. (2024). Using Cover Crops in Transitioning from Traditional Agriculture to Climate-Adaptive Organic Farming in the Southwestern US. New Mexico Crop Production Association 2024 Conference held in Ruidoso, NM on January 29-30, 2024. https://newmexicocropproductionassociation.org/wp-content/uploads/2024/01/2024-conference-agenda.pdf https://research.nmsu.edu/Other/RCW/OralPresentations.html Progress 09/01/22 to 08/31/23 Outputs Target Audience:Experiential learning (field plot research)internships-undergraduate minority students(1 Hispanic, 2 Native American) Ongoing outreach through sIte visitsand one-onone consulting to assistNew Mexico and Colorado small farmers, including those representing minority groups (Hispanic, Native-American, i.e. Isleta Pueblo, Navajo Nation). Supportgrowers with farm management decisions and cover crop trials, Support from university scientists, andprofessional farm consultants associated with Southwest Grain Cooperative and Rodale Institute. Educatational and organizational grower-cooperator meetings (Spring - Farmington NM, Fall - Albuquerque New Mexico). Educational presentation on cover crop research by graduate student to grower/cooperators (Albuquerque, NM 10/20/23). Educationalpresentationon cover crop research by graduate student to public at Fabian Science Center field day (Oct. 10, 2023) Educationalpresentationon cover crop research to public by NMSU scientist (K. Djman) and Farm Adviser(T. Vos) to public at Farmington Ag Science Center(Aug 17, 2023) Experiential learning opportunities for growers through farmer to farmer visits (Isleta Pueblo, Belen, NM, 10/21/23). Education outreach for regional growers, millers, bakers, and consumers - Grain School in the Field (8/4/23, Cortez Colorado) Southwest Grain Cooprative discussing cover crops using grains and legumes (T. Vos, Farm Adviser) Education outreach for regional growers, millers, bakers, and consumers - Grain School in the Field (8/5/23, Cortez Colorado) Biodiversity in the Field with New Mexico State University (R. Pratt, NMSU Professor), Rocky Mountain Farmers Union, and Apple Biodiversity Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?In-person meeting (spring 2023) to introduce farmers and researchers to each other, provide information on grant, discuss cover crop and soil health In-person meeting (fall 2023) to review the season. This included farmer collaborator farm visits that included individualized instruction and mentoring, having in depth conversations together about problem solving, daily management, longer term crop rotation and soil husbandry planning. Student interns have gained valuable practical experience in planning and management of field crops. The graduate student has gained valuable experience in the conduct of cover crop field trial research . The graduate student has realized professional development by making educational presentations to grower/cooperators and the public. How have the results been disseminated to communities of interest?The public was reached at a field day in las Cruces (Fabian Garcia Science Center) and the public (indlucding the Navajo Nation) was reached at a field day at theFarmington Ag Science Center. The public (primarily growers, millers and bakers) was reached through presentations (2) at the Colorado Grain School in the Field event. What do you plan to do during the next reporting period to accomplish the goals?Continue ongoing outreach and consulting to assistNew Mexico and Colorado small farmers. Supportgrowers with farm management decisions and cover crop trials, Support from university scientists, andprofessional farm consultants associated with Southwest Grain Cooperative and Rodale Institute. Provide criteria and examples for trait evaluation using hedonic one to five (stars) rating scale when using SeedLInked variety trial evaluations. Ongoing conversations with farmers will reveal if there are specific traditional farming practices that are compatible with organic principles. We are in the process of developing\"in-house\"educational articles for futue distribution. Continue research plot and on-farm trials of cover crops. Impacts What was accomplished under these goals? Major Goal 1) Identify constraints to adoption of organic farming practices - Through interviews, site visits, and group meetings, we ascertained the following: Primary constraints on small farmers preventing adoption of regenerative organic practices include: the cost of certification fees and time spent on paperwork, finding and/or creating new market opportunities, lack of knowledge about organic farming systems lack of planting, harvesting, and processing equipment when presented with a new crop opportunity In many cases, producers are located far from urban centers, which makes the logistics of marketing a challenge. Risks associated with transitioning to a new cropping system often inhibit farmers from doing so. Building and maintaining soil health takes time, and learning new skills and knowledge can be a challenging process. Major Goal 2) - Determine compatibility of traditional and organic system, increase system resiliency and farmer interest in organic certification Traditional farming practices include livestock as an integral part of the system, which represents a strong link tothe regenerative paradigm. We are working on cover crop trials in research plots and on-farm trials. We have made progress increating a bridge and demonstrating a clear relationship between traditional and organic systems. Also, many Native/Indigenous farmers will tell you that they are averse to using agricultural chemicals, even though they have been encouraged to do so by conventional extension educators over the years. Understanding that the soil is a living ecosystem helps farmers remember traditional values of stewardship and taking care of the land for future generations. Increaed grower knowledge and awareness of procedures and requirements for organic certification was achieved. Major Goal 3) Promote knowledge of the benefits and limitations of cover crops in the Southwest Zoom meeting focused on the organic transition process and requirements. Discussed the development of Organic System Plans as both a thought experiment and valuable management tool. Growers realized that organic certification isnot merely a bureaucreatic necessity. Zoom meeting focused on SeedLinked as a tool for farmers to use to gather data. Growers improved their ability to conduct on-farm viriety trials and how to use SeedLInked. Their understanding of trial results advanced. This year we have been making use of educational materials from CCOF, which will be our certifying agency, and Rodale Institute. Major Goal 4) Promote knowledge and benefits of cover crops - Cover crops in the Southwest have not been as widely used as they should be. Wesharedknowledge about the benefits of cover cropping as a foundational practice for building soil health and fertility. Growers learned that water conservation can be achieved by selectingdrought and heat tolerant crops, which is the focus of the cover crop trials we\'ve undertaken. Growers realized the benefits of cover crops are clear, but growing them under current mega-drought conditions is very challenging. Through research and educational effortswe are demonstratingthe importance of cover cropping for soil water-holding capacity, which then would lead to a more resilient cropping system in the context of future climate change uncertainties. Farmers gained directexperience with the planting of summer cover cropsis integral to the knowledge base of cover cropping. Benefits and limitations irealized ncluded: Successful trialing of cover crop planting with drill Certain cover crops being less competitive with weeds Certain cover crops being more resilient under stress and producing seed heads/pods Farms learned timing of planting is very important to success of cover crops Major goals 5 through 8 are in progress. Nothing to report at this time. Publications

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Leveraging Soil Microbiomes to Promote Climate Change Resilience and Adoption of Organic Agriculture

Accession No.	1029059
Project No.	NYC-Casteel
Agency	NIFA NY.C\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2022-51106-38007
Proposal No.	2022-04685
Start Date	01 SEP 2022
Term Date	31 AUG 2025
Grant Amount	$749,606
Grant Year	2022
Investigator(s)	Casteel, C.

NON-TECHNICAL SUMMARY

Current problem:Farmers are grappling with the impacts of climate change globally, including increased extreme weather events and pest and pathogen outbreaks. While some organic farms are predicted to be more resilient to climate change compared to others, the mechanisms underlying these differences are still poorly understood. Our prior work indicates that changes in the soil microbiome on organic farms mediate ecosystem services, such as crop resilience, however, microbiome-mediate ecosystem services varied across farms. It is also still unknown how time in organic management and farming practices interact to influence different functions of the soil microbiome. Thus, the long-term goal of this projectis to promote the adoption of organic practices by determining which aspects of organic management promote microbiome-mediated resilience and providing tools for growers to leverage this knowledge.Methods and approach:In objective 1, we will collect soil and data on farm characteristic from organic farms across New York. The soil microbiome will be sequenced and soil fertility determined for each sample. This data will then be used to determine specific practices and the amount of time in organic required for optimal soil microbe conservation. In objective two we will identify specific microbiomes that promote climate resilience using different genotypes of plants, the soil samples collected from across New York, and common garden experiments. In objective 3, we develop a soil microbiome sequencing lab and decision support tool app. Organic growers will be able to submit soil samples for sequencing and recieve results using the app. The app will also assist growers in interpreting their data and making management decisions related to soil microbiome conservation. Results and resources from our project will be developed in to webinars with the help of eOrgancics and through communication with extension agents, our farmer advisory committee, and though the publication of peer-reviewed journal articles.Impacts and benefits to society:Over 25% of the earth\'s vegetative land has undergone soil degradation largely due to increases in agricultural production. As agricultural production continues to increase globally, growers will also be forced to utilize more and more marginal land. Thus, adoption of agricultural management practices that increase soil health, such as organic methods, is critical to sustainable food production and will be fundamental to maintain productivity for all agricultural systems in an uncertain future.The long-range implications of this study include the conservation of soil microbiomes, climate change education for all farmers, and increased adoption of organic agriculture. This will lead to a more sustainable agroecological food system in the United States as soil health increases and the economic costs associated with climate change and yield losses are alleviated

OBJECTIVES

1)Evaluate the benefits of long-term organic management for microbiome conservation2)Identify microbiomes that promote climate change resilience in crops3)Provide a microbiome decision support tool for organic farmers

APPROACH

Objective1: Determine thebenefits of long-term organic management for microbiome conservation We will collect soil from a network of 85 organic farms accross NYS that range in location, practices used, and time in organic. Soil ferility will be characterized at the Cornell Soil Health Lab.DNA will be extracted from soil samples, the 16S and ITS regions sequenced, and microbiome characterized as in (Blundell et al 2019). We will calculate loss and replacement of microbe taxa across long-term organic and transitioning sites andfor farming practices used across the paired fields. We will also include two-way interactions between each term characterizing changes in farming practices across fields and time in organic management. To extend our results we will develop a 45-minute webinar on microbiome conservation in organic farming systems in partnership with eOrganic. Objective 2: Microbiomes that promote climate change resilience in crops identifiedWe will use a manipulative experimental approach to evaluate ecosystem services provided by the microbiome of organic farming systems across NYS. Specifically, we will evaluate microbiome-mediated resilience to abiotic (drought) and biotic (herbivory) aspects of climate change using microbiome transplant experiments and greenhouse experiments. To determine the impact of plant-microbiome genotype matches on ecosystem serviceswe will also grow seeds from 7 different seed producers in theirnatal microbiomes(extracted from the farm where they were produced) and inforeign microbiomes(extracted from paired transitioning and long-term organic farms across NYS). Natal and foreign microbiomes will be sequenced and plant resilience to drought and herbivorywill be evaluated in a common garden greenhouseexperiment. To extend our results we will develop a 45-minute webinar with the help of eOrganics that highlights our stakeholder\'s efforts to produce regionally adapted seed crops that are climate change resilient. We will describe how plant-microbe interactions mediate climate change resilience.Objective 3: Provide a microbiome decision support tool for organic farmersWe will set up a regional organic soil sequencing lab using theMinION long-read sequencing platform and by developing a low cost high-throughput DNA extraction and sequeincing protocol for NY soils. We will develop a platform to deliver sequencing results using an descision support tool app we design. Focus groups will be conducted with growers to determine message framing for the app and promotional materials. We will use machine learning algorithums and our soil microbiome databaseto predict the relationships between microbiome taxa and farming practices (e.g., no-till), farm characteristics (long-term organic and transitioning), measures of plant performance (normal conditions and droughted), and pest suppression. In the final year of the project we will trial the tool with farmer submitted soil samples and data on user experience will be collected. To extend our results from this objectivewe will make a finaleOrganic webinar highlighingcurrent resources on the Climate Smart Farming available at Cornell University andourfor rapid microbiome sequencing and our decision support tool piolet program.Evaluation plan:First, we will track the number of organic farmers using our decision support tool. Second, we will track the number of attendees and asynchronous views for our eOrganic webinars. Third we will evaluate the effectiveness of our webinars by asking attendees to fill out a brief survey regarding their experience. We will then follow up 1 year after the webinar to determine if any attendees made changes to their farm to promote microbiome conservation and climate change resilience.Finally, the project team will have quarterly conferences and the annual stakeholder advisory committee meeting to evaluate the project and make modifications if needed.We expect the number of organic farms withcharacterizedsoil microbiomesin NYS toincrease. We expect farmer knowledge on the benefits of organic agriculture for soil microbiome conservation and climate resilliencewill increase.Finally we expect farmers using organic practices thatconserve soil microbiomes that enhanceclimate resiliencewill increase. Progress 09/01/23 to 08/31/24 Outputs Target Audience:Farmer Stakeholder Engagement:During the reporting period, we engaged with our regional farmer stakeholders (n = 7) in the collection of soil samples and market ready seeds (2×) for climate change bioassays (see Obj 2). National Audience: To promote engagement on the national level, we developed an eOrganic webinar (n = 1) highlighting the findings of Obj 1 and our SAC. The webinar engaged 120 attendees from 36 US states, and 7 international attendees from Mexico, India, Canada, and Spain. Our audience breakdown was as follows: 10 agricultural professionals, 13 extension agents, 18 farmers, 24 government agency researchers, 16 nonprofit organization staff, 3 organic certifiers and inspectors, 22 university researchers, and 14 participants representing other aspects of food systems (e.g., gardeners). The webinar is permanently posted to eOrganic and freely available on YouTube. In ≈2mo, the recording has received \> 280 views and 11 likes (≈140 views/mo). Extension Agents:We are currently preparing individualized microbiome reports for farmers who participated in Obj 1. We will leverage our previously described target audience of 18 Cornell University extension personnel in the validation of reports before farmer delivery, ensuring reports are understood by non-academic audiences. Report delivery to 85 farmers who make up a core audience is planned for January 2025. Scientists and Academics: Our research was shared with academics 8X in the reporting period. Specifically, our research was shared at the Entomology Society of America (National Harbor Maryland); American Society of Plant Biologists (Honolulu, HI), University of California (Riverside, CA); X2

Pennsylvania State University (State College, PA); X2 Cornell University (Ithaca Campus), and Cornell University AgriTech (Geneva, NY). Total engagement for the academic environment was ≈350 individuals. Interdisciplinary Researchers: In preparation for the development of the decision support tool, we consulted with Alison Chatrchyan (Cornell University, Senior Research Associate, Earth and Atmospheric Sciences) and Arthur Degaetano (Cornell University, Director of Undergraduate Studies for Atmospheric Sciences). Through these consultations we developed a timeline and framework for the development and deployment of the decision support tool which will have a broad target audience (n ≈ 280 organic vegetable farmers in NYS). Social media: We promoted the publication of our research, eOrganic webinar, and seminars on X (formerly Twitter), generating 818 impressions (views), 54 engagements, and 21 profile visits. Project results will continue to be shared via social media during the final reporting period, and beyond our project completion date. Undergraduate, post-baccalaureate, and graduate student researchers: We successfully recruited 1× full-time research technician with a background in bioinformatics to develop our rapid soil microbiome sequencing resource (see Obj 3), and 1× part-time undergraduate researcher to assist with climate change experiments (see Obj 2). Via these activities each technician is gaining skills useful for career advancement. We plan to recruit 1× graduate student to assist with project completion and the continuation of our research in the final reporting period. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Training activities: Manipulative experimental design 2× (drought, cover cropping lab experiments); Insect rearing, colony management, and handling 5× (1 research technician, 2 undergraduate researchers, 2 graduate students); Microbiome extraction 3× (1 research technician, 2 undergraduate researchers); PCR, library preparation, long read sequencing, and bioinformatics 2× (1 research technician, 1 postdoc); Phytohormone extraction 2× (1 research technician, 1 undergraduate researcher); Phytohormone quantification and interpretation (1× postdoc); Structural equation modeling (1x postdoc). Professional development:Conferences presentations by junior scientists 2× (ASPB/EntSoc); Seminar presentations conducted by project team 8x; DEI Trainings 4x; (Project Biodiversity Affiliates; Wellbeing in Academia Lab Meeting; Introduction to Inclusive & Equity-Minded Mentoring and the Faculty Advancing Inclusive Mentoring, What was that? Identifying bias workshop) 2×; IDP (Individual development plan) for junior and senior scientists 4×; Graduate student training for senior scientists 2×. How have the results been disseminated to communities of interest?Results for organic farming practices that mediate the microbiome, plant defenses, and pest suppression were extended through a 1.5hr eOrganic webinar (Obj 1). This webinar included 4× 15min presentations (2× researchers; 2× members of the SAC) along with a robust 30min question period. Statistics on engagement include: 120 attendees from 36 states. Of the attendees 7 were engaged internationally (Mexico 2×, India 1×, Canada 3×, and Spain 1×). We engaged participants from 8 professional backgrounds (agricultural professionals 10×, extension 13×, farmers 18×, government researchers 24×, nonprofit staff 16×, organic certifiers and inspectors 3×, university researchers 22×). 97% of attendees indicated an improved understanding of soil microbiomes, and 75% indicated that they were greater than somewhat likely to apply the knowledge they gained. Feedback suggests 72% of participants felt the presentation was appropriate in terms of technical information. The webinar has been permanently posted to our eOrganic community of practice website (https://eorganic.info/soilmicrobiome) and YouTube where it has received 297 views and 11 likes in \< 2mo. What do you plan to do during the next reporting period to accomplish the goals?Objective 1: Evaluate the benefits of long-term organic management for microbiome conservation Our results will be extended to 85 farmers through microbiome reports. We will leverage our previously described target audience of 18 Cornell University extension personnel in the validation of reports before farmer delivery, ensuring reports are understood by non-academic audiences. Report delivery to 85 farmers who make up a core audience is planned for January 2025. Feedback from farmers will be gathered to determine changes in practice adoption. Two additional manuscripts on the impacts of compost application and cover cropping are in preparation. Objective 2: Identify microbiomes that promote climate change resilience in crops We will continue conducting experiments and will construct our GEM model. These experiments will expand our seed sources to additional members of our SAC (n = 3), allowing us to determine the generality of our findings across microbiomes and seed sources. Long read microbiome sequencing for soil samples will be performed, along with plant hormone induction quantification. These data along with the sequencing conducted for the 85 farms in our network (Obj 1) will be used to parameterize our rapid microbiome sequencing decision support tool (Obj 3) by July 2025. A manuscript describing the relationship between the microbiome and crop fitness under drought will be prepared. The results of these analyses will be shared in a 1.5hr eOrganic webinar given with 2 members of the SAC. Objective 3: Provide a microbiome decision support tool for organic farmers We will refine our rapid long read microbiome sequencing approach and bioinformatics pipeline. We will then use our pipeline to sequence the soil microbiome of our 85 organic farmer network and the soil microbiomes of the SAC farms. Combining these data with our bioassays (Obj 2) we will use machine learning to determine relationships between farming practices, microbiome taxa, and measures of plant performance under climate change scenarios. In Fall 2025, we will promote our rapid sequencing resource and decision support tool. Farmers indicating interest in using the decision support tool will be sent a soil sampling guide, sample bags, and return postage. Within 1 week of receiving a submission to our rapid sequencing resource we will send the participant a

QR code to access a CSV file with their microbiome results and a link to try our decision support tool. The decision support tool will be built as a web application with Shiny and hosted on the Climate Smart Farming website. At the conclusion of the rapid sequencing resource pilot program, all submissions will be used to cross-validate our models. Participants will be emailed a report detailing the validity of our results and any changes in our suggestions based on this cross-validation in December 2025. Prior to launching our decision support tool, focus group interviews with our SAC will be used to evaluate decision support tool messaging frames for microbiome conservation and climate change. Results from focus groups and the pilot program of our decision support tool will be published in peer-review journals and developed into informative content to be delivered via eOrganic. In our final 1.5hr eOrganic webinar, we will highlight the current resources for climate smart farming. We will then highlight our pilot program for rapid microbiome sequencing and our decision support tool. Members of our SAC will reflect on the usefulness of the decision support tool and barriers to implementation will be discussed. Impacts What was accomplished under these goals? Issue: Functional relationships between the soil microbiomes on organic farms, specific farming practices, and climate change resilience remains largely unresolved. We seek to determine functional microbiome relationships, provide rapid microbiome decision support, and promote climate change resilience in transitioning and long-term organic farms. Objective 1: Major activities. During year 2 we used machine learning and structural equation modeling to determine how farming practices mediate the microbiome, plant defenses, and pest suppression. To confirm these models, we then conducted bioassays manipulating cover cropping and compost applications. Different cover crop species (canola and cereal rye) were found to mediate unique phytohormone pathways via changes in the microbiome, resulting in pest fitness differences for taxa with chewing and piercing sucking mouthparts. The results of these activities were extended to farmers via a 1.5hr eOrganic webinar. Data collected: Using a field soil microbiome survey of 85 farms, we evaluated nine aspects of microbiome alpha and beta diversity for both the fungal and bacterial sequences. To determine which taxa may be driving changes in microbiome diversity and function, we evaluated links between farming practice adoption and the abundance of specific microbial OTUs. Then we establish correlations between farming practices, plant defenses, and pest suppression, by inoculating sterilized potting media with the soil microbiome of farms from across NYS. Finally, we used structural equation models to test the impact of farming practices and farm characteristics (time in organic) on microbiome-mediated pest suppression. Summary statistics and discussion: The adoption of 3 management variables was correlated with decreases in alpha diversity for fungi and bacteria, including pre-planting practices (e.g., tarping and solarization), mineral fertilizer use; and no tillage. Five management practices (diversified cropping, cover cropping with grasses, cover cropping with legumes, compost application, and precision irrigation) correlated with changes in microbiome beta diversity. Twelve practices correlated with changes in specific OTUs across farms (no tillage, vegetative fertilizer, compost application, animal manures, mineral fertilizer, cover cropping with herbs, cover cropping with grasses, synthetic mulch, biological mulch, pesticides, broadcast irrigation, targeted irrigation). Of these microbiome changes, only 2 microbiome beta diversity measures and 3 OTUs were also linked with changes in jasmonic and salicylic acid, two important plant defense related compounds. In combination, our findings suggest the adoption of compost applications and organic pesticides increases crop susceptibility, while the adoption of grass cover cropping, targeted irrigation, and no tillage decreases plant susceptibility, via soil microbiome changes. Key outcomes.Change in Knowledge:Evidence linking 17 farming practices with microbiome diversity, plant defenses, and pest suppression 1×; Change in Action:Adoption of five key practices (no tillage, cover cropping, precision irrigation, compost application, and soil pesticides) linked with pest suppression and plant defenses via the microbiome; Change in condition:Highlighted key areas of improvement for long term organic management including increased adoption of cover cropping and no-tillage 1×; Extension of findings via eOrganic 1× Objective 2: Major activities.Soil sampling was conducted at the 7 organic seed farms in our stakeholder advisory committee. Seeds produced at farms and farming system practices at the site of soil sampling were also collected. Approximately 50ml of soil per sample was stored at -20° C for use in microbiome sequencing (see Obj 3). Data collected.Lab assays: Three 5-week assays were conducted. Bioassays began by extracting the live soil microbiome from each farm (n = 7 microbiomes). These microbiome extractions were applied to triple sterilize potting soil, beginning at the time of seeding, and continuing 2× per week for four weeks. Drought treatments were established by elevating plants on wicking foam blocks above a water reservoir with an approximate depth. The reservoir for well-watered treatments was filled daily, whereas the reservoir for drought treatments was filled 3× per week (≈2.3× less frequently compared to well-watered controls). After 4 weeks, microbiome applications ceased as did supplemental watering for the drought treatments for 8 days. During this 8-day period, plants (either received a cage control (no aphid), 10 aphids for 48hrs to assess induction responses, or 1 aphid for the full 8-day period to assess reproduction (6 replicates per measure). At the end of ≈5w we counted aphid progeny, measured plant biomass, collected leaf tissue samples for phytohormone quantification, sampled soil for microbiome characterization, and used a probe to record the percent soil moisture in each replicate. Plant tissues were then oven dried to determine the actual biomass and water content of plants. Summary statistics and discussion. Across our experiments, the microbiomes of the 7 seed farms provided consistent pest suppression benefits compared to a no microbiome control under droughted and well-watered conditions. These preliminary results suggest soil microbiomes are important for crop resilience to stress. In the next reporting period we will construct a Genotype × Environment × Microbiome (GEM) model to evaluate the impact of local versus foreign microbiomes (environment) on different crops (genotypes). Key outcomes.Change in Knowledge:Increased evidence that organic crops are adapted to local conditions and microbiomes 1×; Change in Action:Indicates importance of historical production characteristics in seed choice and future propagation regardless of microbiome 1×;Change in condition:Farmers may be able to align microbiomes and production practices to promote pest suppression under climate change conditions 1×. Objective 3: Major activities.We conducted a literature review for soil fungi and bacteria sequencing conducted with the ONT MinION device. Based on this review, we developed nanopore a long-read metabarcoding library preparation protocol and metabarcoding data analysis pipeline for downstream analyses. Data collected. A preliminary sequencing run was conducted on 12 of 85 field soil samples collected on NY organic farms, some of which were replicated, along with cell and DNA mock community controls. Following de-multiplexing we evaluated simplex and duplex base called reads for each sample, filtered, and aligned sequences. Summary statistics and discussion: By adjusting filtering, we have reduced false positive alignments for control samples and can now correctly assign taxonomy to the genus level of the mock community controls. We are currently modifying our filtering and clustering approach to further improve alignment. Key outcomes.Change in Knowledge:Developed novel in-laboratory sequencing pipeline for soil microbiomes 1×; Change in Action:Ability to rapidly sequence soil microbiomes of organic farms 1×;Change in condition:Farmers can submit soil samples for rapid microbiome sequencing and decision support in final reporting period 1×. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Exploring the Chemical and Molecular Ecology of Plant and Microbes: Interactions, Advances, and Future Directions. (2024) International Chemical Ecology Short Course. Pennsylvania State University, College Park, PA. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Casteel CL. Exploring the Chemical and Molecular Ecology of Plant-Microbe-Insect Interactions. (2024) Plant Breeding and Genetics Department Seminar Series, Cornell University, Ithaca, NY. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Casteel CL. Adoption of sustainable soil management practices, crop defense capacity, and the soil microbiome. (2024) USDA NIFA Annual Chemical Ecology Multistate Meeting, Cornell University, Ithaca, NY. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Casteel CL. Adoption of sustainable soil management practices, crop defense capacity, and the soil microbiome. (2024) Cornell AgriTech Seminar Series, Cornell University, Geneva, NY. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Bloom EH, Economos Z, Casteel CL (2024) How Organic Practices Affect the Soil Microbiome. eOrganic. Webinar. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Bloom EH, Casteel CL (2024) The causes of soil microbiome mediated insect pest suppression in organic agroecosystems. Entomology Society of America. National Harbor, MD. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Bloom EH (2024) A novel socio-ecological approach for promoting areawide adoption of organic farming practices that enhance microbially mediated pest control. Eco-spatial summit, State College, PA. Type: Conference Papers and Presentations Status: Published Year Published: 2024 Citation: Economos Z, (2024). Cereal rye and canola cover crops uniquely influence dry bean pest resistance through microbiome mediation. American Society of Plant Biologists. Honolulu, HI. Published poster. Progress 09/01/22 to 08/31/23 Outputs Target Audience:New York State Farmers:During project initiation, we described our intent to consult and engage with a group of organic farmers and educators interested in microbiome conservation, soil health, localization of food systems, and climate change resilience. This included 85 commercial organic farmers and a select group of farmers in a stakeholder advisory committee (SAC). In YR1 we met with our SAC advisory committee to generate preliminary feedback on study design and prepare for our YR1 sampling effort. Meeting attendees (n = 7) included Steven Crist (Hudson Valley Seed Company/Four-Fold Farm); Zaid Kurdieh (Norwich Meadows Farm); Zach Pickens (Row 7 Seed Co.); Lia Babitch (Turtle Tree Biodynamic Seed Initiative); Elijah Goodwin (Stone Barns Center); Jason Grauer (Stone Barns Center), and Isabel Hoyos (Stone Barns Center). Our SAC represents a broad range of organic and transitioning farmers in NYS and minoritized groups. For example, our collaborator at Turtle Tree Biodynamic Seeds works extensively with a community of people with developmental differences. This SAC meeting informed our experimental approach for our climate change experiments (seeObj 2). National Farms:Our project is relevant to all US organic farmers (US organic operations ≈ 28,000). To promote engagement on the national level, we are working closely with eOrganic in the development of extension materials including a website and webinars (1 webinar per project year = 3 webinars total). With the support of Alice Formiga at eOrganic we have developed a website showcasing the project, highlighting the SAC, and providing resources on our research to the general public (https://eorganic.info/soilmicrobiome). This website will serve as a repository for products (e.g., webinars, manuscripts, extension manuals) generated by the project. Extension Agents:Through our prior microbiome research (see Grant Number: 2021-67012-35042) we have a target audience of 18 Cornell University extension personnel that have assisted with the development of organic farmer survey tools for the microbiome. We will continue to engage with these extension agents as we deliver the results of our microbiome assessment conducted (see Obj 1) in YR2 to our 85 commercial organic farmer collaborators. We also promoted our research with extension agents at the annual \"All Hands\" Cornell Cooperative Extension meeting (Ithaca, NY). Scientists and Academics:During the reporting period, our research was shared in 4x lectures for post graduate academics and graduate and undergraduate students (see Products). Total engagement for the academic environment was ≈150 individuals;In YR1, the results of our research were shared with academics at the Frontiers in Chemical Ecology Symposium (Max Planck Institute, Jena, Germany) and the American Society of Plant Biologists (ASPB) (Savannah, Georgia) Social media:Posts regarding our research and recruitment for the project on Twitter generated 2768 impressions (views); 215 engagements; 2 new followers; and 114 profile visits. Project results will continue to be shared via social media during the following reporting periods. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Training activities:Microbiome extraction, sequencing, and analysis 1×; Phytohormone extraction and interpretation 2×; Machine learning 1×; Structural equation modeling 1×;Professional development:Conferences for junior scientists 2× (ASPB/EntSoc); Junior scientists co-hosted seminar series 1×; Grant writing and development for junior scientists 1×; Seminar presentations conducted by project team 4×; DEI Trainings (Project Biodiversify, Adult Mental Health First Aid,Fostering Well-being in Racialized Mentoring Environments) 3×; Mentoring (Graduate Mentoring and Well-being: Translating Research into Practice,Introduction to Equity-MindedMentoring,Creating Cultures of Mentoring and Well-being) 3X;IDP (Individual development plan) for junior and senior scientists 3×; Graduate student training for senior scientists 2×. How have the results been disseminated to communities of interest?Dissemination of results is integrated in Objectives 1-3 through the production of eOrganic webinars. In the next reporting period, we will detail the results of these Webinars. In our final reporting period, we will also discuss focus groups that will be hosted to determine appropriate messaging frames for a climate change resilience decision support tool (Sub-objective 3b) and the dissemination of information through rapid microbiome sequencing (Sib-objective 3c). In preparation for dissemination of information we have established an eOrganic community of practice website (https://eorganic.info/soilmicrobiome); conducted a meeting with our stakeholder advisory committee (SAC); presented our preliminary results at conferences and seminars (7×); and met with vegetable extension personnel to discuss the project and potential impacts. What do you plan to do during the next reporting period to accomplish the goals?Objective 1: Evaluate the benefits of long-term organic management for microbiome conservation We are developing two modeling approaches to improve our analysis. One uses machine learning, stability selection, and stepwise AIC to select farming practices that are influential on microbiome alpha and beta diversity, and differential abundance. The second uses structural equation modeling to the direct and indirect effects of economics, soil conditions, and farm characteristics on the microbiome, as mediate by farming practice adoption. Objective 2: Identify microbiomes that promote climate change resilience in crops From fall 2023 - winter 2024, we will collect cleaned market ready seed and soil from our SAC, along with characterizations of their farming practices. Microbiome sequencing for soil samples will be performed. Seeds will then be randomly selected from the lot and used in microbiome transplant experiments and climate change resilience evaluated. In brief, we will extract soil microbes which will be added to OMRI certified sterile (autoclaved) potting soil. Seeds from each of the SAC members will be planted in their natal microbiome, and sterilized controls. Because the same seeds are not produced by all of our stakeholders, multiple plant species (legumes, nightshades, and brassicas) will be evaluated in diverse microbiomes, which will also broaden the impact of our results. In the first experiment we will examine crop resilience to insect outbreak using aphids. A second set of experiments will examine crop resilience to drought stress. We are in the process of developing the methods to induce drought now. The experiments will be repeated at least three times and staggered over a 12-month period from spring 2024 - winter 2025. We will develop a 45-minute webinar that highlights our stakeholder\'s efforts to produce regionally adapted seed crops that are climate change resilient. Objective 3: Provide a microbiome decision support tool for organic farmers In the next reporting period, we will begin developing the hardware and standard operating procedures for a high throughput long read sequencing facility and decision support tool. We are currently in the process of hiring a highly skilled researcher to assist in decision support tool development. In brief, we will purchase the MinION long-read sequencing platform. Via these new sequencing resources, we will pilot a decision support tool in our final reporting period allowing NYS organic farmers to receive rapid microbiome sequencing. Impacts What was accomplished under these goals? Impact Statement. Issue:Farmers are grappling with the impacts of climate change globally, including increased extreme weather events and pest and pathogen outbreaks. We are using soil samples, laboratory and field experiments, and rapid sequencing to link the microbiome with climate change resilience in organic farms through plant health and inform farmer management through decision support. Methods/Preliminary Results:We characterized paired microbiome samples from 85 organic farms in New York State (NYS), and related microbiome characteristics (e.g., diversity) with specific farming practices. The preliminary analysis suggest soil microbiome diversity is highly dependent on the use of no-tillage, pre-planting practices (e.g., solarization), and fertilizer regimes (e.g., the use of mineral fertilizers). We are developing two modeling approaches to improve our analysis. One uses machine learning, stability selection, and stepwise AIC to select farming practices that are influential on microbiome alpha and beta diversity, and differential abundance. The second uses structural equation modeling to the direct and indirect effects of economics, soil conditions, and farm characteristics on the microbiome, as mediate by farming practice adoption. We also conducted a series of field and manipulative studies with combinations of cash and cover crops to assess the induction of plant hormones (ABA) that mediate climate change resilience. In our field and manipulative experiments, we found the microbiomes associated with some cover crops (cereal rye and hairy vetch) may reduce plant stress related to climate change in cash crops, as measured by abscisic acid concentrations in leaf tissues. In the next reporting period, we will work to identify microbiomes that promote climate change resilience in crops and start to develop a microbiome decision support tool for organic farmers. Taken together, our studies will determine if long-term organic management interacts with farming practices to predictably alter the microbiome and ecosystem services related to climate change. Broader outcomes.Climate change is now affecting agroecosystems in all regions of the world, through rising temperatures, changes in precipitation patterns, and increased pest and pathogen outbreaks. Our research is broadly applicable to any agroecosystem interested in leveraging soil microbiome conservation to promote climate change resilience. Details of Work done Toward Each Objective: Objective 1: Evaluate the benefits of long-term organic management for microbiome conservation Major activities.We created a survey tool to assess farm characteristics (time in organic management), farming practices, and collected soil samples from farmers accross New York State. We received 138 usable soil samples from 85 farming systems throughout NYS. We sequenced the soil microbiome of 85 NYS organic farms at MiSeq at Dalhousie University (Halifax, Nova Scotia). Preliminary analysis examiningthe impact of farm organic characteristics and practices on microbiome diversity was conducted. Data collected.DNA sequences:The V4-V5 region of the 16SrRNA, a region of the 18S SSU, and the ITS region of the rRNA gene was sequenced from DNA extracted from each soil sample to characterize the bacterial and fungal communities, respectively. Read preprocessing, data clustering, and post clustering were conducted, yielding the final set of 9,343 and 6,740 OTUs for bacteria and fungi, respectively. Taxonomy was then assigned yielded OTU and taxonomy tables for the soil samples. Phylogenetic tree construction was conducted.Farm and soil properties:Farm characteristics (time in organic management) and farming practices, for each sample were collected in the survey tool. We used the gridded soil survey geographic (gSSURGO) database rasters to retrieved representative values for the following soil properties: pH; available water content; organic matter; percent sand, silt, and clay; and erodibility. Summary statistics and discussion.We detected 6740 and 9343 unique OTUs for fungi and bacteria, respectively. OTU richness ranged from 651.13-1638.13 (mean = 1122.43; median = 1089.23) for fungi and 1078.18-6067.78 (mean = 4534.90; median = 4561.07) for bacteria. Fungi and bacteria were composed of 18 and 51 unique phyla, respectively. For fungi, 56.86% and 21.25% of OTUs belonged to the phyla Ascomycota and Basidiomycota. We observed OTUs were more evenly distributed across phyla for bacteria, with 24.79%, 12.85%, and 12.67% of OTUs belonging to the phyla Planctomycetota, Proteobacteria, and Chloroflexota, respectively.Our work with these microbiomes may indicate idiosyncratic relationships between diversity and ecosystem function, questioning whether conserving microbiome diversity per se is key for promoting biotic and abiotic resistance in farms. In the next reporting period, we may describe these idiosyncrasies in greater detail and the suites of practices that mediate microbiome diversity across farms and practices. Key outcomes.Change in Knowledge:Increased evidence for the factors mediating microbiome diversity in organic farming systems1×;Change in Action:Increase development of research related to the adoption of farming practices found to promote the microbiome and ecosystem function 1×; Increase extension tools geared towards the microbiome1×;Change in condition:Developed a basic understanding of the relationship between time in organic management, farming practices, and the microbiome 1×. Objective 2: Identify microbiomes that promote climate change resilience in crops Major activities.Randomized plots were constructed at two research farms in Upstate NY, Musgrave Research Station (CUAES) and Hudson Valley Farmhub. A cover crop treatment was grown for one season prior to the experiment, and then crimped. Tilled control plots were included. Then, each cash crop was planted within cover crop each treatment. Data collected.Field trials:Rhizosphere soil was sampled, bulked, and frozen for each treatment. Then, cash crop tissue was sampled for at least three plants per treatment plot and frozen in liquid nitrogen when the plants reached maturity before flowering/seeding. To extract the phytohormones, the tissue was lyophilized, then the metabolites were extracted. The concentration of abscisic acid (ABA), a hormone related with drought and climate change resistance in plants, was measured in field collected plants using HPLC/LCMS.Lab Trials:Microbiomes were transferred from the rhizosphere soil samples for each cover crop treatment. Cash crops were planted at the first soil microbe inoculation, then the microbiome slurries were re-applied to the soil twice a week. Then, metabolites were extracted using the same protocol from the field trials. Summary statistics and discussion.Cereal rye & hairy vetch cover crop residues reduced abscisic acid levels in multiple cash crops in both the field and laboratory experiments.Our results indicate that cover cropping may promote microbiomes that aid plants in hormonal responses linked with climate change resilience. In our next reporting period, we will be conducting a series of abiotic and biotic experiments to further link the microbiome with climate change resilience in organic farming systems. Key outcomes.Change in Knowledge:Increased evidence that cover cropping mediates the microbiome and climate change resilience on organic farms 1×;Change in Action:Identified specific cash and cover crop combinations that promote the microbiome and climate change resilience 1×;Change in condition:Farmers may be able to select cash and cover crops that promote the microbiome and climate change resilience 1×. Objective 3: Provide a microbiome decision support tool for organic farmers Publications Type: Peer Reviewed Journal Articles Status: Other Year Published: 2023 Citation: Bloom EH, Atallah SS, Casteel CL (2023) The causes of soil microbiome mediated insect pest suppression in organic agroecosystems. In prep. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Casteel CL (2023) Frontiers in microbial reprogramming of the plant defense system during plant-insect interactions. Frontiers in Chemical Ecology Symposium. Max Planck Institute of Chemical Ecology, Jena, Germany. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Casteel CL (2023) Microbial remodeling of plant-insect interactions. Entomology Seminar Series, Cornell University, Ithaca, NY. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2022 Citation: Casteel CL (2023) Microbial remodeling of the plant to enhance vector performance. University of Georgia, Athens, GA. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Casteel CL (2023) Microbial remodeling of plant-insect interactions. Biology Department, EGE University, Ismir, Turkey. Published presentation. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Economos ZC, Bloom EH, Eddy EH, Menalled UD, Ryan MR, Casteel CL (2023) Cover-crop conditioned microbiomes show promise as tools to manage cash crop stress responses. Savannah, Georgia. Type: Conference Papers and Presentations Status: Published Year Published: 2023 Citation: Bloom EH, Atallah SS, Casteel CL (2023) A novel socio-ecological approach for promoting areawide adoption of organic farming practices that enhance microbially mediated pest control. PPPMB Lecture Series, Ithaca, NY.

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Improving Profitability of Organic Sweetpotato Through Pest Resistant Clones and Enhanced Anaerobic Soil Disinfestation

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NON-TECHNICAL SUMMARY

Weed and nematode infestation significantly reduces yield in sweetpotato. Minimal economically relevant options are available for use in organic sweetpotato to control weeds and nematodes. The research proposed here focuses on evaluating Anaerobic Soil Disinfestation (ASD) in sweetpotato field trials for crop tolerance and weed and nematode management. ASD is biological fumigation process that utilizes carbon inputs and sealed soil to produce volatile organic compounds that kill soilborne pests. In addition to ASD, we will evaluate the impact of novel UV reactive mulch on controlling weeds and total sweetpotato yield. Finally, we will integrate ASD and UV reactive mulch with Sweetpotato germplasm that have increased tolerance to weeds and/or nematodes. Specifically, we will look at germplasm that exhibits a bunch type growth habit and resistance to root knot nematode species. Economic analysis will be conducted to determine how profitable these treatments will be compared to grower standard practices These experiments willbe conducted at the Clemson vegetable research facility in Charleston, the Edisto Research and Education Center in Blackville, SC and at grower locations along Coastal SC.

OBJECTIVES

Our long-term goal is to develop an integrated management approach in organic sweetpotato production that combines anaerobic soil disinfestation (ASD), novel plastic mulch, and sweetpotato clones with improved resistance to the southern root-knot nematode (SRKN) and weed infestation. Our integrated research, extension, and outreach activities will lead to effective management strategies to increase domestic organic sweetpotato production.Evaluate ASD on sweetpotato germplasmScreen a panel of 20 sweetpotato clones to an ASD environment. Include PlantIntroductions (PIs) and commercial germplasm that have either a bunched type growth habit or resistance to southern root-knot nematode (SRKN) as well as commercial standards.Evaluate the impact of time of transplanting (0, 1, 2, and 3 weeks) after ASD has been terminated with selected clones from objective 1a.Evaluate ASD with different locally sourced carbon sources for the ability to reduce the incidence and population density of SRKN and weeds in sweetpotato fields.Evaluate the impact of novel plasticulture materials to control weeds and grow sweetpotato in the field.Integrate thebest practices of ASD, plasticulture material, and improved sweetpotato lines todetermine impact on weed infestation and nematode suppression.Evaluate combination of plasticulture, sweetpotato germplasm, and ASD at Coastal Research andEducation Center (CREC)/United States Vegetable Lab (USVL) and on farm locations.Evaluate the impact of ASD on soil microbial dynamics in sweetpotato production systems.Conduct a cost-return analysis of ASD in combination with improved plastic mulch and novel sweetpotato germplasm compared to currently used management practices and sweetpotato cultivars.Communicate results and guidelines to stakeholders, scientists, and industry professionals in the Southeast and other regions in the U.S. through an aggressive extension and outreach program.

APPROACH

Objective 1a: Screen a panel of 20 sweetpotato germplasm to an ASD environment. Include PIs and germplasm that have either a bunched type growth habit or resistance to SRKN as well as commercial standards.Objective 1b: Evaluate the impact of time of transplanting 0, 1, and 2 weeks after ASD has been terminated with selected cultivars from objective 1a.Methodology and Data Analysis: For Objective 1a, initial greenhouse trials will be conducted at the CREC/USVL. The experiment will be structured as a randomized complete block design with five replications. The treatments will consist of a factorial of carbon source (cottonseed meal) by 20 sweetpotato PIs and commercial cultivars that include several bunched type growth habit and/or resistance to SRKN as well as commercial standard cultivars such as Beauregard and Covington. The experimental unit will consist of a 5-gallon bucket microcosm filled with native South Carolina soil. For nematode experiment, the soil will be sterilized followed by inoculation of 10,000 eggs of SRKN. Amendments will be added to the buckets at a rate equivalent to seven tons per acre, and half the buckets will be covered with an impermeable film (Tiff) mulch, the units that will undergo ASD. An initial irrigation of 5 cm of water will be applied. Water will be applied based on moisture and redux potential measurements throughout the trial. ASD treatment will be performed for 6 weeks, then plastic will be removed. Percent weed emergence and weed biomass will be recorded 6 weeks after ASD initiation. Nematodes will be extracted from a 100 cm3 subsample using centrifugal-flotation technique (Jenkins, 1964). Nematode enumeration will be conducted enumerated using a dissecting microscope at 40x magnification. Sweetpotato biomass will be harvested at 12 weeks after transplanting. All data will be subjected to analysis of variance using JMP. Means will be separated according to Tukey\'s (α= 0.05). Contrast statements will be constructed to analyze differences between specific ASD-carbon source-genotype treatments. For Objective 1b, experiments will be conducted as a randomized complete block with four replications. The treatments will be structured as a factorial with three transplant timings, two carbon amendment treatments, and four sweetpotato cultivars. Sweetpotato biomass will be harvested 12 weeks after transplanting.Fields selected for trials have been previously inoculated with SRKN (M. incognita) and have been planted with susceptible host crops in successive years to increase and maintain the nematode populations in the soil. Nematode populations within each ASD treatment block will be assessed at four times during each growing season (Before ASD treatment, planting, mid-season, and final harvest). Replicate soil samples will be taken from each plot during each time point. For each sampling, twenty soil cores will be taken in a zig-zag pattern across the length of each row within the crop root zone (when present) using a 12-inch soil probe. Soil cores will be combined in a clean bucket, and thoroughly mixed to provide a uniform 500 cm3 sample that will be delivered to the Nematode Assay Lab at Clemson University for nematode extraction and counting. Mean counts of RKN juveniles per 100 cm3 of soil within each plot will be generated and used to assess the effect of ASD treatments.The experiment will be conducted as a randomized complete block split-plot design with four replications at locations (Charleston and Edisto REC, Blackville, SC). The treatments will be constructed as a factorial with the main plot factor being carbon source amendment (Chicken Manure + Molasses, cotton seed meal, brassica waste, mixed cover crop material, brewers\' yeast, or no carbon amendment). All relevant chemical analyses (particularly, C:N ratio) of the carbon sources will be done. To prepare raised beds, the field will be mechanically disked to breakdown weeds, improve soil granulation, and surface uniformity. Raised beds will be prepared using tractor-mounted bed former. Soil carbon treatments will be added to the plots manually and mixed with tractor-mounted peanut hoe. Then, a tractor mounted plastic bedder and drip tape implement will be used to re-bed the field and cover with plastic mulch. Assigned plots will be covered and completely sealed with an impermeable film (TIF) black polyfilm mulch (1.25 mil). An initial 5 cm irrigation will be applied to facilitate Anaerobic Soil Disinfestation in the soil. ASD performed for six weeks. Oxidation-reduction potential (ORP) sensors (Pt combination electrodes, Ag/AgCl reference; Sensorex, Garden Grove, CA, USA) will be installed in the center of all plots at a 15-cm depth to monitor anaerobic soil conditions. A data logging system (CR-1000X with AM 16/32 multiplexers, Campbell Scientific, Logan, UT, USA) will be used to record the outputs from the sensors which monitor readings every 30 s and are averaged on an hourly basis. Nematode counts, weed counts, and sweetpotato yield (weights as well as sorted graded counts) will be taken at the end of the study. All data will be subjected to analysis of variance using JMP. Means will be separated according to Tukey\'s (α= 0.05). If appropriate, data will be averaged across years. A Shapiro-Wilk diagnostic will be used to assess normality on multiple dependent variables.Evaluate the impact of novel plasticulture materials to control weeds in sweetpotato fields.Methodology and Data Analysis:The experiment will be conducted as a randomized complete block split plot with four replications. The treatments will be constructed as a factorial with main plot consisting of a plastic mulch treatment (black UV reactive plastic, white UV reactive plastic, black TIF plastic, white TIF plastic, and bare ground). Each main plot treatment will be split into sweetpotato cultivar (Beauregard, Covington, and two bunched type cultivars). Beds will be formed in the same manner as was described in Objective 2. Each main plot will be 60 ft in length while each subplot will be 15 ft in length. Weed species counts will be collected throughout the trial and sweetpotato yield will be collected at the end of the study. The experiment will be repeated in time as well as space (Charleston SC and Blackville SC). PD Cutulle will coordinate purchasing of novel plastic materials and conduct the trial in Charleston while Co-PI Ward in collaboration with project evaluator Miller will implement the trial in Blackville, SC. Similar statistical methodology will be used as was described in Objective 1 and 2.Partial budget analysis and change in production profits: Partial budget analysis is a widely used analytical method by the farm owners and managers to estimate the net economic effects of changes in production systems. It allows business managers to evaluate changes in production profit - not profitability. It is a standard method to compare the financial impacts of changes in various production practices, such as weed management (Meagher et al. 2021), soil anaerobic disinfestation (Donahoo et al. 2021), and planting methods (Mihretie et al. 2021). This analysis will only consider partial factors that would change because of the adoption of alternative practices, since the remaining elements that will not change will not have any impact on profits. Therefore, the analysis would reveal how profits would increase or decrease with the adoption of alternative farming practices. Labor, cost, and time savings will also be included in the partial analysis, as appropriate. Progress 09/01/23 to 08/31/24 Outputs Target Audience:The three students funded by this project: Simardeep Singh (Nematology and Weed Science) Meredith Tucker, and Sanjeev Sharma (Economics) presented at multiple conferences and field days this past year. Simardeep Singh presented the results of a field trial evaluating carbon source and sweetpotato genotype on yield and weed control in an ASD field trial at the national weed science society of american annual confernce in San Antonio texas. Mr. Singh also presented his research at the southnern American Phytopathology Society meeting in Columbia South Carolina and the national nematology meeting in Utah. The focus of these presentations were the impact of sweetpotato genotype and ASD treatment on nematode suppression in a controlled greenhouse study. Meredith Tucker, Simardeep Singh and Sanjeev Sharma all presented at the Clemson graduate student research symposium this past year. In addition to the hundreds of researchers who observed these talks Dr. Cutulle and Mr. Singh presented the results of the sweetpotato field trials to growers at the annual spring summer field day in Charleston South Carolina. Dr. Cutulle also presented field and greenhouse data on the project to growers at preplant meetings. Changes/Problems:We are repeating the soil micrbiome assay a third time as the 2nd run of the experiment provided data we deemed ususeable. What opportunities for training and professional development has the project provided?Simardeep Singh and Sanjeev Sharma have gained experience conducting sweetpotato field research from both a production perspective as well as enconomic perspective. They have presented their research at multiple conferences and at those meetings went to grad student sessions focused on growing as a scientist as well as presenting applied research results to the public that is readily useable. How have the results been disseminated to communities of interest?The results of the study have been presented at scientific meetings such as the nematology society of america, weed science society of America and horticultural society of America. The field trials have also been show cased at the Coastal Research and Education Center\'s annual vegetable field day in June of 2023 in Charleston SC. What do you plan to do during the next reporting period to accomplish the goals?Objective 1 has been completed and data has been analyzed. We are currently ediiting the draft of the manuscript for publication in the journal of plan disease. We have repeated objective 2 across two field seasons. Next steps would include preparing the data for publication. We are repeating objective 3 during the summer of 2025. Objective 4 will be implemented in the field in 2025 Objective 5 has been conducted by PI Dr. Kerrigan and will be published in her students MS thesis. Objective 6 has been codncuted for the most recent field trials and we plan on publishing an economics paper once teh field trials have been repeated. Objective 7. We will be show casing Objective 4 at a sweetpotato field day in fall of 2025. We also are preparing extension publications in Clemson\'s land grant press article. Impacts What was accomplished under these goals? For objective 1a PhD student Simardeep Singh has repeated the greenhouse screening of the 20 sweetpotato clones in time. Pots that recieved a soil amendment and went anaerobic had significantly less nematodes compared to the control. Also we were able to identify sweetpotato clones that were more resistant to southern root-knot nematode including USDA 20-053. Beauregard was the most susceptible to rootknot nematode. objective 1b Evaluate the impact of time of transplanting (0, 1, 2, and 3 weeks) after ASD has been terminated with selected clones from objective 1a. Objective 1 B Is currently being conducted in the greenhouse. Publications Type: Other Status: Published Year Published: 2023 Citation: Singh, S., Karthike, R., Bridges, W., Ward, B., Khanal, C., and Cutulle, M. 2023. Improving profitability of organic sweetpotato through pest resistant clones and enhanced anaerobic soil disinfection. PES Department Seminar. Clemson. SC. Type: Other Status: Published Year Published: 2024 Citation: Singh, S., Khanal, C., and Cutulle, M. 2024. Anaerobic Soil Disinfestation: a promising method to manage Weeds and Nematodes in Sweetpotato. WSSA/SWSS meeting. San Antonio, Texas. Type: Other Status: Published Year Published: 2024 Citation: Singh, S., Khanal, C., and Cutulle, M. 2024. Screening of sweetpotato germplasm for anaerobic soil disinfestation and southern root-knot nematode resistance. Southern APS. Columbia, SC. Type: Other Status: Published Year Published:

2024 Citation: Singh, S., Khanal, C., and Cutulle, M. 2024. Utilization of anaerobic soil disinfestation for managing nematodes and weeds in organic sweetpotato. Society of Nematology meeting. Park City, Utah. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Currently we have been only conducting greenhouse and field trials. Two greenhouse studies were completed during the reporting period. The field trial was initiated but not in time for the annual field day that the Clemson Coastal Reserach and Education Center hosts. Individuals who have particpated in either conducting the research or observing the treatments include multiple graduate students, including two funded from this grant as well as individuals who attended a Clemson graduate student research symposium. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Two students funded from this grant have presented research at a graduate student symposium. How have the results been disseminated to communities of interest?Currently we have not presented the results of the study to growers or extension agents. The students have presented to other researchers and graduate students. What do you plan to do during the next reporting period to accomplish the goals?Field trial data will be analyzed and results will be presented at grower field days. The replicated Greenhouse trials will be prepared for publication. Students will showcase field trials at the annual Clemson Coastal Research and Education Center field day in June of 2024. Partial budget analysis will be conducted on data from the 2023 sweetpotato field trials. Impacts What was accomplished under these goals? The first portion of goal one was completed in a greenhouse. Sweetpotato cultivars such as Beauregard, which is commonly grown in South Carolina performed well. Some of the best performing sweetpotatogermplasm were from USDA PI lines that exhibted a bunched type growth habit, which indicates potential for improved weed managment in sweetpotato. Field trials associated with goals 2 and 3 have been harvested but data is still being analyzed. Publications

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Can Living Mulch Enhance Soil Health and Ecosystem Services of Organic Vegetable Production Systems in South Dakota?

Accession No.	1029000
Project No.	SD00G703-22
Agency	NIFA SD.\
Project Type	OTHER GRANTS
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Contract / Grant No.	2022-51106-37925
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Start Date	01 SEP 2022
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Grant Year	2022
Investigator(s)	Xu, SU.
Performing Institution	SOUTH DAKOTA STATE UNIVERSITY, PO BOX 2275A, BROOKINGS, SOUTH DAKOTA 57007

NON-TECHNICAL SUMMARY

South Dakota stakeholders have expressed great interest in information on organic vegetable management strategies to improve profitability and ecosystem sustainability. To meet this need, it will require concerted efforts to generate science-based data for field demonstrations and ecosystem service evaluations. Specifically, barriers to production include climatic conditions, lack of knowledge on organic transitioning, and unknown performance of different organic management practices to maintain production and profitability through nutrient management and weed control, with lower reliance on organic manure and tillage. Thus, we proposed to investigate the feasibility and impacts of living mulch integration on agronomic performance, soil health, economic returns, and overall ecosystem services for organic vegetable production.The proposed project will be conducted at one South Dakota State University research farm and one farmer\'s field that are both at the organic transitioning stage, and one USDA organic certified farmer\'s field in South Dakota. It will address questions surrounding the incorporation of perennial clover species in vegetable cropping systems by trialing three varieties (red clover, white clover, and kura - white clover) as living mulch. Three different cash crops (squash, cabbage, and sweet corn) will be grown in rotation in the living mulch and four different tillage management practices will be used. Stakeholders will be closely involved in defining the problems, planning, participating in the study, and providing feedback. Dissemination of information will be to the specialty crop producers and associations, university and high school students, agency personnel, and other stakeholders through formal and informal extension and education channels.The research has the potential to improve the resilience of vegetable cropping systems in South Dakota by identifying new management strategies that utilize organic practices without compromising crop yield, while improving soil health and providing multiple ecological environmental benefits. This work will provide pertinent information in areas with short growing seasons, and therefore a small window for cover crop incorporation, as well as low soil organic matter and fertility, like South Dakota. Specifically, utilizing living mulch as a management option aims to benefit small vegetable farms with little organic manure resources and for those farmers adopting reduced tillage. The findings of this work will also be beneficial to other areas with low adoption of organic practices due to lack of transitioning and certificating information. We hope to promote organic vegetable production in South Dakota and other areas with similar climatic conditions and therefore contribute to growth of overall organic farming in the US. The data generated from this project will fill an important research gap in organic vegetable production and provide valuable information on sustainable vegetable production.

OBJECTIVES

The goal of this project is to determine if using perennial clover cover crops as a living mulch can improve soil health, agronomic performance, and profitability of organic vegetable systems. This work will integrate the research, extension, and education objectives listed below:Objective 1. Soil analysis (soil health, fertility, organic carbon, and microbial activities). Objective 2 Agronomic assessment (yield, biomass, and nutrient uptake). Objective 3 Economic analysis. Objective 4 Extension and outreach (knowledge, research findings, and information distribution). Objective 5 Education (lectures, student training, youth education).This project will provide information and knowledge to producers and other stakeholders on sustainable organic vegetable management with lower reliance on manure and tillage. This could potentially increase the number of organic vegetable farms in South Dakota and other areas with similar barriers to organic transitioning.

APPROACH

The study will be conducted at three sites: 1) SDSU Southeast Research Farm, Beresford, SD, 2) Blue Sky Vegetable Co., Worthing, SD, and 3) Haroldson Farms, Bruce, SD. The research field at the SDSU Southeast Research Farm is in organic transitioning stage and will be USDA certified by 2024. Blue Sky Vegetable Co. (https://blueskyveg.com/) is operated by Kjersten and Dirk Oudman, in Worthing, SD. It has 25-acre CSA farm which has been managed without chemical input and uses non-treated seeds and will be certified organic in 2023. Haroldson Farms (https://haroldsonfarms.com/) is a family-owned produce farm and is USDA certified organic near Bruce, South Dakota. It is a farm.Treatment to be assessed at the SDSU farm will be full combinations of three types of living mulch (and a control without living mulch) and four types of tillage management. The experiment is a randomized complete block design with four replicates. Size of each plot is 30 feet × 40 feet. Three varieties of perennial clover species as living mulch (red clover, white clover, and a kura x white clover mixture) as well as a control without clover will be tested. Clovers will be planted in April, and cash crops will be seeded and grown as transplants and planted into the field by hand in May. Cash crops from the first to the third year in the trial will be squash, cabbage, and sweet corn. When squash is the cash crop, the living mulch will only be mowed at planting. When cabbage and sweet corn are the cash crops, mowing will occur throughout the growing season. Four tillage management practices will be evaluated: 1) Flail-mowing and 30\" tillage strip, 2) Flail-mowing, 30\" tillage strip, and 36\" black landscape fabric, 3) Flail-mowing and 36\" black landscape fabric, and 4) Flail mowing only. The tillage practices will be applied in May in the rows for cash crop planting.Trials at the private farmer sites will only use the red and white clovers, and the non-clover control, and will not include the new kura x white clover mixture. Each plot will be minimum 10 feet x 20 feet. To make it easier for farmers to operate, only one plot for each treatment will be established. Similarly, to make it simple, no tillage treatment will be applied on farmers\' land. For the first two years, the cash crop grown by the farmers will be the same as in the SDSU trial. The third year of sweet corn planting will be optional.Objective 1. Soil analysis. Purpose: Investigate the impacts of perennial clover integration as living mulch on soil health indicators, soil nutrients, soil organic carbon stocks and distribution, and microbial community structure and activities in organic vegetable production systems.At the SDSU Southeast Research Farm, soils will be collected to a depth of 60 cm at the beginning and end of each trial to investigate changes in soil carbon stocks and nutrients after three years organic vegetable management using living mulch. The 0-10 cm soil will be used for soil health assessment including: 1) physical: moisture, macroaggregate stability; 2) chemical: pH, electrical conductivity, total and mineral nitrogen, extractable phosphorus and potassium, and 3) biological: microbial biomass carbon, potential mineralizable nitrogen and carbon, soil organic carbon, enzyme β-glucosidase activity. Soils from the SDSU trials will also be collected at 0-10 cm every year in spring to analyze labile carbon fractions and microbial community.Soil in farmers\' fields will be collected at 15 cm in Spring 2023 before planting cover crops, and every spring until 2026. The soils will be sent to Ward Laboratories, Inc. Soil organic carbon, total nitrogen, pH, nitrate nitrogen, phosphorus, potassium, and other nutrients (calcium, magnesium, sodium, sulfur, zinc, iron, manganese, and copper), and microbial community structure (PLFA) will be analyzed.Objective 2 Agronomic assessment. Purpose: Study living mulch biomass, cash crop yield, nutrient uptake, plant quality, and weeds as influenced by selection of clover species and tillage methods.At the SDSU Farm, clover and weed biomass will be evaluated separately for alley and cash crop rows during the growing season. Samples will be sorted into weed and cover crop biomass, dried using a forced air drying oven, and weighed to assess dry matter. It is anticipated that biomass will be collected at least four times throughout the growing season. Crop yield will be assessed by harvesting cash crops at horticultural maturity over several days, not to exceed four harvest events at which time all produce will be removed during the final harvest, and all plants will be harvested and graded to determine a count and weight of marketable and un-marketable cash crops. Prior to the final harvest of either cash crop, the plant height will be measured; additionally, cash crop plant biomass will be collected. These data will aid in understanding treatment effects on cash crop plant growth and yield. One composited clover and one cash crop sample from each plot will be collected in September/October before cash crop harvesting for measuring nutrient uptake. On farmers\' sites, similar analysis will be conducted with three samples to be collected from each treatment plot. Objective 3 Economic analysis. Purpose: Estimate the input costs, output prices, and overall profitability at transitioning stage in organic vegetable production, and/or early stages of living mulch integration.Total revenue will be calculated by multiplying crop yield with crop price reported by the average USDA NASS price of the harvested year. We will calculate the potential benefits of living mulch under organic systems, which include: 1) reduced fertilizer cost for the cash crop, 2) reduced herbicide/pesticide costs, and 3) yield/farm revenue increase from consequent cash crop. Farmers will be provided with the economic profit information of cash crop only, of living mulch only, and of a combination of both factors. Furthermore, producers will obtain information regarding economic effects of tillage on cover crop field.Objective 4 Extension and outreach. Purpose: Organize field days and webinars to demonstrate field management and distribute findings from the study to increase the impact and the adoption of living mulch integration practices. Provide knowledge, technologies and information on organic vegetable production, organic transitioning, and USDA organic certifying processes to promote organic vegetable production in South Dakota.In July 2023-2026, research field days will be held at the SDSU Southeast Research Farm for field demonstration. In both August 2024-2025, one of the two participating farmers will host on-farm field day on their farm. In January 2024 to 2026, webinars will be presented virtually to provide intensive science-based production information for small and medium-scale producers. During both 2025-2026, there will be at least one SDSU Extension web article published, three social media posts highlighting project progress, and one in-field video (3-5 minutes in length) to be posted on the SDSU Extension YouTube Channel.Objective 5 Education.Purpose: Offer lectures for university students to gain knowledge of organic vegetable production. Train students through participation in research projects. Provide tours to undergraduate and high school students to introduce organic vegetable farming.The project team will give at least two guest lectures for SDSU undergraduate and graduate courses: e.g., Organic Food and Plant Production, Introduction to Sustainable Agriculture, Environmental Soil Management (. This research project creates the opportunity to host in-person tours and engage in science communication with a secondary audience above and beyond specialty crop producers. Progress 09/01/22 to 02/12/25 Outputs Target Audience:The audience includes students, farmers, researchers, and extension personnel who are interested in sustainable agriculture and organic vegetable projection. Research goals, experimental designs, project progress and preliminary data were introduced to audience at Field Days and tours held at Beresford, Southeast Research Farm, and Blue Sky Vegetable Co. Knowledge of organic management has been introduced to students in undergraduate and graduate courses. Information associated with this research project was distributed to the audience through extension publications, online videos, seminar presentations, virtual courses and other outreach products. The audience includes students, farmers, researchers, and extension personnel who are interested in sustainable agriculture and organic vegetable projection. Research goals, experimental designs, project progress and preliminary data were introduced to audience at Field Days and tours held at Beresford, Southeast Research Farm, and Blue Sky Vegetable Co. Knowledge of organic management has been introduced to students in undergraduate and graduate courses. Information associated with this research project was distributed to the audience through extension publications, online videos, seminar presentations, virtual courses and other outreach products. Changes/Problems:The selection of vegetable main crop was adjusted to the interest of farmers on the farmers sites. More varieties were planted. The squash plant, which was the initial plan of the year 1 planting, was also included in their fields. Due to the drought weather, cover crops were replanted in some fields. One of the farm participants wanted to restart a new trial along with the previous established trail remain being used. With that, we collected soil from both trials on this farm and will continue managing both for next year. What opportunities for training and professional development has the project provided?Three graduate students were trained in field establishment, maintenance and management in organic vegetable projection systems. One graduate student is trained in soil sampling, lab analysis, instrument operation, and data analysis. All students have gained experience of giving field talks and conference presentations. Audience from this project, including farmers and other stakeholders, obtained knowledge and information on sustainable organic farming, and extended network to know each other for future communications. PIs from this project gained knowledge through participating conferences and workshops. How have the results been disseminated to communities of interest?Preliminary results were shared with the public through outreach events such as field day tours and talks, extension publications, videos and short courses, and conference presentations. Details can be shown in Products and Accomplishments sessions in this report. Moreover, the research team has also been meeting with the participating farmers to report the progress on data collection and analysis. 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. Soil analysis. 50% accomplished? Soil samples were collected in 2022 and 2023 initiated trials at 60 cm before field establishment and then collected at 0-10 cm in 2023, 2024. The baseline soils for trial 2022 were analyzed for Nitrate N, P, and K. The highest Nitrate N in 2022 was about 30ppm, dropping to below 20 ppm in 2023 and about 10 ppm in 2024. P decreased from about 100 ppm in 2022 to lower than 100 or lower than 80 under some treatments in 2023 and 2024. K also decreased from higher than 350 ppm in 2022, to lower than 350 ppm in 2023 and 2024. Under no till 2023, nitrate N was highest under white clover, P was highest from kura clover plots, and K was the highest under red clover. Soil total carbon and nitrogen increased from baseline in 2022 to 2024 in some no-till plots. In 2022, carbon concentration was about 30-35 g/kg, increasing to above 40 g/kg in some no-till plots. The total nitrogen was about 5 g/kg in 2022 and was above 5 g/kg in 2024. Similar trends were also observed in trial 2023, which showed an increased enzyme activity (β-glucosidase activity) of above 200 μg pNP g-1 soil h-1 in many plots in 2024 than below 160 μg pNP g-1 soil h-1 in 2023. On farmers\' fields, soil sampling was conducted in 2023 and 2024. Results showed a decrease in nitrate, P, and K in 2024 compared to 2023. However, there was a slight increase in soil microbial activity, including total bacterial biomass, actinomycetes biomass, and total fungal biomass, in 2024. Impact: Maintaing soil health, especially soil nutrients, is essential for sustainable organic farming. A good strategy of management with the potential of improving soil health may improve organic farming in this location. Objective 2 Agronomic assessment. 70% completed In squash trials at the Southeast Research Farm, due to limited moisture and heavy weed competition, clover struggled to take off and weeds overcame the project site. Red clover had the tallest height among the clover treatments. Weed biomass decreased throughout the season. Marketable squash yield was reduced in the no till plots for clover treatments. Kura clover treatments produced significantly fewer squash compared to other clover treatments. Marketable squash harvested from the red clover plots produced the most fruit per plant compared to white clover and kura treatments. For cabbage trial, cabbage in the no till treatments have shown signs of stem elongation and reduced growth with a lack of head development. From May and June 2023, red clover had greater biomass and weed biomass continued to trend towards higher pressures in the clover treatments compared to the tilled bare ground in August and September. In 2024, the clover whole block living mulch was successful at suppressing weed accumulation throughout the season. Clover biomass was the highest for the white clover treatment, being 150% greater than kura clover and 214% greater than red clover. The bare ground had the highest count of marketable heads, with 155 US Number 1 heads, and 75 Commercial heads, followed by white clover, kura clover and then red clover. In the corn fields in 2024, white clover was also the best living mulch at suppressing weeds, accumulating only 594 kilograms/hectare (530 lbs/acre) of weed biomass over the growing season. Kura clover was second in suppression. The bare ground produced the highest yield of US Fancy ears at 7.3%. The red clover had the highest replicated percentage of unmarketable ears, with an average of three unmarketable out of the 15 ears analyzed. On-farm trials were established at Haroldson Farms (HF) and Blue Sky Farms(BSF). Because of lack of moisture and weed competition, the clover population quickly died off in 2023. The 2024 growing season cover crops and cash crop management have continued as planned. One farmer decided to have an adjacent field to redo the work in 2024. In HF, red clover was on average taller than white clover. There was little difference in weed height throughout the season. The weight of oats was higher in the red clover treatment by 136.7 pounds per acre. Red clover had almost 500 pounds per acre more biomass than white clover. Both clovers decreased the biomass of weeds compared to the bare ground. White clover performed best when it came to weed biomass suppression. Impact: This project will provide information and knowledge to producers and other stakeholders on sustainable organic vegetable management with lower reliance on manure and tillage. This could potentially increase the number of organic vegetable farms in South Dakota and other areas with similar barriers to organic transitioning. Objective 3 Economic analysis. 45% completed Since the start of the project, economic data has been recorded. This includes the tracking of costs and expenses for purchasing equipment, seeds, labor, and other input. Data will be transferred to digital format and will be used for economic analysis. One student will keep tracking remaining data. Another student has been trained by co PI Dr. Wang to learn how to organize data and will analyze the available data soon. Impact: Accomplishment of this objective will provide information for farmers with financial decisions on transitioning to organic farming for vegetable production. Objective 4 Extension and outreach. 85% completed. In 2022-2023, two field talks were given at Southeast Research Field Day, and five talks were given at other events (Cedar Creek Gardens Field Day, Garden Hour Presentation, 3rd Annual Specialty Crop Field Day, SERF High School Field Day, Dordt University Agroecology Class Tour). Two videos and four extension publications were given. In 2023-2024, the team hosted an Organic Field Day at Southeast Research Farm and also gave talks on the annual field day. Besides, four invited talks, three videos, three extension publications, three conference poster presentations and four Booth and farm forum were given. In 2024-2025, one field day was hosted at Blue Sky Vegetable Co. and talks have been given at the Southeast Research Farm field day. One report and three talks were given at other activities. One video and four extension publications were generated. Four oral presentations and two poster presentations were given at conferences. Impact: The distribution of our research progress and finding, as well as knowledge and techniques on managing organic farms, cover crops, living mulch, and sustainable vegetable production, is important for producers to have a better idea on decision making for their future farm management. Objective 5 Education (lectures, student training, youth education). 80% completed. From 2022 to 2023, sustainable agriculture and organic management has been introduced in courses Environmental Soil Management and Soil Health in Agroecosystems. From 2023 to 2024, Organic Plant Production was given, included three guest lectures on Organic Vegetable. Soil Health in Agroecosystems was given again with a guest lecture on Organic Agriculture. Besides, a virtual short course was given. Co PI Dr. Mahal from Texas A&M developed Sustainable Organic Horticulture course and offered it in the year 2024-2025. Organic Plant Production was given again in 2024-2025. Also, 2 virtual training and 3 short courses were given in the third year. Four graduate students (Nitish Joshi, Connor James, Alexis Barnes-graduated, Kristina Harms) and an additional graduate student/technician hired from Southeast Farm (Joslyn Fousert) have been working on the project. Three other students from PI Dr. Xu\'s lab have assisted in field work or lab training for this project). Students obtained training in field establishment, tillage management, sampling, data analysis, and experience on presentations. Impact: The educational objective of this project will help with educating next generation producers, researchers, scientists, and extension workers who need to learn concepts and updates on organic farming. Publications Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Joshi, N., Xu, S., Lang, K., Nleya, T. M., Sexton, P. J., Burrows, R., Wang, T., & Mahal, N. K. Assessment of soil health improvements through living mulch integration in South Dakota\'s organic vegetable production systems. Oral presentation at the ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. November 2024 Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Joshi, N., Xu, S., Lang, K., Nleya, T. M., Sexton, P. J., Burrows, R., Wang, T., & Mahal, N. K. Quantifying Soil Health Dynamics Under Living Mulch Integration and Different Tillage Practices in Organic Vegetable Production Systems in South Dakota (poster). ASA, CSSA, SSSA International Annual Meeting, San Antio, TX. November 2024. Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Ruen, C., K. Lang, and T. Nleya. 2024. Lessons Learned from Living Mulch Trials on Midwest Vegetable Farms. Annual Conference. American Society for Horticultural Science. Honolulu, HI. Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Lang, K. 2024. Room to Grow: What\'s Next for the SDSU Local Food and Flowers Extension and Research Program. Departmental Seminar. SDSU Natural Resources Management. Brookings, SD. 74 attendees. Type: Conference Papers and Presentations Status: Other Year Published: 2025 Citation: Ruen, C., K. Lang, and T. Nleya. 2025. Digging Into Clover Living Mulch Effect on Soil. Annual Meeting. (Poster) Midwest Cover Crops Council. Mankato, MN. Type: Other Status: Other Year Published: 2024 Citation: SDSU Extension. 2024. SDSU\'s Guide to Advanced Vegetable Production. South Dakota Ag Connection. southdakotaagconnection.com/news/sdsus-guide-to-advanced-vegetable-production. Type: Other Status: Other Year Published: 2024 Citation: Integrating Living Mulch on Vegetable Farms in South Dakota: 2024 Results. SDSU Extension: P-00320-v2. extension.sdstate.edu/integrating-living-mulch-vegetable-farms-south-dakota-2024-results. Progress 09/01/23 to 08/31/24 Outputs Target Audience:The audience include students, farmers, researchers, and extension personnel who are interested in sustainable agriculture and organic vegetable projection. Research goals, experimental designs, project progress and plans were introduced to audience at Field Day held at Beresford, Southeast Research Farm. Knowledge of organic management has been introduced to students in undergraduate course Environmental Soil Management. Changes/Problems:The selection of vegetable main crop was adjusted to the interest of farmers on the farmers sites. More varieties were planted. The squash plant, which was the initial plan of the year 1 planting, was also included in their fields. Due to the drought weather, cover crops were replanted in some fields. One of the farm participants wanted to restart a new trial along with the previous established trail remain being used. With that, we collected soil from both trials on this farm and will continue managing both for next year. What opportunities for training and professional development has the project provided?Three graduate students were trained in field establishment, maintenance and management in organic vegetable projection systems. One graduate student is trained in soil sampling, lab analysis, instrument operation, and data analysis. All students have gained experience of giving field talks and conference presentations. Audience from this project, including farmers and other stakeholders, obtained knowledge and information on sustainable organic farming, and extended network to know each other for future communications. PIs from this project gained knowledge through participating conferences and workshops. How have the results been disseminated to communities of interest?Preliminary results were shared with the public through outreach events such as field day tours and talks, extension publications, videos and short courses, and conference presentations. Details can be shown in Products and Accomplishments sessions in this report. Moreover, the research team has also been meeting with the participating farmers to report the progress on data collection and analysis. What do you plan to do during the next reporting period to accomplish the goals?Soils collected from the past two years will be finished in analysis. Soils will be collected again in spring 2025. Agronomy data from Y2 will be collected. Economic data will be kept recorded for future analysis and the already collected data will start to be analyzed. Another field day will be conducted at a participating farm. Extension publications and other outreach activities will be continued. Education and Mentoring will be continued. One or two students may be graduated. Impacts What was accomplished under these goals? Objective 1. Soil analysis. ?45% accomplished? Soil samples were collected in 2022 and 2023 initiated trials at 0-60 cm before field establishment as baseline samples. After that, soil at surface (0-10 cm) was collected again in spring in following years from each replicated subplots under treatments of cover crop species and tillage management. Baseline soils for trial 2022 were analyzed for Nitrate N, P, and K, which were all the highest at top layer (0-10cm) and decreased at the lower depths. The highest Nitrate N in 2022 was about 30ppm, while it dropped to below 20 ppm in 2023 and about 10 ppm in 2024. Similarly, P decreased from about 100 ppm in 2022 to lower than 100 or lower than 80 under some treatments in 2023 and 2024. Moreover, K also decreased from higher than 350 ppm in 2022, to lower than 350 ppm in 2023 and 2024. The advantage of no till management, on the other hand, was shown in some soil nutrients under specific cover crop species, such as nitrate N in 2023 under white clover, and P in 2023 kura clover plots, and potassium in 2023 under red clover. Treatment effects, however, need to be further analyzed after statistical analysis is completed. Different from the soil nutrients, the soil total carbon and nitrogen was increased from baseline in 2022 to 2024. In 2022, carbon concentration was about 30-35 g/kg, and it increased to above 40 g/kg in some no-till plots. Total nitrogen, on the other hand, was about 5 g/kg in 2022, and was above 5 g/kg in some plots under no-till in 2024. Similar trends were also observed in trial 2023, which showed an increased enzyme activity (β-glucosidase activity) of above 200 μg pNP g-1 soil h-1 in many plots in 2024 than below 160 μg pNP g-1 soil h-1 in 2023. On the farmers\' fields, baseline soil sampling was conducted in May 2023, at a depth of 0-15 cm, and the samples were taken again in 2024. Results showed a decrease in nitrate, P, and K levels in 2024 compared to baseline in 2023. However, there was a slight increase in soil microbial activity, including total bacterial biomass, actinomycetes biomass, and total fungal biomass, in the 2024 samples. Impact: Maintaing soil health, especially soil nutrients, is essential for sustainable organic farming. A good strategy of management with potential of improving soil health may improve organic farming in this location. Objective 2 Agronomic assessment. 65% completed For cabbage trial, clover biomass was collected six times from May to October 2023. From May and June, red clover had greater biomass than the kura or white clover. July trended towards a peak in clover cover crop biomass production and then decreased most likely due to the drought conditions experienced. In May, weed biomass was greater in the white clover plots compared to the bare-ground treatments. In June and July, bareground plots had greater weed biomass than clover plots. Weed biomass continued to trend towards higher pressures in the clover treatments compared to the tilled bare-ground during the months of August and September, possibly due to managing clover height with mowing allowing the weeds to demonstrate their ease in out competing clover in drought conditions. The use of landscape fabric did guard against yield reductions in some clover plots for both Farao and Famosa production; however there was a trend of steep yield reduction for cabbage grown in any of the three clover plots compared to bare-ground conditions. The no-till treatment rows did not yield desirable cabbage quality. This was not unexpected as the increased competition from the clover under no-till management greatly impacted cabbage growth. In squash trials, kura clover height and biomass was lower than other clover treatments, due to its low growing potential and rhizomatous root structure. Red clover had the tallest height among the clover treatments. White clover and kura height performed similarly due to their similar growing pattern. Weed biomass did decrease throughout the season presumably due to squash vine length and canopy outcompeting late season weeds. Marketable squash yield was reduced in the no till plots for clover treatments due to clover and weed competition. Kura clover treatments produced significantly fewer squash compared to the other clover treatments. Marketable squash harvested from the red clover plots produced the most fruit per plant compared to white clover and kura treatments. The 2024 growing season cover crops and cash crop management have been continued as planned and the data will be provided in the next report period. On the two farmers\' fields, the cover crops were not established well due to drought, especially on one site. So the farmer decided to have an adjacent field to redo the work by establishing fields again in 2024. Impact: This project will provide information and knowledge to producers and other stakeholders on sustainable organic vegetable management with lower reliance on manure and tillage. This could potentially increase the number of organic vegetable farms in South Dakota and other areas with similar barriers to organic transitioning. Objective 3 Economic analysis. 45% completed Since the start of the project, economic data has been recorded. This includes the tracking of costs and expenses for purchasing the equipment, seeds, labor, and other input. Data will be transferred to digital format and will be used for economic analysis. One student (Kristina) will keep tracking the remaining data. Another student (Nitish) has been trained by co PI Dr. Wang to learn how to organize data and will analyze the available data soon. Impact: The accomplishment of this objective will provide information for farmers with financial decisions on transitioning to organic farming for vegetable production. Objective 4 Extension and outreach. 75% completed. The team hosted one Organic Field Day in Aug 2024. Tours were given on this research at two annual Southeast Research Farm field days (Sep 2023 and July 2024). Field presentations on field management and soil analysis were given at these events. Besides, four invited talks were given at other outreach events, including the events from other universities. Also, the team produced three videos, three extension publications, and four Booth and farm forum. Impact: The distribution of our research progress and finding, as well as knowledge and techniques on managing organic farms, cover crops, living mulch, and sustainable vegetable production, is important for producers to have a better idea on decision making for their future farm management. Objective 5 Education (lectures, student training, youth education). 70% completed. A course at South Dakota State university (SDSU) HO/PS 447/547 Organic plant production was given by co PI Dr. Nleya in Spring 2024 to introduce the concepts on organic farming. This course also included three guest lectures given by co PI Dr. Lang on the topic of Organic Vegetable Production. A course at SDSU PS792 Soil Health in Agroecosystems was given by PI Dr. Xu in Fall 2023, including a guest lecture given by Dr. Nleya talking about Organic Agriculture. Co PI Dr. Mahal from Texas A&M

developed HORT 489 Sustainable Organic Horticulture course. Besides, a virtual short course on vegetable production has been given in Jan 2024. Four graduate students (Nitish Joshi, Connor James, Alexis Barnes, Kristina Harms) and an additional graduate student/technician hired from Southeast Farm (Joslyn Fousert) have been working on the project. Three other students from PI Dr. Xu\'s lab have assisted in field work or lab training for this project). Students obtained training in field establishment, tillage management, sampling, data analysis, and experience on presentations. Impact: The educational objective of this project will help with educating next generation producers, researchers, scientists, and extension workers who need to learn concepts and updates on organic farming. Publications Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Barnes, A., K. Lang, and R. Burrows. Integrating Early Season Clover Cover Crops as a Living Mulch in Broccoli and Organic Winter Squash Production. Marbleseed Organic Farming Conference. February 22, 2024. La Crosse, WI. Type: Conference Papers and Presentations Status: Other Year Published: 2024 Citation: Lang, K. Horticulture Research Recap and 2024 Plans. SDSU Southeast Research Farm Board Annual Meeting. January 30, 2024. Virtual. Type: Conference Papers and Presentations Status: Other Year Published: 2023 Citation: 3) Nitish, Xu, S., Lang, K., Nleya, T., Sexton, P., Burrows, R., Wang, T., Mahal, N. Soil health influenced by living mulch in organic vegetable production systems in South Dakota. ASA, CSSA, SSSA annual meeting, October 29-November 1, 2023. St Louis, Missouri. Progress 09/01/22 to 08/31/23 Outputs Target Audience:The audience include students, farmers, researchers, and extension personnel who are interested in sustainable agriculture and organic vegetable projection. Research goals, experimental designs, project progress and plans were introduced to audience at Field Day held at Beresford, Southeast Research Farm. Knowledge of organic management has been introduced to students in undergraduate course Environmental Soil Management. Changes/Problems:The selection of vegetable main crop was adjusted to the interest of farmers on the farmers sites. More varieties were planted. The squash plant, which was the initial plan of the year 1 planting, was also included in their fields. What opportunities for training and professional development has the project provided?Two graduate students were trained on field establishment, maintenance and management in organic vegetable projection systems. One graduate student is trained on soil sampling, lab analysis, instrument operation, and data analysis. Farmers got opportunities to speak with our research team and get suggestions on selection of crop species and management techniques. How have the results been disseminated to communities of interest?Since the project is at the early stage of field establishment. We don\'t have results to share yet. However, we shared the experience on field establishment to the audience. What do you plan to do during the next reporting period to accomplish the goals?Baseline soil analysis results will be accomplished by the next reporting period. The second set of soils will be collected. Agronomy data from Y 1 will be collected. Education and Mentoring will be continued. Another field day will be conducted. Economic data will be kept recorded for future analysis. Impacts What was accomplished under these goals? Objective 1. Soil analysis. ?25% accomplished? Baseline soils were collected from both university site and farmers sites. At Southeast Research Farm, soil was collected from 0-60 cm and divided into 4 depths. The soils were weighed to analysis bulk density. The fresh soils were kept at 4oC for analyzing soil moisture and microbial biomass carbon. Part of each soil was kept in freezer at -20oC for microbial community structure analysis. Part of each soil was air dried for carbon and total nitrogen analysis. Soil moisture from samples collected in 2022 in the 2022 initiated trial (T22) ranged from 0.11-0.30. The moisture range of soils from 0-10 cm were 0.23-0.27. The moisture data from this trial in 2023 ranged from 0.21-0.29. Since this trial was established before this grant was funded, bulk density data were not collected at that time. Soil moisture from samples collected in 2023 in the 2023 initiated trial (T23) ranged from 0.18 to 0.28. The moisture from 0-10 cm ranged from 0.18-0.25. The bulk density for the four layers are 1.1, 1.3, 1.3 and 1.3. The ongoing analysis of these soils are total carbon and nitrogen and microbial biomass, which are during the process currently and could be completed analysis by the end of this year. Other soil analysis will be conducted soon after that to ensure data is available to be compared with new soils to be collected next year. Baseline soils from farmers sites were collected at 0-15 cm in 2023 before planting cover crops, and they were directly sent to commercial lab to analyze microbial community structure and soil chemical properties. Data will be analyzed soon after they are received, and to be compared with soils to be collected next year. The sampling depth and analysis methods were selected to benefit farmers in future if they would like to monitor their soil health status. Objective 2 Agronomic assessment. 35% completed From the Southeast Research Farm, clovers were seeded Late April 2023. Unfortunately, due to limited moisture and heavy weed competition, the clover struggled to take off and weeds overcame the project site. Clovers were Re-seeded in Late June but did not establish like we wished. Weed populations were pretty high in the beginning of the season and started to decrease by the July 28th due to squash canopying. In September, weeds were considerable low visually (not statistically) in the in-row plots due to increased moisture and further squash canopying. Farmers should consider weather and soil moisture before proceeding with living mulches. Clovers can outcompete cash crops in no-till systems and struggle to establish if early Spring moisture is not consistent. Frost seeding may be a good option in certain areas. However, some positives, the squash crop was great with 62% of total squash harvested being marketable according to the USDA winter squash standards. 2330 pounds of winter squash was donated at the end of the 2023 field season to Feeding South Dakota. Focusing on the cabbage, we selected 3 varieties with three separate maturity date cabbage. The cabbage seeds were sourced from Johnny\'s Selected Seed and are all certified organic. The cabbage in the no till treatments have shown signs of stem elongation and reduced growth with a lack of head development. There have also been some differences noted in the observations regarding cabbage looper and white butterfly worm damage. Cabbage loopers and white butterfly worms this year have been a huge issue for the cabbage production. The decision to opt out of the use of row cover was made leading to a more intentional focus on an integrated pest management system (IPM). With this in mind, we decided to utilize the guard rows for beneficial flowers in hopes of drawing in beneficial insects. Crop scouting for the economic threshold levels were also completed for cabbage looper worms and the white butterfly worms.This led to utilizing a few applications of DiPel DF for control which is certified organic and on the OMRI approved list for use in the field. The harvest events that have occurred thus far demonstrated a difference between the Farao and Famosa regarding worm damage on the cabbage heads. The Farao were mostly damaged beyond marketability due to looper damage, while the Famosa thus far are looking far better. Looking at the data once all harvest events are complete will offer a more definitive direction within this area though. On-farm trials were established at Haroldson Farms(HF) and Blue Sky Farms(BSF). Both farms had a variety ofCucurbitaspecies grown within the clover plots. HF had threebiomass sample events, and BSFhadfour biomass sample events. Both on-farm trails had the clover established and were present at the first initial biomass collection. However, because of the lack of moisture and weed competition, the clover population quickly died off. HF mowed three times and BSF mowed once the first week of July after biomass collection to knock down weeds and allow light to reach the clover. Since the cash crops were vining plants the living pathways were not able to be mowed once they started trailing. Farmer\'s (HF) thoughts - moisture was lacking this year so irrigation will be needed to establish Clover next year. Lay plastic before seeding the clover and oat mix to prevent the 6-12\" of soil from being exposed, allowing weeds to grow. Black plastic used for squash was too hot, stressing out the cash crops. (BSF) - Clover and oats were established well with a drill but were out-competed by a lack of moisture and weeds. Break ground on sod to establish clover before weeds can move in. For the 2024 season, we will be attempting to do frost seeding so the clover can be established as soon as conditions are favorable, and the snow melt will provide enough water for a strong tap root to grow. This head start will hopefully allow clover to outgrow any weed pressure as the season progresses. Objective 3 Economic analysis. 15% completed Economic data has been recorded along with the progress of this project. Costs and expenses for purchasing the equipment, seeds, labor, and other inputs were kept tracking, which will be used for economic analysis. The analysis will be conducted at the late stage of the project. Objective 4 Extension and outreach. 40% completed. Two field talks were given at Southeast Research Field Day in July 2023 by students from this project to introduce the goals, objectives, methods, progress of this project, and demonstrate the field set up. Other field day talks and presentations are: Cedar Creek Gardens Field Day ?Aug 2023?, Garden Hour Presentation (Aug 2023)?3rd Annual Specialty Crop Field Day (Sep, 2023), SERF High School Field Day ?Sep 2023?? Dordt University Agroecology Class Tour ?Oct 2023?. Objective 5 Education (lectures, student training, youth education). 25% completed. Lectures were given based on the PI\'s teaching opportunities. The concept of sustainable agriculture has been introduced in Environmental Soil Management undergraduate course in Spring 2023. The co PI of the project, Dr. Nleya, has given a lecture on Organic Management in Dr. Sutie Xu\'s graduate course Soil Health in Agroecosystems in Fall 2022. Three graduate students hired from this project (Nitish, Connor James, Alexis Barnes) and an additional graduate student/technician hired from Southeast Farm (Joslyn Fousert) started participating the project. They obtained training on field cover crop and cash crop establishment, tillage management, crop sampling, or soil sampling and analysis, depending on their focus of graduate project. This project will provide information and knowledge to producers and other stakeholders on sustainable organic vegetable management with lower reliance on manure and tillage. This could potentially increase the number of organic vegetable farms in South Dakota and other areas with similar barriers to organic transitioning. Publications

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Optimizing Organic Corn Production Under Different Living Mulch Systems

Accession No.	1028992
Project No.	TEN2022-04697
Agency	NIFA TEN\
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2022-51106-37923
Proposal No.	2022-04697
Start Date	01 SEP 2022
Term Date	31 AUG 2025
Grant Amount	$688,360
Grant Year	2022
Investigator(s)	Oakes, R. N.; Yin, XI, FR.; Boyer, CH, NE.; Kelly, HE, MA.; Sykes, VI, RO.
Performing Institution	UNIVERSITY OF TENNESSEE, 2621 MORGAN CIR, KNOXVILLE, TENNESSEE 37996-4540

NON-TECHNICAL SUMMARY

Demand for organic products has increased in recent years, especially organic corn (Zea mays L.). This market expansion has been driven by rising consumer demand for products produced with and animals fed by organic grain. However, corn is one of the most challenging crops to grow organically due to the need for high inputs such as fertilizers and herbicides, which are not allowed to be used in these systems. In addition, synthetic seed treatments are normally used in conventional systems to protect the corn seed from seedling diseases and promote adequate emergence. However, these treatments are not allowed in organic cropping systems, which warrants the need to examine natural seed treatments that could benefit organic producers. Therefore, organic corn production requires intensive management to ensure succesful seed emergence and stand establishment, and to achieve a reliable fertilization and weed competition program.There is a rising interest in expanding organic corn production in the Southeast, but many producers are still hesitant to transition their conventional operations due to a lack of management recommendations appropriate to the Southeastern environmental conditions. The development of adequate organic corn management recommendations, such as introduction of living mulch, can encourage producers to adopt this system, and successfully transition from conventional to organic practices.This study will examine several perennial legume species that can also contribute to nitrogen management, weed suppression, corn grain yield, forage yield, and forage nutritive value when used as a living mulch in an organic corn grain system.The University of Tennessee Institute of Agriculture strives to develop methods and approaches to become a leader in sustainable and organic crop production research, dedicating certified organic fields in two research and education centers strategically selected within the state, being one in East Tennessee (Knoxville metropolitan area) and one in Middle Tennessee (Nashville metropolitan area). The Southeastern U.S. has yet to develop organic crop methodologies that can be useful to producers in this area; therefore, the University of Tennessee facilities and locations are ideal for conducting the proposed study.This study will provide important information that can improve the profitability to producers interested in capitalizing on the increasing demand for organic corn grain. Although this study will focus on living mulch in organic systems, results will also be relevant to producers managing conventional corn grain systems who are interested in introducing potentially cost-saving sustainable production practices.

OBJECTIVES

The specific goal of this project is to develop a multi-location study aiming to develop management recommendations to produce organic corn under different living mulch systems. To achieve the overarching goal, the project will look to:expand organic corn production in the Southeastern U.S.,improve organic corn yield,reduce weed competition,reduce the need for N (nitrogen) fertilization, andincrease profitability in the system.Our specific objectives are:Objective 1: To identify alternative seed treatments to be used in organic corn production in the Southeast.Objective 2: To determine how different living mulch species will influence corn yield, fertilization needs, weed competition, while maintaining soil health.Objective 3: To determine the potential economic benefits of introducing living mulch species into organic corn for organic crop producers in the Southeast.Objective 4: To develop an extension program to help educate agents and producers about successful strategies in producing organic corn under living mulch systems.

APPROACH

For Objective 1, the potential efficacy of organic corn seed treatments will be evaluated with artificial inoculum in the greenhouse. The experiment will be implemented in the fall 2022 and set up in a randomized complete block design with four replicates. The treatments will consist of two controls, non-inoculated and inoculated without seed treatment, as well as the following organic seed treatments with and without pathogen inoculation: organic quick roots, AgriCoat Natural II ™, and 1r seed treatment. If any additional organic seed treatments become available for corn they will also be included. Organic corn seed will be treated using a Hege seed treater, as it would be in a commercial setting. Additionally, germination assay will be done on all treatments.Pathogenic Pythium spp. or Rhizoctonia solani isolates will be cultivated on autoclaved milo medium, individually, to use for inoculation in the furrow when planting corn seed in pots. These pathogens represent oomycetes and true fungi that regularly cause seedling disease and death. In conventional seed treatments, compounds that control one does not control the other, hence the importance to evaluate each pathogen individually. Many species of Pythium can cause seedling disease; hence a complex of Pythium species will be used for inoculum, from Tennessee fields. In the trial, each pot will serve as a replicate, with the 3 seeds serving as subsamples. Pots will be watered daily, and greenhouse lighting will be programmed to a 12-hour light/dark cycle. Each plant will be assessed daily to record date of emergence and at 7, 14, 21, and 28 days plant vigor will be assessed and the number of plants surviving. The trial will be repeated. Data (emergence, vigor and survival of plants from each treatment) from the greenhouse trial will be analyzed using PROC MIXED of SAS .For Objective 2, the experimental design will be a randomized complete block design with four replicates (Fig. 1). The treatments will consist of the following: 1) no-living mulch, soil tilled prior to corn planting; 2) hairy vetch as a cover crop, soil tilled prior to corn planting; 3) white clover as living mulch; 4) red clover as living mulch; 5) hairy vetch as living mulch; and 6) sericea lespedeza as living mulch. All treatments (with exception of the no-living mulch treatment) will be established in Fall 2023 using a no-till drill. Plots will be 20 ft by 30 ft at each location. Prior to planting corn, manure will be applied at a rate of 80 lbs. N/ac. In April 2024, corn will be planted using strip tillage on 30-inch row spacing with a target population of 28,000 plants per acre.After establishment, monthly, a 0.1-m2 grid will be randomly placed in two locations within each individual plot to measure living mulch botanical composition (forage grass species, alfalfa, broadleaf weeds, grassy weeds). Once the individual botanical components have been dried at 60oC to constant weight, each component will be weighed to determine its percentage. Samples will then be recombined to determine total living mulch mass. After determination of botanical composition and living mulch mass, samples will be ground through a 1-mm screen in a Wiley milland analyzed for crude protein (CP), neutral detergent fiber (NDF) and NDF digestibility (NDFD) using Near Infrared Reflectance Spectroscopy (NIRS). Data at each location will be analyzed using PROC MIXED of SAS.At the termination date of cover crop or the end of living mulch growing season, a 0.5-m2 cover crop or living mulch biomass sample will be collected from each plot. These biomass samples will be dried at 65ºC until they achieve a constant weight, and final dry weights will be recorded. Samples will then be ground to pass through a 2-mm sieve. Ground biomass samples will be measured for nutrient (N, P, K, S, Ca, Mg, and selected micronutrients) concentrations. The total accumulation of each of these nutrients by each plot will be calculated as the product of dry weight of the cover crop or living mulch multiplied by that specific nutrient concentration in the dry cover crop or mulch.A composite leaf sample will be collected from each corn plot at the following growth stages: V6, V10, R1, physiological maturity. A composite corn stalk and grain sample will also be taken from each plot at corn harvest, respectively. Nutrient (N, P, K, S, Ca, Mg, and selected micronutrients) concentrations in leaf, stalk, and grain samples will be determined. The total uptake of each of these nutrients by corn plants (stalk plus grain) will be calculated. The removal of each of these nutrients due to corn harvest will also be calculated. A composite soil sample of 10 cores (2.5-cm diameter) will be collected at 0-15, 15-30, 30-60, and 60-90 cm depths at each of the aforementioned growth stages and analyzed for available nitrogen (NO3\--N + NH4+-N) in the soil profile. At the V4 growth stage of corn, a composite soil sample with 10 cores (2.5-cm diameter) will be collected in 0-15 cm from each plot in Years 2 and 3 for assessing the soil health. Additionally, four cores of a 5-cm diameter and 15-cm depth will be taken from each plot for soil bulk density.The soil physical indicators will include surface and subsurface hardness (PR15 and PR45, respectively) measured using a penetrometer, wet aggregate stability measured using a wet sieving apparatus, and bulk density measured using the core method (Grossman and Reinsch, 2002). Meanwhile, soil moisture content will be determined with a moisture meter at the following growth stages of corn: planting, V6, V10, and R1.The soil chemical indicators will include soil pH measured on a 1:1 soil:water (v/v) suspension, Mehlich-3 extractable macro- and micro-nutrients (P, K, Mg, Fe, Mn, and Zn) analyzed by Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES), and ammonium N (NH4-N) and nitrate N (NO3-N) using 2-M potassium chloride (KCl) extraction followed by measurement on a Skalar Continuous Flow Analyzer. Available nitrogen, phosphorus, and potassium (lb./acre) for crop will be calculated. Some important soil nutrient ratios \Ca:Mg, (Ca+Mg):Al\ will also be calculated.Soil biological indicators will include soil respiration from 4-day incubation (4d CO2) using potassium hydroxide (KOH) trap method , permanganate oxidizable C (POXC), soil organic C measured by dry combustion using a CN analyzer, microbial biomass C (MBC) and N (MBN) using chloroform fumigation method.Analysis of variance will be performed on each measurement under a randomized complete block design using the ANOVA procedure in SAS version 9.4. The treatments will be used as a fixed factor, whereas the replicates being used a random factor. Treatment means will be separated with the Fisher\'s protected LSD. Probability values less than 0.05 will be considered significant for all analyses. For Objective 3, production records will be kept each year to quantify total costs of production from the establishment of living mulch and corn through the entire project. We will analyze cost of production for each of the six treatments described in Objective 2. We will also take into account costs of successful seed treatments as described in Objective 1. These records will be used to calculate and demonstrate the relative treatment costs. This will allow us to construct enterprise budgets comparing the cost of producing organic corn by including different living mulch species (as well as comparisons with different systems such as conventional corn production and organic corn with cover crops system). A keyway to analyze enterprise budgets is by calculating breakeven yields and prices. We will use these budgets to develop breakeven corn yields for each treatment. This will show the yield a producer would need to achieve to break even for the year. Progress 09/01/23 to 08/31/24 Outputs Target Audience: For this reporting period, the target audience for the project included undergradute students, graduate students, farm personnel, post doctoral research associates and faculty. These groups were reached by practicum experiments when implementing and conducting the project,by internships provided to three graduate students (domestic and international), seminar presentations, conference participation including poster presentationand experiential learning opportunities. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Training activities: during this reporting period, there were many opportunities for training conducted by professionals. Undergraduate and graduate students had the chance to observe first-hand how an organic experiment is conducted and sampled monthly for plant and soil materials. Activities included field work, data organization and preliminary analysis, as well as one-on-one meetings with all mentors in the project. Professional development: activities included preparation and presentation of poster including the project objectives and goals. Graduate students have also presented their proposals at the University seminar class, and they are schedule to present their initial results at the Agronomy Society of America conference, under the graduate student competition. 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? For the next reporting period, we plan to accomplish the following goals: conclude the field experiment for 2024, and collectdata on corn harvest establish/plant corn in the spring 2025 for the second experimental period conduct the second year of field trial and appropriate sample collection poster presentation of the project by the graduate students at a professional conference continuestatistical analyses on the project full data presentation at conferences, workshops and field days. conclude Objective 3 data analysis organize extension and outreach to conclude Objective 4 goals. Impacts What was accomplished under these goals? Forobjective 1, a greenhouse experiment was conducted and seed treatments identified. Soil Biotics 1r Organic seed treatment was selected and applied to organic corn seeds on April 12th 2024. Forobjective 2, the experimental trial was implemented in the field in September 2023, and the organic living mulch was established at the research and education centers located in Spring Hill and Knoxville. Corn was planted at both locations on April 18th, 2024. A week before corn planting, manure was applied at a rate of 80lb N/acre. After all plants were established (living mulch and corn), monthly samples were taken from the living mulch to measure botanical composition, living mulch mass, and future forage nutritive value. Corn plant measurements are currenlty undergoing as well. Plots are estimated to be harvested sometime in September, 2024. Soil sampling has also been conducted simultaneously for future analysis. Publications Type: Other Status: Other Year Published: 2023 Citation: Martinez, V., R.L.G. Nave, and O.G. Almeida. 2023. Productivity and nutritive value of living mulch species in organic corn systems. 8th Annual UT Beef and Forage Center Graduate Research Poster Competition. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Target audience: for this reporting period, the target audience for the project included undergradute student, graduate student, farm personnel, post doctoral research assistants and faculty. These groups were reached mostly by practicum experiments when implementing the project, and also by internships, seminar presentations and experiential learning opportunities. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?During this reporting period, there were opportunities for training and professional for undergraduate and graduate students, post doctoral research assistantsand research associates. Training and professional activities included project research and development, seminar presentation, study groups and field activities. 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?For the next reporting period, we plan to accomplish the following goals: determine the appropriate organic corn seed treatments establish/plant corn in the spring 2024 conduct the first year of experimental trial and appropriate sample collection seminar presentation of the project by the graduate students final recruitment of all graduate students initial statistical analyses on the project partial data presentation at conferences, workshops and field days. Impacts What was accomplished under these goals? For objective 1, there were several seed treatments evaluated, and two organic seed treatments and Phythium isolates to make inoculum were identified. Greenhouse screening of these treatments are scheduled to take place during fall-winter of 2023 in the greenhouse. For objective 2, the experimental trial was implemented in the field in September 2023, withthe organic living mulch was establsihed in two education and research centers, in Spring Hill and Knoxville. Publications

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Liquid, Composted or Dry-stacked? Unravelling the Effects of Manure Treatment on Pests in Organic Field Crops

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Investigator(s)	Rowen, E.; Kotcon, JA, .; Chandran, RA, S.; Pena-Yewtukhiw, EU, .; Morrissey, EM, M.; Sant\'Anna, AN, .
Performing Institution	WEST VIRGINIA UNIVERSITY, 886 CHESTNUT RIDGE RD RM 202, MORGANTOWN, WEST VIRGINIA 26505-2742

NON-TECHNICAL SUMMARY

The US currently imports \$233B in corn, soybeans, and wheat annually to fill the demand for organic livestock feed. Increasing production to meet this demand presents an opportunity for organic-certified and organic-transitioning field crop producers. However, optimizing yield using organic approved fertilizers like manurecan be challenging. Research on manure as a fertilizer has focused on meeting plant nutrientneeds.However, manure may also may effect pests like weeds, insects and pathogens to increase or decrease grain yield.We propose to evaluate the relative effects of three manure management strategies:liquid cowmanure, dry-stacked cow manure, and composted cow manure on weeds, pathogens, and insect pests, yield, and profitablity. We will 1) measure the effect of manure types on weeds, insects, and pathogens, 2) investigate the relative contributions of nutrients, organic matter, and microbes from different manure types on corn damage by insect pests, 3) document decision-making about manure management strategies on three representative organic farms, and 4) provide grower focused extensionpublications and meetings to support their use of manure fertility and pest management. Our ultimate goal is to support organic and transitioning field crop producers by increasing our understanding of how different manure handling methods can influence pests, ultimatelyincreasing their profitablity.

OBJECTIVES

We propose to evaluate the relative effect of liquid, dry-stack, and composted bovine manure on weeds, pathogens, and insect pests, yield, and economics. We will 1) measure the effect of manure types on weeds, insects, and pathogens, 2) investigate the relative contributions of nutrients, organic matter, and microbes from different manure types on corn susceptibility to insect pests, 3) document decision-making about manure management strategies on three representative organic farms, and 4) provide extension publications and meetings to local organic growers to support their use of manure fertility and pest management.

APPROACH

In our first objective,?we will ivestigate how dry-stacked, composted, and liquid cow manures affect weeds, insect pests, and disease incidence as well as soil nutrients and microbiome, and quantify economic costs and returns for established organic land and land in transition. To achieve this, we will conduct a field experiment on the WVU Agronomy Farm over 3 years, fertilizing wheat, soy and corn with these different types of cow manures and measuring pest metrics described above.In our second objective, we willidentify the mechanisms by which different types of manure influence herbivory of corn, we can hypothesize the effects not only of the manure management strategies tested, but how other types of manure may influence herbivores.We will manipulate different nutrient sources and presence of the microbiomeof each manure to understand why manure decreases chewing and sucking herbivore performance on corn in the greenhouse using aphid and caterpillar pests.In our third objective, to better understand producer choices, we will conduct case studies of manure management decision making on 3 Northern Appalachian farms. This will help us determine why these growers treat and apply their manure in different ways. We will also ask questions about pest pressure and pest management practices and get feedback about how the results of our study may affect their choices. ?Finally, in objective 4, we will train organic growers in manure and pest management tactics and share results to support grower needs. We will use the opportunities provided in objectives 1 and 2 to increase grower knowledge about managing manure and scouting for pests through field days and extension meetings and share the results of these experiments. Progress 09/01/23 to 08/31/24 Outputs Target Audience:The target audience for this work includes organic farmers and agricultural scientists. A poster was presented at the WVU organic farm field day: \"Manures ad fertilizers in organic crops\". The audience was the public and a few organic growers. Additionally, we reached academic and scholarly audiences at the WVU Davis college research day and the eastern branch meeting of the Entomological Society for America. Changes/Problems:PD Rowen left WVU and is now employed at UC Riverside. As most of the research is being conducted at WVU, Dr. Morrissey has become the new lead PD. Dr. Rowen will remain involved in the grant and we are in the process of setting up a subaward for UC Riverside so she can continue to perform the entomological work associated with the project. This change presents some challenges; however, Dr. Rowen\'s PhD student plans to return to WVU to perform the onsite entomological work during the summer of 2025. An additional personnel issue arose in 2024 as the PhD student hired to perform the soil and microbial analyses decided to leave graduate school. Luckly, a new incoming PhD student has been recruited to work on the project. This change in personnel is likely to slow some of the soil and microbial analyses; however, we are continuing to make good progress. Lastly, the field plots have experienced significant pressure from deer and weeds. In 2023 the soy was heavily grazed by deer, as such in 2024 we installed perimeter fencing to prevent deer grazing which was largely effective. Weed pressure was significant in 2024 especially in the wheat plots. What opportunities for training and professional development has the project provided?To date three PhD students have worked in association with this award as well six undergraduate research assistants who have helped with sample and data collection. How have the results been disseminated to communities of interest?Preliminary results have been shared with grower stakeholders at the WVU organic farm field day in 2023 and with academic audiences at the Davis college Research Day in 2024. Further in March of 2024 results were presented at the Eastern branch meeting for the Entomological Society of America. What do you plan to do during the next reporting period to accomplish the goals?During the next reporting period we will conduct the third and final year of the field experiment. Additionally, we will proceed with the analysis of samples collected thus far from the field and greenhouse experiments. To address the third objective will we contact our organic growers to perform a survey to document decision making about organic fertility choices. This survey has been drafted and is expected to be conducted in late 2024. Impacts What was accomplished under these goals? Project was initiated in fall 2022 with the preparation of the field for planting. In 2023 we initiated the field experiment by planning corn, wheat and soy after the 4 manure fertilizers were applied. Sample and data collection on weeds, insects, soil (for nutrient and microbial analysis), and labor for the economic analysis In 2024 we implemented the second year of the field experiment, keeping the manure addition consistent on each plot and proceeding with the crop rotation. As in year one, samples and data were collected throughout the growing season. Additionally, we continued with sample analysis for the soil and microbial work we completed all the soil analysis from the samples collected in year one and sequenced the bacterial communities in rhizosphere soils and on root surfaces. To address the second aim, in 2024 we conducted two greenhouse experiments which aimed to determine the mechanism of manure effects on corn susceptibility to insect pests. For this experiment we grew corn in media fertilized with NPK, NPK + micronutrients, dry stacked manure, or heat killed (autoclaved) manure. The plants were then challenged with black cutworm larva to determine susceptibility to insect pests. Plant biomass was measured, and root and soil samples were collected for microbial analysis. Publications Type: Conference Papers and Presentations Status: Accepted Year Published: 2024 Citation: Musekwa M, Rowen E, Morrissey E, Goddard E, Kotcon J(2024) Manure Management and Weeds: Implications for Organic Grain Production. WVU Davis College Research and Creative Scholarship Day. Type: Conference Papers and Presentations Status: Accepted Year Published: 2024 Citation: Goddard E, Musekwa M, Rowen E, Kotcon J, Morrissey E (2024) Microbial Response to Varied Manure Treatments for Organic Agricultural Methods. WVU

Davis College Research and Creative Scholarship Day. Progress 09/01/22 to 08/31/23 Outputs Target Audience:Poster presensted at the WVU organic farm field day: \"Manures ad fertilizers in organic crops\". Audience was the general public and a few organic growers. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?2 PhD students have been hired and have started working on this project, 4+ undergraduate research assistants have been involved in data collection. How have the results been disseminated to communities of interest?We have presented a poster at the WVU Organic farm field day in August \'Manures as fertilizers in organic crops\' What do you plan to do during the next reporting period to accomplish the goals?We will continue with collecting data in the next year of our crop rotation. Greenhouse work will start this fall to complete objective 2. We will contact our organic growers to perform an initial survey to document decision making about organic fertility choices. Impacts What was accomplished under these goals? Project was initiated in fall 2022 with the preparation of the field for planting. Corn, wheat and soy were planted spring 2023 after the 4 manure fertilizers were applied. Data has been collected throughout the summer. This includes data on weeds, insects, soil (for nutrient and microbial analysis), and labor for the economic analysis. Manure has been collected and stored for objective 2 in the greenhouse which will start this fall. Publications

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