ORG Project Details

Award Year 2010

7 Research Projects

PROJECT INDEX

Soil Carbon and Nitrogen Dynamics in Organic Crop and Forage Production of the Northern High Plains Ecoregion, Wyoming and Nebraska

Accession No.	0223695
Subfile	CRIS
Project No.	WYO-00617
Agency	NIFA WYO
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51106-21805
Proposal No.	2010-03952
Start Date	01 SEP 2010
Term Date	31 AUG 2014
Grant Amount	$0
Grant Year	2010
Investigator(s)	Norton, U.; Norton, J. B.; Garcia y Garcia, A.; Ritten, J. P.; DelGrosso, S. J.; Hergert, G. W.
Performing Institution	Plant Sciences, UNIVERSITY OF WYOMING, 1000 E UNIVERSITY AVE DEPARTMENT 3434

NON-TECHNICAL SUMMARY

This research compares organic farming to reduced-tillage and conventional approaches, both in transition and in long-term use, in agroecosystems of eastern semiarid Wyoming and western Nebraska. We propose to evaluate the relative impact of these systems on soil quality, C sequestration, and greenhouse gas (GHG) emissions. Rising costs of fuel, fertilizer, and related inputs, along with declining and unreliable sources of irrigation water, threaten the economic viability of agriculture in this semiarid region. In response to pressures that squeeze profit margins, producers are seeking alternatives that decrease costs, increase yields, or increase value while conserving water. Organic production that incorporates reduced-tillage and crop-forage components may achieve these goals, while at the same time providing important environmental services of sequestering carbon (C) and offsetting GHG emissions. It is known that similar services provide alternative income streams via C markets or incentive payments in other parts of the US, but the magnitude of these services relative to conventional practices is not well documented for the Northern High Plains region. Our approach utilizes established frameworks of on-station research trials in transition from conventional to reduced tillage and organic practices, and on-farm organic and reduced-tillage systems in long-term use by area producers. This three-year project integrates four research components in both transitional (on-station) and long-term (on-farm) settings under irrigated and dryland production. Research components include measurement and modeling of: 1) soil C processes, including sequestration and GHG emissions to quantify performance of organic production relative to conventional and reduced tillage systems; 2) water use efficiency to determine short- to long-term feasibility of both irrigated and non-irrigated production in this moisture-deficient environment; 3) field- and farm scale economics to determine the need, timeframe, and level of possible incentives for transition to sequester C in organic production; and 4) energy input:output and C footprint impacts to determine true environmental impacts or services resulting from the practices. On-station research (transitional impacts) will take place within the framework of a long term study comparing the three approaches established at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2009. On-farm research (long

term impacts) will take place on the farms of producers in Wyoming and Nebraska who are actively collaborating in studies of conventional, reduced-input, and organic approaches to irrigated crop and forage production and dryland winter wheat production. The proposed project builds upon the on-going on-station research and established relationships with farmers. It will benefit from research data currently being collected that are critical to complement the proposed set of measurements to validate biochemical and economic models we are proposing and will strengthen the quality of data inventories we are to build.

OBJECTIVES

This research compares organic farming to reduced-tillage and conventional approaches, both in transition and in long-term use, in agroecosystems of eastern semiarid Wyoming and western Nebraska. We assess the relative impact of these systems on soil quality, C sequestration and greenhouse gas (GHG) emissions. Our approach utilizes established frameworks of on-station research trials in transition from conventional to reduced tillage and organic practices, and on-farm organic and reduced-tillage systems in long-term use by area producers. Results will provide much needed inventory of GHG emissions and C storage and will support development and improvement of predictive biogeochemical, water use, and economic models for irrigated and dryland cropping systems. These outcomes will support producer decision making and government planning for possible incentive programs. They will also highlight specific needs for development of practices and technologies for improvement of environmental services with organic practices. We believe it is important to evaluate organic practices side by side with both conventional and reduced-tillage approaches for two reasons: 1) to determine whether organic production practices achieve environmental services provided by reduced-tillage practices already incentivized under USDA conservation programs and the CCX, and 2) to investigate possibilities for better integrating reduced-tillage practices into organic production. Research components include measurement and modeling of: 1) soil C processes, including sequestration and GHG emissions to quantify performance of organic production relative to conventional and reduced tillage systems; 2) water use efficiency to determine short- to long-term feasibility of both irrigated and non-irrigated production in this moisture-deficient environment; 3) field- and farm scale economics to determine the need, timeframe, and level of possible incentives for transition to sequester C in organic production; and 4) energy input:output and C footprint impacts to determine true environmental impacts or services resulting from the practices. On-station research (transitional impacts) will take place within the framework of a long-term study comparing the three approaches established at the University of Wyoming James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC) in 2009. On-farm research (long term impacts) will take place on the farms of producers in Wyoming and Nebraska who are actively collaborating in studies of conventional, reduced-input, and organic approaches to irrigated crop and forage production and dryland winter wheat production. The proposed project builds upon the on-going on-station research and established relationships with farmers. It will benefit from research data currently being collected that are critical to complement the proposed set of measurements to validate biochemical and economic models we are proposing and will strengthen the quality of data inventories we are to build.

APPROACH

1. Document and model soil quality, C sequestration, and GHG associated with organic production practices. This work combines monitoring of soil GHG emissions and SOM dynamics in irrigated and dryland agriculture. Data from organic transition comes from plots established in 2009 at SAREC. Data from long-term organic management comes from fields of collaborating farmers in both states. Some data on soil quality and economics will be supplied by current or recently completed projects, while GHG, water use, and energy ratio/C footprint data will be collected under this proposed work. Data will contribute to documentation of effects of both irrigated and dryland organic production practices on soil quality and C sequestration, and will be used to validate DayCent biogeochemical model for predicting C storage and GHG emissions in the northern High Plains region. 2. Document and model the soil water dynamics, water use, and water use efficiency associated with organic production practices. This study monitors soil moisture in dryland and irrigated cropping systems. Data will be collected from on-station experiments established in 2009 at SAREC and from on-farm of collaborating farmers in Wyoming and Nebraska. The information will contribute to documenting the effects of different cropping systems on soil water dynamics and water use and water use efficiency. 3. Document and model economic and energetic parameters of organic production. This work analyzes the overall profitability and efficiency of organic, reduced-tillage and conventional systems for the study area. Economic performance will be measured both long term and during the period of transition. The economic analyses will include scenarios that include revenues for trading C based on the existing market and empirical data on C sequestration obtained in Objective 1. In order to better understand the full environmental impacts of these systems, the overall energy budget (C footprint and energy input-to-energy output ratio) will also be estimated. Policy makers can use this information to help create

economic incentives that are able to offset the upfront conversion costs in order to elicit more producers to engage in organic and conservation tillage practices. 4. Develop extension materials. We will develop extension and outreach activities and materials for many learning styles. In year three, researchers and extension specialists on the team will work with the Cooperative Extension publications offices at the Universities of Wyoming and Nebraska to joint bulletins reporting research results. In project year three, team members with extension appointments will develop training workshops targeted at extension educators, producers, and consultants. 5. Develop curriculum modules for the agroecology courses. Capstone Agroecology Seminar is a required course in the interdepartmental agroecology major at the University of Wyoming. Students take the course during their last semester and the research activities and results will provide a framework for a class activity. In a semester-long site-study activity students will develop a projection of what will happen in their plots.

PROGRESS

2010/09 TO 2014/08 Target Audience: Winter wheat farmers, local citizens, university scientists, research station techhnical support staff who participated in the Wyoming and Nebraska Agricultural Experiment Station Field Days in Lingle, WY and Sidney, NE; farmers who are on the project steering committee, farmers and researchers from other universities who inquired about research after reading published research articles; freshmen undergraduate students taking Agroecology 1000 class, senior undergraduate students taking the capstone seminar \"Issues in Sustainable Agriculture\" (AECL 4990), graduate srtudents taking PLNT 5790 \"Soil-Plant-Atmosphere Relationships in Managed Ecosystems\", students and scientists attending Plant Sciences Department seminar series; small-scale organic producers who attended Wyoming Organic Conference, Farm and Ranch Days, Westi Ag Days; local highschool and elementary school teachers, extension educators and extension specialists, USDA ARS researchers who work on model simulations, ASA-CSSA-SSSA annual conference atendees. Changes/Problems: Two-year severe drought resulted in need to collect additional year of data that added to budget analytical expenditures. Health related leave of a MS student in Ag Economics slowed the process of additional analyses associated with C footprint and energetics analyses. It is our hope that the data can be used by another student or when the original MS student returns. Project started at the same time new analytical equipment for gas chromatography was installed in the lab. Trouble shooting and student learning impacted QA/QC of a number of sample analyses and resulted in spotty data sets. What opportunities for training and professional development has the project provided? Two graduate students completed a week-long training to learn how to perform model simulations using their own data. They successfully completed their exercises and drafted the results into their thesis/dissertation. A couple of undergraduate work study students collected data for research projects to complete their internship requirements. Project provided data to explore possibilities of additional data analyses of cross-comparison between dryland and irrigated agroecosysems in winter wheat production regions of higher annual precipitation. How have the results been disseminated to communities of interest? Results were disseminated as a series of mini articles published in Agricultural Experiment Station Field Days Bulletins. Results were presented as open cross-campus presentations during graduate student PhD and MS defense seminars. Oral presentation was given at Dryland Agriculture Community (American Society of Agronomy) annual meeting in Sidney, NE. Oral presentation was given during annual ASA-CSSA-SSSA meeting in Long Beach, CA in November. One article was published in ASA monthly Crops and Soils and one article was published in Western Soil Nutrient Management Newsletter. Based on published information, a number of inquiries came from Montana State University, ARS, and from a couple of dryland winter wheat farmers who contacted PD via phone. PIs intend to continue publishing the results and collaborate with ARS to disseminate the information. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09/01 TO 2013/08/31 Target Audience: Farmers who participated in the Research Station Field Days at WY and NE Agricultural Research Stations, farmers who are on the project steering committees, undergraduate students taking the capstone AECL 4990 (Issues in Sustainable Agriculture) class; local highschool and elementary school teachers, extension educators and extension specialists, researchers who work on model simulations, conference attendees. Changes/Problems: 2012 was a drought year that created a need for additional 2013 field sampling and hence, non-funded one year project extension. What opportunities for training and professional development has the project provided? Training and professional development: One PhD student attending a week-long training to learn how to model using DAYCENT; One MS student attended a week long training to learn how to model soil water relationships; Two Agronomy students participated in annual ASA-CSSA-SSSA conference where they presented their results and attended a variety of workshops offerred by the society to graduate students; Agronomy graduate students and post-doc met weekly with project PD and discussed research results and interpretation; PIs and students met twice to discuss progress and results; PD attended a series of on-campus workshops to learn how to handle large datasets using ACCESS; PIs

participated in a teacher training workshop aimed at designing a module for local teachers to use as intergrated science based project; How have the results been disseminated to communities of interest? Field Day Presentation to an audience of 30 plus farmers, local community members and educators; Class presentations to senior undergraduate capstone class; Individual conversations with farmers via phone or email; Field trips organized for teachers and graduate students to tour the sites; Visits by international undergraduate and graduate students to learn the methodologies used to collect data. What do you plan to do during the next reporting period to accomplish the goals? Finish data collection; Carry-on modeling exercises; Continue submitting papers for peer-reviewed publications; Write extension bulletins that will include student participation; Graduate two more students; Organize a workshop about the outcomes at the research stations; Organize Teachers workshop. Present outcomes at the PDproject meetingin October, annual ASA-CSSA-SSSA meeting and multi-state project conference.

2011/09/01 TO 2012/08/31 OUTPUTS: Activities: Six separate experiments were well under way in year two. Experiments established in dryland and irrigated production at MAP of 11 inches (Lingle, WY) and MAP of 14 inches (Sidney, NE) included: (1) dryland winter wheat fallow production in second year of transition to organic; (2) impacts of first field preparation of winter wheat fallow while transitioning to organic; (3) irrigated organic cash crop production (a) and livestock integrated crop production (b) in the third year of transition to organic; (4) organic dryland winter wheat/fallow/sunflower (or millet) crop production; (5) no inputs irrigated or dryland alfalfa grass hay production; and (6) impacts if summer rainfall events in dryland and irrigated no-inputs alfalfa grass hay production. Survey and inventory data was also collected for economic analysis and assessment of agroecosystem sustainability by using carbon (C) footprint approach that will lead to future Life Cycle Assessment (LCA). Assessments: PI meetings held in late fall (November); meeting with the steering committee (spring), 5 graduate student committees; weekly meetings with individual graduate students, a post doc and undergraduate interns. Teaching: PD, U. Norton used preliminary results during undergraduate/graduate Soil Ecology Class and mentored 3 US and one international undergraduate internships. Conference presentations: Bista, P, U. Norton and R. Ghimire, and J. Norton. 2011. ASA-CSSA-SSSA annual meetings, San Antonio, TX; Peterson, B., U. Norton, and J. Krall. 2011.ASA-CSSA-SSSA annual meetings, San Antonio, TX; Peterson, B., U. Norton, and J. Krall. 2012. ESA annual meetings, Portland, OR; Ghimire, R., U. Norton, and J. Norton. 2012. Western ASA-CSSA-SSSA annual meetings,Davis, CA; Bista, P, U. Norton and R. Ghimire. 2012. ASA-CSSA-SSSA annual meetings, Cincinnati, OH; Kaur, G., T. Persson, T. Kelleners, U. Norton and A. Garcia y Garcia. 2012. ASA-CSSA-SSSA annual meetings Cincinnati, OH. Field Days presentations: Sustainable Agriculture Research and Education Center (SAREC) Field Days, August 2012, Lingle, WY: Norton, J.B., R. Ghimire, U. Norton, J. Meeks, S. Paisley. Peterson, B., U. Norton, and J. Krall. Kaur, G., and A. Garcia y Garcia. Symposia/public meeting presentations: Norton, U., P. Bista, B. Peterson, R. Ghimire and T. Hurrisso. Public meeting at SAREC, Lingle WY in April 2012. Norton, U., P. Bista, R. Ghimire, B. Peterson, J. Odhiambo, T. Hurrisso and J. Norton. Annual ASA Dryland Agriculture Systems Community meeting, August 2012. Workshops: One day workshop attended by two PIs, three science teaching leaders and three K-12 science teachers from WY on designing outcomes and objectives for the upcoming science teachers (K-12). Dissemination: public meeting in April, 2012 (attended by 20 people), annual ASA Dryland Agriculture Community meeting in SAREC in August 2012 (attended by 50 people) and SAREC Summer Field Days in August 2012 (attended by over 150 people). PARTICIPANTS: PD, Urszula Norton: organized steering committee meetings, participated in biweekly field sampling trips, gave presentations to public during ASA Dryland Community meeting, managed grant budget, recruited one more PhD student in Agronomy, recruited three undergraduate interns and two summer part-time undergraduate field assistants, co-authored one peer-reviewed paper, six conference presentations and two Field Days presentations; helped prepare three PhD students seminar presentations; participated in preparatory workshop to develop K-12 teacher training. PI, Axel Garcia y Garcia: participated in steering committee meeting, purchased and installed sensory equipment for soil water and temperature monitoring, mentored one MS student in Agronomy, co-authored one conference presentation, and one Field Day presentation; helped prepare one MS student seminar presentation. PI, John Ritten: participated in steering committee meeting; mentored one MS student in Agricultural Economics; purchased software for economic modeling. PI, Jay Norton: participated in two steering committee meetings; mentored one post doc scientist in Soil Science, co-authored four conference presentations, and two Field Day presentations, supervised field operation manager located at SAREC in Lingle, WY, participated in preparatory workshop to develop K-12 teacher training. PI, Gary Hergert: participated in two steering committee meetings, participated in two trips to Agriculture Experiment Station (Sidney, NE). PI, Steve DelGrosso: mentored one PhD student in Agronomy, Prakriti Bista: participated in two steering committee meetings, led biweekly field trips to Lingle, WY, co-authored two conference presentations; supervised one part-time undergraduate field technician. PhD student in soil Science, Rajan Ghimire: participated in two steering committee meetings, led biweekly field data collection to Lingle, WY; authored (main) one peer-reviewed article and one submitted in press, authored (main) one conference oral presentation, co-authored two conference poster presentations. Post-doc Scientist, Tunissa

Hurisso: participated in one steering committee meeting, led biweekly field sampling trips to Sidney, NE. Undergraduate field technician, Haley Roberts: participated in field and lab work. Undergraduate field technician, Erin Anders: participated in field and lab work. Field Operations Manager , Jenna Meeks: participated in the steering committee meeting, participated in all biweekly field monitoring; managed experimental plots and authored one lay audience article. Partner Organizations: University of Wyoming; UW Sustainable Agriculture Research and Education Center, Lingle, WY; University of Nebraska; University of Nebraska Agricultural Experiment Station, Sidney, NE; ARS USDA NPA- Ft. Collins, CO. Collaborators and contacts: Neil Hansen-Colorado State University; Anowar Islam, James Krall-University of Wyoming. Training: 3 MS students, 4 PhD students, 1 post doc, 4 undergraduate internships, 3 K-12 science coordinators, 3 K-12 science teachers, 3 undergraduate summer field technicians; 1 MS student spent one week attending a modeling workshop. TARGET AUDIENCES: Dryland winter wheat farmers and ranchers from WY and NE, students from the University of Wyoming who intend to become farmers after graduation, scientists, local politicians and administrators who participate in Field Days presentations, Formal classroom instructions (AECL 4990 Capstone seminar), laboratory instruction (SOIL 4140/5140), national and international internships, K-12 science leaders\' workshop, development of a curriculum module for K-12 science teachers, informal science presentations, student seminars, extension and outreach. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Activities: In spring 2011 we established plots in dryland winter wheat-fallow at SAREC (Lingle, WY). Treatments included conventional, no-till and organic farming systems. \"Transition to organic\" treatments were superimposed in conventional and no-till systems. Total of 10 trts replicated 5 times were created. These plots were monitored biweekly for greenhouse gas emissions (GHG), soil and plant biomass parameters starting in May 2011. In July 2011 we carried out an intensive GHG and soil sampling following a single tillage event in no-till plots as a part of conversion from no-till to organic. In May 2011 we established biweekly GHG, soil and plant parameters monitoring under irrigated cash crop and livestock integrated production in conventional, reduced inputs and organic farming at SAREC (Lingle, WY). In late summer 2011 we started establishing plots on dryland winter wheat millet (and/or sunflower) fallow rotations on Agriculture Experiment Station in Sidney, NE. Treatments included conventional, minimum-till and organic farming systems. \"Transition to organic\" treatments will be superimposed in spring 2012. Total of 12 trts replicated 5 times are going to be created. In fall 2011 sensors for monitoring soil water and temperature were purchased and are currently installed on all sites. Events: In April 2011 we convened a project meeting between the farmers who are a part of the steering committee, PIs. students and support staff to discuss project objectives and research establishment. In June 2011 preliminary project results were presented during Western Crop Science Society of America-Soil Science Society of America-Agronomy Society of America (CSSA-SSSA-ASA) meetings in Laramie, WY (http://a-c-s.confex.com/crops/ws2011/webprogram/Paper69113.html). In July 2011 research was presented to a large group of farmers during the Field Day organized by Sustainable Agriculture Research and Education Center (SAREC) Lingle, WY. In August 2011 project Director, Urszula Norton gave a synopsis of the research as an oral presentation to a large group of scientists and farmers from CO, NE, KS, WY and MT during \"Tear Down the Walls\" ASA Dryland Cropping section annual meetings in Ft. Collins, CO. Two abstracts are submitted for the presentations during annual ASA-CSSA-SSSA meetings in San Antonio, TX in October, 2011. Products: (1) baseline data of soil, plant and residue parameters collected before treatment establishment; (2) data from biweekly monitoring of GHG, soil, residue and plant parameters starting in May 2011; (3) data from intensive hourly monitoring of GHG, soil and plant parameters following conversion from no-till to organic production; (4) LAI measurements at peak winter what biomass growth; (6) data from the end of season root sampling. Dissemination: In April 2011 we met with farmers who specialize in no-till, organic and conventional winter wheat production to discuss the project objectives and solicit the feedback. In July 2011 research was presented during SAREC Field Day attended by farmers, ranchers, scientists, local citizens and politicians. PARTICIPANTS: PD, Urszula Norton: (1) organized two steering committee meetings in April and June 2011, (2) convened meeting with scientists in ARS Ft. Collins, CO on data collection and development of model simulation, (3) experiment establishment in SAREC (Lingle, WY) and biweekly monitoring trips, (4) trip to Agriculture Experiment Station (Sidney, NE) and experiment establishment, (5) presented during ASA Dryland Cropping section annual meetings in Ft. Collins, CO in August, 2011, (6) managed grant budget, (7) recruited one PhD student in Agronomy (spring 2011), (8) recruited one summer part-time undergraduate field assistant, (9) co-authored two presentations during Western CSSA-SSSA-ASA meetings; PI, Axel Garcia y Garcia: (1) participated in first steering committee meeting in April 2011, (2) purchased sensory equipment for soil water and temperature monitoring soon to be established, (3) recruited one MS student in Agronomy (fall 2011) PI, John Ritten: (1) participated in first steering committee meeting in April 2011; (2) recruited one MS student in Agricultural Economics (Fall 2011); (3) purchased software for economic modeling PI, Jay Norton: (1) participated in two steering committee meetings; (2) recruited one post doc scientist in Soil Science (summer 2011), (3) co-authored two presentations during Western CSSA-SSSA-ASA meetings, (4) supervised field operation manager

located at SAREC in Lingle, WY PI, Gary Hergert: (1) participated in two steering committee meetings,(2) participated in two trips to Agriculture Experiment Station (Sidney, NE) and experiment establishment PI, Steve DelGrosso: (1) participated in a meeting between PIs and scientists in ARS Ft. Collins, CO on data collection and development of model simulation PhD student in Agronomy (spring 2011), Prakriti Bista: (1) participated in two steering committee meetings, (2) participated in the meeting with scientists in ARS Ft. Collins, CO, (3) participated in experiment establishment in SAREC (Lingle, WY) and all biweekly monitoring trips, (4) participated in two trips to Agriculture Experiment Station (Sidney, NE), (5) co-authored two presentations during Western CSSA-SSSA-ASA meetings;(6) supervised one part-time undergraduate field technician PhD student in soil Science (fall 2009), Rajan Ghmire: (1) participated in two steering committee meetings, (2) participated in the meeting with scientists in ARS Ft. Collins, CO, (3) participated in experiment establishment in SAREC (Lingle, WY) and all biweekly monitoring trips, (4) co-authored two presentations during Western CSSA-SSSA-ASA meetings Post Doc Scientist, Tunissa Hurisso: (1) participated in one steering committee meeting, (2) participated in biweekly monitoring trips, (3) participated in experiment establishment and two trips to Agriculture Experiment Station (Sidney, NE) Undergraduate field technician, Sarah Legg: (1) participated in field and lab work Field Operations Manager (spring 2011), Jenna Meeks: (1) participated in the first steering committee meeting in April 2011, (2) participated in experiment establishment in SAREC (Lingle, WY) and all biweekly monitoring trips; (3) managed experimental plots TARGET AUDIENCES: Target audiences: dryland winter wheat farmers and ranchers from WY and NE, students from the University of Wyoming who intend to become farmers after graduation, scientists, local politicians and administrators who participate in Field Days presentations Efforts: formal classroom instructions (Agroecology 4990 Issues in Sustainable Agriculture), capstone class for students graduating in Agroecology, one internship offered to undergraduate student majoring in Agroecology, development of innovative teaching approach of using this project as a case study , extension and outreach through meetings with farmers and field day presentations PROJECT MODIFICATIONS: None

IMPACT

2010/09 TO 2014/08 What was accomplished under these goals? Activities: Our main transition experiments: dryland winter wheat-fallow production, irrigated cash crop production, irrigated livestock integrated crop production, all at the James C. Hageman Sustainable Agriculture Research and Extension Center (Lingle, WY) were sampled for GHG emissions, soil and plant parameters and soil water once a month through the winter months and biweekly during the third year until June 2013. Dryland winter wheat-sunflower-fallow production at the Agricultural Experiment Station in Sidney, NE were sampled for GHG emissions, soil and plant parameters and soil water once a month through the winter months and biweekly during the third year until January 2014. All datasets were completed by May 2014, data analyzed, first drafts completed and submitted to peer review journals. Three graduate students defended their PhD dissertations based on research generated in this project. Specific objectives met: 1. Soil C processes, including sequestration and GHG emissions to quantify performance of organic production relative to conventional and reduced tillage systems: field sampling completed; GHG data sets are completed and available, soil datasets completed. First modeling exercises completed. All data written into dissertation chapters and first manuscripts. 2. Water use efficiency to determine short- to long-term feasibility of both irrigated and non-irrigated production in this moisture-deficient environment: 1-year dataset completed and available. First modeling exercises completed. The second year of data completely processed. MS thesis defended, Manuscript for submission in the final stage of reviews. 3. Field- and farm scale economics to determine the need, timeframe, and level of possible incentives for transition to sequester C in organic production: data collection complete and analyses done. MS thesis not defended yet due to graduate student health-related temporary leave. 4. Energy input:output and C footprint impacts to determine true environmental impacts or services resulting from the practices. Not completed yet. Significant results achieved, including major findings, developments, or conclusions (both positive and negative): • Yields vary by annual precipitation. Transition from no-till to organic has highest yields after drought. • 10-years of no-till improves soil TN by 40% and TOC by 23% compared with frequently tilled soils. This SOM accrual may be lost while tilling during transition to organic but it may take 10 years for SOM to decline. • Reducing tillage intensity while transitioning to irrigated organic production or transitioning to dryland winter wheat farming from no-till production will result in reduced GHG emissions, mainly N2O and production. No-till transition to organic does not impact CO2 and has 26% lower N2O emissions than organic suggesting more efficient way of N retention in soil. • Transitioning to irrigated organic farming requires soil fertility management through periodic manure application. It increases CO2 production at the initial phase of the transition. Research past the transition period is needed to fully embrace accrual of benefits. • Transitioning to dryland organic farming in very low precipitation region requires a period of no-till to accrue SOM benefits instead of manure. Additional challenges include additional efforts associated with combating weeds as more intensive tilling associated with the system enhances weed germination. Alternative

tillage practices focusing on evading weed pressures may be required which will accelerate SOM loss.. • Economics: due to poor yields, long-term no-till is the least favorable. This may change if yields increase over time due to improved soil health of no-till but organic is far more profitable, once certification is obtained. Without organic premiums, conventional systems are slightly more profitable in most years. New OREI grant was successfully funded based on hypotheses created from the results of this project. Modelling efforts continue as more data gets published in peer-reviewed literature. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/08 1. Type: Journal Articles Status: Published Year Published: 2014 Citation: Norton, U., P. Bista, R. Ghimire and J.B. Norton. 2014. One-time summer tillage does not negate long-term benefits of no-till. Crop and Soils, May-June 2014. 2. Type: Journal Articles Status: Published Year Published: 2014 Citation: Norton, U., P. Bista, R. Ghimire and J.B. Norton. 2014. One-time summer tillage of chemical fallow in a dryland winter wheat rotation does not negate long-term benefits accrued under no-till management. Nutrient digest, Nutrient management newsletter for the western US, Spring 2014. 3. Type: Other Status: Published Year Published: 2013 Citation: Bista, P., U. Norton, R. Ghimire, J.B. Norton, J. Meeks. 2013. Effect of Summer Tillage on Greenhouse Gas Emissions from Organic, Conventional, and No-Till Fallows in Dryland Winter Wheat Production. 2013 Field Days Bulletin, pp 89-90. Wyoming Agricultural Experiment Station, University of Wyoming, Laramie, Wyoming. http://www.uwyo.edu/uwexpstn/ files/docs/2013-field-days-bulletin.pdf 4. Type: Other Status: Published Year Published: 2013 Citation: Ghimire, R., U. Norton, J.B. Norton and P. Bista. 2013. Greenhouse gas emissions from alternative management approaches of irrigated crop and forage production system. 2013 Field Days Bulletin, pp 87-88. Wyoming Agricultural Experiment Station, University of Wyoming, Laramie, Wyoming, USA. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Bista, P, U. Norton, R. Ghimire, J. Norton. Greenhouse gas emissions and soil nitrate in dryland winter wheat/fallow cropping systems under contrasting precipitation years. Oral presentation Nov 2-5, 2014, Long Beach, California, USA. 6. Type: Journal Articles Status: Submitted Year Published: 2015 Citation: Ghimire R., U. Norton, P. Bista, A.K. Obour, and J.B. Norton. Greenhouse gas emissions and nitrogen mineralization during transitioning to irrigated crop rotation. Manuscript under review, Soil Science Society of America Journal (submitted Sept. 25, 2014). 7. Type: Theses/Dissertations Status: Published Year Published: 2014 Citation: Bista, P., Effects of management practices on greenhouse gas fluxes, soil organic matter dynamics and crop performance in dryland wheat production in Wyoming. University of Wyoming, 2014. 8. Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Ghimire, R., Effects of management practices on soil C and N dynamics in organic, reduced-input and conventional cash crop and livestock integrated irrigated production. University of Wyoming, 2013. 9. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Norton, U., B. Bista, J. Norton. GHG emissions and soil C and N dynamics from dryland organic, no-till and conventional winter wheat production in eastern Wyoming. 10. Type: Journal Articles Status: Under Review Year Published: 2015 Citation: Tunsisa T. Hurisso, Urszula Norton, Jay B. Norton, Judith Odhiambo, Stephen J. Del Grosso, Gary W. Hergert, Drew J. Lyon. Seasonal Greenhouse Gas Fluxes and Plant Growth Parameters in Dryland Winter Wheat/Summer Crop/Fallow Rotations in western Nebraska. For submission to Soil Science Society of America Journal. 11. Type: Journal Articles Status: Under Review Year Published: 2015 Citation: Bista, P., U. Norton, R. Ghimire, J. Norton. Greenhouse gas fluxes and soil carbon and nitrogen following single summer tillage. For submission to Journal of Environmental Quality. 12. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Kaur, G., A. Garcia y Garcia, U. Norton, T. Kelleners, and T. Persson. 2013. Sustainability of cropping systems for dryland winter wheat production: A simulation approach. In: Abstracts of the ASA-CSSA-SSSA International Annual Meetings. Tampa, FL. 13. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Kaur, G., U. Norton, and A. Garcia y Garcia. 2013. Effects of Cropping System on Water Use and Water Productivity of Dryland Winter Wheat. In: 2013 Field Days Bulletin, Wyoming Agricultural Experiment Station, College of Agriculture and Natural Resources, University of Wyoming. \Xtension

2012/09/01 TO 2013/08/31 What was accomplished under these goals? Activities: Our main transition experiments: dryland winter wheat-fallow production, irrigated cash crop production, irrigated livestock integrated crop production, all at James C. Hageman Sustainable Agriculture Research and Extension Center (Lingle, WY) and dryland winter wheat-sunflower-fallow production at the Agricultural Experiment Station in Sidney, NE were sampled for GHG emissions, soil and plant parameters and soil water once a month through the winter months and biweekly during the growing season for the second year in the row. Economic data collection was initiated in late fall 2012. However, the 2012 growing season appeared to be the driest season on record, starting as early as January 2012, and WY and NE dryland experiments experienced a couple of crop planting failures and significant winter wheat yield loss. All researchers agreed to continue sampling for the third consecutive year until September 2013. Specific Objectives met: 1. Soil C processes, including sequestration and GHG emissions to quantify performance of organic production relative to conventional and reduced tillage systems: field sampling completed; GHG data sets are completed and available, soil datasets are still not fully completed. First modeling exercises are underway. 2. Water use efficiency to determine short- to long-term feasibility of both irrigated and

non-irrigated production in this moisture-deficient environment: 1-year dataset completed and available. First modeling exercises are underway. The second year of data is not completely processed yet. 3. Field- and farm scale economics to determine the need, timeframe, and level of possible incentives for transition to sequester C in organic production: data collection is almost complete. 4. Energy input:output and C footprint impacts to determine true environmental impacts or services resulting from the practices. Not completed yet. Significant results achieved, including major findings, developments, or conclusions (both positive and negative). Preliminary results from GHG analyses: reducing tillage intensity while tranistioning to irrigated organic production or tranistioning to dryland winter wheat farming from no-till production will result in reduced GHG emissions, mainly N2O and CO2 production. Transitioning to irrigated organic farming results in active soilf fertility management and manure application which also increases CO2 production at the intitial phase of the transition. Research past the transition period is needed to fully embrace accrual of benefits. Transitioning to dryland organic farming has an additional challenge of combating weed invasion as more intensive tilling associated with the system enhances weed germination. Alternative tillage practices focusing on evading the weed pressure problems could help make the dryland winter wheat organic system more successful. Organic dryland practices that involve additional tillage result in greater C and N losses to CO2 and N2O. Designing dryland organic practices that involve reduced tillage operation will help improve soil C and N retention. Field observations suggest that experimenting with alternative crop to sunflower or millet in dryland plots in NE, such as specialty crops that would not deplete deep water from the soil profile would increase winter wheat yields and increase economic benefits.

2011/09/01 TO 2012/08/31 Large datasets are being prepared for validation of the biogeochemical, hydrological, crop performance, economic sand energetics model simulations. Preliminary field data generated numerous additional research questions and experiments. Second year of biweekly results is almost complete. Manuscripts are being prepared for complete sets of data associated with short experiments that will aim at helping interpret large scale field data sets. Second year of data generated that shows notable differences while converting from no-till to organic winter wheat fallow system in terms of the magnitude of the greenhouse gas (GHG) emissions. Plant community dynamics and plant growth parameters show benefits of conversion from no-till to organic. The practice of reintroduction of tillage during this process results in rapid decline in soil organic matter and increase in GHG emissions reducing carbon sequestration and increasing the environmental impact. More data needs to be generated to create simulation models to show long-term impacts. Additional experiment is proposed to evaluate the feasibility of using no-till as an alternative for organic production. The dissemination of the results at public meetings and presentation made public aware of the relationships between land uses and GHG emissions. Farmers\' future decisions on land use changes are better supported and validated by two years of data.

2010/09/01 TO 2011/08/31 Our preliminary results suggest that converting from no-till to organic winter wheat fallow system typically used in the area requires reintroduction of tillage. This practice will result in rapid decline in soil organic matter and increase in GHG emissions reducing carbon sequestration and increasing the environmental impact. More data needs to be generated to create simulation models to show long-term impacts. Additional experiment is proposed to evaluate the feasibility of using no-till as an alternative for organic production.

PUBLICATIONS

2012/09/01 TO 2013/08/31 1. Type: Other Status: Published Year Published: 2013 Citation: Peterson, B., U. Norton, J. Krall, and A. Islam. 2013. Summer Rainfall Effects on Greenhouse Gas Emissions from Dryland and Irrigated Alfalfa/Grass Hay Production. Wyoming Agricultural Experiment Station Field Days Bulletin 2. Type: Journal Articles Status: Published Year Published: 2012 Citation: Ghimire, R., J.B. Norton, U. Norton, J.P. Ritten, P.D. Stahl, and J.M. Krall. 2012. Long- term farming systems research in the Northern High Plains. Renewable Agriculture and Food Systems. November 2012: 1-11, doi: 101017/S1742170512000208 3. Type: Journal Articles Status: Accepted Year Published: 2013 Citation: Hurisso, T., J. B. Norton, and U. Norton. 2013. Soil profile carbon and nitrogen in prairie, perennial grass-legume cover and wheat-fallow production in the Central High Plains, USA. Agriculture, Ecosystem and Environment. Accepted. 4. Type: Journal Articles Status: Accepted Year Published: 2013 Citation: Ghimire, R., J.B. Norton, T. Hurisso and U. Norton. 2012. Dryland tillage and cropping system effects on soil profile carbon and nitrogen in the central High Plains, USA. Soil and Tillage Research. Accepted. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Bista, P, U. Norton and R. Ghimire. 2012. Greenhouse Gas Emissions and Soil Nitrogen Following the First Tillage Event in the Fallow Phase of Long-Term No-Till Winter Wheat. Abstracts ASA-CSSA-SSSA annual meetings in Cincinnati, OH. 6. Type: Conference Papers and Presentations Status: Published Year Published:

2012 Citation: Kaur, G., T. Persson, T. Kelleners, U. Norton and A. Garcia y Garcia. 2012. Water Use Productivity of Dryland Winter Wheat in the High Plains Ecoregion of Wyoming. ASA-CSSA-SSSA annual meetings in Cincinnati, OH. 7. Type: Other Status: Published Year Published: 2013 Citation: Meeks, J., and J. Norton. 2013. The longer the data harvest, the more valuable the crop. Reflections, College of Agriculture and Natural Resources Research Report. Pp 43-46. 8. Type: Other Status: Published Year Published: 2013 Citation: Norton, J. Norton, U., R. Ghimire, et al., 2013. Sustainable Agriculture Systems Project: results from four years after conversion from continuous irrigated corn to cash-crop and forage rotations under typical, reduced tillage and organic management. Wyoming Agricultural Experiment Station Field Days Bulletin 9. Type: Other Status: Published Year Published: 2013 Citation: Kaur, G., U. Norton, and A. Garcia y Garcia. 2013. Effects of Cropping System on Water Use Efficiency and Water Productivity of Dryland Winter Wheat. Wyoming Agricultural Experiment Station Field Days Bulletin 10. Type: Other Status: Published Year Published: 2013 Citation: Ghimire, R., U. Norton, J. Norton and P. Bista. Greenhouse Gas Emissions from Alternative Management Approaches of Irrigated Crop and Forage Production system. Wyoming Agricultural Experiment Station Field Days Bulletin 11. Type: Other Status: Published Year Published: 2013 Citation: Bista, P., U. Norton, R. Ghimire, J. Norton, and J. Meeks. 2013. Effect of Summer Tillage on greenhouse Gas Emissions from Organic, Conventional, and No-Till Fallows in Dryland Winter Wheat Production. Wyoming Agricultural Experiment Station Field Days Bulletin

2011/09/01 TO 2012/08/31 1. Ghimire, R., J.B. Norton, U. Norton, J.P. Ritten, P.D. Stahl, and J.M. Krall. 2012. Long-term farming systems research in the central High Plains. Renewable Agriculture and Food Systems. Published Abstracts of Conference presentations. 2. Bista, P, U. Norton and R. Ghimire, and J. Norton. 2011 Greenhouse Gas Emission and Crop Productivity From the Contrasting Management Approaches, In Dryland Winter Wheat-Fallow of the Northern High Plains. ASA-CSSA-SSSA annual meetings in San Antonio, TX. 3. Peterson, B., U. Norton, and J. Krall. 2011. Soil and Nitrogen Budgets and Greenhouse Gas Emissions from Irrigated and Dryland Alfalfa Hay in the Northern high Plains. ASA-CSSA-SSSA annual meetings in San Antonio, TX. 4. Peterson, B., U. Norton, and J. Krall. 2012. Summer Water Pulse Effects on Soil C and N and GHG Fluxes from Irrigated and Dryland Alfalfa/Grass Hay Production in Eastern Wyoming. ESA annual meetings in Portland, OR. 5. Kaur, G., and A. Garcia y Garcia. 2012. Enhancing Water-Holding Capacity of Soils with Organic and No-till Production Practices. 6. Ghimire, R., U. Norton, and J. Norton. 2012. GHG Emissions during Transition to Integrated Crop Livestock Production Systems in Eastern Wyoming. Western region ASA-CSSA-SSSA annual meetings in Davis, CA. 7. Bista, P, U. Norton and R. Ghimire. 2012. Greenhouse Gas Emissions and Soil Nitrogen Following the First Tillage Event in the Fallow Phase of The Long-Term No-Till Winter Wheat. ASA-CSSA-SSSA annual meetings in Cincinnati, OH. 8. Kaur, G., T. Persson, T. Kelleners, U. Norton and A. Garcia y Garcia. 2012. Water Use Productivity of Dryland Winter Wheat in the High Plains Ecoregion of Wyoming. ASA-CSSA-SSSA annual meetings in Cincinnati, OH. 9. Published Abstracts of Field Days presentations: Norton, J.B., R. Ghimire, U. Norton, J. Meeks, S. Paisley. 2012. The Sustainable Agriculture systems Project. Sustainable Agriculture Research and Education Center (SAREC) Field Days, August 2012, Lingle, WY. 10. Peterson, B., U. Norton, and J. Krall. 2012. Symbiotic and Non-Symbiotic Biological N2 Fixation in Dryland and Irrigated Alfalfa/Grass Hay Production. Sustainable Agriculture Research and Education Center (SAREC) Field Days, August 2012, Lingle, WY. 11. Lay media: Meeks, J., J. Norton, R. Gebauer-King, R. Ghimire, U. Norton, P. Bista, J. Ritten, D. Peck. 2012. Long-term project begins yielding results. University of Wyoming College of Agriculture and Natural Resources Reflections magazine.

2010/09/01 TO 2011/08/31 1. Bista, P. and U. Norton. 2011. Greenhouse Gas Emissions and Crop Productivity from the Contrasting Management Approaches In Dry Land Wheat Farming System of the Northern High Plains. Western CSSA-ASA-CSSA meetings, June, 2011 Laramie, WY (http://a-c-s.confex.com/crops/ws2011/webprogram/Paper69113.html) 2. Bista, P., U. Norton, R. Ghmire, and J. Norton. 2011. Greenhouse Gas Emissions from Dryland Winter Wheat Fallow System under Conventional, No-Till, Organic and Transition to Organic Management. University of Wyoming College of Agriculture and Natural resources Agricultural Experiment Station 2011 Field Days Bulletin; 3. Ghmire, R., P. Bista, U. Norton and J. Norton. 2011. Trace gas emission from conventional, reduced-input, and organic approaches of crop-range-livestock farming in Wyoming. Field Days Bulletin. University of Wyoming College of Agriculture and Natural resources Agricultural Experiment Station 2011; 4. Ghmire, R., J. Norton, U. Norton and N. Ward. 2011. More than one way to raise a crop. Reflections 2011. University of Wyoming College of Agriculture and Natural Resources.

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Greenhouse Gas Emissions in the Transition from Traditional to Organic Dairy Farming: an Education and Research Collaboration

Accession No.	0223831
Subfile	CRIS
Project No.	NHW-2010-03957
Agency	NIFA NH.W
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51106-21834
Proposal No.	2010-03957
Start Date	01 SEP 2010
Term Date	31 AUG 2014
Grant Amount	$0
Grant Year	2010
Investigator(s)	Varner, R. K.; Li, C.

NON-TECHNICAL SUMMARY

Conversion from conventional to organic dairy farming in Northeast United States will result in enhanced ecosystem services and improved environmental benefits through the reduction in nitrate leaching and greenhouse gas emissions and increases in soil organic matter. Through an integrated research and education approach we plan to measure and model the greenhouse gas emission inventory of traditional and organic dairy practices at the University of New Hampshire. Field measurements of greenhouse gas emission from all components of the dairy farms will be completed. Manure-DNDC, a biogeochemical model, will be calibrated and validated for the UNH sites then applied to other organic dairy sites throughout the region. A decision support tool will be developed to in collaboration with stakeholders, Organic Valley and Stonyfield Farms, to provide farmers training in using the tool, assistance with accessing data and information regarding the ecosystems services and environmental benefits from organic farming. We will engage not only with stakeholders in the dairy industry but with the K-12 community in an effort to educate both the users and the public about greenhouse gas emission inventories, organic farming and sustainable agriculture. A graduate student will work with science teachers to develop and implement inquiry based authentic research in their classrooms.

OBJECTIVES

The goal of our proposed research is to develop a decision support tool for quantitatively evaluating the best management practices (BMPs) to enhance the ecosystem services produced by livestock systems at the site and regional scale for the Northeast U.S. Our specific objectives are: 1. Test and improve Manure-DNDC using farm-level observational data. A suite of research farms at UNH will be used as primary sites for testing the applicability of Manure-DNDC for the Northeastern livestock farms. Some additional sampling and chemical analysis will be conducted to quantify the primary of C and N biogeochemical stocks and flows across farm facility components. Data will be utilized for modifying, calibrating, and validating Manure-DNDC. 2. Quantify the impacts of baseline and alternative management practices on the ecosystem services of the selected farm with Manure-DNDC. A baseline scenario and a group of alternative management scenarios will be designed based on the current and prospective management practices for the UNH farms. BMP scenarios will be identified and evaluated based on their ecosystem service and economic incentives for the farm. 3. Develop Northeastern U.S. GIS database to support Manure-DNDC applications at regional scale. To make Manure-DNDC useful for dairy

farms in the Northeast, we will create a GIS database containing necessary input information of climate/weather data, soil properties, livestock and crop parameters, and default management practices required to run Manure-DNDC for the region. The data will be collected from a variety of sources and stored in a geo-referenced database in the Manure-DNDC required format. 4. Develop a decision support tool by developing a user-friendly interface to link Manure-DNDC to regional database. The interface will allow the user to select a specific location or a region, automatically extracting the required information from the database, allow the user to modify the default data to their own site specific conditions, execute Manure-DNDC, and provide modeled results in graphical and tabular form. 5. Evaluate the decision support tool. A two-day workshop will be held during the third year of the project to teach interested parties to use the decision support tool and to get their assessment of its usefulness and potential improvements. After reviewing the feedback from the users, the decision support tool will be modified and finalized. 6. Integrate the research objectives with an educational initiative that partners a graduate student with science teachers and their students. A partnership between middle and high school science teachers and a Ph.D. level graduate student will be established to enable the graduate student to build communication skills around greenhouse gas inventories, organic farming and sustainable agriculture and promote authentic inquiry-based research projects with middle and high school teachers and students.

APPROACH

The University of New Hampshire (UNH) offers two very different livestock-crop systems which cover the range of current systems in the region and provide a rigorous test for the generality of the model to be produced. The UNH Organic Dairy Research Farm (ODRF) encompasses the adjacent Burley-Demerrit and Bartlett-Dudley farms in Lee, NH, about 7 km from the UNH campus. The two holdings include 40 hectares of certified organic pastures, and 65 hectares of woodlands. The farm currently supports a herd of 43 milking cows and 18 heifers, all Jerseys (http://www.organicdairy.unh.edu/). UNH also supports an advanced, conventional dairy system. The Fairchild Dairy Teaching and Research Center (DTRC, http://www.colsa.unh.edu/aes/facilities.html) houses about 125 milking-age Holsteins and approximately 70 growing, replacement animals. These two facilities offer a diverse set of feed/manure systems for development and testing of the Manure-DNDC model, and will be utilized in the following way. Firstly, systematic sampling and chemical analysis will be conducted across all the farm facility components to establish a relatively complete framework of the N biogeochemical cycle for the prototype ecosystems. Secondly, contributions to ecosystem services of each of the farm facility components (feed, housing, compost, lagoon, anaerobic digester or crop field) will be quantified by identifying its efficiency and leaks within the N cycling framework. Some of the ecosystem N cycling or individual components studies have been carried out within the on-going projects. The results from the on-going projects will be used to calibrate and validate Manure-DNDC for the livestock-crop ecosystem. Data gaps will be identified, and additional sampling and analysis will be conducted to complete the description of the manure life cycle for the entire livestock-crop ecosystems. To allow the farmers or resource managers to utilize Manure-DNDC without having to acquire and organize necessary input data, we will collect and organize all necessary input data for the domain region and link them to the model in advance. For our selected domain, the livestock-crop ecosystems in the Northeast US, we will develop a georeferenced database containing relevant data on climate and soil properties, as well as necessary parameterizations characterizing Northeastern U.S. livestock, crop and farm management. The decision support tool will extract relevant data for a specific user (daily weather for one or more years from station data which we will have acquired from the National Climate Data Center database, soil properties which we will have acquired from the USDA NRCS soil STATSGO2 and SSURGO databases, and default or characteristic farm management information - herd size, housing, manure management, etc., which we will have prescribed in consultation with UNH agronomists). The user can then review this information and make any adjustments needed to match their own soils and livestock operation through the model interface.

PROGRESS

2010/09 TO 2014/08 Target Audience:The target audiences reached for the entire proposal persiod include the dairy farming industry including the Northeast Organic Dairy Association and UNH Cooperative Extension. We also had outreach to the K-16 community. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Extension and/or education activities We have describedin the previous section thespecific opportunities for training and professional development related to K-12 activities. Dr. Varner also used/s this approach as a portion of her undergraduate course \"Techniques in Environmental Science\" to teachundergraduate Environmental Science majors about the measurement of greenhouse gases, data anlalysis and relationships between temperature, moisture and CO2 emissions. She was able to reach a total of 80 undergraduates with this research over the project period.In addition to this, ourresearch has also supported one post-doc (part-time), one master\'s students (full-time), a senior

undergraduate thesis, and several class projects as part of a UNH Soil Ecology course and the Techniques in Environmental Science course. How have the results been disseminated to communities of interest?In addition to our publications, presentations and outreach to K-16, the broader impact of this study was to develop a web-based decision support tool for quantitatively evaluating the best management practices that enhance ecosystem services in livestock systems, both at individual farms and across the Northeast. We built the foundation for this outcome with our intensive field data collection, model testing, and GIS database development.We also develped this decision support tool, the Northeast Dairy Emissions Estimator and this is currently online and accessible. http://nedairy.ags.io/ What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2010/09 TO 2014/08 What was accomplished under these goals? To date, project outputs have addressed allsix objectives of our study: 1) to collect farm-level observational data for testing and improving the process-based biogeochemical model, Manure-DNDC; 2) to quantify the impact of baseline and alternative management practices on ecosystem services with Manure-DNDC; 3) to develop a Northeastern GIS database to support Manure-DNDC applications at a regional scale, 4) Develop a decision support tool by developing a user-friendly interface to link Manure-DNDC to regional database; 5) Evaluate the decision support tool and 6) Integrate the research objectives with an educational initiative that partners a graduate student with science teachers and their students. To meet out first objective, we initiated a systematic sampling and chemical analysis of pools and fluxes of carbon and nitrogen at two University of New Hampshire farms. We used these farms as model systems to calibrate Manure-DNDC and include the UNH Burley-DeMerrit (organic) and Fairchild (conventional) dairies. In the spring and summer of 2011, plots were established in the cropping areas of each of the farms for measuring carbon and nitrogen pools in crop biomass and soils. We also used the plots for measuring soil greenhouse gas emissions of carbon (methane, carbon dioxide) and nitrogen (nitrous oxide). A spatially intensive soil sampling was completed at both farms during the 2011 and2012 growing seasons, and soil profiles have been characterized for DNDC model inputs such as texture, pH, bulk density, carbon, and nitrogen. Soil greenhouse gas emissions began in July 2011 and consisted of bi-monthly measurements of methane, carbon dioxide, and nitrous oxide. An automated system that continuously collects data on carbon dioxide emissions was deployed to the organic dairy in July 2011. This automated system allowed us to observe fine scale responses to changes in temperature, moisture, and management that our bi-monthly observations may have missed. We also identified and measured \"hotspots\" and \"hot moments\" of greenhouse gas emissions on each of the farms. A \"hotspot\" is a relatively small area where large amounts of greenhouse gases are released, such as in manure and silage stockpiles. A \"hot moment\" is a short period of time where a pulse of greenhouse gases may be released to the atmosphere, such as when manure is applied to a field. We also quantified greenhouse gas fluxes from manure, silage, bedding, and from the cows themselves (enteric emissions), and experimentally manipulated the effects of manure and urine inputs, mowing, grazing, and precipitation on soil greenhouse gas fluxes.The enteric emissions methodology has been published (Dorich et al. 2015) and Mr. Dorich completed his masters degree and has gone on to a position at Colorado State University. To address our second objective, we compiled management data on all aspects of farm operations for both the organic and conventional dairies. We conducted initial DNDC model runs examining the effects of grazing and manure applications on soil carbon sequestration and greenhouse gas emissions. These findings were presented at the 2012 meeting of the Ecological Society of America in Portland, OR. A more complete suite of Manure-DNDC runs for model calibration, validation, and simulation of management scenarios were completed and were used for the development of the decision support tool outlined below. we have three separate manuscripts in preparation addressing 1) hotspots of greenhouse gas emission, 2) experimentally manipulated the effects of manure and urine inputs, mowing, grazing, and precipitation on soil greenhouse gas fluxes and 3) DNDC modeling of these farm ecosystems. For our third objective, we have compiled a GIS database that will enable regional modeling of dairy management throughout the Northeast. The database includes characteristics of soils (clay fraction, organic matter fraction, pH, and bulk density) managed for pasture in the Northeastern US. It contains spatially explicit estimates of dairy farm distribution, daily weather data, and nitrogen deposition. This GIS database was combined with Manure-DNDC to produce the web-based decision support tool outlined in the project proposal. Objective four, to develop a decision support tool using a user friendly interface to link DNDC to a regional database has also been completed. Through our collaboration with AGS, we have developed the Northeast Dairy Emissions Estimator (<http://nedairy.ags.io/>). This web application is a simple yet powerful way for farmers or other interested parties to learn about the general implications of changes to dairy farm management. Its intuitive design allows a user to quickly and easily create an account, locate a farm, and define farm management. Emissions and reactive N losses can be viewed for a single management scenario or compared across management alternatives. We designed, built, and deployedthis web-based application that produces DNDC-based greenhouse gas emissions estimates for New England dairy agriculture systems in response to user specified conditions. These scenarios

are described using a key subset of DNDC input parameters. This simplified model, referred to as the DNDC meta-model, utilizes a data mining approach to mimic the functioning of the full complex model and compare results graphically. The purpose of implementing this simplified tool is to allow easy access over the web to DNDC emissions estimates. This addresses a set of issues related to the complexity of DNDC and effort required to set up and execute DNDC simulations. Our fifth objective was to evalaute the decision support tool. On 5/21/14 we held an all day workshop at the Instiutue for the Study of Earth, Oceans and Space at the University of New Hampshire withinvited guestsfrom industry and UNH Cooperative Extension who specifically work with farmers on management practices. This workshop was meant to introduce the concept of theNortheast Dairy Emissions Estimator and gather feedback on the usability of the interface and content. It was organized by the PI Ruth Varner and included presentations by Dr. Varner, Dr. Alexandra Contosta, Mr. Christopher Dorich (all at UNH) and Dr. Pete Ingraham (AGS). Our invited guests included: Nancy Hershberg (formerly of Stoneyfield) Michal Lunak (UNH Extension) John Porter (UNH Extension, emeritus) Dorn Cox (NH Association of Conservation Districts). Obejective 6,to integrate the research objectives with an educational initiative that partners a graduate student with science teachers and their students included graduate student Mr. Christopher Dorich developinga full day workshop to work with12 middle and high school teachers. The workshop consisted of an initial session on carbon cycles and greenhouse gas emissions, a field trip to the organic dairy where Mr. Dorich and Dr. Varner allowed the teachers to investigate a research question of thier own (How does CO2 emission vary across a farm ecosystem?) using a portable CO2 flux unit developed by Dr. Varner as part of her leadership of the Joan and James Letizel Center for STEM education. The teachers collected flux data from 3 differnt sites on the famr and then returned to the university to anlayze their results. They discussed implementation of this kind of research, both the content and the scientific appraoch to thier classrooms. Three of the teachers worked with Mr. Dorich in their classes by borrowing the instrument and having him come in to support the measurements and interpretation in their classroom reaching approximately 60 middle and high school students. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/08 1. Type: Theses/Dissertations Status: Accepted Year Published: 2014 Citation: Dorich, Christopher(2013)Comparison of greenhouse gas emissions on an organic and conventional dairy farm in New Hampshire, Masters Thesis, University of New Hampshire: Durham, New Hampshire. 2. Type: Journal Articles Status: Published Year Published: 2015 Citation: Dorich, C., R.K. Varner, A. Pereira, R. Martineau, K. Soder, A. Brito, (2015) Comparing the sulfur hexafluoride tracer technique and a portable automated open-circuit head chamber system for measurements of enteric methane emissions in mid lactation Holstein cows, J. Dairy Sci., doi:10.3168/jds.2014-8348.

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Organic Systems and Climate Change

Accession No.	0223651
Subfile	CRIS
Project No.	ILLU-875-634
Agency	NIFA ILLU
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51106-21824
Proposal No.	2010-03954
Start Date	01 SEP 2010
Term Date	31 AUG 2014
Grant Amount	$0
Grant Year	2010
Investigator(s)	Wander, M. M.; Ugarte, C.; Zaborski, E.; Phillips, E.
Performing Institution	Natural Resources & Environmental Sciences, UNIVERSITY OF ILLINOIS, 2001 S. Lincoln Ave.

NON-TECHNICAL SUMMARY

This project quantifies the C sequestration potential and, thus, opportunities for participation in carbon trading markets of Midwestern organic grain production systems, in comparisons with their conventional and no-till counterparts, and critically assesses and validates the tools used by NRCS to rank applications for enrollment in the CSP. The results generated from farm surveys for the Conservation Measurement Tool (CMT) and Soil Conditioning Index (SCI) out of RUSLE2 will be compared against direct measures of soil performance in organic, conventional, and no-till management systems. The education and outreach components of this project will deliver research results and address basic questions identified by our group of stakeholders. In addition, a conference on Organic and Carbon Sequestration and the development of training modules for Certified Crop Advisors, Extension educators, and other service providers will set the stage for other activities designed to promote awareness and increase stakeholder knowledge of C sequestration and other conservation goals, C markets, and their benefits.

OBJECTIVES

The long-term goal of this project is to provide individual organic growers with research-based tools and recommendations to guide them in selecting practices to optimize the conservation, greenhouse gas (GHG) mitigation, and soil quality benefits of their production systems (ORG Priority 1); and to provide metrics relevant to organic production systems that allow growers to quantify environmental services, qualify for current cost-share programs or potential carbon credit programs, and predict optimal practices (ORG Priority 2). The specific objectives proposed in support of this long-term goal are as follows: Research Objectives: 1. Evaluate the carbon sequestration potential of organic farming systems in comparison to their no-till and conventional counterparts in a variety of regions within the state of Illinois. 2. Use on-farm research to critically assess and/or validate tools farmers can use to improve management of soil organic matter, soil and water quality, and nutrient use efficiency and to reduce their carbon footprint. 3. Identify and refine tools or protocols that help a diverse array of organic farmers achieve their stewardship goals in a socially and economically viable manner. Education and Extension Objectives: 4. Hold a conference to raise awareness among organic farmers and other conservation-minded growers about the potential for farming practices to contribute to carbon sequestration and other conservation

goals, and about opportunities to benefit from conservation programs and carbon markets; and to develop contacts between farmers and agency/service providers. 5. Provide online educational resources for organic and other conservation-minded growers about farming practices and their relationship to carbon sequestration and other conservation goals, and about supporting programs and markets. 6. Develop a training module and supporting educational materials to train certified crop advisors, Extension educators, and other service providers about the role of organic and other conservation practices in promoting carbon sequestration and other environmental services, and about conservation programs, tools, and markets that can reward farmers for adopting these practices. Furthermore, an outreach effort will be implemented to make this information more available and accessible to farmers, Extension educators, and decision makers wishing to apply and improve organic soil management practices in order to achieve both conservation and production goals. Outreach objectives will be met through delivery of educational materials to raise awareness of C sequestration and other conservation practices by using conference settings, factsheets, webinars, and other web related resources.

APPROACH

Farm fields will be selected that are areas in which the Delta Institute has farmers enrolled in the Illinois Conservation and Climate Initiative, which is a voluntary C trading program, for the adoption of non-tilled management practices. Neighbor farmers working with organic and conventional management practices will be identified and asked to participate in the project. Soil samples from working farms will be taken in the spring before crop establishment. Samples will be used to 1) determine C sequestration, and 2) determine dynamic soil properties that can be linked to the soil and water concerns defined in the Natural Resources Conservation Services\' Conservation Management Tool (CMT). Measures of organic matter and dynamic soil properties will be assessed in multiple soil depths. Samples will be taken in two consecutive years (first two years of the project) to allow us to capture information about field-to-field and yearly variability within farms as fields progress through their rotations. Participating farmers or field managers will be interviewed to gather data about their farming inputs, practices and infrastructure that are needed to run simple computational tools using NRCS tools for different habitats and farms. Surveys will capture data on field location, climatic information, drainage class, topography, tillage use, crop rotations (length, diversity, inclusion of cover crop within the rotation), water conservation, residue, nutrient, salinity, and irrigation. Associated outreach efforts will include organization of a conference on Organic and Carbon Sequestration, and development of internet resources posted through the eOrganic CoP. Materials will highlight research results and practical applications for producers and introduce guidelines for interactive use and interpretation of farm assessment tools and field indicators of soil resource conditions.

PROGRESS

2010/09 TO 2014/08 Target Audience: Our target audience includes farmers, educators, and the general public. We have reached these groups through presentatons at professional meetings, meetings for growers, field days, and through electronic media, webinars and websites. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? We have held interactive sessions at field days and grower conferences, given webinars through eOrganic and the NRCS, and organized a panel discussion at the National Soil and Water Conservation Society\'s annual meeting. The panel discussion \"Beg, Borrow or Steal to Improve Stewardship: Will Segmenting Midwest Row Crop Actors Improve Management?\" considered how technical standards and decision tools might be used to alter lease agreements and federal programs to improve stewardship and be tailored for effective use by different farming segments, consumers, and the public. How have the results been disseminated to communities of interest? Interactive session: Partnerships for Conservation Innovation Field Day, Alison Organic Research and Demonstration Farm, Illinois Organic Growers Association. Roseville IL. August, 2011. Wander, M.M. Benefits of Organic Management. Organic Environmental Benefits: Climate Change & Water Quality Use Session. Invited speaker. Organic Trade Association, All Things Organic, Expo East. Baltimore, MD. September, 2011. Wander, M.M. Organic Agriculture and Soil Conservation. Invited presentation. Illinois Specialty Growers, Agritourism and Organic Conference. Springfield, IL. January, 2011. Wander, M. and C. Ugarte. Soil Quality and Stewardship. Invited presentation. MOSES and the Illinois Organic Growers Association\'s Organic Grain Production, Soil Carbon Monitoring, and Cover Crops Field Day.Malta IL. September, 2012. Ugarte, C., Zaborski, E. and M. M. Wander. Total and Active Soil Carbon Fractions in Row Crop Systems Under Organic and Conventional Management: Assessment for Adequate Sampling. Volunteered presentation. Soil Science Society of America Annual Meeting. Cincinnati OH. October, 2012. Wander, M., Jackson, L., Snapp, S. and Grossman, J. Highlights from E-organic\'s Soils and Climate Change Communities. Soil Science Society of America Annual Meeting.Cincinnati, OH. October, 2012. Andrews, S.A., Ugarte, C. and M.M. Wander. eOrganic Webinar. NRCS Conservation Practices Organic

Management and Soil Health Webinar.http://www.extension.org/pages/67366/. Also on YouTube http://www.youtube.com/watch?v=87poEEwckvM. March, 2013. Wander, M. and C. Ugarte.Methods and Metrics for Soil Conservation and Stewardship; What Works for You? For the Organic Track at the Illinois Specialty Crops, Agritourism and Organic Conference, Springfield, IL. January, 2014. Wander, M. , Ugarte, C. and E. Phillips. Illinois Grain Farmers\' Goals and Soil Stewardship Behaviors. For theNational Soil and Water Conservation Meeting. Chicago, IL. July, 2014. Wander, M., Ugarte, C. and E. Phillips. Beg, Borrow, or Steal to Improve Soil Stewardship: Will Segmenting Midwest Row Crop Actors Improve Management? Panel discussion at the National Soil and Water Conservation Meeting, Chicago, IL. July, 2014. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Farmers, educators, researchers, and policy makers. Changes/Problems: We received a no cost extension so the date should be rolled back one year to be 2014. What opportunities for training and professional development has the project provided? The second part of our study evaluates tools used to predict changes in carbon sequestration, soil quality and the associated benefits resulting from different farming practices and determines barriers to the use of instruments that rank system performance. We are considering practice-based instruments (organic certification, NRCS program tools, and process models) that focus on soil stewardship and carbon sequestration. We have used a mixed method approach that includes focus groups, interviews, and a quantitative survey to apply the theory of planned behavior to identify groups of farmers and issues that influence practice choice and willingness to participate in the program to incentivize carbon sequestration and resource conservation. The qualitative research phase has been completed. First year efforts included farmer focus groups, expert interviews and a design workshop that used clickers to document behavior and attitude change. We used a post-then-pre instrument design for the clicker exercise to allow participants to more accurately assess their baseline behaviors. First year efforts were used to inform qualitative farmer interviews conducted in 2012 and 2013 that are being used to develop scales, refine questions about attitudes, norms, and perceived and actual behavioral control factors. The qualitative summary is being used to design a quantitative survey that will be distributed in this winter. Farm interviews have also been used to gather management history needed to run evaluation tools and models to predict outcomes for individual farms. Preliminary analysis of the CMT shows that the tool ranks the performance of organic farms more highly than conventionally tilled grain farms for all eight macro-concerns. Average CMT scores (conservation points) for organic and conventional farms using conservation tillage both exceed the stewardship thresholds for all eight macro-concerns. Organic systems ranked highest in all cases except for energy. Conventionally-managed farms that use standard tillage practices failed to meet stewardship thresholds for all areas except for plant production. These results will be compared with estimates for carbon sequestration, erosion, and greenhouse gas emissions made using process models that are widely used to rank or inventory stewardship. Where possible, sub-scores for macro-concerns are being compared against measured properties that are dominant contributing factors within the NRCS scoring system. How have the results been disseminated to communities of interest? Extension and/or education activities completed or upcoming: Wander, M.M. Methods and Metrics for Soil Conservation and Stewardship; What Works for You? Interactive session. Partnerships for Conservation Innovation Field Day, Alison Organic Research and Demonstration Farm, Illinois Organic Growers Association. Roseville IL. August 3, 2011. Wander, M.M. Benefits of Organic Management. Organic Environmental Benefits: Climate Change & Water Quality Use Session. Invited speaker. Organic Trade Association, All Things Organic, Expo East. Baltimore, MD. September 2011. Wander, M.M. Organic Agriculture and Soil Conservation. Invited presentation. Illinois Specialty Growers, Agritourism and Organic Conference. Springfield, IL. Jan. 8, 2011. Wander, M. and C. Ugarte. Soil Quality and Stewardship. Invited presentation. MOSES and the Illinois Organic Growers Association's Organic Grain Production, Soil Carbon Monitoring, and Cover Crops Field Day.Malta, IL. September 6, 2012. Ugarte, C., Zaborski, E. and M. M. Wander. Total and Active Soil Carbon Fractions in Row Crop Systems Under Organic and Conventional Management: Assessment for Adequate Sampling. Volunteered presentation. Soil Science Society of America Annual Meeting. Cincinnati, OH. October 22-24th 2012. Wander, M., Jackson, L., Snapp, S. and Grossman, J. Highlights from E-organic\'s Soils and Climate Change Communities. Soil Science Society of America Annual Meeting.Cincinnati, OH. October 22-24th 2012. Andrews, S.A., Ugarte, C. and M.M. Wander. eOrganic Webinar. NRCS Cconservation Practices Organic Management and Soil Health Webinar. http://www.extension.org/pages/67366/. Also on Youtube http://www.youtube.com/watch?v=87poEEwckvM. March 2013. Websites, patents, inventions, or other community resources created: We are now developing a public page for eOrganic's Climate Change and Organic Farming Systems group that will allow all users of the workspace to aggregate related resources for eOrganic users. The group workspace is at http://eorganic.info/group/5461. Once the public page is launched it will reside on the home page in the list of Projects at eOrganic. What do you plan to do during the next reporting period to accomplish the goals? We will present an update to IOGA at the January conference (Illinois Soil Quality Initiative III: Stewardship on Organic, Conventional and Conservation Till Grain Farms) and plan to conduct a workshop at the National Soil and Water

Conservation July 2014 meeting in Chicago as part of a session on 'Informing Conservation through Social Science: Factors Influencing Adoption of Agricultural and Natural Resource Best Management Practices'.

2011/09/01 TO 2012/08/31 OUTPUTS: The 2012 field season began earlier due to the warm dry weather. It was more difficult to identify organic and true no-till farms that had well matched soil types. Due to these challenges we were not able to maintain perfect matching between soybean and corn fields. A total of 21 farm fields were sampled in Spring; 9 of them had produced soybean and 12 had produced corn. We are on track to sample many more fields than initially proposed. On the fields that had produced corn, we established 10ft by 10ft micro-plots with organic soybean provided by Albert Lee. Hand watering was required to rescue crops due to the extreme drought. Poor stand establishment created significant variability and limited our ability to detect differences among systems. Interviews with farmers continued. Instead of meeting through focus groups we visited each farm and conducted one on one interviews after asking them to complete the Conservation Measurement Tool for the fields we are studying. Laboratory analyses continue. Reports summarizing results for 2011 farms and an interpretation guide have been developed and returned. Planning for a future workshop is underway. We had the following presentations: Michelle Wander and Carmen Ugarte presented a project update Soil Quality and Stewardship at the Organic Grain Production, Soil Carbon Monitoring, and Cover Crops Field Day, Organized in partnership with MOSES and IOGA, September, Malta IL. Carmen M. Ugarte, Edmond Zaborski, and Michelle M. Wander. \'Total and Active Soil Carbon Fractions in Row Crop Systems Under Organic and Conventional Management: Assessment for Adequate Sampling\' Soil Science Society of America. October, Cinncinatti, Ohio. Michelle Wander maintains ongoing outreach efforts to organize webinars for eOrganic and series of articles on organic and climate change. For more information consult eorganic.info. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Multiple sets of farms (locations) selected for inclusion in the study include fields that have been under (1) Conventional, (2) Non tillage, and (3) Organic management for at least 5 years. (1) and (2) were corn-soybean based rotations and (3) were 3-5 year rotations that include small grains and cover crops or forages. Soil samples were collected using stratified grid sampling from 5-ha fields from the corn and soybean phases of the rotation in the spring. Samples (24 cores per field in 24 fields) were collected in depth increments of 0-15, 15-30 and 30-60 cm. Biochemical and physical measures have been or are being analyzed. We conducted four focus groups and had participating farmers complete detailed management surveys used for field assessment using the NRCS\'s Conservation Measurement Tool (CMT). To Meet Education and Extension Objectives: 1. We partnered with Western Illinois University and the Illinois Organic Growers Association on \"Innovations in Soil Conservation\" Field Day held on Wednesday, August 3, 2011. Our team added a morning session to the traditional lunch and afternoon tour at the Allison Organic Research and Demonstration Farm. This was an interactive discussion on various aspects of soil conservation, including nutrient management, water quality, and carbon sequestration. Participants included organic and conventional farmers, IEPA, NRCS and SWCDs. 2. We facilitated content development of eOrganic\'s Climate Change and Organic Agriculture and Soils groups including a webinar series: 1. http://www.extension.org/pages/30850/impact-of-organic-grain-farming- methods-on-climate-change-webinar; 2. http://www.extension.org/pages/32626/greenhouse-gas-emissions-associa ted-with-dairy-farming-systems-webinar; 3. http://www.extension.org/pages/30835/greenhouse-gases-and-agriculture :-where-does-organic-farming-fit-webinar 3. We provided staff support for eOrganic\'s administrative core by providing copy editing and review support for articles published to eXtension. PARTICIPANTS: Ryan Anderson of the Delta Institute helped to identify potential participants and provided input on educational content to be shared at the field day. Dick Breckinridge, IEPA, and Brett Roberts, NRCS provided educational content and participated in the Field Day. TARGET AUDIENCES: The research component is participatory in nature. This educational exchange is multi-directional (researchers, educators, farmers and agency personnel). The eOrganic community of practice includes farmers, educators and experts in the organic arena. The eXtension website that eOrganic supports serves educators, farmers, and the public including policy makers and industry. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2014/08 What was accomplished under these goals? Sampling and preliminary analyses of data gathered from 72 farm fields and participating farmers have been completed. The field sampling effort assesses how different soil management practices influence soil function including soil productivity and soil carbon storage

by comparing soils from organically managed farms with soils from conventionally managed sites that have used standard and reduced tillage practices for at least five years. We sampled fields that had been in corn or soybeans the previous year with a truck-mounted soil probe, taking 5.08 cm soil cores to a depth of 60 cm from a 10-acre area within each field. Soil analyses include: standard soil test measures (pH, plant available P and K, base saturation), texture and bulk density, soil organic carbon (SOC), particulate organic matter (POM), soil biological activity using fluorescein diacetate hydrolysis (FDA) and nitrogen mineralization potential (PMN). All analyses are completed and we are finalizing individualized reports for the farmers who participated in the project. The report format modifies the standard soil test to emphasize the functional role of indicators and permit individuals to determine where their values fall in terms of optimums and study norms. We used year one data for power analysis to determine that sampling efforts can be optimized to detect 7% SOC (1.26 Mg SOC ha-1) change with a 90% degree of precision by collecting 16 samples per 10 acre field in a grid sampling design. Power analysis also indicated we needed to sample a greater number of locations than originally proposed to draw robust conclusions about the relative ability of different practices to build SOC and that study power is greater for important dynamic properties (eg: POM, FDA and PMN) that might be used to index stewardship more readily than total SOC. Management histories were used to run evaluation tools and models to predict outcomes for individual farms. The CMT scores ranked Org\>Conv-reduced till\>Conv-full till, with scores for Org systems being twice those computed for the Conv-full till systems. Measured data suggests organic and conservation management are similar in their ability to increase SOC and active organic matter stocks; the CMT tool over estimates benefits of organic management; and the Century Model accurately ranks sequestration potential if it is initialized and run with detailed field management and yield histories. A mixed method approach was used to apply the theory of planned behavior to and explore the attitudes, norms and perceptions of participants in order to identify groups of farmers and issues that influence practice choice and farmers\' willingness to participate in programs to incentivize carbon sequestration and resource conservation. We found business orientation, land access and social connectedness most influence farmers practice choice and propensity to participate in voluntary stewardship efforts. This information can be used to segment producers into groups with distinct information/programmatic needs. Farmer input suggests refining management within segments is unlikely to improve stewardship unless information can somehow reverse trends of farm-size expansion and increasingreliance on crop insurance that promotes resource degradation and discourages conservation. Our results will improve instruments used to assess C sequestration rates and ecosystem services on organic farms and help to identify practices that perform well enough to allow organic farmers to compete for carbon trading and conservation programs. In addition, we are developing indicators that will be useful to individuals, planners, andbusiness entities. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/08 Type: Journal Articles Status: Published Year Published: 2014 Citation: Ugarte, M.C., Kwon, H.-Y., Andrews, S.A. and M.M. Wander. A meta-analysis of soil organic matter response to soil management practices in the continental United States. Journal of Soil and Water Conservation. 69:422-430

2012/09 TO 2013/08 What was accomplished under these goals? We have finished sampling and interviewing participating farmers.The field sampling effort was designed to allow us to measure how different soil management practices influence important soil quality characteristics, including soil productivity and soil carbon storage. This work compares soils in organically-managed farms with soils from conventionally-managed sites that have used standard and reduced tillage practices. We used the USDA list of certified organic farms to identify prospective sites followed by phone interviews to identify farms that had applied organic practices in a consistent manner for over five years. We then used soil maps, plat books and word of mouth to identify nearby conventionally-managed fields with similar soil types.We only sampled fields that had been in corn or soybeans the previous year. A truck-mounted soil probe was used to collect 24 (in 2011) or 16 (in 2012 and 2013) 5.08cm soil cores to a depth of 60 cm from a 10-acre area within the field. Soil analyses include: standard soil test measures (pH, plant available P and K, base saturation), texture and bulk density, soil organic carbon (SOC), particulate organic matter (POM), soil biological activity using fluorescein diacetate hydrolysis (FDA) and nitrogen mineralization potential (PMN).We have been preparing individualized reports for the farmers participating in the project as results come in to allow them to use the data for individual decision making. These reports pilot a more holistic approach to soil testing. We have modified the standard soil test representation to allow them to understand the functional role of indicators and where their values fall in terms of optimums and study norms. We conducted power analysis of inorganic nutrients and organic matter measurements from 2011 samples to determine whether sampling intensity was sufficient to meet our objectives and inform the development of protocols for monitoring sequestration in agricultural soils. Power analysis is the probability that the null hypothesis will be rejected when it is false. Power A depends on the aplha value, the replication and the statistical effect size. This evaluates the probability of finding a difference that does exist. Both ad hoc and post hoc power analysis can be very helpful at different stages of hypothesis testing. Using these methods we determined how many fields we need to sample to detect differences of expected magnitudes and how many soil cores would be required to document changes in soil organic carbon (SOC) that might be expected to occur within an individual

field during a five year period. After the first year of sampling, the power of our statistical analysis for SOC was around 16% which was inadequate to find SOC differences among systems of 1.8 g C kg-1 soil. This was not sufficient to detect significant differences among crop phases (corn and soybean) or cropping systems that are of the magnitude of interest to carbon trading schemes or aggregators who might need to verify changes in C stocks. We did find a significant depth interaction with higher stocks found in the organic systems. Power analysis of 2011 results suggests that study power is greater for important dynamic properties (eg: POM, FDA and PMN) that might be used to index stewardship more readily. Based on these results, we decided to reduce sampling intensity within individual fields from 24 to 16 0-60cm cores. Conclusions about the C sequestration potential of practices could not be drawn from the small number of fields used in our 2011 analysis. Power analysis indicated we needed to sample a greater number of locations than originally proposed to draw robust conclusions about the relative ability of different practices to build SOC in Illinois. Some of the pairs sampled in 2012 and 2013 only consider the tilled organic and conventional treatments because we were unable to find well-matched no-tillage or even reduced-tillage practices consistently. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 Type: Journal Articles Status: Awaiting Publication Year Published: 2014 Citation: Ugarte, M.C., Kwon, H.-Y., Andrews, S.A. and M.M. Wander. A meta-analysis of soil organic matter response to soil management practices in the continental United States. Journal of Soil and Water Conservation. (In Press).

2011/09/01 TO 2012/08/31 We conducted power analysis of inorganic nutrients and organic matter measurements from 2011 samples to determine whether sampling intensity was sufficient to meet our objectives. Power analysis is the probability that the null hypothesis will be rejected when it is false. Power A depends on the aplha value, the replication and the desired statistical effect size. This evaluates the probability of finding a difference that truly exists. Both Ad hoc and post hoc power analysis can be very helpful at different stages of hypothesis testing. Using these methods we determined how many fields we need to sample to detect differences of expected magnitudes and how many soil cores would be required to document changes in soil organic carbon (SOC) of specified magnitudes within an individual field. The power of the study during the first year of the project was unable to find SOC differences among systems of a 1.8 g C kg-1 soil magnitude. The power was not sufficient to detect significant differences among crops (corn and soybean) or among cropping systems. We did find a significant depth interaction. Differences were evident in the particulate organic matter (POM) fraction from surface soils, with concentrations higher in organic and conservation than in conventional cropping systems. Using this method we were able to determine that C sequestration monitoring programs could evaluate changes within individual fields using approximately 14 soil samples in a 10-acre based field under similar soil characteristics. Based on these results, we decided to reduce sampling intensity within individual fields from 24 to 16 0-60cm cores. Direct measurement and tool-based evaluations rank cropping systems\' performance differently with direct measures being less conclusive when applied at the farm scale. Summary of first year CMT surveys was completed and compared against field results and results from meta-analysis on the relative performance of organic, no-tillage and conventional systems estimated from the peer reviewed literature. Conclusions about the efficacy of practices could not be drawn from the small number of fields used in our preliminary analysis; the power of our statistical analysis was around 26%. Analysis suggests we will need to sample a greater number of locations (\>15 sets of fields) to draw conclusions about the relative ability of different practices to build soil organic matter in Illinois. Moreover, a much greater number of farms must be sampled to evaluate the use of CMT as a tool to verify C contracts or estimate provision of other ecosystem services of interest.

2010/09/01 TO 2011/08/31 A poster on the project was presented by C. Ugarte, E. Zaborski, and M. Wander entitled \"The Potential for Carbon Sequestration: The Case of Organic Grain Farming Systems in the Midwestern United States\" at the ASA/SSSA/CSA held in October in San Antonio, Texas.

PUBLICATIONS

2011/09/01 TO 2012/08/31 No publications reported this period

2010/09/01 TO 2011/08/31 No publications reported this period

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Integrating Community College Students & Organic Farmers Throughout Feasibility Studies in Pest Mgmt, & Horticulture Production in So. Tx.

Accession No.	0223710
Subfile	CRIS
Project No.	TEXN-0049
Agency	NIFA TEXN
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51106-21803
Proposal No.	2010-03990
Start Date	01 SEP 2010
Term Date	31 DEC 2014
Grant Amount	$0
Grant Year	2010
Investigator(s)	Villanueva, R. T.; Ribera, L. A.; Storz, B. A.; Villalon, D. K.
Performing Institution	Weslaco - TAMU Agr Res & Ext Center, TEXAS COOPERATIVE EXTENSION, COLLEGE STATION, TEXAS 77843

NON-TECHNICAL SUMMARY

In this proposal we plan to integrate and teach community college students agricultural activities through organic farming production; and second, guide organic transitional farmers in the acquisition of technology for sustainable growth in horticulture practices and pest management in South Texas. Texas AgriLIFe Extension service and South Texas College (STC) in the Rio Grande Valley will be partners in this project. Students of STC will apply and compete for scholarship funds presenting a project in organic farming. A panel composed by STC faculty, invited experts, and local organic growers will judge the projects. We will develop two organic demonstration sites located in San Juan and Weslaco. These sites will be used for student\'s studies and public visits. Also, we will conduct studies in organic farms of local growers; these studies will deal with horticultural practices such as the use of cover crops, and manure applications. We plan to develop an organic pest management program for local growers. The latter will be completed in large organic and conventional farms, there we will compare control strategies of pests, natural enemy abundance, and evaluate costs under these two management programs. Finally, we propose to develop, along with comparison of production practices and crop enterprise budgets, carbon sequestration/emission analysis of different organic production practices. All findings in this proposal will be delivered to growers, students and researchers in print form, on the web, and/or at conferences throughout the three year program.

OBJECTIVES

The main goal of this project will be to teach community college students about organic agricultural farming, and advice large and small organic farmers the production of sustainable farming systems through demonstrations, in situ tests and publication of educational material through the web and print in Spanish and English. We will accomplish this with the following objectives: 1.To promote organic farming development through scholarships programs for STC and student participation in demonstration farming sites. 2.To establish demonstration sites for organic vegetable producers. 3.To evaluate horticultural practices to improve soil fertility and reduce erosion 4.To

evaluate organic arthropod pest management in demonstration sites and large plot farms. 5.To evaluate carbon sequestration and study the feasibility for organic production 6.To deliver all sections included in this project using diverse media and delivery systems

APPROACH

1.- Scholarship funding rules for student awards will be publish every semester during the three-year period of this project. Decisions on the adjudication of scholarships will be made by a panel formed with members of STC faculty, invited experts in organic farming and organic farmers of south Texas. 2.- A research associate will be hired to coordinate activities in demonstration sites. In these sites, awarded students may develop their projects and hourly labor will be hiredto assist in monitoring pest problems, natural enemies and pollinators. 3.- Evaluation of horticultural practices to improve soil fertility and reduce erosion. We will plant cover crops in the two demonstration sites in small plots; and replicated in two other organic sites. In half of the small plots, cover crops will be maintained during the entire year and in other half only during growing season, whereas in the organic grower\'s fields, we will test different cover crops. In the large plots we will have two objectives: i)Evaluation of yield and measuring of nitrogen. Soil analysis will be performed prior to the cover crop but after the last crop. Cover crop will be planted and yields and percent nitrogen will be recorded with the crop plowed into the soil for a green manure crop. ii)Measuring pest impacts and abundance of natural enemies: Here we are going to evaluate the impact of a cover crop in organic vs. conventional in pest and natural enemies abundance. All studies will be completed in a three-year period. 4.- Arthropod pest management studies in organic demonstration sites and comparisons of conventional and organic farming in large plot farms In the demonstration sites, population of pests, natural enemies and native pollinator will be tallied with live counts and yellow sticky traps. In farmers sites, two of each organic and conventional fields will be studied and the most important pests and natural enemies will be tallied every two weeks. Comparisons between the two demonstration sites and the organic farmer sites will be analyzed. 5.- To perform a carbon sequestration feasibility study, a stochastic simulation of a model farm will be used to empirically estimate the net income distributions for alternative production systems. Prices and yield will be stochastic variables in the model starting on the second year of the project. A multivariate empirical distribution of prices and yields will be estimated and used to simulate these variables. A research assistant will be hire to work in activities related in this objective. 6.- Results of all objectives will be delivered with diverse media, including media announcements, newsletters, publication in trade magazines and scientific journals, and a well designed web page for Hispanic growers based on research conducted in the RGV. Also we will publish research information, recommendations and educational opportunities in Spanish and English. All people involved in this proposal will participate in state, national and international conferences disseminating the information collected in this study. An organic pest management guide will be published in Spanish and English.

PROGRESS

2010/09 TO 2014/12 Target Audience: Target audiences: Growers in the Rio Grande Valley in south Texas, these included small to medium size vegetable producers, large citrus farmers and organic sorghum growers. These include mostly Hispanic educationally disadvantaged population and mid size Caucasian farmers. Four Annual conferences were completed from 2011 to 2014. Students in the Rio Grande Valley, in south Texas had learning opportunities thanks to annual competitive awards where they developed short studies in organic agriculture. Students partnered with a Texas A&M AgriLife Extension Faculty to conduct an study with a farmer. Students were able to be trained on data collection in fields and conduct laboratory studies. These studies were delivered in the four annual organic conferences with a wide assistance of the public of diverse ages. Scientific community: several presentations were deliver on science-based studies to the scientific community in the USA, Mexico, Peru and Spain. Also, people were educated through formal or informal educational programs such as filed days, master gardener classes and invitations to different educational activities. The significance of finding for organic agriculture: The studies completed in this grant is a compendium of preliminary findings on pest and beneficial insects in transitional organic farms in the Rio Grande Valley; we found that some mulch types affected directly insect pest populations and others increased yields, identified the leaf cutter ant as main pest defoliating vineyards, identify main insect pollinators, and compared pests, and natural enemies densities of organic and conventional systems. We also found that a three-acre organic vegetable farm can be profitable averaging \$41,318 in net cash income per year. Farmers are utilizing some of the tools provided such as the use of mulch (due to intense heat some mulch types last only one year), T-tape for water efficiency, organic insecticides for pest management decision for control of pests Some of the farmers are expanding their farms, including a mixture of crops and livestock or starting new farms by young farmers as described below: Farmer Markets: in 2009 there was only three in the valley in McAllen, Brownsville, and South Padre Island to this date there are 9 new farmer markets across the RGV: 2 in McAllen, 1 in each Weslaco, Harlingen, Edinburg, Brownsville, San

Juan, Mission and South Padre Island. Yahweh Farm continued with CSA and move into providing land for a CSA\' type community garden, now including animals and projected opening of a farm market. Two former technicians started his new Organic farms, now using tools learned in this program to develop their business. Citrus organic: Thompson Rio Pride in Weslaco -a grower cooperator during the last 3 yrs- had 12 organic transitional acres in 2010, however now in 2014 is transitioning all his acreage into organic farming production (\>200 acres). This company sends grapefruit all over the U.S. and Canada. In 2014, an invasive pest (sugarcane aphid) was eefectively controlled on sorghum using organic insecticides A 1.5 acre is being used and designated as an Organic area in the Texas A&M AgriLife Research and Extension Center in Weslaco Changes/Problems: These studies shown that in the RGV region of Texas organic agriculture can be profitable at all levels: organic established growers can sell their high priced grapefruits at 3 to 4 times higher prices than conventional growers, and help to support underprivileged individuals bringing an income that will benefit the entire family. Students of STC were able to develop knowledge and discipline to carry on systematic data recording. Involving these students in research is a contribution not only in their professional development but also in research conduction where labor and basic knowledge is scarce. Below are some noticeable examples on how this project contributed to the development of these students: Currently, J. Borden, A. Lopez, B. Rich, A. Pecero and C. Ybarra are students of Texas University Pan American. David Garza presented at the national meeting, and finishing his studies at UT San Antonio Antonio Martinez winner of the first organic conference presentation, moved to Texas A&M Kingsville. He had chosen a major in Agriculture Guadalupe Alaniz: accepted to participate as a National Community Aerospace Scholar, once a nursing major, now Biology major since gaining the experience of both Microbiology (in class) Juan Enciso: Co Author of first publication (see above) he concluded his studies in Economy at UT Pan-American in McAllen, and hired to work for Texas A&M AgriLife Extension. Lauren Fann started in this program when she was doing a simultaneous enrollment with STC and was a 12th grade high school student. Now transferred to Texas A&M University and working part time in one of the laboratories of the Department of Entomology, in 2013 won the third place on the Subtropical Plant Soc. Conf. in 2013 (http://subplantsci.org/2013%20Subtropical.html) competing against graduate student. In November 2013 she presented her study in the Annual meeting of the Entomological Society of America. Problem with growing seasons of this region: For this southern region (Rio Grande Valley) of the USA the change in the extension of this grant was necessary, the growing season had already been completed by September and a new season starts in January. This complicates the work of the students because most of the work need to complete while students are attending classes while this not happen in the rest of the nations and even in Texas. Number of student awards: Depending of the load of work these awards need to be reduced from the original eight to a maximum of six. Working with undergraduate students is demanding, and although in this case most of the students completed their presentations and reports there were two that did not complete a report or not conduct a presentation. Carbon sequestration studies were not completed. What opportunities for training and professional development has the project provided? Presentations to community: 37 =2 in 2010, 8 in 2011, 10 in 2012, 9 in 2013, 6 in 2014, 2 in 2015 Presentations were conducted supporting the local extension agents, community and church organizations, local schools, colleges and universities. The audience included growers, kids, educators and students. We used video projectors as well hands-on in orchards, and community gardens Scientific meeting presentations: 21= 1 in 2010, 2 in 2011, 5 in 2012, 9 in 2013 and 4 in 2014 Presentations were conducted in National meetings of the Entomological Society (national and branch meetings), the small farm conference all in the USA, the international congress of acarology in Japan, the sustainable agriculture meeting in Peru, the biological control meeting in Merida, Mexico. Conferences organized: 4 = 2 in 2011 (Science conference at STC and 1st Joint Organic Conference STC-Texas A&M AgriLife Extension in Weslaco), 2nd and 3rd Organic Conferences in 2012 and 2013. 2 in 2011 (Science conference at STC and 1st Joint Organic Conference STC-Texas A&M AgriLife Extension in Weslaco), 2nd and 3rd Organic Conferences in 2012 and 2013. How have the results been disseminated to communities of interest? Presentations Several in situ demonstrations and presentations were conducted byresearchers and students with awardsin collaboration with the extension agents of Willacy, Cameron, Hidalgo, and Starr counties, as well as community organizations and churches as mentioned above Websites, or other community resources created: Economic feasibility of a small acreage organic vegetable farm in South Texas: -http://agecoext.tamu.edu/fileadmin/user upload/Documents/Resources/Publication s/SmallAcreage.pdf -http://southtexas.tamu.edu/programs-and-services/entomology/organic-transition / -http://biologygrants.southtexascollege.edu/org-farm/ What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2011/09 TO 2012/08 OUTPUTS: Students awarded with scholarships on the 1st year developed short studies and made presentations on the 1st Joint Organic Conference in Weslaco on 12/10/11. Dr. Villalon encouraged awardees to participate in meetings such as Subtropical Hort. Sci. Conference (2/29/12). Awardees testimonials are in the www of STC. Mrs. Storz expanded the South Texas Educational Garden, in San Juan, TX to serve as an outdoor learning space overseen by Texas A&M AgriLife Extension and the Hidalgo Co. The site demonstrates best management practices in plant selection, rainwater collection and irrigation techniques,

maintenance for the south Texas sub-tropical, semi-arid environment, and teaches classes to everyone to be good stewards of our land and, to re-cycle materials and compost waste. Organic research is conducted in the site in cooperation with local colleges and universities. Dr. Villanueva conducted studies on: a) Non-woven 100% polypropylene and woven polypropylene mulches used against weed and to observe the effects on arthropod populations. Predatory arthropods in watermelon were similar under the 2 mulches, but pests such as leafminers and whiteflies were greater in the nonwoven than woven mulch. Light reflectance or temperatures might have affected pest abundances. These 2 mulches deteriorated after 1-yr due to the environmental conditions of S. TX; b) Damage of leaf cutter ants (LCA) in Black Spanish grapes was evaluated using organic pesticides in a vineyard. LCA caused great defoliation to the vines in 2011and 2012. Spinosad treated vines had high yield and low damage in 2011 but not in 2012. LCA damage showed that 60% defoliation can cause \>90% reduction on grape yield; c) we tallied pollinators on yellow traps. Six insect families of pollinators were found. There were 1.9 honeybees/trap across all dates, others pollinators were sphecid, chrysid wasps, sweat bees, cuckoo, red, paper, mud dauber, and threadtail wasps; d) Studies comparing organic and conventional control strategies on mites on grapefruits from 2010 to 2012 resulted on effective controls of spider mites and rust mites under the two systems. Dr. Ribera studied the Economic feasibility of small organic vegetable farms. Income relied on 3 streams; a CSA Program, farmers markets, and sales to local restaurant establishments. CSA income was estimated at \$40,500. Sales to farmers markets in Harlingen and McAllen, accounted for sales of \$18,021. Restaurant sales accounted \$5,185/yr. Income was high from Jan-Jun because leafy greens are not produced from Aug-Dec. Actual costs of production were utilized and estimated at \$20,063. Labor cost accounts for about 62.2 % of the total cost of production as 2 part-time workers are needed to help, the owner is assumed to work full time. The farm experienced positive net cash income in 2011 of \$41,318 (total cash receipts minus total cash expenses). Amount does not reflect profit, as principal payments on loans, and employment and income taxes must be paid from this value. This sensitivity analysis demonstrates the importance of the CSA program to organic farm\'s profitability over sales on farm markets and/or restaurants. PARTICIPANTS: From 1/1/11 to 12/31/11 awarded students included David Garza, Antonio Martinez, Guadalupe Alaniz, Juan Enciso, Araceli Lopez, Josiah Borden, Bobby Castillo, Juan Davila and Ruben Navarro From 1/1/12 to 12/31/12. awarded students included David Garza, Juan Enciso, Araceli Lopez, Brian Rich, Sandra Ureste, Lauren Fann, Jonathan Martinez, and Vanessa Candanoza In addition, Dr. Gabriela Esparza was hired to work as post doc and Mr. Frank Garza was hired to supervise tests from 09/01/11 to 07/31/12. M Raulston from the Agric. Economy department and Juan Anciso and Horticulturist participated in the publication. TARGET AUDIENCES: Three presentations were conducted targeting underserved socially disadvantaged mostly Hispanic women, two presentations were made to local growers and local students in Weslaco, and four presentations were made in scientific venues at the regional and national level. Presentation at local level targeting locally disadvantaged women: Insects in Organic Gardens: What we need to know Growing Grower\'s Program Organized by Barbara Storz, 11/30/11, San Juan, TX. Pest Control in Organic Vegetable Gardens. . Growing Grower\'s Program Organized by Barbara Storz, 12/14/11, San Juan, TX. Control of Insects, Mites and Mollusks in Backyard Gardens, Presented to Earth Kind Vegetable Garden, Organized by Barbara Storz, 08/9/12 in San Juan Student and grower talks: Insect problems in the organic production of watermelon, onions, and grapes in the valley. Texas AgriLife, Entomology Science Conference, 11/1/11, College Station, TX. Major Problems in Organic Agriculture in the Rio Grande Valley. 2011. First Joint Organic Meeting STC and Texas AgriLife Extension, 12/10/11, Weslaco, TX. Scientific meeting: Learning organic farming while working with college students and small farmers in South Texas. G. Esparza, L. Ribera, R T. Villanueva. Annual Meeting of the Entomological Society of America Reno, NV, 3/6/12. Insect problems growing organic citrus, onions, watermelon and grapes in the Rio Grande Valley. Villanueva, R. T., G.Esparza-Diaz and L. Ribera. Southeastern/ Southwestern Joint Annual Meeting of the ESA, 3/6/12. Little Rock, AR. Endemic pollinators of a small organic farm in the Rio Grande Valley. Esparza-Diaz , G.; A. Martinez and R. T.Villanueva.. Southeastern/Southwestern Joint Annual Meeting of the ESA, 3/6/12. Little Rock, AR. Can spinosad be used to manage Texas leafcutter ants in organic Black Spanish Grapes 2012. Garza, D., G. Esparza-Diaz, and R. T.Villanueva. Southeastern/Southwestern Joint Annual Meeting of the ESA, 3/6/12. Little Rock, AR. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: The first event conducted under this program was to search for student to be selected as recipients of 8 scholarships (\$3000 each) between Oct. to Nov. 2010. We had near 30 applications, and the selections of students were made by a committee of 4 South Texas College (STC) instructors and 4 Texas Agrilife faculty. Scholarships for the students were divided in three parts (\$1000 each on Feb., May and Aug.). Students were assigned to a faculty to develop a short study. Preliminary results of seven different short studies were presented in Aug. 26, 2011; the final presentation for this first group of STC awardees will be titled \"First joint organic conference in Weslaco: South Texas College-Texas Agrilife Extension\" on Dec. 10, 2011. The titles of the studies and their authors for the Aug. 26 preliminary conference were: (1) Organic farming evaluating vineyards, D. Garza; (2) Native pollinators of a small organic farm in the Rio Grande Valley, A. Martinez; (3) What\'s BUGGIN\' organic crops, A. Lopez; (4) Differences of microbial communities in organic and

conventional soil, G. Alaniz Jr.; (5) Conventional Vs. organic research 2011 presented by J. Borden; (6) Weed control for organic crops, J. Davila; (7) Economic analysis of two small farms in the RGV, J. Enciso and R. Navarro. This event was attended by the faculty and student of STC as well as by farmers and the public in general (approx. 100 people) Full time personnel hired under this program include a Research Associate, Mr. J. Raulston, hired to conduct economic and carbon sequestration analysis for this project; an Extension Assistant, Mr. F. Garza, hired to provide support, make evaluations and to apply pesticide in the organic tests, and a Postdoctoral Extension Associate in Entomology, Dr. G. Esparza-Diaz, hired to design, conduct tests, data analysis, and support students. All working 100 percent of their times in this project. Results from the studies conducted by Drs. R. Villanueva, G. Esparza-Diaz, and L. Ribera had been presented in annual meeting of the Entomological Society of America, and the Southern Agricultural Economics Association Annual Meeting, respectively; as well as at the Departmental Seminar of Entomology of the Texas A&M U. in College Station. Also, in cooperation with Mrs. B. Storz, all PI presented their findings at the Master Gardeners programs in Hidalgo and Cameron Co. meetings, the Growing Grower\'s Program and the Vegetable Gardening Class Organized by Barbara Storz, July 28, 2011 in McAllen, the TOTAP Coop. of Cameron Co., Weslaco elementary schools and in the \"Kids appreciation day\" at the Gladys Porter Zoo of Brownsville. People that attended these events were small local farmers, backyard gardeners and people interested in transitioning organic production and children interested to learn about pollinators. The dissemination of this information was done through local newspaper notes, in the official web sites of STC and Texas Agrilife and gardening sites (i.e. Grant helps grow a fresh crop of organic vegetable farmers: http://www.texasgardener.com/Newsletters/101117/). PARTICIPANTS: Raul Villanueva (PI) and coordinator of this program participated in two national presentations dealing with studies from this project (Comparison of the foliar acarine in grapefruit under conventional and organic pest management programs in Texas-2010 in San Diego CA; and Learning organic farming while working with college students and small farmers in South Texas-2011 in Reno, NV). Luis Ribera (Co-Pi) working in the economic analysis of small to medium size organic farms as well as carbon footprint analysis. B. Storz (Co-PI) organizer of the Growing Grower\'s and the Organic Vegetable Gardening Class. Debbie Villalon, coordinator of the activities of STC students, organizer of the selection of students awarded with scholarships and prepared the preliminary report conference on short studies conducted by STC awardees. Student awarded with scholarships are David Garza, Anthony Martinez, Araceli Lopez, Guadalupe. Alaniz Jr., Josiah Borden, Juan Davila, Juan. Enciso, and Ruben Navarro. Full time personnel hired to work in this program: J. Raulston, hired to conduct economic and carbon sequestration analysis for this project; Mr. F. Garza, hired to provide support, make evaluations and to apply pesticide in the organic tests, and Dr. G. Esparza-Diaz, a Postdoctoral Extension Associate in Entomology. In addition, Texas Agrilife Research faculty, STC instructors, and ARS-USDA personnel are collaborating providing support to students awarded with scholarships. TARGET AUDIENCES: During the Aug 26 report the majority of the audience was STC students, and faculty. However, in our meeting on Dec. 10, 2011 the audience will be diverse and include many small to medium size growers. In addition, all growers that were attending presentations by Dr. L. Ribera, R. Villanueva and B. Storz will be recruited due to effect that local studies are scarce and this will be the first event with studies conducted in organic production in the Rio Grande Valley. PROJECT MODIFICATIONS: Recruiting qualified personnel for the full time positions offered was difficult; this event delayed the initiation of parts of the program (i.e. Mr. F. Garza started on Jan. 2011 and Dr. Esparza-Diaz started in June 2011). Also, to accommodate STC students, their projects will run from January to December of each of the three-yr program, hopefully we will have an extension to complete this project until December 2013 A major problem we had was providing the funds to the students; the first year program we gave the funds in advance (January, April and August), the next two years the funds will be awarded by the end April, August and December.

IMPACT

2010/09 TO 2014/12 What was accomplished under these goals? Brief overview In 2010 south Texas growersdid not have any information on organic production. Several studies were developed in manycrops with funds provided by this grant.These studies described below can be the foundation for the future growth of this sector to provide additional resources to low income families and development of the organic production systems from medium to large growers. Fourteen (93.3%) of the fifteen students selected for this program were able to finish their program at South Texas College or switched to a four year university programs. Students were able to complete a small project, some of them lead to a more in depth studies (PDF). Currently there are 9 Famer markets in the Rio Grande Valley since the original three in 2010. Three small acreage growers that worked in this project are showcased as exemplary cases of success (Yahweh\'s All Natural Farm Garden in Harlingen, Terra Preta in Edinburg, and Monte Alto Vineyard near Edcouch). Completed from 2010 to 2014: Combined effects of different pest programs and mulch types in organic tomato, watermelon and bell peppers: These crops

were subjected to organic pesticide programs and grown using from 3 to 6 types of mulch from 2011 to 2013: nonwoven polypropylenes (silver reflective, white, and black color), black woven, and cover crop (beans) and hay (Bermuda grass).During 2011 and 2012 a severe drought was observed and populations of whiteflies, aphis or caterpillars did not reach high levels. In most cases the treatments with pyrethrin and azadirachtin controlled whiteflies or aphids in this study. However, the low numbers of caterpillars did not provide an opportunity to evaluate the efficiency of Bt, Beauveria bassiana or spinosad. Mulches can provide a microclimate for some pest species that alter pest populations. Whiteflies in watermelon were more abundant in black non-woven mulch compared with woven mulch in 2011 and 2012. In watermelon grown in hay and pyrethrin plus B. Bassiana rotated with spinosad had the lowest whitefly population and highest marketable fruit. In tomato, silver reflective mulch had less whitefly and aphid population however; black plastic mulch had the highest yield. Field and laboratory assays on Phthia picta and Murgantia histrionica using organic insecticides: P. picta was evaluated on tomato in the field, and tomato fruit in the laboratory; while M. histrionica was tested on kale in the field, and cabbage leaves in the laboratory. Mortalities for both pests were estimated in laboratory experiments every 12 h for 72 h. Azadirachtin, B. thuringiensis, Beauveria bassiana, spinosad, and pyrethrin were the insecticides utilized in these studies. Laboratory results for P. picta shown that azadirachtin produced mean mortalities of 100% with 4 g a.i./L at 24 h and 6 g a.i./L at 12 h. Similarly, mortalities of 100% were obtained with spinosad at 6 g a.i./L. Field studies shown that spinosad (6 g a.i./L) caused significantly highest mortalities of P. picta (60%) after 48 h, and azadirachtin (4 g a.i./L) mortality reached only 10%. In laboratory tests, M. histrionica caused 100% mortalities at 24 h with 6 g a.i./L of spinosad and 5 g a.i./L of pyrethrin. In the field, spinosad and azadirachtin had the lowest population increases of M. histrionica compared with pyrethrin and the untreated control. The latter results were affected by initial non- uniform population on each treatment and were inconsistent with the laboratory test. Importance of planting time on the incidence of yellow leaf curl virus in organic tomatoes: In this study we found that virosis incidence was decreased delaying the transplanting time on tomatoes from 17 September to 5 October. As a consequence those tomatoes planted early (17 and 26 September) were the most infected, these plants had very low yields and some produced no fruit at all. Those planted on 5 October had 50% more yield than those planted early and the rate of infection was low. Economic feasibility of small organic vegetable farms: The study examines the 2011 revenue stream on this three-acre produce operation that relies on three income streams: a Community Supported Agriculture (CSA) program, farmers markets, and sales to local restaurant establishments. We found that when both CSA members and farmers markets/restaurant sales present no reduction, the net cash income is \$41,318. However, if there are no CSA members, meaning the only source of revenue is the farmers markets and restaurant sales, the net cash income is only \$820. Conversely, if the only source of revenue were the CSA, then the net cash income would be \$18,113, thus demonstrating the importance of the CSA to the farm\'s profitability. For more detailed information check the following URL: http://agecoext.tamu.edu/fileadmin/user upload/Documents/Resources/Publications /SmallAcreage.pdf Control of the potato psyllid, incidence of Zebra Chip Disease (ZCD) and effect of silver mulch in organic potatoes:ZCD is caused by Candidatus Liberibacter solanacearum (CaLsol) and transmitted by the potato psyllid Bactericera cockerelli. This is a yearly problem in the Rio Grande Valley, S.Texas. In this study none of the organic insecticides (azadirachtin, pyrethrin or spinosad) controlled B. cockerelli or reduced percentages of ZCD symptoms in tubers in 2013 and 2014. However, pyrethrin and azadirachtin controlled effectively B. tabaci in 2013. Populations of both pests in 2014 were very low to make a conclusive evaluation of the insecticides. In all the studies the percentages of tuber showing ZCD symptoms were \>70%. Yields on silver plastic mulch were significantly different than bare ground planted potatoes; however percentages of ZCD ranged from 80% to 89% in silver plastic mulch and \>99% in bare ground planting. Control of the sugarcane aphid(SCA)in sorghum using organic insecticides: SCA (Melanaphis sacchari) a \'new\' invasive pest has been affecting sorghum fields in the U.S since mid-2013. Nowadays, the SCA is considered the most devastating pest of sorghum; it was invaded 11 states in the USA and 8 in Mexico. In this study we worked with HillTop Farm to control SCA using and evaluated the costs expended to control this pest. Applications of a blend of 4 oz/A of each Karanja oil and Neem oil (Ahimsa Organics®) and 8oz/A BioRepel Garlic (JH Biotech. Inc.) were conducted on three occasions and wew effective controlingSCA however, the costs incurred to control SCA were \$44.55 compared to \$22.38, and \$16.25, for conventional irrigated, anddryland, repectively. Phytoseiids as potential natural enemies of the potato psyllid in organic potato production in south Texas: To evaluate the organic control of the potato psyllid B. cockerelli and the silverleaf whitefly B. tabaci, a 2-y study was conducted in south Texas in 2013 and 2014. We found that azadirachtin, pyrethrin, or spinosad did not provide an adequate control of B. cockerelli in 2013. However, azadirachtin and pyrethrin reduced significantly B. tabaci nymphs and phytoseiids compared with the untreated control and spinosad treatment. The highest numbers of phytoseiids and lowest numbers of potato psyllids in the control plots in 2013 demonstrated a potential predatory-prey relationship of these organisms. The phytoseiids Amblyseius largoensis, Typhlodromips near tennesseensis, and Typhlodromus near peregrinus were identified in this study. Here, we reported for first time the phytoseiid Amblyseius largoensis as predator of B. cockerelli eggs and nymphs. Yields were not different among treatments in 2013 and 2014. However, the high numbers of B. cockerelli in 2013 affected yields that year. Tuber sizes were small, consequently yields were

reduced between 1/5 to 1/3 in 2013 compared with yields in 2014. The impact of the predacious phytoseiids needs further evaluations, as well as their potential for mass rearing and release to be used in organic production systems. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/12 1. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: DEPREDACI?N DEL PS?LIDO DE LA PAPA POR FITOSEIDOS EN PAPA ORG?NICA EN LA REGI?N SUBTROPICAL DE TEXAS 2. Type: Other Status: Under Review Year Published: 2015 Citation: Short Organic Agriculture Reports: Integrating community college students and organic farmers throughout feasibility studies in pest management and horticulture production in South Texas 3. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: Phytoseiids as potential natural enemies of the potato psyllid in organic potato production in south Texas

2011/09 TO 2012/08 Transition organic farmers are starting to utilize preliminary results provided in this study such as the use of mulch, drip and t-tape for water efficacy use, organic pesticides for control of pests, expanding their farms, and the establishment of new farms by young farmers. In addition, farmer markets had increased from only one in 2009 in the valley in Brownsville, to about 8 farmer markets across the RGV: McAllen (2), Weslaco, Harlingen, Edinburg, Brownsville, San Juan, and Mission (one on each city). These number will increase soon as organic farms in Rio Grande City (upper Rio Grande Valley) starting to plant organically. The Yahweh\'s Farm and Garden -closely related with these studies- had switched its attention toward CSA members instead of farmer markets due to our study on the economic feasibility of organic farmers in the RGV described above. Also the far has been expanded move into providing land for a CSA\'type community garden, now including goats and chicken; and project to open of a community farm market in 2013. The Thompson citrus orchard (a \>50 year old conventional farm) that initiated with 12-acres of organic production has moved toward expanding its orchard into organic farming production triplicating the initial acreage. Two former field assistants (\<30 yr-old) that worked under Dr. Villanueva\'s supervision started to farm organically and use tools developed in program such as t-tape for irrigation, mulch and a pest management program. Regarding the results, these studies represent a compendium of preliminary findings on pest management in transitional organic farms in the Rio Grande Valley. Local growers are adopting mulch and irrigation techniques that affect IPM and best management practices. We showed that a three-acre organic vegetable farm can be profitable averaging \$41,318 in net cash income per year. Students of STC granted scholarships were able to develop knowledge and discipline to carry on systematic data recording. Involving these students in research is a contribution not only in their professional development but also in research conduction where labor and basic knowledge is scarce. Some noticeable examples on how this project contributed to the development of these students are: (1) David Garza presented his research titled \"Can spinosad be used to manage Texas leafcutter ants in organic Black Spanish Grapes at Joint Meeting of the Southeastern and Southwestern Branches of the Entomological Society of America in 2012. Now he is studying Geology at UT San Antonio. (2) Antonio Martinez winner of the 1st organic conference presentation, moved to Texas A&M Kingsville. After this scholarship he decided for a major in Agriculture. (3) Guadalupe Alaniz: recently accepted to participate as a National Community Aerospace Scholar, once a nursing major, now Biology major since gaining the experience of both Microbiology (in class) (4) Juan Enciso: Co Author of first publication an currently studying Economy and (5) Araceli Lopez Biology- Premed at UT and (6) Josiah Borden Biology, the 3 latter students at UT-Pan-American in McAllen. **PUBLICATIONS (not previously reported):** 2011/09 TO 2012/08 Ribera, L.A., M. Raulston, R. T. Villanueva, J. Enciso-Siller, B. Storz, and J. Anciso Economic feasibility of a small acreage organic vegetable farm in south Texas. Agricultural and Food Policy Center. Texas A&M University. April 2012. Texas AgriLife Research Texas AgriLife Extension Service.

2010/09/01 TO 2011/08/31 The participating college students were able to develop knowledge and discipline to carry on systematic data recording. Involving college students in this program throughout this organic transition project was and is an ongoing contribution not only in their professional development but also in research conduction where labor and basic knowledge is scarce. Students are 85 to 100% satisfied in their programs and what they are learning. The South Texas College faculty that attended the student\'s preliminary report was 85 to 95% percent satisfied on the presentations conducted by the eight students. Participating growers in this program starting to learn about the most damaging pests; for example some of the grower cooperators did not know that thrips and broad mites were the arthropods causing damages to their onions and pepper plants, respectively. Between 72 to 87% of the participants on the organic programs conducted by Dr. Villanueva requested additional presentations; and an average of 78% will recommend to partners and friends to attend his program if they are interested in organic agriculture. Close to 90% of growers require more local research for organic pest management.

PUBLICATIONS

2010/09/01 TO 2011/08/31 No publications reported this period

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Effect of Cover Crops, Soil Amendments and Reduced Tillage on Carbon Sequestration and Soil Health in a Long-term Organic Vegetable System

Accession No.	0223698
Subfile	CRIS
Project No.	IOW05278
Agency	NIFA IOW
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51106-21857
Proposal No.	2010-03956
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Delate, K.; Cambardella, C.; Chase, C.
Performing Institution	Horticulture, IOWA STATE UNIVERSITY, 2229 Lincoln Way

NON-TECHNICAL SUMMARY

The relationship of organic practices with soil properties, crop performance, and resistance to pests has been identified as one of the most important research needs by organic farmers. This multi-disciplinary, multi-state project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. The long-term goal of the proposed project is to provide organic producers with science-based information they can use to make decisions affecting the sustainability of their operations. This multi-region study will be conducted across two contrasting soil types (low vs. high fertility) and climatic conditions (sub-tropical vs. temperate) to yield widely applicable results. On-farm trials will be conducted with cooperating farmers to strengthen the on-station research and contribute to more effective outreach. Results from this project will be disseminated to a broad audience involving organic producers, researchers, extension agents, policy makers, and students, through a variety of methods including field days, conference and classroom presentations, focus groups, publications, and e-Organics. Potential economic, social and environmental benefits will include an accurate assessment of the effect of compost, cover crops, and reduced tillage, on soil indicators related to soil and water quality, vegetable crop yields, pest status, quality attributes of vegetables, and economic performance. Annual C budgets for each phase of the 3-yr rotation will be used to calculate C budgets for entire rotation, along with a quantification of changes in soil profile C storage and in C distribution within the soil profile. Surface samples will be used to evaluate soil biological, chemical, and physical properties related to soil quality and mathematical relationships will be developed between individual soil quality indicator variables or the integrative index and environmental (i.e., leached NO3-N concentrations and CO2 flux) and productivity (i.e., vegetable yield) endpoints. Stakeholder engagement has been key throughout proposal development, as organic vegetable growers in each state are considered peers with researchers. An advisory panel will be established to provide suggestions and feedback throughout the project, ensuring successful generation of applicable outcomes that place direct benefits in the organic agriculture community.

OBJECTIVES

In this project, we will be addressing the goal of investigating the environmental services provided by organic farming systems that support soil conservation and contribute to climate change mitigation. The Objectives to achieve project goals are: 1. Encourage organic transition by developing and establishing organic vegetable cropping systems that maximize soil quality, foster carbon sequestration, and minimize nutrient loss through cover crops, composting, and reduced tillage; 2. Develop recommendations for methods to enhance ecosystem services and improve soil quality on organic vegetable farms based on results derived from horticultural, soil, gas flux, and soil water data in experimental sites a. Develop annual and full-rotation carbon (C) budgets from sites b. Develop relationships between individual/integrative indicators of soil quality and environmental/productivity endpoints; 3. Determine how product quality and shelf life are affected by different management practices in organic systems and identify relationships among soil properties, crop health, and postharvest quality; 4. Increase economic returns for organic vegetable growers by reducing costs of production in field operations and labor, decreasing dependence on external sources of applied fertility, lowering energy costs, and obtaining carbon/emission credits; and 5. Develop and offer educational programs on organic vegetable production and postharvest handling for farmers, students, and agricultural professionals to facilitate the transition to organic production.

APPROACH

Research will begin in Fall 2010 on University Experiment Station sites in Iowa and Florida, and on grower-cooperator fields in each state. For each on-station trial, the design will be a split-split-split plot in time. Crop varieties and soil fertility treatments are based on grower recommendations. The main unit treatments will be two crop sequences in rotation, with tillage and soil amendments as sub-treatments. Crop sequence 1 will consist of spring tomato − fall lettuce; followed by spring yellow squash − fall broccoli; and spring onions - fall beans. Crop sequence 2 will consist of spring onions - fall beans; followed by spring tomato − fall lettuce; and spring yellow squash − fall broccoli. The two, 3-year rotations will include 6 cash crops. The sub-plot treatments will be tillage: (1) till with plastic mulch (2) till without plastic mulch and (3) organic no-till. Sub-sub plots will be organic fertility treatments: (1) composted animal manure alone (no cover crops) and (2) composted animal manure + cover crops. Hairy vetch and rye will be grown as fall cover crops in Iowa while only rye will be planted in FL. In summary, the treatment structure is a 2 x 3 x 2 where the factors are crop sequence, tillage system, and fertility amendment. Treatments will be replicated four times for a total of 48 plots. Hairy vetch and rye will be planted at a rate of 25 lb hairy vetch + 90 lb rye/acre in Fall 2010. In FL, rye will be planted at a rate of 115 lb/acre. Cover crops will be terminated at the appropriate phonological stage in spring 2011 at all locations with the roller/crimper. Cover crop management in the following years may be modified based on the previous year\'s results. Tomato, broccoli, lettuce, and onions will be planted using transplants, while yellow squash and beans will be direct seeded. The same varieties will be used across locations; organic seeds will be used for all varieties in the organic plots if commercially available. Composted poultry manure will be applied prior to vegetable planting at rates based on N content and availability from the organic amendments, soil test results, and crop needs. Compost will also be side-dressed at the time of vegetable planting in the cover crops treatments. Application rates will be determined based on the above calculations plus estimates of N availability from cover crop decomposition. Total (aboveground + belowground) vegetable and cover crop plant biomass C inputs, vegetable C, compost C, and annual net CO2 flux will be used to construct annual C budgets. Annual C budgets for each phase of the 3-yr rotation will be used to calculate C budgets for entire rotation. Rotation C budgets developed by estimating plant and compost inputs and CO2 losses will be compared to measured changes in soil profile C content. Carbon budgets, gas flux estimates, and nitrate-N leaching below the rooting zone will be conducted at the ISU on-station site only, due to the Iowa location of equipment needed for this component. Aboveground and belowground vegetable plant biomass C inputs will be measured for each crop every year at harvest.

PROGRESS

2010/09 TO 2015/08 Target Audience:Target audiences include organic farmers and conventional farmers interested in organic practices or methods to improve organic vegetable production and soil qulaity in organic systems. Additional target audiences include ag professionals such as USDA NRCS and Extension. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?There were several training and professional development activities associated with this project, including field days, workshops, conference presentations and presentations at professional society annual meetings. Extension specialists and farmer-educators were recruited for these technology transfer events, and their expertise blended with project results to increase impact for a wider audience. Over the course of the

project, numerous educational programs have been offered, including 10 Publications and 10 Presentations at Conferences or Workshops. Research findings also have been integrated into course lectures in Iowa State University\'s Organic Agriculture: Theory and Practice class (AGRON/HORT/SUSTAG 484/584), offered in 2012 and 2014, and in the core courses in the Organic Crop Production specialization within the Horticultural Sciences major at the University of Florida, including HOS3281C - Principles of Organic and Sustainable Crop Production (Fall 2012-2014) and HO4283C - Advanced Organic and Sustainable Crop Production (Spring 2013-2015). All information from this project was uploaded to the ISU Organic Ag website: http://extension.agron.iastate.edu/organicag/. How have the results been disseminated to communities of interest?Results from this project were disseminated to an audience of 1,689 participants through 4 field days, 10 publications and 10 conferences/workshop presentations. All produce produced in the Iowa experiment was used by UI Dining Services for over 1,200 participants at the Iowa Organic Conference each November of the project, where attendees received information on the project. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2013/09 TO 2014/08 Target Audience: Target audiences include organic farmers and conventional farmers interested in organic practices or methods to reduce nitrate leaching and runoff in agriculture. Additional target audiences include ag professionals such as USDA NRCS and Extension. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? There were several training and professional development activities associated with this project, including field days, workshops, conference presentations and presentations at professional society annual meetings. Extension specialists and farmer-educators were recruited for these technology transfer events, and their expertise blended with project results to increase impact for a wider audience. How have the results been disseminated to communities of interest? Results from this project were disseminated to an audience of 328 participants through a field day, and three conference presentations. All produce produced in the experiment was used by UI Dining Services for 325 participants at the Iowa Organic Conference at University of Iowa, held on November 16-17, 2014. What do you plan to do during the next reporting period to accomplish the goals? We intend to conduct a fifth field season in Iowa to allow for additional lysimeter, soil quality and yield data in order to publish two years each of data related to organic sweet corn, pepper and tomato production. We hope to build on our strengths and address the weaknesses uncovered through this research, including the need to apply organic-compliant treatments for timely corn earworm management.

2012/09/01 TO 2013/08/31 Target Audience: Target audiences include organic farmers and conventional farmers interested in organic practices or methods to reduce nitrate leaching and runoff in agriculture. Additional target audiences include ag professionals such as USDA NRCS and Extension. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? There were several training and professional development activities associated with this project, including field days, workshops, conference presentations and presentations at professional society annual meetings. Extension specialists and farmer-educators were recruited for these technology transfer events, and their expertise blended with project results to increase impact for a wider audience. How have the results been disseminated to communities of interest? Results from this project were disseminated to an audience of 268 participants through a field day and four conference presentations in Iowa. All produce produced in the experiment was used by UI Dining Services for the Iowa Organic Conference at University of Iowa, held on November 17-18, 2013. In Florida, results from the project were delivered in four classroom/conference presentations to an audience of 120 producers, students and ag professionals. What do you plan to do during the next reporting period to accomplish the goals? We intend to conduct a fourth field season in Iowa to allow for additional lysimeter, soil quality and yield data in order to publish two years of data related to organic sweet corn, pepper and tomato production. We hope to build on our strengths and address the weaknesses uncovered through this research, including the need to apply irrigation on a timely basis during drought months.

2011/09/01 TO 2012/08/31 OUTPUTS: This multi-disciplinary, multi-state project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. In 2012, experiments were continued in two states (Iowa and Florida) across two contrasting soil types (low vs. high fertility) and climatic conditions (sub-tropical vs. temperate) using vegetable rotations appropriate for the region. Two long-term rotation sequences were established at each site. Six cropping system treatments with different management practices were examined at each site: four treatments using cover crops (CC) and two without CC. Of the four CC treatments, two were treated as organic no-till (cover crop rolled) and two were tilled prior to vegetable crop planting/transplanting. Compost and mulch were applied to a sub-set of these treatments to test the effect of these potential soil amendments. In 2012, peppers and sweet corn were grown in Iowa, and squash and zucchini

in Florida. Using lysimeter measurements, leached nitrate-N concentrations were determined throughout the growing season in Iowa and compared with vegetable yield and quality. In Iowa, organic no-tillage crops performed better in 2012 than in 2011, with no-tillage peppers averaging 5,532 lb/acre compared to 8,012 lb/acre in tilled yields. Mulch provided an advantage to pepper yields, with mulched pepper plots averaging 9,385 lb/acre, while non-mulched averaged 6,640 lb/acre. No-tillage sweet corn failed to compete with mulched and tilled yields, averaging 2,472 lb/acre. Tilled and mulched yields were excellent, with tilled sweet corn plots producing 4,545 and mulched yielding 4,423 lb/acre. While the tilled crops were more productive, the mulched and no till peppers had higher quality fruit. In Florida, the organic no-till system performed better than in Iowa, but any novel system will be difficult to compete with the performance of crops grown with plastic mulch, due to intense weed pressure under sub-tropical conditions. Plastic mulch treatments resulted in the highest tomato yields in 2011, but in 2012, organic no-till summer squash yields were not significantly different from mulched plots, averaging 5,689 lb/acre over all systems. Zucchini yields were equivalent in no-till (3,161 lb/acre) and mulched plots (5,821 lb/acre). In both years, cover crops did not significantly increase yields, but some weed management was observed. Populations of grass and annual broadleaf weeds did not differ among treatments, but higher populations of perennial broadleaf weeds were observed in treatments without plastic mulch. Use of plastic mulch in tilled plots and the no-till treatment reduced the nutsedge weed population, demonstrating a benefit of organic no-till. Results from this project were disseminated to an audience of 701 participants through two field days, four conference presentations and three classroom presentations in Iowa. In Florida, results from the project were delivered in one workshop and four classroom/conference presentations to an audience of 116 producers, students and ag professionals. PARTICIPANTS: USDA ARS National Lab for Ag and the Environment; Iowa State University Departments of Agronomy, Horticulture, Plant Pathology, and Food Science; organic farmers. TARGET AUDIENCES: Target audiences include organic farmers and conventional farmers interested in organic practices or methods to reduce nitrate leaching and runoff in agriculture. Additional target audiences include ag professionals such as USDA NRCS and Extension. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: This multi-disciplinary, multi-state project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. The long-term goal is to provide organic producers with decision-making tools to enhance environmental services derived from mulches, compost, cover crops, and reduced tillage in organic vegetable systems. In 2011, experiments were established in two states (Iowa and Florida) across two contrasting soil types (low vs. high fertility) and climatic conditions (sub-tropical vs. temperate) using vegetable rotations appropriate for the region (tomatoes and onions in Iowa; squash and tomatoes in Florida). Using lysimeter measurements, leached NO3-N concentrations were determined throughout the growing season in Iowa and compared with vegetable yield and quality. In Iowa, organic no-tillage yields (tomatoes: 317 kg/ha; onions: 281 kg/ha) failed to compete with mulched and tilled tomato and onion yields. Tilled and mulched yields were excellent, with tilled onion plots producing 2,215 kg/ha, and mulched onions yielding 2,266 kg/ha. Cover crops and compost offered no advantage in terms of increasing onion production. Tilled tomato plots averaged 16,831 kg/ha, while mulched tomatoes averaged 12,170 kg/ha, compared to 10,905 kg/ha without mulch. While the tilled tomatoes and onions were more productive, the mulched and no-till vegetables had higher quality fruit, due to the straw or mulch barrier affording greater protection from soil particles. Several factors impacted no-tillage production: delay in planting due to wet spring soil conditions and inability to use the mechanical transplanter because of transplants that were too large for the machine. Hand-transplanting suffered from inadequate preparation of planting area. Additionally, re-growth of the hairy vetch/rye cover crop and weeds in no-till plots impacted production. In Florida, plastic mulch treatments resulted in the highest tomato and squash yields, while cover crops did not significantly increase yields. Winter cover crops in Florida did not provide expected biomass and nutrient quantities, possibly due to slow establishment. As a result of colder weather impacting biomass production, cereal rye mulch was added to no-till plots to simulate a mulch cover in lieu of actual cover crops. No-till vegetable squash and tomato yields were similar to tilled plots without mulches, and weed populations were reduced compared to tilled plots. Overall, root-knot nematode galling was lowest in plots without cover crops. On-farm trials were conducted with cooperating farmers to strengthen the on-station research and contribute to more effective outreach. In Iowa, cover crops in on-farm no-till plots suffered from winter-kill and tomato yields were greater in tilled plots. In Florida, the on-farm trial tested the influence of summer cover crops (sorghum-sudangrass and sunnhemp) on yield of fall vegetables. PARTICIPANTS: Iowa State University and University of Florida Departments of Agronomy, Horticulture, Plant Pathology, and Food Science. TARGET AUDIENCES: Target audiences include organic farmers and conventional farmers interested in organic practices or methods to reduce nitrate leaching and run-off in agriculture. Additional target audiences include ag professionals such as USDA-NRCS and Extension. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? This multi-disciplinary, multi-state project demonstrated that organic vegetable farming practices could be improved through the use of cover crops, compost and mulch to optimize pest management, crop quality, and profitability, while enhancing soil quality. Organic no-till production is still in its infancy, so additional research is needed to provide recommendations for the exact timing for cover crop planting, termination and vegetable crop planting. In Florida\'s sandy soils, organic no-till holds the most promise because of the potential for early cover crop planting, continuous cover crop growth over the year, and earlier termination dates. Broadleaf vegetable crops, such as zucchini, squash, and pac choi also performed better under no-till production in Florida than finer-leafed crops, such as tomato and pepper, in Iowa. Mulch did not improve organic sweet corn production, while mulched zucchini, squash, tomato and pepper yields and overall appearance were greater in mulched vs. non-mulched plots. The response from cover crops was mixed: overall yield benefits were not as apparent as soil quality improvements at both sites. Overall, soil quality data showed enhanced storage of soil organic C, total N, and biologically active soil C and N when cover crops were planted; improved soil structure under reduced tillage; and more soil organic C, total N, biologically active soil N, and higher plant nutrient concentrations with composted animal manure. Lysimeter data showed that the concentration of leached N was consistently lower under vegetables grown with a cover crop and in no-till. Economic analysis showed increased costs with cover crop seed and planting, but, with green payments, these costs could be compensated by increased carbon storage in these fields. Thus, organic farmers are encouraged to use a combination of cover crops and compost to enhance production and environmental quality. Over 1,689 farmers and ag professionals received this information through workshops, Field Days and conferences. Because cover crops in rotation have always been a part of certified organic regulations, in surveys from these events, 100% of farmers stated they are interested in soil conservation and plant cover crops, with 10% having tried organic no-till on their farms. The treatments we studied included three tillage comparisons: (1) tilled followed by straw mulch (2) tilled without straw mulch and (3) organic no-till; and two organic fertility treatments (1) composted animal manure alone and (2) composted animal manure + cover crops. From 2011 to 2014, experiments were conducted in Iowa and Florida across two contrasting soil types and climatic conditions using vegetable rotations appropriate for the region. Iowa had an additional season in 2015. Two long-term rotation sequences were established at each site. Compost and mulch were applied to a sub-set of these treatments. The cover crop in Iowa was hairy vetch/rye, while in Florida sunnhemp was used. Florida also substituted plastic mulch for straw mulch, as is the convention on organic farms in Florida. A fifth season was established in Iowa, by planting a cover crop of hairy vetch and rye (hairy vetch at 25 lb/acre and rye at 1.5 bu/acre) in 15 x 20 ft. plots on October 19, 2014, at the ISU Neely-Kinyon Farm, Greenfield, Iowa. Cover crop emergence and establishment in Spring 2015 were good, but there were many gaps in the cover crop stand, possibly due to winter-kill or poor growth in that particular area. On June 2, 2015, cover crops were either: 1) tilled under with a rotary tiller, or 2) crushed using a no-till roller/crimper when the rye was at anthesis, based on previous research. Tomatoes (an organic cultivar, Defiant, from Johnny\'s Seed, Albion, ME) were seeded on April 24. Sweet corn (organic \'Luscious\', Johnny\'s Seed, Albion, ME) and tomatoes were seeded and transplanted, respectively, into the tilled and no-till plots on June 25 (corn) and June 22 (tomatoes). Manure-based compost (made from local sources) was applied at a rate of 100 lb/acre of nitrogen (N) in vegetable plots before planting on May 12. An additional 50 lb N/acre (Midwest Bio-Ag organic 2-5-4 (N-P-K) fertilizer, Blue Mounds, WI) was side-dressed on July 28. Tilled plots were maintained using typical organic weed management techniques. Crops were harvested at maturity using timely hand harvesting to ensure quality vegetable crops. There were three sweet corn and tomato harvests from September 1 to 30. In 2015, sweet corn silks were attacked by corn rootworm beetles leaving neighboring GMO corn fields, which led to reduced pollination and yields. While there were no significant differences among treatments at Harvest 1, there was trend towards greater sweet corn performance in the tilled plots, averaging 523 lb/acre, compared to 87 lb/acre in the no-till plots. The addition of compost increased no-till production by 134 lb/acre. Plots with mulch averaged 552 lb/acre, while yields from no mulch plots were similar, at 494 lb/acre. An increase in 440 lb/acre was demonstrated with cover crops compared to no cover crops. Because of the high variability in yields among plots and between harvests, there was no statistical difference over the entire season, although yields ranged from 1,201 lb/acre in no-till plots to 4,909 lb/acre in the CC-CAM-T-NM plots. Because of the late planting, earworm pressure was high, and ears from all treatments exhibited earworm damage, with similar earworm presence between treatments. Tomato yields followed the same pattern as sweet corn, with lowest yields in no-till plots, and the addition of compost aiding no-till production. While tilled, mulched plots produced numerically greater yields and cleaner fruit, there were no significant yield differences when compared with tilled, no mulch treatments. These results demonstrate the need for supportive weather conditions for no-till to succeed, allowing cover crop rolling/crimping at an earlier date and earlier application of side-dressed organic fertilizer. The combined effect of planting cover

crops and amending the soil with composted animal manure is particularly beneficial for enhancing surface soil quality, regardless of tillage management. We observed significant increases in soil organic C, total N, particulate organic matter C, N mineralization potential, and aggregate stability at the end of the second growing season in the tilled and reduced-till soils that remained stable through the fall of 2014. The observed positive changes in soil quality from planting cover crops were mirrored in enhanced ecosystems services. Nitrate-N leaching below the rooting zone was consistently lower with cover crops under all vegetable crops for all years. Soil respiration, quantified as CO2 flux (gmCO2/m2/h), was consistently higher under reduced tillage. This result demonstrates that rolling cover crops prior to vegetable planting enhances microbial activity compared to tilling cover crops. Changes in soil profile C and N were observed in the top two depth increments only with no change measured below 30 cm. After 4 years of vegetable cropping, the soils with cover crops and composted animal manure, regardless of tillage, had up to 16% higher SOC concentrations and an average of 8% higher TN concentrations in the top 15 cm of soil compared to baseline values. Increased TN concentrations in the top 15 cm were accompanied by an average of 8% decrease in TN concentration in the 15-30 depth increment. The results of this experiment demonstrate that vegetable cropping systems that utilize fall-planted cover crops and composted animal manure will increase overall soil quality, enhance microbial activity, increase C sequestration, and reduce N leaching loss from the rooting zone. Most of these benefits will be derived regardless of whether the cover crop is tilled or roller/crimped prior to vegetable transplanting. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 Type: Journal Articles Status: Published Year Published: 2015 Citation: Delate, K., C. Cambardella, C. Chase, and Robert Turnbull. 2015. A review of long-term organic comparison trials in the U.S. Sustainable Agriculture Research 4(3): http://www.ccsenet.org/journal/index.php/sar/article/view/50095

2013/09 TO 2014/08 What was accomplished under these goals? This multi-disciplinary, multi-state project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. The treatments we are studying include three tillage comparisons: (1) tilled followed by straw mulch (2) tilled without straw mulch and (3) organic no-till; and two organic fertility treatments (1) composted animal manure alone (no cover crops) and (2) composted animal manure + cover crops. In 2014, experiments were continued in two states (Iowa and Florida) across two contrasting soil types (low vs. high fertility) and climatic conditions (sub-tropical vs. temperate) using vegetable rotations appropriate for the region. Two long-term rotation sequences were established at each site. Six cropping system treatments with different management practices were examined at each site: four treatments using cover crops (CC) and two without CC. Of the four CC treatments, two were treated as organic no-till (cover crop rolled) and two were tilled prior to vegetable crop planting/transplanting. Compost and mulch were applied to a sub-set of these treatments to test the effect of these potential soil amendments. The cover crop in Iowa was hairy vetch/rye while in Florida, sunnhemp was used. Florida also substitutes plastic mulch for straw mulch, as is the convention on organic farms in Florida. Fall cover crops were planted in Iowa on October 11, 2013, at a rate of 25 lb hairy vetch + 90 lb rye/acre. Treatments were replicated four times for a total of 48 plots. Because of the cool, wet spring, cover crops did not mature until late May. Cover crops were mowed at anthesis, and disked on June 3 or terminated with the Rodale Institute roller/crimper on June 6. The late planting date was on June 18 -- two weeks behind schedule. Compost was applied at a rate of 100 lb N/acre on April 14, and organic fertilizer (2-5-4; MBA, Blue Mounds, WI) was side-dressed at 50 lb N/acre on July 28. Tilled plots were tilled for weed management on July 3, 17 and 31. Sweet corn ears were harvested on August 28 and September 4, 2014. Treatments were as follows: 1) no cover crop, composted animal manure, tilled, mulched; 2) no cover crop, composted animal manure, tilled, no mulch; 3) cover crop, composted animal manure, no-tilled; 4) cover crop, composted animal manure, tilled, mulched; 5) cover crop, composted animal manure, tilled, no mulch; and 6) cover crop, no-tilled. In the first harvest, highest yields were obtained in Treatment 2 (animal manure, tilled) and in Treatment 1 (animal manure, tilled, mulched), Treatment 4 (cover crops, animal manure, tilled, mulched), and Treatment 5 (cover crops, animal manure, tilled). The two lowest yielding Treatments (3 and 6) were the organic no-till plots. In the second harvest, yields were not statistically different, but yields from the no-till plot (Treatment 6) tended to be more similar to Treatment 4 (cover crops, animal manure, tilled, mulched), which could indicate a later harvest in the no-till plots. Overall total harvest comparisons showed the same pattern as the first harvest, with highest yields in Treatment 2 (animal manure, tilled), followed by the second highest yields in Treatment 1 (animal manure, tilled, mulched), 4 (cover crop, animal manure, tilled, mulched), and 5 (cover crop, animal manure, tilled). The lowest yielding treatments (3 and 6) were no-till, demonstrating the need for supportive weather conditions, allowing cover crop rolling/crimping at an earlier date and earlier application of side-dressed organic fertilizer. Earworm damage was extensive in 2014 because of the late planting and excessive rains during silking, which prohibited the application of Dipel™, an organic-compliant Bacillus thuringiensis formulation. In Florida's sandy soils at the UF-Citra Research Station in 2013, no-till summer squash yields of 443 to 641 grams per plant were equal or greater than tilled yields, with no significant difference between no-till and plastic mulch. Side-dressed organic fertilizer added a numeric boost to no-till yields, but yields were not significantly different from no-till without fertilizer. In the yellow zucchini crop,

there were no significant differences between treatments, with no-till equaling tilled treatments, and yields ranging from 376 grams per plant in tilled cover crop plots to 487 grams per plant in the tilled cover crop plots with plastic mulch. Marketable fruit yields followed a similar pattern as the fruit yields, with no differences between treatments for zucchini, and organic no-till squash with extra fertilizer having the highest fruit numbers. Although the no-till plots did not have favorable yields in 2014 in Iowa, soil quality parameters have been higher in no-till plots. Soils results from the 2013 organic sweet corn plots showed that Treatment 3 (organic no-till) contained the highest amount of soil organic carbon (SOC) at 30.3 g/kg. The two tilled treatments without a cover crop (1 and 2) had the lowest microbial biomass carbon (MBC). Treatments 4 and 5 had the highest MBC, demonstrating the value of composted manure in adding beneficial soil microbes. Treatment 3 had the highest total nitrogen content, followed by the other treatments with cover crops (5 and 4). The lowest total nitrogen content was in treatments without cover crops (1 and 2), with exception of treatment 6 (which had no animal manure application). Overall, soil quality data showed enhanced storage of soil organic C, total N, and biologically active soil C and N when cover crops were planted in the fall before vegetable cropping; improved soil structure under reduced tillage; and more soil organic C, total N, biologically active soil N, and higher plant nutrient concentrations when composted animal manure was applied in the spring. Lysimeter data has been showing that the concentration of leached N has been consistently lower under vegetables grown with a cover crop and in no-till. In Florida, no-till plots showed higher total soil N, particulate organic matter C, extractable K and Mg, electrical conductivity; high biologically active organic matter: POM-C (particulate organic matter carbon): 43% of total soil organic C compared to 22% in Iowa soils under no-till with compost. Mulching with cover crops showed more extractable P and Mg and higher electrical conductivity. Overall, there has been enhanced storage of soil N and biologically active soil C, and higher concentrations of plant nutrients in the no-till treatments. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Delate, K., C. Cambardella, and X. Zhao. 2014. Cover Crop, Mulch, Compost, and No-Till Effects in Organic Vegetable Production Systems. American Society for Horticultural Science Annual Conference, Orlando, FL, ASHS, Alexandria, VA. Abstract.

2012/09/01 TO 2013/08/31 What was accomplished under these goals? This multi-disciplinary, multi-state project addresses critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality to help mitigate global climate change. The treatments we are studying include three tillage comparisons: (1) tilled followed by straw mulch (2) tilled without straw mulch and (3) organic no-till; and two organic fertility treatments (1) composted animal manure alone (no cover crops) and (2) composted animal manure + cover crops. In 2013, experiments were continued in two states (Iowa and Florida) across two contrasting soil types (low vs. high fertility) and climatic conditions (sub-tropical vs. temperate) using vegetable rotations appropriate for the region. Two long-term rotation sequences were established at each site. Six cropping system treatments with different management practices were examined at each site: four treatments using cover crops (CC) and two without CC. Of the four CC treatments, two were treated as organic no-till (cover crop rolled) and two were tilled prior to vegetable crop planting/transplanting. Compost and mulch were applied to a sub-set of these treatments to test the effect of these potential soil amendments. The cover crop in Iowa was hairy vetch/rye while in Florida, sunnhemp was used. Fall cover crops were planted in Iowa on October 11, 2012, at a rate of 25 lb hairy vetch + 90 lb rye/acre. Treatments were replicated four times for a total of 48 plots. Cover crops were disked under or terminated with the Rodale Institute roller/crimper. Because of extensive spring rains in 2013, cover crops were not disked until June 8 and not rolled until June 20, leading to a planting date of June 24 \-- three weeks behind schedule. Also because extensive spring rains caused a delay in planting, transplants were too large for the mechanical transplanter. Compost is applied at a rate of 100 lb N/acre each spring and organic fertilizer side-dressed after vegetable crop establishment at 50 lb N/acre. Using lysimeter readings from each plot, leached nitrate-N concentrations are determined throughout the growing season in Iowa. In 2013, tomatoes and sweet corn were grown in Iowa, and squash and zucchini in Florida. In Iowa, organic no-tillage crops performed similarly to 2012 results, with tilled CC and compost plots providing higher yields than organic no-tillage plots. Mulch provided an advantage to tomato yields. No-tillage sweet corn failed to compete with mulched and tilled yields. While the tilled crops were more productive, the mulched and no-till tomatoes had higher quality fruit. Lysimeter data has been showing that the concentration of leached N has been consistently lower under vegetables grown with a cover crop and in no-till. Soil quality comparisons show greater soil carbon sequestration with cover crops and compost. An on-farm trial was conducted in summer 2013 in Florida to compare the effects of different mulching methods on plant growth, yield, and pest control in organic yellow zucchini production. Mulches such as paper, rye straw, black plastic, and rye straw + paper greatly reduced weeds as compared with the bare soil control and were not significantly different in their weed suppression effect. Black plastic mulch, however, resulted in significantly higher early and total yields as compared to all other treatments and the bare soil control. The highest yields were also accompanied by the highest detected soil temperatures. Greater densities of squash bugs and stink bugs were also found in the black plastic mulch treatment, suggesting a preventative benefit in terms of pest

protection. Soil quality differences were observed within the two organic vegetable rotation sequences at the Florida site in January 2013. Total soil N, particulate organic matter C, extractable K and Mg, and electrical conductivity were significantly lower in the tilled soils. Bulk density and extractable P were significantly greater with a cover crop. Mulching in the presence of a cover crop resulted in more extractable P and Mg and higher electrical conductivity. Mulching in the absence of a cover crop also increase electrical conductivity and resulted in higher bulk density in the top 15 cm of soil. Overall, soil quality data in 2013 for these relatively un-structured Florida soils shows enhanced storage of soil N and biologically active soil C, and higher concentrations of plant nutrients in the no-till organic vegetable rotations compared to the tilled rotations.

2011/09/01 TO 2012/08/31 Results from this project to date have shown excellent organic vegetable yields with improvements in soil and water quality with the use of cover crops. Results from the second season (2012) suggest that, with adequate cover crop biomass and weather conditions permitting vegetable planting on normal dates, organic no-till systems can provide excellent weed management and yields equivalent to tilled systems. The greatest benefits from cover crops in these vegetable systems appear to be related to improvements in soil and water quality. After the first season, in Fall 2011, soil nitrate was lower in tomato plots under cover crop treatments than in plots without a cover crop in Iowa. Without a cover crop, the non-mulched tomato treatment had more nitrate than the mulched plots. In the onion plots, the non-mulched plots had more nitrate for both cover crop and no cover crop treatments. In both the tomato and onion plots, there was more phosphorus in tilled vs. no-till treatments, probably due to tillage stimulating the mineralization of organic phosphorus from added compost. Both phosphorus and electrical conductivity were lower in the no compost treatments. In Florida, soil quality differences were observed in Rotation 2 in 2011 and 2012, where mulching in the absence of a cover crop resulted in higher microbial biomass carbon compared to the no mulch treatment. This suggests that the mulch may be stabilizing soil microclimate (i.e., cooler and wetter) in these relatively un-structured soils to favor the accumulation of microbial biomass carbon, an easily decomposable form of biologically active organic matter. The importance of biologically active organic matter in these very sandy soils is demonstrated by the observation that particulate organic matter carbon represents on average 43.6% total soil organic carbon compared to Iowa soils, where particulate organic matter accounted for 15.4% of total soil organic carbon averaged across treatments. There was a trend toward increasing soil quality from 2011 to 2012 in Florida, where total nitrogen increased in this time frame and soil C:N ratio decreased because of the change in nitrogen content. Extractable phosphorus and calcium also increased from 2011 and 2012. The Florida soils have relatively low amounts of potentially mineralizable nitrogen, but it increased from 2011 to 2012 in the Florida soils, suggesting that the organic management practices encourage accumulation of labile organic nitrogen even in these very sandy Florida soils. Overall, soil quality temporal patterns observed from 2011 to 2012 for Florida soils suggest enhanced cycling and storage of soil nitrogen and soil nutrients in the organically managed vegetable rotation sequences. The benefits of cover crops in this project were primarily from enhancing soil quality and from reducing nitrate-N in lysimeters, which could be extended to enhancement of water quality and groundwater protection. Comparisons with conventional systems may provide larger differences than observed between organic systems and are under evaluation at other sites.

2010/09/01 TO 2011/08/31 In relation to impacts of organic vegetable production treatments on nitrate-N leaching, a primary goal of this project, preliminary lysimeter data showed that the seasonal average root zone nitrate N concentrations under organic tomato and onion were similar and did not exceed the drinking water standard of 10 ppm. In tomato plots, cover crops were associated with decreased nitrate-N in lysimeters compared to plots with no cover crops, particularly in August 2011, when nitrate-N levels in cover cropped plots averaged 5 ppm compared to 15 ppm in plots without cover crops. The concentration of leached N was also consistently lower under onion with a cover crop. No-tillage did not decrease nitrate-N in lysimeters under onions, possibly due to the shallow rooting pattern of the onions. Mulch responses were highly variable under onions and tomatoes, with no obvious benefit in terms of reducing nitrate-N in lysimeters from applying straw mulch. The benefits of cover crops in the first season of this project were primarily from reducing nitrate-N in lysimeters, which could be extended to groundwater protection. Results from this project were disseminated to a broad audience through two field days, two conference presentations and several classroom presentations in Iowa. In Florida, a presentation on the project was delivered in an organic systems workshop organized by Florida Certified Organic Growers and Consumers.

PUBLICATIONS

2012/09/01 TO 2013/08/31 1. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Delate, K., and C. Cambardella. 2013. Compost, cover crops, and mulch effects in organic vegetable systems. American Society for Horticultural Science Annual Conference, Palm Desert, CA, ASHS, Alexandria, VA. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Huang, Y., X. Zhao, C.A. Chase, and J.M. Neumann. 2013. Effects of cover crops and reduced tillage on yield and weed population in organic lettuce production. Southern Region ASHS Meeting, Orlando, FL. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Zhao, X., K. Delate, and C. Cambardella. 2013. Vegetable yield and soil quality as affected by organic cropping systems. American Society for Horticultural Science Annual Conference, Palm Desert, CA, ASHS, Alexandria, VA.

2011/09/01 TO 2012/08/31 1. Delate, K., and C. Cambardella. 2012. Organic no till production in Iowa: Effects on crop productivity and soil quality. American Society of Agronomy Annual Meetings, October 23, 2012: http://scisoc.confex.com/scisoc/2012am/webprogram/Paper75770.html. 2. Delate, K., C. Cambardella and X. Zhao. 2012. Effect of cover crops, soil amendments and reduced tillage on carbon sequestration and soil health in a long term organic vegetable system. p. 22-26. In S. Smith, M. Peet and M. O Reilly (eds.). Proceedings of Organic Programs Project Directors Meeting, October 2012. USDA NIFA, Washington, D.C. 3. Delate, K., C. Cambardella, C. Shennan, C. Cogger, E. Silva, and X. Zhao. 2012. Organic vegetable research: Twenty years of progress across the U.S. American Society for Horticultural Science Annual Conference, Miami, FL, ASHS, Alexandria, VA. 4. Huang, Y., X. Zhao, C.A. Chase, and C.R. Hamilton. 2012. Influence of management practices on lettuce yield and weed population in organic production. American Society for Horticultural Science Annual Conference, Miami, FL, ASHS, Alexandria, VA. 5. Marose, B.H., M. Cavigelli, K. Delate, E. Mallory, C. Shapiro, L. Kolb, C. Reberg Horton, J. Maul and S. Mirsky. Growing the eOrganic grains Community of Practice. American Society of Agronomy Annual Meetings, October 22, 2012: http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73223.html.

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Environmental and Economic Costs of Transitioning to Organic Production Via a Sod-based Rotation and Strip-tilling in the Southern Coastal P

Accession No.	0223693
Subfile	CRIS
Project No.	FLA-NFC-005068
Agency	NIFA FLA
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51106-21866
Proposal No.	2010-03958
Start Date	01 SEP 2010
Term Date	31 AUG 2014
Grant Amount	$0
Grant Year	2010
Investigator(s)	Andersen, P. C.; Wright, D. L.; Mizell III, R. F.; Marois, J. J.; Olson, S. M.; Treadwell, D. D.; Blount, A. R.; Funderburk, J. E.; Rich, J. R.; Richardson, V. H.; Mackowiak, C.; Boyhan, G.
Performing Institution	North Florida Research and Education Center, Quincy, UNIVERSITY OF FLORIDA, G022 MCCARTY HALL

NON-TECHNICAL SUMMARY

Soil conditioning is a core tenet of successful organic production. Rotational systems for this purpose have been successfully implemented nation-wide contributing to the 15% annual increase in organic production for the last decade. However, comparatively few systems have been utilized within the Southern Coastal Plain of Florida, Georgia and Alabama which provides the majority of fall/winter vegetables for much of the US. These states have less than 0.3% of the national acreage for organic production. Poor soils, high temperatures and humidity pose unique regional problems. Over the last decade we have developed and tested rotational and tillage systems that are highly amenable to incorporation into organic production. Sod rotations including 2-year plantings of bahiagrass have repeatedly been shown to increase soil carbon and water retention, reduce fertilizer and irrigation inputs, and produce higher yields for a variety of crops. We have also shown that strip tillage coupled with cover crops further enhances soil carbon sequestration, organic matter and moisture retention. Our long growing seasons allow year-round conditioning of the soil, and potentially expedite transition from conventional to organic systems. Moreover, the high ability of bahiagrass to sequester both carbon and water are in concert with responsible land stewardship. We will test the effects of these rotational and tillage systems for organic vegetable production in the Southern Coastal Plain. Crop rotations and tillage will be evaluated on an ecological level (carbon sequestration, plant biomass, and carbon, nitrogen and nutrient partitioning, water usage), plant (yield, fruit quality, etc.) and economic level.

There is a critical need for information about how the effects of organic agriculture, specifically cover crop combinations, are quantified when assessments for carbon sequestration are employed to determine associated incentive payments. This project will strengthen organic production in the long-term by providing information about how to best manage cover crop residue in Southern climates during the transition process to retain and protect recently added carbon. As policy makers move in the direction of recognizing and subsidizing carbon as a

key indicator of environmental services it is important to develop scientific datasets to support organic farms as leaders in this capacity. This project joins together Southeastern U.S leaders in organic agriculture research, including North Carolina State University (NCSU), the Center for Environmental Farming Systems (CEFS) and North Carolina Agricultural & Technical University (NCA&T) to respond to farmer concerns about soil carbon sequestration through a fully integrated research-, education- and extension-based project. The primary long term goals of this project are: (1) Evaluate common and novel cover crops for their potential to contribute to soil organic matter development to develop tools for conservation planners to quickly identify beneficial practices for transitioning organic farmers, and (2) develop models for educating agricultural stakeholders, future extension leaders (students), and low-income urban populations about the benefits and challenges of cover crop use. To meet our first goal we will study the contribution of cover crop plant biomass additions to soil carbon by investigating the microbial processes controlling both decomposition and stabilization of added carbon. To meet our second goal we will use a multi-tier outreach approach to disseminate the information produced by our proposed research. Specific outreach efforts include: 1) hosting 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel, with particular emphasis placed on small and limited-resource farmers in the Southeast, 2) developing and piloting 5 cover crop teaching lessons for low-income urban populations using urban gardens to increase food security, and 3) designing two academic components including an upper-level oClimate Change & Agricultureo course and a unique extension training program for graduate students, the Young Extension Professionals (YEP) program. The goal of YEP is to train effective extension personnel and farmer communicators following completion of their academic program.

OBJECTIVES

Our primary objective is to integrate the advances that we have made on sod-based rotation and strip tillage into organic systems for vegetable production in the Southern Coastal Plain. Our methodologies are based on the long term enrichment of soil characteristics, which is also a requirement for any successful, sustainable organic system. Experiments will be designed so that these technologies can be compared directly to alternative techniques currently being used for organic production in the Southern Coastal Plain. We will assess each of these techniques from a production, as well as an environmental standpoint. Adoption of these systems will promote land stewardship practices designed to rejuvenate depauperate soils. Objective 1. Experimental Design. To develop and implement a system of organic vegetable production based on: 1) sod-rotation (2 year rotations of bahiagrass), and; 2) strip-tillage for vegetable crops in the Southern Coastal Plain. A 2 x 2 split plot design will be used so that each technique (sod-rotation and tillage) can be compared. Objective 2. Production and Profitability. To evaluate each component (sod-based rotation and tillage) of the system in terms of productivity (plant biomass, yield, fruit quality, plant physiology), and pest impacts (arthropods, pathogens, nematodes and weeds). Enterprise budget will be constructed. Objective 3. Ecological Impacts. To evaluate each component (sod-based rotation and tillage) of the system in terms of ecological impact with emphasis on soil conditioning (soil carbon sequestration, soil organic matter, and soil moisture retention), and water quality. Chemical analyses of plant material and ground water will also be conducted and budgets can be constructed to fully examine the effects of treatments on carbon, nitrogen, and water budgets in these systems. Objective 4. Outreach. We will establish an effective outreach program to disseminate knowledge about these techniques to those interested in organic production. The proposed project activities are intended to have the following anticipated outcomes: 1) Conventional and limited resource farmers will gain knowledge and skills to incorporate organic production and marketing as viable alternatives to farm operations; 2) Development of an effective outreach and education model for introducing organic production and marketing to limited-resource audiences; 3) Use of Farmers\' markets by all targeted sectors will increase; 4) Acreages of organic production will increase; 5) Local availability of organic produce will increase; 6) New markets for limited resource farmers will be developed; 7) New organizations of organic growers of all types will be implemented, and; 8) Publicity of the accomplishments and the application of the results will be presented, and extramural funding leveraged by the strategic rotations will increase dramatically.

Global concerns about the rapidly rising CO2 in the atmosphere, coupled with the promise of future payments for captured carbon, have prompted a renewed interest in soil C sequestration, especially in organic systems where application of complex organic materials is a common management practice. This project will strengthen organic production in the long-term by providing information about how to best manage cover crop residue in Southern climates during the transition process in order to retain and protect recently added carbon. The primary long term goals of this project are: Goal (1) Evaluate common and novel cover crops for their potential to contribute to soil organic matter development in order to develop tools for conservation planners to quickly identify beneficial practices for transitioning organic farmers, and Goal (2) develop models for educating agricultural stakeholders,

future extension leaders (students), and low-income urban populations about the benefits and challenges of cover crop use. Our supporting objectives for our first goal include: Objective (1): Evaluate root and shoot contributed-C of both grass and legume cover crop species to determine C sequestration potential; and Objective (2): Select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. The timeline and outputs for our first two research objectives include the following: Fall/Winter of 2011 and 2012 we will plant our field trials at two field sites in North Carolina, taking data in the Spring and Summer of 2012 and 2013. Rhizobia evaluation will be completed by the end of 2011. At least two manuscripts will be produced based on the findings of our research in 2013. To meet our second goal we will use a multi-tier outreach approach to disseminate the information produced by our proposed research. Specific outreach and educational objectives include: Objective (3): Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop soil fertility and organic matter in low-income neighborhoods where community gardens are located. Objective (4): Develop a professional development extension training program for graduate students, the Young Extension Professionals (YEP) program, including two field days at the Center for Environmental Farming Systems designed and carried out in-part by graduate student trainees. Objective (5): Develop a new course \"Climate Change & Agriculture\" for undergraduate and graduate students. The timeline and outputs for teaching and outreach objectives 3-5 include the following: The \"Climate Change & Agriculture\" course will be held twice in Spring semester of 2012 and 2013. The YEP program offerings will be held each Fall and Spring semester over two years: Fall 2011, Spring 2012, Fall 2012, and Spring 2013. A fifth offering will be made available based on student interest. Two CEFS workshops will be offered in each summer of our project: Summer 2012 and 2013. Cover crop teaching modules will be designed by students each Fall semester of Fall 2011 and 2012, with 2-3 modules developed per class group.

APPROACH

The following systems will be compared: 1) Winter cover crops (oat/rye mix) followed by conventional tillage prior to planting and as needed on a spring green bean crop followed by soybeans in the summer as a green manure crop followed by a fall broccoli crop; 2) A field that has had bahiagrass for two year will be turned and planted to winter cover crops (oat/rye mix) followed by conventional tillage prior to planting and as needed on a spring green bean crop followed by soybeans in the summer as a green manure crop followed by a fall broccoli crop; 3) Winter cover crops (oat/rye mix) followed by strip tillage into rolled down cover crops in the spring prior to planting green beans which will be harvested. Soybeans will be no tilled drilled into the greenbean stubble as a nitrogen producing crop for the strip tilled fall broccoli crop; 4) A field that has had bahiagrass for two year will be turned and planted to winter cover crops (oat/rye mix) followed by rolling the cover crop and strip tilling green beans into them for harvest. Soybeans will be notilled drilled into the greenbean stubble as a nitrogen producing crop for the strip tilled fall broccoli crop. Systems 1 and 3 and systems 2 and 4 can be compared for tillage effects and systems 1 and 2 and systems 3 and 4 can be compared to the impacts of rotating perennial grass through vegetable land. These plots wil be monitored for ecosystem function and farm economics. All treatments will have green beans (spring) and broccoli (fall) as cash crops. The four rotation treatments will be set up on organically-certified land at the NFREC-Quincy. After initial plot layout, we will collect baseline data on the plots. The weeds species and densities will be assessed. Plant mesurements include stand density, fruit quality, yield, net photosynthesis, stomatal conductance, and leaf nutrient analyses. Pest management will include OMRI-approved organic pesticides such as Matran, BT and Entrust. The population of athropods,nematodes, soil microbes and plant pathogens will be examined every two weeks. The physical (bulk density, particle size distribution, soil water status, wet aggregate stability), chemical (Kjeldahl N, extractable soil nutients) and biological (organic matter) properties will be examined. Plant and soil data will be used to construct carbon, nitrogen and water budgets for the four rotation treatments. We will perform a complete economic budget using enetrprise budgets. Community level analyses on arthropods (herbivores and predators), pathogens, nematodes, soil microbes and weed species will consist of diversity indices and principle component analyses to determine significant factors and relationships of plot factors to fauna populations. We will track the individual treatment plot variables over the course of the rotations and expenditures such as fuel, etc. will be recorded by plot. Outreach will comprise extension venues of field days, presentation at grower meetings, county agent in service trainings, web site postings, and presentations at professional and grower meetings.

Objective (1): Evaluate root and shoot contributed-C of both grass and legume cover crop species to determine C sequestration potential. We will collect C- related data of cover crop treatments to help us understand how direct C contribution and indirect microbial activities leading to long-term protection and stability vary among cover crop species and management techniques commonly used in organic agriculture. We will use a split plot design on transitioning organic land at two field sites, including 4 levels of main-plot cover crop termination method (roll,

mow/incorporation, mow/surface residue, burndown with herbicide). Sub-plots will be a completely randomized design including 6 levels of legume species and appropriate no-cover crop control. Direct measures of C contribution include cover crop shoot biomass, root C biomass, soil nutrients, and particulate organic matter (POM). Indirect measures of cover crop C contribution include indicators of C protection and stabilization such as bacterial:fungal biomass ratios using marker fatty acids, soil enzyme activity, dissolved organic matter (DOM), and mineralization and respiration one month after cover crop termination. Objective (2): Select high-fixation rhizobia appropriate for use with legume cover crops. We will use REP-PCR molecular characterization approaches, and traditional growth chamber assessment to assess a collection of over 800 strains of N-fixing rhizobia bacteria for hairy vetch. Objective (3): Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop organic matter. The Grossman lab has established a successful partnership with an NGO focused on developing community gardens programming in two low-income neighborhoods. As part of the undergraduate Soil Agroecology/Ecological Soil Management course, students will develop 5-6 teaching modules related to cover crop management to be taught to neighborhood residents where gardens are located. Modules will be developed and tested by students in Grossman\'s Fall course in each of the 3 project years, and will become part of the NGO\'s educational curriculum. Objective (4): Develop a professional development extension training course. This project purposefully involves this project\'s graduate students and post-doc trainees (4), plus our SARE project\'s PhD student, in a unique and much needed training program to develop highly skilled extension personnel who are extremely knowledgeable about organic agriculture practices. This Young Extension Professional (YEP) program will involve extension enrichment professional development workshops over 3 years on topics necessary for successful agricultural extension. Objective (5): Develop a new course \"Climate Change & Agriculture\" for undergraduate and graduate students. We (Hu, Grossman) will develop a new upper-level undergraduate / graduate student course named \"Climate Change & Agriculture\". This course aims at developing a comprehensive understanding of the cause and effects of global climate change, its social, economic and ethical dimensions, and its impacts on the productivity and sustainability of agricultural lands. **KEYWORDS:** climate change; cover crops; soil carbon; nitrogen fixation; n fixation; biological nitrogen fixation; rhizobia; legumes; global warming; extension; service learning; soil fertility; hairy vetch; crimson clover; pom; soc; soil enzymes; decomposition; dom; roots

PROGRESS

2010/09 TO 2014/08 Target Audience: Our target audience primarily includes small scale and commercial growers, Extension agents, and the scientific community. Much of our results concerns the interactions between soil chemistry, soil microbiology, nematodes, weed ecology, insect density and diversity and plant productivity. Lastly, we will subject the agricultural inputs and outputs to a complete economic analysis. We have had several grower meetings and have developed a Organic Vegetable Sod-based Rotation Website (northfloridaorganics.com). We have had many presentations and abstracts at scientific meetings including the American Society for Soil Science, the American Society of Agronomy, the American Society for Horticultural Sciences, and the International Society of Horticultural Sciences. We will continue to disseminate results after the grant termination date as we complete the 5 papers in preparation. Changes/Problems: The one major change of this project was associated with the resignation of my PhD student. This occurred more than two years into the project and it was diificult to hire another student as the project was nearing completion. I did hire a MS student that is handling some elements of this project. A one year no cost extension of this grant was beneficial in this regard. What opportunities for training and professional development has the project provided? In addition to the ten faculty members from Florida and two from Georgia, a full time post-doc was hired for the execution of the project. A PhD student resigned after the second year; however, another graduate student was recruited toward the end of the project. Training also occurred for the part time technical support personnel associated with the project. How have the results been disseminated to communities of interest? Scientific talks and abstracts have been presented at national and international meetings throughout the duration of the project. Five refereed publications are in progress concerning all aspects of this project. Grower presentations on the applied aspects of the project have also taken place. A North Florida Organic Vegetable website was established (northfloridaorganics.com) that is dedicated to the results of this particular grant. In addition, information and data will also be available on the larger and more inclusive UF Small Farms and Alternative Enterprise website. Lastly, the results of this project will be summarized in the form of electronic publications using the University of Florida EDIS website. As mentioned earlier, Extension Outreach will contiue well beyond the official termination date of this grant. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2010/09 TO 2011/08 OUTPUTS: Crop rotation systems designed to improve soil quality have been successfully implemented nation-wide, and have contributed to the 15% annual increase in organic production for the last

decade. However, comparatively few systems have been utilized within the Southern Coastal Plain of Florida, Georgia and Alabama which provides the majority of fall/winter vegetables for much of the US. These states have less than 0.3% of the national acreage for organic production. Poor soils, high temperatures and humidity and high pest pressures pose unique regional problems. Over the last decade we have developed and tested rotational and tillage systems that are highly amenable to incorporation into organic production. We have shown that sod rotations including 2-year plantings of bahiagrass increase soil carbon and water retention, reduce fertilizer and irrigation inputs, and produce higher yields for a variety of crops. Strip tillage coupled with cover crops further enhances soil carbon sequestration, organic matter and moisture retention. Our long growing seasons allow year-round conditioning of the soil, and potentially expedite transition from conventional to organic systems. Moreover, the high ability of bahiagrass to sequester both carbon and water are in concert with responsible land stewardship. We are testing the effects of these rotational and tillage systems for organic vegetable production in the Southern Coastal Plain. Crop rotations and tillage are being evaluated on an ecological level (carbon sequestration, plant biomass, and carbon, nitrogen and nutrient partitioning, water usage), plant production level (yield, fruit quality, etc.), weed and nematode populations and densities and on a economic level. Our primary objective is to integrate the advances that we have made on sod-based rotation and strip tillage into organic systems for vegetable production in the Southern Coastal Plain. Adoption of these systems will promote land stewardship practices designed to rejuvenate depauperate soils. We are evaluating sod-based rotation and tillage in terms of productivity (plant biomass, yield, fruit quality, plant physiology), and pest impacts (arthropods, pathogens, nematodes and weeds), soil impacts (bulk density, soil carbon sequestration, soil nutrients, soil organic matter, and soil moisture retention), and water quality. Plant and soil data will be used to construct carbon, nitrogen and water budgets for the four rotation treatments. We will perform a complete economic budget using enterprise budgets. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09 TO 2015/08 Target Audience:Students: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Minority and underserved target audiences: In Y1, students in SSC 428 taught their soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. In 2011 and 2012 Dr. Grossman mentored 3 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to this project\'s goals (legume cover crops and rhizobia ecology). Dr. Grossman also served as a guest lecture at NCSSM in 2011 and 2012 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. Farmers: Farmers were directly impacted by the presentations listed under \'Products - Events\', with nine presentations geared toward farmers or extension personnel presented over the life of the project. We organized and delivered 2 half-day face-to-face field-based workshops and training opportunities for farmers, organic educators, and NRCS personnel. The first workshop, \"Growing Your Own N: Improving Legume Cover Crop Management\" was held in April 2011 at a North Carolina organic field crop farm. This workshop emphasized farmer-friendly tools for quantifying the amount of nitrogen contributed by legume cover crops. Changes in knowledge and action related to cover crop use were documented from our field workshop (summarized in Products-Events in this final report). The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series and had 29 attendees from around the state. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Three graduate students trained: Three North Carolina State University graduate students were trained as part of this project, two at the M.S. level (Arun Jani and Shangtao Liang), and one PhD student, Sean Bloszies. One M.S. graduate student was trained at North Carolina Agricultural and Technical University (NCA&T), Jason Shelton. Six graduate students taught: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Extension personnel trained: eOrganic online webinar series trained approximately 500 registrants in online Excellence in Organic Extension webinar series. Four national webinars each attracted between 100-300 registrants, exceeding many other eOrganic webinars. A majority of participants were current Extension

personnel, ranging from 28-55% of participants. Minority and underserved target audiences: In Y1, students in SSC 428 at NC State taught soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. In 2011 and 2012 Dr. Grossman mentored 3 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to this project\'s goals (legume cover crops and rhizobia ecology). Dr. Grossman also served as a guest lecture at NCSSM in 2011 and 2012 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. Farmers: Farmers were directly impacted by the presentations listed under \'Products - Events\', with nine presentations geared toward farmers or extension personnel presented over the life of the project. We organized and delivered 2 half-day face-to-face field-based workshops and training opportunities for farmers, organic educators, and NRCS personnel. The first workshop, \"Growing Your Own N: Improving Legume Cover Crop Management\" was held in April 2011 at a North Carolina organic field crop farm. This workshop emphasized farmer-friendly tools for quantifying the amount of nitrogen contributed by legume cover crops. Changes in knowledge and action related to cover crop use were documented from our field workshop (summarized in Products-Events in this final report). The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series and had 29 attendees from around the state. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. How have the results been disseminated to communities of interest?Results of this project have been disseminated in multiple diverse ways. First, three peer-reviewed published manuscripts and six published abstracts (posters or talks) have been presented at a national level to reach scientific audiences. Another is pending revision and will be submitted for peer review within two months. Second, multiple graduate students were involved, including four trained at the M.S. or PhD level, and those involved in our Climate Change and Agriculture course at NCSU. Since organic farmers are one of the primary beneficiaries of this project, a third group to whom we disseminated our information included farmers. or those that train farmers. These efforts included two half-day workshops, and eight shorter 1-2 hour workshops to farmer-focused audiences. Fourth, we disseminated information through undergraduate students enrolled in our service learning-course in which soils and cover crop lesson plans were designed and taught to diverse minority audiences in the Raleigh, NC region. A more detailed account of how the results have been disseminated, and evaluation results of each of these approaches, is presented in the \"Products\" section of this final report. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Students: Same as previous years Minority and underserved target audiences: In 2011, 2012, and 2013 Dr. Grossman mentored 3-4 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to legume cover crops and rhizobia ecology. Dr. Grossman also served as a guest lecture at NCSSM in 2011, 2012 and 2013 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. Changes/Problems: The PI on this award will be moving to the Univerisity of Minnesota in June 2013, prior to the end of our first no-cost extension year. The post-doc funded by this project will also be relocating and will complete the molecular rhizobia assessment when our lab is up and running again. One sttudent manuscript is in review, and two additional manuscriipts will be submitted for the first round of review in the next two months. We are requesting an additional no-cost extension year to complete the molecular assessment. What opportunities for training and professional development has the project provided? This project trained three graduate students and one post-doc. Two were masters students and are in the process of submitting their work for publicatoin (Jani and Liang). One is a PhD student who is completing his first manuscript (Bloszies). The post-doc (Sooksa-nguan) is completing the rhizoba molecular assessment. As presented above, a webinar series entitled Excelence in Organic Extension was organized by the post-doc for a national audience through eOrganic and provided numerous opportunities for professional development of current and future extension personell. How have the results been disseminated to communities of interest? Invited presentations to farmer groups, academic classes, or the public Grossman, J. Soil fertility in organic systems. Carolina Farm Stewardship Association Conference, November 17, 2013, Durham, NC. Grossman, J. and Hitt, A. Workshop: Cover Crops. August 19, 2013. Chatham County Cooperative Extension in conjunction with Debbie Roos, Silk Hope, NC. Grossman, J. Putting Legumes to Work on Organic Farms. Annual Sustainable Agriculture Seminar Series, The Pennsylvania State University, January 17, 2013, State College, PA. Grossman, J. Managing Plant-Soil-Microbe Relationships for Better Soil Fertility. Southern Sustainable Agriculture Working Group (SAWG), January 25 and January 26, 2013, Little Rock, AK. Grossman, J. Legume Cover Crops in an Organic System. Carolina Farm Stewardship Association

Conference, December, 2012, Greenville, SC.Invited speaker, North Carolina School of Science and Mathematics 'Labs for Learning' program for high-potential minority 9th graders. guest lecture 7/2013Invited speaker, North Carolina School of Science and Math Mini-Term course on local food and sustainable agriculture. 2/2013 What do you plan to do during the next reporting period to accomplish the goals? Project completion involves two significant goals: - Submit for publication five peer-reviewed manuscripts. Planned include two from Jani, one from Bloszies, one from Liang and one from Sooksa-nguan. - Complete rhizobia molecular assessment and summarize results in a peer-reviewed manuscript

2011/09/01 TO 2012/08/31 OUTPUTS: In Y2 we established two two fields, located in Kinston and Goldsboro/CEFS, NC. Cover crop species included hairy vetch, crimson clover, and Austrian winter pea and four termination treatments (flail, disk, roll, and chemical-spray). We mentored 1 post-doc, 4 graduate students, and one undergraduate. Obj 1: Develop an understanding of contributed-C of cover crop species to determine species C sequestration potential. Decomposition parameters included three lignin-cellulose extracellular enzyme activities \β-glucosidase (BG), exoglucanase (EXG), β-glucosaminidase (NAG) and peroxidase (PER)\, net C and N mineralization, nitrification potential, and soil aggregation. Soil samples were collected 1 week before and 14 weeks after termination in 2011 and 2012 to determine microbial biomass carbon and nitrogen (MBC/MBN), hot water soluble carbohydrates, and water stable aggregation. Shoot and root litterbags were employed in order to monitor decomposition rates. Bags were removed at regular intervals throughout growing season and contents analyzed for C, N and P. Root morphology was assessed using PVC cylinders for 12 weeks, analyzed with WinRhizo software. Obj 2: Select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. As a confirmation of rhizobia status, 350 rhizobia strains were screened for expression of the nitrogen-fixation nitrogenase gene (NifH) Strains screening positive for the NifH gene were fingerprinted using rep-PCR. Twenty-five strains were selected for further study. A growth chamber study has been initiated to determine selected strain effects on nodule mass, plant biomass, and total plant nitrogen. Obj 3: Develop and pilot 5 teaching modules for urban educational farms, and host 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel. In fall 2011 six students were enrolled in the course SSC 428 Service-Learning for Urban Food Production Systems and in 2012 five were enrolled. Students taught 8-weeks of lessons to one underserved communities where urban gardens are based. The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. Obj 4: Develop and execute a professional development extension training course for graduate students preparing to work in careers with practicing farmers. We have continued conversations with eOrganic regarding making this a nationally-available program. Obj 5: Develop a new course \"Climate Change & Agriculture\" for upper level undergraduate and graduate students. In 2010 six graduate students enrolled, as well as several visiting scholars. Each week involved a different guest lecture, supplemented by lectures by Drs. Hu and Grossman, plus recent literature. PARTICIPANTS: Julie Grossman, PI, Supervises all project activities, post-doctoral researcher, undergraduate trainees, and co-advises Plant Pathology graduate student, co-teaches -Climate Change in Agriculture- course, helps organize YEP program. Shuijin Hu, Co-PI, advises plant pathology graduate student, oversees soil aggregate work, co-teaches -Climate Change in Agriculture- course. Wei Shi, Co-PI, advises Soil Science M.S. student, oversees all soil enzyme activity work. G.B. Reddy, Co-PI, advises NCA&T M.S. student, oversees all root decomposition and quantification work. Alan Meijer, Co-PI, organizes and helps instruct YEP program. Amanda Roth is a biology undergraduate student assisting with the rhizobia diversity experiments and learning lab culture techniques. Jacob Rutz is an undergraduate researcher assessing total root carbon present in field sites at cover crop termination. TARGET AUDIENCES: Students: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Minority and underserved target audiences: In Y1, students in SSC 428 taught their soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. In 2011 and 2012 Dr. Grossman mentored 3 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to legume cover crops and rhizobia ecology. Dr. Grossman also served as a guest lecture at NCSSM in 2011 and 2012 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. PROJECT MODIFICATIONS: Changes in Y1 reflected the need to condense YEP extension programming for graduate students into one course rather than annual workshops on each proposed extension topic. Current difficulties in scheduling the

online YEP program with eOrganic web based program have resulted in delays deciding which semester the course will be taught. Currently It is scheduled to be offered during 2013, likely in the fall.

2010/09/01 TO 2011/08/31 OUTPUTS: In Y1 we have established one of the two field plots, located in Kinston, NC. Cover crop species included Auburn Early Cover variety of hairy vetch, Auburn Sunrise crimson clover, Austrian winter pea, and balansa clover. Experiment was harvested in May, 2011 using four proposed termination treatments. Biomass was dried, ground and analyzed for C and N content. We have sampled for particulate organic matter (POM) at the baseline and post-termination time points. We are mentoring 1 post-doc, 3 graduate students, and 3 undergraduates and one high school student. Recruitment of a post-doctoral scholar resulted in the recent hire of an expert in soil microbial communities and rhizosphere activities. We have also recently hired a graduate student at NCA&T who will be conducting the root-related experiments with the post-doc. The student will assess greenhouse-grown plant roots and use Win-Rhizo software to assess cover crop root architecture. Two graduate students will be based at NCSU, one (Ph.D. Plant Pathology) will assess aggregate size and stability of soils under the different cover crops and termination treatments and the other (M.S. Soil Science) will investigate enzyme activity under decomposing mulches. Three additional students were hired as bi-weekly labor; two conducting field experiment maintenance and help with service-learning project, another carrying out the rhizobia evaluation, and a third minority high school student from the NC School of Science and Math providing general assistance. Ten students are registered for the service-learning course, Service-Learning for Urban Food Production Systems, in which five teaching modules on cover crop use and management for urban settings will be developed. We will pilot the new modules in two communities, Parish Manor, which is primarily Hispanic, and the Longview Alternative School Horticulture program. In April 2011 Dr. Julie Grossman and her service-learning team was awarded the Opal Mann Green Engagement Award from NCSU for her work in community based teaching and learning. The extension-training program for graduate students (YEP) will be a nationally aired webinar series through eOrganic, and a syllabus has been developed. A workshop was offered as part of the CEFS Seasons of Sustainable Agriculture workshop series, presenting growers with information they could use to understand legume cover crop management on their farm and took place on an organic grain farm in Eastern North Carolina. Twenty-five individuals participated including farmers, extension personnel, students, NRCS staff and others. PARTICIPANTS: INDIVIDUALS. Julie Grossman, PI, Supervises all project activities, post-doctoral researcher, undergraduate trainees, and co-advises Plant Pathology graduate student, co-teaches -Climate Change in Agriculture- course, helps organize YEP program. Shuijin Hu, Co-PI, advises plant pathology graduate student, oversees soil aggregate work, co-teaches -Climate Change in Agriculture- course. Wei Shi, Co-PI, advises Soil Science M.S. student, oversees all soil enzyme activity work. G.B. Reddy, Co-PI, advises NCA&T M.S. student, oversees all root decomposition and quantification work. Alan Meijer, Co-PI, organizes and helps instruct YEP program. Max Sherard, undergraduate helping with field maintenance and service-learning student research. Greg Wilson, graduate student in Agricultural Education at NCSU helping with summer field maintenance. Malik Oliver, High school student at NC School of Science and Math, provides general lab and field assistance. Brenna Hannapel, undergraduate student conducting rhizobia diversity growth chamber study. PARTNER ORGANIZATIONS. Inter-Faith Food Shuttle, Non-profit food bank organizing Farm and Community Gardens project with whom NCSU students collaborate as part of the service-learning experience. eOrganic / Alex Stone; Collaborating to design Young Extension Professionals (YEP) webinar series to train graduate students interested in organic agriculture extension employment. Longview Alternative School / Mr. Patrick Faulkner; Horticulture program at alternative school for youth on probation at traditional high schools. NCSU students pilot cover crop teaching modules with Mr. Faulkner\'s class. TRAINING AND PROFESSIONAL DEVELOPMENT. One post-doc level trainee, three graduate student trainees, 4 undergraduate trainees, one high school trainee. Other: -Growing Your Own N: Cover Crop Management for Your Farm- workshop, part of the Center for Environmental Farming Systems (CEFS) workshop series. Young Extension Professional (YEP) Program to train graduate students interested in organic agriculture extension employment. Pre-Service-Learning training; 6h workshop for undergraduates enrolled in -Service-Learning for Urban Food Production Systems- course, including diversity and teaching training for students. -Soil Science and Organic Farming- - presentation to high-potential minority middle school students, NC School of Science and Math, Durham, NC. -CAALS 3D Summer Research Experience- for Minority School of Science and Math students, hands-on 3d training experience in organic agriculture and cover crop nitrogen fixation for three high school juniors. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Budget reductions at NCA&T have eliminated the Plant and Soil Science major in which the graduate student was to be enrolled, and greatly delayed the hiring of the student at this institution. Based on reviewer comments of our original proposal, changes were made to the proposal to more closely link the activities at NCA&T to the activities at NCSU. To this end, the NCA&T graduate student will be conducting the root-related experiments together with the post-doc. The student at NCA&T will also take many classes at NCSU as part of his graduate program.

IMPACT

2010/09 TO 2014/08 What was accomplished under these goals? All experiments involving sod based rotation and strip versus conventional tillage have been completed, and all data have been collected and statistically analyzed, with the exception of a complicated weed diversity database. Five manuscripts are being prepared dealing with the interactions of plant productivity, carbon and nitrogen budgets, soil chemistry (inorganic nutrients, mineralizable nutrients, labile carbon, carbon sequestration, soil organic matter, soil moisture), soil microbiology, nematology, weed ecology, and entomology. Lastly, the economics of organic vegetable culture associated with sod-based rotation and tillage are being established. A summary of some of our results will follow: We have shown that two or more years in bahiagrass and strip tillage increases soil organic matter and reduces fertilizer and water inputs (http://nfrec.ifas.ufl.edu/sodrotation.htm) . In our organic vegetable production systems, yields of green beans and broccoli (cash crops)were usually comparable to that published for conventional production. In the initial year of the study, yields were higher for conventional compared to strip tillage treatments. In subsequent years, the effect of tillage was reduced and yields were better correlated with years in bahiagrass. Experiments conducted in a field that had been in bahiagrass for 20 years indicated that high vegetable yields continued until three years of continued vegetable production indicating that the benefits from bahiagrass may diminish in the third year of vegetable production. Available soil N and P decreased with years in bahiagrass, especially in year three. Carbon mineralization was not affected by treatments, possibly due to vegetation inputs from cover crops and weed biomass. The activities of nutrient cycling enzymes (phosphatases, beta glucosidase, beta glucosaminidase, arylsulfatase) and microbial community shifts were sometimes affected by tillage, but not by years in bahiagrass. Increasing years in bahiagrass often reduced populations of Meloidgyne root knot and Rotylenchus reniform nematodes. Weed communities were altered by years in bahiagrass, and grasses and sedges were much more problematic in strip-tilled treatments. Sixty seven species of organisms were collected in pitfall traps. Arthropod abundance and biodiversity were calculated using Shannon-Weiner\'s, Simpson\'s and Horn\'s indices. In general, strip-tilled plots produced a greater number of trap captures, increased species richness and supported greater epigeal diversity than conventionally-tilled plots. Arthropod diversity was lowest in uncultivated plots of bahiagrass. A Risk Rated Enterprise Budget and an Analysis of Variance-Covariance Matrix economic analysis were performed utilizing sod-based rotation (years in bahiagrass) and tillage (strip tillage versus conventional tillage). Three years of bahiagrass in rotation with green bean and broccoli (with rye/oats winter and soybean summer cover crop) in combination with conventional tillage had the highest profitability and was the least risky. Six scientific presentations and several grower talks have taken place during the conduct of this grant. An organic vegetable website has been created (northfloridaorganics.com) that incorporates much of our sod-based rotation data. In addition, we will present our results concerning the organic production of vegetables with sod-based rotation andstrip/conventional in the Southern Coastal Plain on the University of Florida electronic database (EDIS) website. Our results will also be posted on the UF Small Farms and Alternative website receives millions of hits per year. Our major task during this year is to complete the refereed publications associated with this grant. This information has relevance far beyond north Florida, and the dissemination of this research must be national and international. Although the grant has terminated, we will also continue our outreach to vegetable growers and landowners. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/08 Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: 1. Bliss, C.M., P.C. Andersen, C. Mackowiak, S.M. Olson, D.L. Wright, R.F. Mizell, J.J. Marois, A. Blount and D.D. Treadwell. 2012. Tillage impact on carbon and nutrient dynamics within a transitioning organic sod-based rotation. Amer. Soc. Agron. Ann. Meeting Cincinnati, OH 21 - 24 Oct. 2012. Conf. title: Visions for a Sustainable Planet Session No. 142. Agricultural Management Practices on Soil Carbon and Nitrogen Pools and Soil Quality Dynamics: II. Abstr. No. 142-18 2. Bliss, C.M., P.C. Andersen, C. Mackowiak, S. Olson, D.L. Wright, A. Blount and J.J. Marois and R.F. Mizell III. 2013. Tillage impact on soil quality within an organic, sod-based vegetable rotation. 2013 Intern. Meeting Amer. Soc. Agron., Crop Sci. Soc. Amer., Soil Sci. Soc. Amer. Conf. title: Water, Food, Energy and Innovation for a Sustainable World. Session No. 317, General Organic Management Systems: II. 6 Nov. Tampa FL. Abstr. No. 13

2010/09 TO 2011/08 This project is intended to have the following anticipated outcomes: 1) Conventional and limited resource farmers will gain knowledge and skills to incorporate organic production and marketing as viable alternatives to farm operations; 2) Development of an effective outreach and education model for introducing organic production and marketing to limited-resource audiences; 3) Use of Farmers\' markets by all targeted sectors will increase; 4) Acreages of organic production will increase; 5) Local availability of organic produce will increase; 6) New markets for limited resource farmers will be developed; 7) New organizations of organic growers of all types will be implemented, and; 8) Publicity of the accomplishments and the application of the results will be presented, and extramural funding leveraged by the strategic rotations will increase dramatically. We are

currently in the data collection phase. Statistical analyses have been initiated. Publications will be forthcoming in years two, three and four of this project. Once sufficient data are collected, outreach will comprise extension venues of field days, presentation at grower meetings, county agent in service trainings, web site postings, and presentations at professional and grower meetings. **PUBLICATIONS (not previously reported):** 2010/09 TO 2011/08 No publications reported this period ACCESSION NO: 0223756 SUBFILE: CRIS PROJ NO: NC09799 AGENCY: NIFA NC. PROJ TYPE: OTHER GRANTS PROJ STATUS: EXTENDED CONTRACT/GRANT/AGREEMENT NO: 2010-51106-21872 PROPOSAL NO: 2010-04008 START: 01 SEP 2010 TERM: 31 AUG 2015 GRANT AMT: \$0 GRANT YR: 2015 AWARD TOTAL: \$650,906 INVESTIGATOR: Hu, S.; Hu, S.; Shi, W.; Meijer, A.; Reddy, G. PERFORMING INSTITUTION: Soil Science NORTH CAROLINA STATE UNIV RALEIGH, NORTH CAROLINA 27695 **EVALUATING THE POTENTIAL OF WINTER COVER CROPS FOR CARBON SEQUESTRATION IN DEGRADED SOILS TRANSITIONING TO ORGANIC PRODUCTION**

2010/09 TO 2015/08 What was accomplished under these goals? Summary of overall project: This project determined the degree to which planting cover crop legumes in organic systems can impact soil carbon levels in degraded Southeastern soils transitioning to organic production. One of our most striking findings was that tiny fine cover crop roots are an enormous contributor to both soil nitrogen and carbon, with more than 70% of total cover crop roots systems made of these tiny fine roots, and 40-50% of their nitrogen released in only a week after cover crops are killed. Given this, as payment policies for soil carbon contributions are developed, cover crop roots should be considered. Further, this project provided food production knowledge to over 50 underserved youth in Raleigh, NC through our service-learning organic agriculture programming, and developed teaching curricula that will be used into the future by organic garden-based educational NGO\'s. Moving beyond the content of educational programs, we provided tools related to how to best educate in the realm of organic production. We did this by providing training through a national webinar series on how to be an effective extension educator, including from 100-300 registrants at each of the four offered webinars, and through training of 12 undergraduate students on how to develop lessons and teach organic agriculture to diverse urban audiences. Obj 1: Develop an understanding of contributed-C of cover crop species to determine species C sequestration potential. Shoot and root decomposition and soil microbial processes were assessed to evaluate the suitability of several legume cover crops and termination methods for organic transition in southeastern USA. Roots: In one set of experiments, root morphological characteristics relevant to root decomposition were quantified for three legume cover crop species, followed by a controlled incubation to determine the effects of root particle size and soil inorganic N status on root decomposition and N mineralization. Greenhouse-grown Austrian winter pea (Pisum sativum), crimson clover (Trifolium incarnatum), and hairy vetch (Vicia villosa Roth) were characterized for length of coarse (\> 1-mm diameter) and fine (\< 1-mm diameter) root fractions, and total surface area. Fine roots comprised greater than 70% of total root mass for all species, indicating that these fractions are likely an important, and often overlooked, source of C and N to soils where cover crops are grown. After 12 weeks of controlled growth chamber decomposition, of the original mass, only 9% of hairy vetch and 14% of crimson clover fine roots remained, while remaining coarse roots were 12% for hairy vetch and 19% for crimson clover. Root N release proceeded most rapidly early in the incubation, especially from fine roots, which released 40 to 50% of their N, and coarse roots 11 to 30%, after only one week. There also was a net increase in soil inorganic N for all treatments after 12 weeks. These results indicate that under favorable soil temperature and moisture conditions, legume cover crop coarse and fine root fractions decompose readily and may function as an early season source of N for subsequent crops. Microbial Processes Related to Decomposition: To learn if cover crop species and/or termination approach affected soil microbial processes related to decomposition and carbon accrual, soil samples (0-15 cm depth) were taken from our two field study sites located in Kinston and Goldsboro, North Carolina, each having 12 treatment combinations of three termination methods (disk, flail, and spray) and four cover types (no cover crop, Austrian winter pea, hairy vetch, and crimson clover. Compared to disking and spraying, flail mowing significantly increased soil microbial biomass C by ~17%, C mineralization by ~25%, N mineralization by ~16%, and nitrification potential by ~36%, 12 weeks after cover crop termination. The activities of soil enzymes (exoglucanase, β-glucosidase, and β-glucosaminidase) appeared to be more responsive to cover species than to termination methods. Among three cover crops, Austrian winter pea showed the greatest positive effects on nitrification potential, β-glucosidase, and β-glucosaminidase. The ratio of C mineralization to microbial biomass C also differed with cover types, being lowest in Austrian winter pea. Our results indicated that legume species even with small differences in C-to-N ratio and lignin and cellulose contents could have varied effects on soil microbial properties and processes. Nitrification potential, representing the function of a small group of soil microbial community, was proven to be sensitive to both legume species and termination methods. In this final year we are continuing analysis of soil heavy and light fractions of particulate organic matter, as well as the C and N content of particulate organic matter obtained by soil density fractionation. Obj 2: Our second objective was to select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. Based on biomass contribution from objective one, hairy vetch was chosen as the species of interest for this objective. A total of 240 rhizobia strains were isolated from nodules grown in both inoculated and

un-inoculated soils, and their dna analyzed using rep-PCR and sequence analysis. This allowed us to select a smaller subset of 25 rhizobia that were genetically dissimilar, and that may have differences in nitrogen fixation potential with hairy vetch. Surprisingly, genomic fingerprints that included both rhizobia from inoculated plants and those from un-inoculated soils indicated low levels of relatedness between inoculated plant rhizobia and recommended hairy vetch inoculant strains. In 2013, these 25 rhizobia strains were assessed for nitrogen fixation efficiency with hairy vetch, and genetic similarity to inoculant strains added at legume planting. Growth chamber experimental units including one strain per pot were arranged in a randomized complete block design, using ten replicates of un-inoculated, nitrogen-free negative controls and 4 positive fertilized controls. Growth chamber results show plants inoculated with native strains to have greater nodule number and mass than those inoculated with strains isolated from field-grown inoculated plants, but lower nitrogen concentrations. In summary, native strains were shown to be competing with recommended hairy vetch inoculant rhizobia added at planting, with native strains occupying most nodules. Native strains were found to be both high and low performers. Obj 3: Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop soil fertility and organic matter, and host 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel. Obj 4: Develop and execute a professional development extension-training course for graduate students preparing to work in careers with practicing farmers. Obj 5: Develop course \"Climate Change & Agriculture\" for upper level undergraduate and graduate students. Detailed summary results of objectives 3-5 are covered under \"Products-Events and Products\" in this report. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Journal Articles Status: Published Year Published: 2015 Citation: Jani, A.D. Grossman, J.M., Smyth, T.J., Hu, S. 2015. Winter annual legume cover crop root decomposition and N release dynamics under disking and roller-crimping termination approaches, Renewable Agriculture and Food Systems, Available online. doi:10.1017/S1742170515000113 2. Type: Journal Articles Status: Published Year Published: 2015 Citation: Jani, A.D. Grossman, J.M., Smyth, T.J., Hu, S. 2015. Influence of soil inorganic nitrogen and root diameter size on legume cover crop root decomposition and nitrogen release, Plant and Soil 393(1):57-68. 3. Type: Journal Articles Status: Published Year Published: 2014 Citation: Liang, S., Grossman, J.M., Shi, W. 2014 Microbial response to winter cover cropping management during transition to organic farming, European Journal of Soil Biology 65:15-22. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Brown, M., Grossman, J. Shi, W., Reberg-Horton, S.C. Evaluating termination methods of leguminous cover crops for optimizing nitrogen synchrony, Ecological Society of America Conference, 97th Annual, August 5th-10th, 2012. Portland, OR. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Liang ST, Grossman J, Shi W. 2012. Microbial response to winter cover cropping management during transition to organic farming. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Brown, M., Grossman, J. Horton, S.C. and Shi, W. The influence of termination techniques on plant available nitrogen mineralized from winter annual leguminous cover crops. ASA-CSSA-SSSA International Annual Meetings, 22-24th 2012, Cincinnati, OH. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Rutz, J., Grossman, J. Jani, A. 2012. Potential contributions of legume cover crop root biomass to labile organic matter pools. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Grossman, J. Schroeder-Moreno, M., Jayaratne, K. S. U., Smith, S. Application of service-learning in two courses for a hands-on, minds-in, and hearts-felt educational experience. National Association for College Teachers of Agriculture (NACTA) Conference, July 25-29, 2013, Blacksburg, VA 9. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Shelton, J. Gudigopuram B. R., Raczkowski C.W., and Grossman, J. Decomposition rates of legume winter cover crops and nutrient release under three kill methods. ASA, CSSA, and SSSA international annual meetings; Nov 3-6, 2013 Tampa, FL.

2012/09 TO 2013/08 What was accomplished under these goals? Obj 1: In 2011 enzyme activities showed no difference between plots with cover crops and no-cover crop controls; in 2012 all cover crop species appeared to increase enzyme activities, except for peroxidase, when compared with control treatments. IN 2013, soil samples (0-15 cm depth) were taken from our study sites located in Kinston and Goldsboro, North Carolina, each having 12 treatment combinations of three termination methods (disk, flail, and spray) and four cover types (no cover crop, Austrian winter pea \Pisum sativum\, hairy vetch \Vicia dasycarpa\, and crimson clover \Trifolium incarnatum\). In this final year we continued analysis of soil heavy and light fractions of particulate organic matter, and associated enzyme activity (exoglucanase, β-glucosidase, and β-glucosaminidase), as well as the C and N content of particulate organic matter obtained by soil density fractionation. Spring 2013 also marked the completion of aggregate stability, hot water extractable carbohydrate, microbial biomass C, bulk density, soil moisture, cover crop biomass production, and microbial respiration data collection for 2013 Goldsboro growing season. Root morphology studies were completed and two manuscripts are currently being prepared for publication as a result of the graduate student research.With regard to organic matter fractionation in 2013, soil

light fraction mass, C, and N varied by termination method, with cover crop plots terminated via disking being greatest. In contrast, cover crop species did not affect the quantity, but rather the quality of soil light fraction. Compared to crimson clover, Austrian winter pea produced soil light fraction with the greatest C:N ratio. Soil light fraction mass was inversely related to the activities of exoglucanase, β-glucosidase, β-glucosaminidase, and peroxidase. We found that crimson clover plots had higher microbial biomass carbon than non-cover cropped plots. Non-cover cropped plots had higher aggregate stability than cover cropped plots, which decreased as tillage intensity increased. Soil respiration was stimulated by tillage, possibly as a result of increased microbial access to previously protected organic matter. There was no effect of termination treatment on hot water extractable carbohydrates. In summary, our data provides evidence that cover crop species affect the quality of organic matter deposition as well as soil microbial activity, while termination approach used to kill winter cover crops affects the amount of active fraction organic matter (in this case, light fraction) present within the first year following kill. A separate litterbag study showed that cover crop biomass buried under flail mowed plots decomposed at a more accelerated rate relative to the other two termination approaches. In particular, this study showed that termination approach can decrease soil aggregate stability (a measure of soil quality) as soil disturbance (tillage) increases. Obj 2: In 2013, a total of 25 rhizobia strains were assessed for nitrogen fixation efficiency with hairy vetch and genetic similarity to inoculant strains added at legume planting. Growth chamber experimental units including one strain per pot were arranged in a randomized complete block design, using ten replicates of uninoculated, nitrogen-free negative controls and 4 positive fertilized controls. Genomic fingerprints indicated low levels of relatedness of inoculated plant rhizobia to recommended hairy vetch inoculant strains. Growth chamber results show plants inoculated with native strains to have greater nodule number and mass than those inoculated with strains isolated from field-grown inoculated plants, but lower nitrogen concentrations. In summary, native strains were shown to be competing with recommended hairy vetch inoculant rhizobia added at planting, with native strains occupying most nodules. Native strains were found to be both high and low performers. Current work is underway to tease apart competitive abilities between native rhizobia strains. Obj 3: All deliverables met in previous years Obj 4: With few opportunities for gaining Extension experience during their college careers, new Extension personnel may feel ill prepared to deliver information to audiences outside of the realm of academia. As part of our funded NIFA project we organized a national webinar series and associated face-to-face class at NC State, Excellence in Organic Extension in Fall 2013, organized jointly with the E-extension portal eOrganic. This 4-session webinar series provided training for graduate students and others hoping to work directly with farmers in their future jobs, in four areas: 1) How to develop and deliver a farmer-friendly talk; 2) utilizing social media to engage and interact with your audience; 3) how to plan and put on an engaging, informative and successful field day; and 4) improving your program by evaluating your Extension program with feedback and follow-up. The national webinars attracted between 100-300 registrants, higher than many eOrganic webinars. A majority of participants were current Extension personnel, ranging from 28-55% of participants. Many predicted that they would use elements of each webinar, with most participants saying that they would use the information 'somewhat' or 'a lot' (the top likert scale score). Of the total participating in each webinar, 84% gave one of these two responses for developing a farmer friendly talk; 81% of social media participants; 76% of field day participants, and finally, 80% of the evaluation participants, showing that a clear majority of participants took something useful away from the webinar series. An attempt was made to offer an equivalent for-credit class at NC State with live presentations from extension personnel, however enrollment was limited, with only two students signing up after extensive promotion. In summary: There is a clear interest in professional development for extension training within organic agriculture, with current extension personnel among the most curious about ways they can expand their teaching toolbox to increase effectiveness. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Shelton, J. Reddy, G.B., Raczkowski, C.W., Grossman, J. Decomposition rates of legume winter cover crops and nutrient release under three kill methods. Soil Science Society of America Annual Meetings, Tampa, FL, Nov 3-6, 2013. 2. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Grossman, J., Seehaver, S., Sooksa-nguan, T., Parr, M. Effects of Vicia Villosa cover crop inoculation on rhizobia ecology in organic farming systems of the Southeastern United States. Soil Science Society of America Annual Meeting Nov 3-6, 2013, Tampa, FL. 3. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Jani, A. Grossman, J., Hu. S. and Smyth, T.J. Effect of Root Morphology and Termination Approach on Legume Cover Crop Root Decomposition, 98th ESA Annual Meeting August 4 - 9, 2013, Minneapolis, MN. 4. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Grossman, J. Schroeder-Moreno, M., Jayaratne, K. S. U., Smith, S. Application of service-learning in two courses for a hands-on, minds-in, and hearts-felt educational experience. National Association for College Teachers of Agriculture (NACTA) Conference, July 25-29, 2013. 5. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Bloszies, S.A., J.M. Grossman, J.L. Heitman, S.C. Reberg-Horton, S. Hu. Managing for soil carbon in organic agroecosystems with cover crops and reduced tillage. Soil Science Society of North Carolina Annual Meeting, January 22, 2013.

2011/09/01 TO 2012/08/31 Obj 1: In 2011 enzyme activities showed no difference between cover crop treatments and controls with no cover crop. In 2012, all cover crop treatments appeared to increase enzyme activities except for peroxidase, when compared with control treatments. Among cover crop species, hairy vetch showed the least effect on enzyme activity. For termination methods, chemical desiccation had the lowest enzyme activity in both years. Flail mowing stimulated enzyme activity more than disking or spraying in 2011. However, the difference between flail and disk treatments disappeared in 2012. With regard to soil aggregation at Kinston, prior to termination, there were no differences in either MWD or percentages within individual size fractions between all species and the control plots. Fourteen weeks post-termination, there was again no difference in either MWD or individual size fractions between ground covers or between termination approaches. Microbial biomass carbon was considerably higher at CEFS in 2012 than in Kinston in 2011. At this site, before termination, significant depth and cover-depth interaction effects were found. After termination, significant cover crop species, depth, cover-termination method-depth interaction, date and cover-date interaction effects were found. When monitoring root decomposition at Kinston, a trend of more rapid decomposition of crimson clover compared to the other cover crops over the 16-week period. Crimson clover roots had the lowest lignin content and highest surface area, both of which are conducive to rapid decomposition. However, no significant differences in decomposition between species in Goldsboro were observed. Termination method effect on decomposition was significant for some treatments in both locations. The main effect of termination method was significant in Kinston with roots from rolled plots decomposing faster than disked plots. At this same site, the general trend was for slower initial rate of decomposition within 4 weeks of termination in bare plots where cover crops were not grown. In Goldsboro, there was no overall effect of termination approach on decomposition rate, however the trend of slower decomposition rate in controls was observed over the entire 16-week period. Morphologically, crimson clover was found to produce significantly greater total root length than both Austrian winter pea and hairy vetch. Hairy vetch, in turn produced greater total root length than Austrian winter pea. Crimson clover also produced greater total fine root length (\< 2.0 mm) than Austrian winter pea and hairy vetch. Obj 3: Teaching modules from course SSC 428 in 2011 included 1) Cover Crop Use and Management, and in 2012 included 2) Vermicomposting, 3) Thermophilic Composting, 4) Soil Biology, and 5) The Carbon Cycle. All lesson plans have been delivered to IFFS for use in their programming. Obj 5: The CEFS workshop included 29 attendees. Students enrolled in the Climate Change and Agriculture course ranked it significantly higher than our departmental average, especially with regard to improving student knowledge on the subject (mean of 4.8 out of 5.0). Outputs pending for Objectives 2 and 4.

2010/09/01 TO 2011/08/31 Changes in knowledge and action related to cover crop use were documented from our field workshop and from the student service-learning activities. When participants in our workshop were asked which concepts learned from the CEFS workshop they will now use in their farming systems, responses indicated that they will 1) wait until plants are mostly flowered before tilling under, 2) inoculate, 3) modify the types of cover crops used, 4) experiment with termination techniques (mow v. incorporate), 5) plant cover crop this fall, and 6) modify planting date for cover crops, among other responses. According to our evaluation plan, participants will be contacted 6 months following the workshop to follow up on any long-term changes in farming practice resulting from the workshop information. Changes in knowledge also resulting from student participation in the service-learning course where NCSU undergraduates taught agriculture lessons to children in low-income neighborhoods with community gardens. Increases in a number of student skills were link to program participation, including improved ability to work as part of a team, ability to adapt and improvise, development of new skills for educating groups of individuals, improved understand challenges faced by underserved communities, and increased comfort teaching agriculture to a diverse population.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Liang ST, Grossman J, Shi W. Microbial response to winter cover cropping management during transition to organic farming. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 2. Rutz, J., Grossman, J. Jani, A. 2012. Potential contributions of legume cover crop root biomass to labile organic matter pools. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. (Undergraduate student poster competition First Place winner) 3. Bloszies, S., S. Hu, C. Reberg-Horton, J. Grossman, and J. Heitman. Managing for soil carbon in organic agroecosystems with cover crops and reduced tillage. CEFS Field Day, May 2, 2012, Goldsboro, NC.

2010/09/01 TO 2011/08/31 1. 1.Parr, M. and Grossman, J. Nitrogen Fixation and Legume Cover Crops in North Carolina. Fifty-Fourth Annual Meeting of the Soil Science Society of North Carolina, January 19-20, 2011 Raleigh, NC. 2. 2.S. Chris Reberg-Horton, Scott Wells, Adam Smith, Julie Grossman, Mary Parr, and George Place, Weed Management Impacts of Roll Killed Cover Crops for Organic Corn and Soybeans, S. Northeast Weed Society Meeting, Jan 3-6, 2011, Baltimore, MD. **SUPPLEMENTARY DATA:** **Institution Type:** SAES **Coop Dept:** Plant Pathology **Region:** 2 **Process Date:** 2010/09/07 **Progress Update:** 2014/03/05 **Program Code:** 112.E

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Evaluating the Potential of Winter Cover Crops for Carbon Sequestration in Degraded Soils Transitioning to Organic Production

Accession No.	0223756
Project No.	NC09799
Contract / Grant No.	2010-51106-21872
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Hu, S.; Hu, S.; Shi, W.; Meijer, A.; Reddy, G.
Performing Institution	Soil Science, NORTH CAROLINA STATE UNIV, RALEIGH, NORTH CAROLINA 27695

NON-TECHNICAL SUMMARY

There is a critical need for information about how the effects of organic agriculture, specifically cover crop combinations, are quantified when assessments for carbon sequestration are employed to determine associated incentive payments. This project will strengthen organic production in the long-term by providing information about how to best manage cover crop residue in Southern climates during the transition process to retain and protect recently added carbon. As policy makers move in the direction of recognizing and subsidizing carbon as a key indicator of environmental services it is important to develop scientific datasets to support organic farms as leaders in this capacity. This project joins together Southeastern U.S leaders in organic agriculture research, including North Carolina State University (NCSU), the Center for Environmental Farming Systems (CEFS) and North Carolina Agricultural & Technical University (NCA&T) to respond to farmer concerns about soil carbon sequestration through a fully integrated research-, education- and extension-based project. The primary long term goals of this project are: (1) Evaluate common and novel cover crops for their potential to contribute to soil organic matter development to develop tools for conservation planners to quickly identify beneficial practices for transitioning organic farmers, and (2) develop models for educating agricultural stakeholders, future extension leaders (students), and low-income urban populations about the benefits and challenges of cover crop use. To meet our first goal we will study the contribution of cover crop plant biomass additions to soil carbon by investigating the microbial processes controlling both decomposition and stabilization of added carbon. To meet our second goal we will use a multi-tier outreach approach to disseminate the information produced by our proposed research. Specific outreach efforts include: 1) hosting 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel, with particular emphasis placed on small and limited-resource farmers in the Southeast, 2) developing and piloting 5 cover crop teaching lessons for low-income urban populations using urban gardens to increase food security, and 3) designing two academic components including an upper-level oClimate Change & Agricultureo course and a unique extension training program for graduate students, the Young Extension Professionals (YEP) program. The goal of YEP is to train effective extension personnel and farmer communicators following completion of their academic program.

OBJECTIVES

Global concerns about the rapidly rising CO2 in the atmosphere, coupled with the promise of future payments for captured carbon, have prompted a renewed interest in soil C sequestration, especially in organic systems where application of complex organic materials is a common management practice. This project will strengthen organic production in the long-term by providing information about how to best manage cover crop residue in Southern climates during the transition process in order to retain and protect recently added carbon. The primary long term

goals of this project are: Goal (1) Evaluate common and novel cover crops for their potential to contribute to soil organic matter development in order to develop tools for conservation planners to quickly identify beneficial practices for transitioning organic farmers, and Goal (2) develop models for educating agricultural stakeholders, future extension leaders (students), and low-income urban populations about the benefits and challenges of cover crop use. Our supporting objectives for our first goal include: Objective (1): Evaluate root and shoot contributed-C of both grass and legume cover crop species to determine C sequestration potential; and Objective (2): Select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. The timeline and outputs for our first two research objectives include the following: Fall/Winter of 2011 and 2012 we will plant our field trials at two field sites in North Carolina, taking data in the Spring and Summer of 2012 and 2013. Rhizobia evaluation will be completed by the end of 2011. At least two manuscripts will be produced based on the findings of our research in 2013. To meet our second goal we will use a multi-tier outreach approach to disseminate the information produced by our proposed research. Specific outreach and educational objectives include: Objective (3): Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop soil fertility and organic matter in low-income neighborhoods where community gardens are located. Objective (4): Develop a professional development extension training program for graduate students, the Young Extension Professionals (YEP) program, including two field days at the Center for Environmental Farming Systems designed and carried out in-part by graduate student trainees. Objective (5): Develop a new course \"Climate Change & Agriculture\" for undergraduate and graduate students. The timeline and outputs for teaching and outreach objectives 3-5 include the following: The \"Climate Change & Agriculture\" course will be held twice in Spring semester of 2012 and 2013. The YEP program offerings will be held each Fall and Spring semester over two years: Fall 2011, Spring 2012, Fall 2012, and Spring 2013. A fifth offering will be made available based on student interest. Two CEFS workshops will be offered in each summer of our project: Summer 2012 and 2013. Cover crop teaching modules will be designed by students each Fall semester of Fall 2011 and 2012, with 2-3 modules developed per class group.

APPROACH

Objective (1): Evaluate root and shoot contributed-C of both grass and legume cover crop species to determine C sequestration potential. We will collect C- related data of cover crop treatments to help us understand how direct C contribution and indirect microbial activities leading to long-term protection and stability vary among cover crop species and management techniques commonly used in organic agriculture. We will use a split plot design on transitioning organic land at two field sites, including 4 levels of main-plot cover crop termination method (roll, mow/incorporation, mow/surface residue, burndown with herbicide). Sub-plots will be a completely randomized design including 6 levels of legume species and appropriate no-cover crop control. Direct measures of C contribution include cover crop shoot biomass, root C biomass, soil nutrients, and particulate organic matter (POM). Indirect measures of cover crop C contribution include indicators of C protection and stabilization such as bacterial:fungal biomass ratios using marker fatty acids, soil enzyme activity, dissolved organic matter (DOM), and mineralization and respiration one month after cover crop termination. Objective (2): Select high-fixation rhizobia appropriate for use with legume cover crops. We will use REP-PCR molecular characterization approaches, and traditional growth chamber assessment to assess a collection of over 800 strains of N-fixing rhizobia bacteria for hairy vetch. Objective (3): Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop organic matter. The Grossman lab has established a successful partnership with an NGO focused on developing community gardens programming in two low-income neighborhoods. As part of the undergraduate Soil Agroecology/Ecological Soil Management course, students will develop 5-6 teaching modules related to cover crop management to be taught to neighborhood residents where gardens are located. Modules will be developed and tested by students in Grossman\'s Fall course in each of the 3 project years, and will become part of the NGO\'s educational curriculum. Objective (4): Develop a professional development extension training course. This project purposefully involves this project\'s graduate students and post-doc trainees (4), plus our SARE project\'s PhD student, in a unique and much needed training program to develop highly skilled extension personnel who are extremely knowledgeable about organic agriculture practices. This Young Extension Professional (YEP) program will involve extension enrichment professional development workshops over 3 years on topics necessary for successful agricultural extension. Objective (5): Develop a new course \"Climate Change & Agriculture\" for undergraduate and graduate students. We (Hu, Grossman) will develop a new upper-level undergraduate / graduate student course named \"Climate Change & Agriculture\". This course aims at developing a comprehensive understanding of the cause and effects of global climate change, its social, economic and ethical dimensions, and its impacts on the productivity and sustainability of agricultural lands. **KEYWORDS:** climate change; cover crops; soil carbon; nitrogen fixation; n fixation; biological nitrogen fixation; rhizobia; legumes; global warming; extension; service learning; soil fertility; hairy vetch; crimson clover; pom; soc; soil enzymes; decomposition; dom; roots

PROGRESS

2010/09 TO 2015/08 Target Audience:Students: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Minority and underserved target audiences: In Y1, students in SSC 428 taught their soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. In 2011 and 2012 Dr. Grossman mentored 3 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to this project\'s goals (legume cover crops and rhizobia ecology). Dr. Grossman also served as a guest lecture at NCSSM in 2011 and 2012 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. Farmers: Farmers were directly impacted by the presentations listed under \'Products - Events\', with nine presentations geared toward farmers or extension personnel presented over the life of the project. We organized and delivered 2 half-day face-to-face field-based workshops and training opportunities for farmers, organic educators, and NRCS personnel. The first workshop, \"Growing Your Own N: Improving Legume Cover Crop Management\" was held in April 2011 at a North Carolina organic field crop farm. This workshop emphasized farmer-friendly tools for quantifying the amount of nitrogen contributed by legume cover crops. Changes in knowledge and action related to cover crop use were documented from our field workshop (summarized in Products-Events in this final report). The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series and had 29 attendees from around the state. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Three graduate students trained: Three North Carolina State University graduate students were trained as part of this project, two at the M.S. level (Arun Jani and Shangtao Liang), and one PhD student, Sean Bloszies. One M.S. graduate student was trained at North Carolina Agricultural and Technical University (NCA&T), Jason Shelton. Six graduate students taught: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Extension personnel trained: eOrganic online webinar series trained approximately 500 registrants in online Excellence in Organic Extension webinar series. Four national webinars each attracted between 100-300 registrants, exceeding many other eOrganic webinars. A majority of participants were current Extension personnel, ranging from 28-55% of participants. Minority and underserved target audiences: In Y1, students in SSC 428 at NC State taught soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. 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The first workshop, \"Growing Your Own N: Improving Legume Cover Crop Management\" was held in April 2011 at a North Carolina organic field crop farm. This workshop emphasized farmer-friendly tools for quantifying the amount of nitrogen contributed by legume cover crops. Changes in knowledge and action related to cover crop use were documented from our field workshop (summarized in Products-Events in this final report). The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series and had 29 attendees from around the state. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. How have the results been disseminated to communities of interest?Results of this project have been disseminated in multiple diverse ways.

First, three peer-reviewed published manuscripts and six published abstracts (posters or talks) have been presented at a national level to reach scientific audiences. Another is pending revision and will be submitted for peer review within two months. Second, multiple graduate students were involved, including four trained at the M.S. or PhD level, and those involved in our Climate Change and Agriculture course at NCSU. Since organic farmers are one of the primary beneficiaries of this project, a third group to whom we disseminated our information included farmers. or those that train farmers. These efforts included two half-day workshops, and eight shorter 1-2 hour workshops to farmer-focused audiences. Fourth, we disseminated information through undergraduate students enrolled in our service learning-course in which soils and cover crop lesson plans were designed and taught to diverse minority audiences in the Raleigh, NC region. A more detailed account of how the results have been disseminated, and evaluation results of each of these approaches, is presented in the \"Products\" section of this final report. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Students: Same as previous years Minority and underserved target audiences: In 2011, 2012, and 2013 Dr. Grossman mentored 3-4 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to legume cover crops and rhizobia ecology. Dr. Grossman also served as a guest lecture at NCSSM in 2011, 2012 and 2013 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. Changes/Problems: The PI on this award will be moving to the Univerisity of Minnesota in June 2013, prior to the end of our first no-cost extension year. The post-doc funded by this project will also be relocating and will complete the molecular rhizobia assessment when our lab is up and running again. One sttudent manuscript is in review, and two additional manuscriipts will be submitted for the first round of review in the next two months. We are requesting an additional no-cost extension year to complete the molecular assessment. What opportunities for training and professional development has the project provided? This project trained three graduate students and one post-doc. Two were masters students and are in the process of submitting their work for publicatoin (Jani and Liang). One is a PhD student who is completing his first manuscript (Bloszies). The post-doc (Sooksa-nguan) is completing the rhizoba molecular assessment. As presented above, a webinar series entitled Excelence in Organic Extension was organized by the post-doc for a national audience through eOrganic and provided numerous opportunities for professional development of current and future extension personell. How have the results been disseminated to communities of interest? Invited presentations to farmer groups, academic classes, or the public Grossman, J. Soil fertility in organic systems. Carolina Farm Stewardship Association Conference, November 17, 2013, Durham, NC. Grossman, J. and Hitt, A. Workshop: Cover Crops. August 19, 2013. Chatham County Cooperative Extension in conjunction with Debbie Roos, Silk Hope, NC. Grossman, J. Putting Legumes to Work on Organic Farms. Annual Sustainable Agriculture Seminar Series, The Pennsylvania State University, January 17, 2013, State College, PA. Grossman, J. Managing Plant-Soil-Microbe Relationships for Better Soil Fertility. Southern Sustainable Agriculture Working Group (SAWG), January 25 and January 26, 2013, Little Rock, AK. Grossman, J. Legume Cover Crops in an Organic System. Carolina Farm Stewardship Association Conference, December, 2012, Greenville, SC.Invited speaker, North Carolina School of Science and Mathematics 'Labs for Learning' program for high-potential minority 9th graders. guest lecture 7/2013Invited speaker, North Carolina School of Science and Math Mini-Term course on local food and sustainable agriculture. 2/2013 What do you plan to do during the next reporting period to accomplish the goals? Project completion involves two significant goals: - Submit for publication five peer-reviewed manuscripts. Planned include two from Jani, one from Bloszies, one from Liang and one from Sooksa-nguan. - Complete rhizobia molecular assessment and summarize results in a peer-reviewed manuscript

2011/09/01 TO 2012/08/31 OUTPUTS: In Y2 we established two two fields, located in Kinston and Goldsboro/CEFS, NC. Cover crop species included hairy vetch, crimson clover, and Austrian winter pea and four termination treatments (flail, disk, roll, and chemical-spray). We mentored 1 post-doc, 4 graduate students, and one undergraduate. Obj 1: Develop an understanding of contributed-C of cover crop species to determine species C sequestration potential. Decomposition parameters included three lignin-cellulose extracellular enzyme activities \[β-glucosidase (BG), exoglucanase (EXG), β-glucosaminidase (NAG) and peroxidase (PER)\], net C and N mineralization, nitrification potential, and soil aggregation. Soil samples were collected 1 week before and 14 weeks after termination in 2011 and 2012 to determine microbial biomass carbon and nitrogen (MBC/MBN), hot water soluble carbohydrates, and water stable aggregation. Shoot and root litterbags were employed in order to monitor decomposition rates. Bags were removed at regular intervals throughout growing season and contents analyzed for C, N and P. Root morphology was assessed using PVC cylinders for 12 weeks, analyzed with WinRhizo software. Obj 2: Select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. As a confirmation of rhizobia status, 350 rhizobia strains were

screened for expression of the nitrogen-fixation nitrogenase gene (NifH) Strains screening positive for the NifH gene were fingerprinted using rep-PCR. Twenty-five strains were selected for further study. A growth chamber study has been initiated to determine selected strain effects on nodule mass, plant biomass, and total plant nitrogen. Obj 3: Develop and pilot 5 teaching modules for urban educational farms, and host 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel. In fall 2011 six students were enrolled in the course SSC 428 Service-Learning for Urban Food Production Systems and in 2012 five were enrolled. Students taught 8-weeks of lessons to one underserved communities where urban gardens are based. The second of the two workshops was held at the Center for Environmental Farming Systems in July 2012 as part of the Seasons of Sustainable Agriculture workshop series. The workshop emphasized proper inoculation of cover crop legume seeds to positively affect growth and development of these species in the field. Obj 4: Develop and execute a professional development extension training course for graduate students preparing to work in careers with practicing farmers. We have continued conversations with eOrganic regarding making this a nationally-available program. Obj 5: Develop a new course \"Climate Change & Agriculture\" for upper level undergraduate and graduate students. In 2010 six graduate students enrolled, as well as several visiting scholars. Each week involved a different guest lecture, supplemented by lectures by Drs. Hu and Grossman, plus recent literature. PARTICIPANTS: Julie Grossman, PI, Supervises all project activities, post-doctoral researcher, undergraduate trainees, and co-advises Plant Pathology graduate student, co-teaches -Climate Change in Agriculture- course, helps organize YEP program. Shuijin Hu, Co-PI, advises plant pathology graduate student, oversees soil aggregate work, co-teaches -Climate Change in Agriculture- course. Wei Shi, Co-PI, advises Soil Science M.S. student, oversees all soil enzyme activity work. G.B. Reddy, Co-PI, advises NCA&T M.S. student, oversees all root decomposition and quantification work. Alan Meijer, Co-PI, organizes and helps instruct YEP program. Amanda Roth is a biology undergraduate student assisting with the rhizobia diversity experiments and learning lab culture techniques. Jacob Rutz is an undergraduate researcher assessing total root carbon present in field sites at cover crop termination. TARGET AUDIENCES: Students: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Many visiting faculty also regularly attended our course. In SSC 428, the service-learning course, 11 students over two years were enrolled who on a weekly basis taught soil science and gardening lessons to underserved youth in the Raleigh, NC region. Minority and underserved target audiences: In Y1, students in SSC 428 taught their soil science lessons to students enrolled in a Horticulture course at Longview School, a Raleigh alternative school for middle and high school youth who have not been successful in traditional public school settings. A majority of these students were from minority backgrounds. Y2, students in SSC 428 also taught weekly lessons to a \'manufactured home\' community comprising both Hispanic and African American youth in the lessons. In 2011 and 2012 Dr. Grossman mentored 3 minority male youth in her laboratory from the School of Science and Math (NCSSM) in Durham, NC, where students carried out short-term research projects related to legume cover crops and rhizobia ecology. Dr. Grossman also served as a guest lecture at NCSSM in 2011 and 2012 for the Labs for Learning program, designed to pipeline high-potential minority middle school students to NCSSM. All activities involved presentation of results from research funded by this project. PROJECT MODIFICATIONS: Changes in Y1 reflected the need to condense YEP extension programming for graduate students into one course rather than annual workshops on each proposed extension topic. Current difficulties in scheduling the online YEP program with eOrganic web based program have resulted in delays deciding which semester the course will be taught. Currently It is scheduled to be offered during 2013, likely in the fall.

2010/09/01 TO 2011/08/31 OUTPUTS: In Y1 we have established one of the two field plots, located in Kinston, NC. Cover crop species included Auburn Early Cover variety of hairy vetch, Auburn Sunrise crimson clover, Austrian winter pea, and balansa clover. Experiment was harvested in May, 2011 using four proposed termination treatments. Biomass was dried, ground and analyzed for C and N content. We have sampled for particulate organic matter (POM) at the baseline and post-termination time points. We are mentoring 1 post-doc, 3 graduate students, and 3 undergraduates and one high school student. Recruitment of a post-doctoral scholar resulted in the recent hire of an expert in soil microbial communities and rhizosphere activities. We have also recently hired a graduate student at NCA&T who will be conducting the root-related experiments with the post-doc. The student will assess greenhouse-grown plant roots and use Win-Rhizo software to assess cover crop root architecture. Two graduate students will be based at NCSU, one (Ph.D. Plant Pathology) will assess aggregate size and stability of soils under the different cover crops and termination treatments and the other (M.S. Soil Science) will investigate enzyme activity under decomposing mulches. Three additional students were hired as bi-weekly labor; two conducting field experiment maintenance and help with service-learning project, another carrying out the rhizobia evaluation, and a third minority high school student from the NC School of Science and Math providing general assistance. Ten students are registered for the service-learning course, Service-Learning for Urban Food Production Systems, in which five teaching modules on cover crop use and management for urban settings will be developed. We will pilot the new modules in two communities, Parish Manor, which is primarily Hispanic, and the Longview Alternative School Horticulture program. In April 2011 Dr. Julie Grossman and her

service-learning team was awarded the Opal Mann Green Engagement Award from NCSU for her work in community based teaching and learning. The extension-training program for graduate students (YEP) will be a nationally aired webinar series through eOrganic, and a syllabus has been developed. A workshop was offered as part of the CEFS Seasons of Sustainable Agriculture workshop series, presenting growers with information they could use to understand legume cover crop management on their farm and took place on an organic grain farm in Eastern North Carolina. Twenty-five individuals participated including farmers, extension personnel, students, NRCS staff and others. PARTICIPANTS: INDIVIDUALS. Julie Grossman, PI, Supervises all project activities, post-doctoral researcher, undergraduate trainees, and co-advises Plant Pathology graduate student, co-teaches -Climate Change in Agriculture- course, helps organize YEP program. Shuijin Hu, Co-PI, advises plant pathology graduate student, oversees soil aggregate work, co-teaches -Climate Change in Agriculture- course. Wei Shi, Co-PI, advises Soil Science M.S. student, oversees all soil enzyme activity work. G.B. Reddy, Co-PI, advises NCA&T M.S. student, oversees all root decomposition and quantification work. Alan Meijer, Co-PI, organizes and helps instruct YEP program. Max Sherard, undergraduate helping with field maintenance and service-learning student research. Greg Wilson, graduate student in Agricultural Education at NCSU helping with summer field maintenance. Malik Oliver, High school student at NC School of Science and Math, provides general lab and field assistance. Brenna Hannapel, undergraduate student conducting rhizobia diversity growth chamber study. PARTNER ORGANIZATIONS. Inter-Faith Food Shuttle, Non-profit food bank organizing Farm and Community Gardens project with whom NCSU students collaborate as part of the service-learning experience. eOrganic / Alex Stone; Collaborating to design Young Extension Professionals (YEP) webinar series to train graduate students interested in organic agriculture extension employment. Longview Alternative School / Mr. Patrick Faulkner; Horticulture program at alternative school for youth on probation at traditional high schools. NCSU students pilot cover crop teaching modules with Mr. Faulkner\'s class. TRAINING AND PROFESSIONAL DEVELOPMENT. One post-doc level trainee, three graduate student trainees, 4 undergraduate trainees, one high school trainee. Other: -Growing Your Own N: Cover Crop Management for Your Farm- workshop, part of the Center for Environmental Farming Systems (CEFS) workshop series. Young Extension Professional (YEP) Program to train graduate students interested in organic agriculture extension employment. Pre-Service-Learning training; 6h workshop for undergraduates enrolled in -Service-Learning for Urban Food Production Systems- course, including diversity and teaching training for students. -Soil Science and Organic Farming- - presentation to high-potential minority middle school students, NC School of Science and Math, Durham, NC. -CAALS 3D Summer Research Experience- for Minority School of Science and Math students, hands-on 3d training experience in organic agriculture and cover crop nitrogen fixation for three high school juniors. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Budget reductions at NCA&T have eliminated the Plant and Soil Science major in which the graduate student was to be enrolled, and greatly delayed the hiring of the student at this institution. Based on reviewer comments of our original proposal, changes were made to the proposal to more closely link the activities at NCA&T to the activities at NCSU. To this end, the NCA&T graduate student will be conducting the root-related experiments together with the post-doc. The student at NCA&T will also take many classes at NCSU as part of his graduate program.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Summary of overall project: This project determined the degree to which planting cover crop legumes in organic systems can impact soil carbon levels in degraded Southeastern soils transitioning to organic production. One of our most striking findings was that tiny fine cover crop roots are an enormous contributor to both soil nitrogen and carbon, with more than 70% of total cover crop roots systems made of these tiny fine roots, and 40-50% of their nitrogen released in only a week after cover crops are killed. Given this, as payment policies for soil carbon contributions are developed, cover crop roots should be considered. Further, this project provided food production knowledge to over 50 underserved youth in Raleigh, NC through our service-learning organic agriculture programming, and developed teaching curricula that will be used into the future by organic garden-based educational NGO\'s. Moving beyond the content of educational programs, we provided tools related to how to best educate in the realm of organic production. We did this by providing training through a national webinar series on how to be an effective extension educator, including from 100-300 registrants at each of the four offered webinars, and through training of 12 undergraduate students on how to develop lessons and teach organic agriculture to diverse urban audiences. Obj 1: Develop an understanding of contributed-C of cover crop species to determine species C sequestration potential. Shoot and root decomposition and soil microbial processes were assessed to evaluate the suitability of several legume cover crops and termination methods for organic transition in southeastern USA. Roots: In one set of experiments, root morphological characteristics relevant to root decomposition were quantified for three legume cover crop species, followed by a controlled incubation to determine the effects of root

particle size and soil inorganic N status on root decomposition and N mineralization. Greenhouse-grown Austrian winter pea (Pisum sativum), crimson clover (Trifolium incarnatum), and hairy vetch (Vicia villosa Roth) were characterized for length of coarse (\> 1-mm diameter) and fine (\< 1-mm diameter) root fractions, and total surface area. Fine roots comprised greater than 70% of total root mass for all species, indicating that these fractions are likely an important, and often overlooked, source of C and N to soils where cover crops are grown. After 12 weeks of controlled growth chamber decomposition, of the original mass, only 9% of hairy vetch and 14% of crimson clover fine roots remained, while remaining coarse roots were 12% for hairy vetch and 19% for crimson clover. Root N release proceeded most rapidly early in the incubation, especially from fine roots, which released 40 to 50% of their N, and coarse roots 11 to 30%, after only one week. There also was a net increase in soil inorganic N for all treatments after 12 weeks. These results indicate that under favorable soil temperature and moisture conditions, legume cover crop coarse and fine root fractions decompose readily and may function as an early season source of N for subsequent crops. Microbial Processes Related to Decomposition: To learn if cover crop species and/or termination approach affected soil microbial processes related to decomposition and carbon accrual, soil samples (0-15 cm depth) were taken from our two field study sites located in Kinston and Goldsboro, North Carolina, each having 12 treatment combinations of three termination methods (disk, flail, and spray) and four cover types (no cover crop, Austrian winter pea, hairy vetch, and crimson clover. Compared to disking and spraying, flail mowing significantly increased soil microbial biomass C by ~17%, C mineralization by ~25%, N mineralization by ~16%, and nitrification potential by ~36%, 12 weeks after cover crop termination. The activities of soil enzymes (exoglucanase, β-glucosidase, and β-glucosaminidase) appeared to be more responsive to cover species than to termination methods. Among three cover crops, Austrian winter pea showed the greatest positive effects on nitrification potential, β-glucosidase, and β-glucosaminidase. The ratio of C mineralization to microbial biomass C also differed with cover types, being lowest in Austrian winter pea. Our results indicated that legume species even with small differences in C-to-N ratio and lignin and cellulose contents could have varied effects on soil microbial properties and processes. Nitrification potential, representing the function of a small group of soil microbial community, was proven to be sensitive to both legume species and termination methods. In this final year we are continuing analysis of soil heavy and light fractions of particulate organic matter, as well as the C and N content of particulate organic matter obtained by soil density fractionation. Obj 2: Our second objective was to select high-fixation rhizobia symbionts appropriate for use with legume cover crops with the highest potential for C contribution. Based on biomass contribution from objective one, hairy vetch was chosen as the species of interest for this objective. A total of 240 rhizobia strains were isolated from nodules grown in both inoculated and un-inoculated soils, and their dna analyzed using rep-PCR and sequence analysis. This allowed us to select a smaller subset of 25 rhizobia that were genetically dissimilar, and that may have differences in nitrogen fixation potential with hairy vetch. Surprisingly, genomic fingerprints that included both rhizobia from inoculated plants and those from un-inoculated soils indicated low levels of relatedness between inoculated plant rhizobia and recommended hairy vetch inoculant strains. In 2013, these 25 rhizobia strains were assessed for nitrogen fixation efficiency with hairy vetch, and genetic similarity to inoculant strains added at legume planting. Growth chamber experimental units including one strain per pot were arranged in a randomized complete block design, using ten replicates of un-inoculated, nitrogen-free negative controls and 4 positive fertilized controls. Growth chamber results show plants inoculated with native strains to have greater nodule number and mass than those inoculated with strains isolated from field-grown inoculated plants, but lower nitrogen concentrations. In summary, native strains were shown to be competing with recommended hairy vetch inoculant rhizobia added at planting, with native strains occupying most nodules. Native strains were found to be both high and low performers. Obj 3: Develop and pilot 5 teaching modules for urban educational farms using cover crops to develop soil fertility and organic matter, and host 2 traditional face-to-face workshops and training opportunities for farmers, organic educators, and NRCS personnel. Obj 4: Develop and execute a professional development extension-training course for graduate students preparing to work in careers with practicing farmers. Obj 5: Develop course \"Climate Change & Agriculture\" for upper level undergraduate and graduate students. Detailed summary results of objectives 3-5 are covered under \"Products-Events and Products\" in this report. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Journal Articles Status: Published Year Published: 2015 Citation: Jani, A.D. Grossman, J.M., Smyth, T.J., Hu, S. 2015. Winter annual legume cover crop root decomposition and N release dynamics under disking and roller-crimping termination approaches, Renewable Agriculture and Food Systems, Available online. doi:10.1017/S1742170515000113 2. Type: Journal Articles Status: Published Year Published: 2015 Citation: Jani, A.D. Grossman, J.M., Smyth, T.J., Hu, S. 2015. Influence of soil inorganic nitrogen and root diameter size on legume cover crop root decomposition and nitrogen release, Plant and Soil 393(1):57-68. 3. Type: Journal Articles Status: Published Year Published: 2014 Citation: Liang, S., Grossman, J.M., Shi, W. 2014 Microbial response to winter cover cropping management during transition to organic farming, European Journal of Soil Biology 65:15-22. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Brown, M., Grossman, J. Shi, W., Reberg-Horton, S.C. Evaluating termination methods of leguminous cover crops for optimizing nitrogen synchrony, Ecological Society of America Conference, 97th Annual, August 5th-10th, 2012. Portland, OR. 5. Type: Conference Papers and

Presentations Status: Published Year Published: 2012 Citation: Liang ST, Grossman J, Shi W. 2012. Microbial response to winter cover cropping management during transition to organic farming. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Brown, M., Grossman, J. Horton, S.C. and Shi, W. The influence of termination techniques on plant available nitrogen mineralized from winter annual leguminous cover crops. ASA-CSSA-SSSA International Annual Meetings, 22-24th 2012, Cincinnati, OH. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Rutz, J., Grossman, J. Jani, A. 2012. Potential contributions of legume cover crop root biomass to labile organic matter pools. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Grossman, J. Schroeder-Moreno, M., Jayaratne, K. S. U., Smith, S. Application of service-learning in two courses for a hands-on, minds-in, and hearts-felt educational experience. National Association for College Teachers of Agriculture (NACTA) Conference, July 25-29, 2013, Blacksburg, VA 9. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Shelton, J. Gudigopuram B. R., Raczkowski C.W., and Grossman, J. Decomposition rates of legume winter cover crops and nutrient release under three kill methods. ASA, CSSA, and SSSA international annual meetings; Nov 3-6, 2013 Tampa, FL.

2012/09 TO 2013/08 What was accomplished under these goals? Obj 1: In 2011 enzyme activities showed no difference between plots with cover crops and no-cover crop controls; in 2012 all cover crop species appeared to increase enzyme activities, except for peroxidase, when compared with control treatments. IN 2013, soil samples (0-15 cm depth) were taken from our study sites located in Kinston and Goldsboro, North Carolina, each having 12 treatment combinations of three termination methods (disk, flail, and spray) and four cover types (no cover crop, Austrian winter pea \[Pisum sativum\], hairy vetch \[Vicia dasycarpa\], and crimson clover \[Trifolium incarnatum\]). In this final year we continued analysis of soil heavy and light fractions of particulate organic matter, and associated enzyme activity (exoglucanase, β-glucosidase, and β-glucosaminidase), as well as the C and N content of particulate organic matter obtained by soil density fractionation. Spring 2013 also marked the completion of aggregate stability, hot water extractable carbohydrate, microbial biomass C, bulk density, soil moisture, cover crop biomass production, and microbial respiration data collection for 2013 Goldsboro growing season. Root morphology studies were completed and two manuscripts are currently being prepared for publication as a result of the graduate student research.With regard to organic matter fractionation in 2013, soil light fraction mass, C, and N varied by termination method, with cover crop plots terminated via disking being greatest. In contrast, cover crop species did not affect the quantity, but rather the quality of soil light fraction. Compared to crimson clover, Austrian winter pea produced soil light fraction with the greatest C:N ratio. Soil light fraction mass was inversely related to the activities of exoglucanase, β-glucosidase, β-glucosaminidase, and peroxidase. We found that crimson clover plots had higher microbial biomass carbon than non-cover cropped plots. Non-cover cropped plots had higher aggregate stability than cover cropped plots, which decreased as tillage intensity increased. Soil respiration was stimulated by tillage, possibly as a result of increased microbial access to previously protected organic matter. There was no effect of termination treatment on hot water extractable carbohydrates. In summary, our data provides evidence that cover crop species affect the quality of organic matter deposition as well as soil microbial activity, while termination approach used to kill winter cover crops affects the amount of active fraction organic matter (in this case, light fraction) present within the first year following kill. A separate litterbag study showed that cover crop biomass buried under flail mowed plots decomposed at a more accelerated rate relative to the other two termination approaches. In particular, this study showed that termination approach can decrease soil aggregate stability (a measure of soil quality) as soil disturbance (tillage) increases. Obj 2: In 2013, a total of 25 rhizobia strains were assessed for nitrogen fixation efficiency with hairy vetch and genetic similarity to inoculant strains added at legume planting. Growth chamber experimental units including one strain per pot were arranged in a randomized complete block design, using ten replicates of uninoculated, nitrogen-free negative controls and 4 positive fertilized controls. Genomic fingerprints indicated low levels of relatedness of inoculated plant rhizobia to recommended hairy vetch inoculant strains. Growth chamber results show plants inoculated with native strains to have greater nodule number and mass than those inoculated with strains isolated from field-grown inoculated plants, but lower nitrogen concentrations. In summary, native strains were shown to be competing with recommended hairy vetch inoculant rhizobia added at planting, with native strains occupying most nodules. Native strains were found to be both high and low performers. Current work is underway to tease apart competitive abilities between native rhizobia strains. Obj 3: All deliverables met in previous years Obj 4: With few opportunities for gaining Extension experience during their college careers, new Extension personnel may feel ill prepared to deliver information to audiences outside of the realm of academia. As part of our funded NIFA project we organized a national webinar series and associated face-to-face class at NC State, Excellence in Organic Extension in Fall 2013, organized jointly with the E-extension portal eOrganic. This 4-session webinar series provided training for graduate students and others hoping to work directly with farmers in their future jobs, in four areas: 1) How to develop and deliver a farmer-

friendly talk; 2) utilizing social media to engage and interact with your audience; 3) how to plan and put on an engaging, informative and successful field day; and 4) improving your program by evaluating your Extension program with feedback and follow-up. The national webinars attracted between 100-300 registrants, higher than many eOrganic webinars. A majority of participants were current Extension personnel, ranging from 28-55% of participants. Many predicted that they would use elements of each webinar, with most participants saying that they would use the information 'somewhat' or 'a lot' (the top likert scale score). Of the total participating in each webinar, 84% gave one of these two responses for developing a farmer friendly talk; 81% of social media participants; 76% of field day participants, and finally, 80% of the evaluation participants, showing that a clear majority of participants took something useful away from the webinar series. An attempt was made to offer an equivalent for-credit class at NC State with live presentations from extension personnel, however enrollment was limited, with only two students signing up after extensive promotion. In summary: There is a clear interest in professional development for extension training within organic agriculture, with current extension personnel among the most curious about ways they can expand their teaching toolbox to increase effectiveness. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Shelton, J. Reddy, G.B., Raczkowski, C.W., Grossman, J. Decomposition rates of legume winter cover crops and nutrient release under three kill methods. Soil Science Society of America Annual Meetings, Tampa, FL, Nov 3-6, 2013. 2. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Grossman, J., Seehaver, S., Sooksa-nguan, T., Parr, M. Effects of Vicia Villosa cover crop inoculation on rhizobia ecology in organic farming systems of the Southeastern United States. Soil Science Society of America Annual Meeting Nov 3-6, 2013, Tampa, FL. 3. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Jani, A. Grossman, J., Hu. S. and Smyth, T.J. Effect of Root Morphology and Termination Approach on Legume Cover Crop Root Decomposition, 98th ESA Annual Meeting August 4 - 9, 2013, Minneapolis, MN. 4. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Grossman, J. Schroeder-Moreno, M., Jayaratne, K. S. U., Smith, S. Application of service-learning in two courses for a hands-on, minds-in, and hearts-felt educational experience. National Association for College Teachers of Agriculture (NACTA) Conference, July 25-29, 2013. 5. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Bloszies, S.A., J.M. Grossman, J.L. Heitman, S.C. Reberg-Horton, S. Hu. Managing for soil carbon in organic agroecosystems with cover crops and reduced tillage. Soil Science Society of North Carolina Annual Meeting, January 22, 2013.

2011/09/01 TO 2012/08/31 Obj 1: In 2011 enzyme activities showed no difference between cover crop treatments and controls with no cover crop. In 2012, all cover crop treatments appeared to increase enzyme activities except for peroxidase, when compared with control treatments. Among cover crop species, hairy vetch showed the least effect on enzyme activity. For termination methods, chemical desiccation had the lowest enzyme activity in both years. Flail mowing stimulated enzyme activity more than disking or spraying in 2011. However, the difference between flail and disk treatments disappeared in 2012. With regard to soil aggregation at Kinston, prior to termination, there were no differences in either MWD or percentages within individual size fractions between all species and the control plots. Fourteen weeks post-termination, there was again no difference in either MWD or individual size fractions between ground covers or between termination approaches. Microbial biomass carbon was considerably higher at CEFS in 2012 than in Kinston in 2011. At this site, before termination, significant depth and cover-depth interaction effects were found. After termination, significant cover crop species, depth, cover-termination method-depth interaction, date and cover-date interaction effects were found. When monitoring root decomposition at Kinston, a trend of more rapid decomposition of crimson clover compared to the other cover crops over the 16-week period. Crimson clover roots had the lowest lignin content and highest surface area, both of which are conducive to rapid decomposition. However, no significant differences in decomposition between species in Goldsboro were observed. Termination method effect on decomposition was significant for some treatments in both locations. The main effect of termination method was significant in Kinston with roots from rolled plots decomposing faster than disked plots. At this same site, the general trend was for slower initial rate of decomposition within 4 weeks of termination in bare plots where cover crops were not grown. In Goldsboro, there was no overall effect of termination approach on decomposition rate, however the trend of slower decomposition rate in controls was observed over the entire 16-week period. Morphologically, crimson clover was found to produce significantly greater total root length than both Austrian winter pea and hairy vetch. Hairy vetch, in turn produced greater total root length than Austrian winter pea. Crimson clover also produced greater total fine root length (\< 2.0 mm) than Austrian winter pea and hairy vetch. Obj 3: Teaching modules from course SSC 428 in 2011 included 1) Cover Crop Use and Management, and in 2012 included 2) Vermicomposting, 3) Thermophilic Composting, 4) Soil Biology, and 5) The Carbon Cycle. All lesson plans have been delivered to IFFS for use in their programming. Obj 5: The CEFS workshop included 29 attendees. Students enrolled in the Climate Change and Agriculture course ranked it significantly higher than our departmental

average, especially with regard to improving student knowledge on the subject (mean of 4.8 out of 5.0). Outputs pending for Objectives 2 and 4.

2010/09/01 TO 2011/08/31 Changes in knowledge and action related to cover crop use were documented from our field workshop and from the student service-learning activities. When participants in our workshop were asked which concepts learned from the CEFS workshop they will now use in their farming systems, responses indicated that they will 1) wait until plants are mostly flowered before tilling under, 2) inoculate, 3) modify the types of cover crops used, 4) experiment with termination techniques (mow v. incorporate), 5) plant cover crop this fall, and 6) modify planting date for cover crops, among other responses. According to our evaluation plan, participants will be contacted 6 months following the workshop to follow up on any long-term changes in farming practice resulting from the workshop information. Changes in knowledge also resulting from student participation in the service-learning course where NCSU undergraduates taught agriculture lessons to children in low-income neighborhoods with community gardens. Increases in a number of student skills were link to program participation, including improved ability to work as part of a team, ability to adapt and improvise, development of new skills for educating groups of individuals, improved understand challenges faced by underserved communities, and increased comfort teaching agriculture to a diverse population.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Liang ST, Grossman J, Shi W. Microbial response to winter cover cropping management during transition to organic farming. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. 2. Rutz, J., Grossman, J. Jani, A. 2012. Potential contributions of legume cover crop root biomass to labile organic matter pools. ASA, CSSA, and SSSA international annual meetings; 2012 Oct 21-24; Cincinnati, OH. (Undergraduate student poster competition First Place winner) 3. Bloszies, S., S. Hu, C. Reberg-Horton, J. Grossman, and J. Heitman. Managing for soil carbon in organic agroecosystems with cover crops and reduced tillage. CEFS Field Day, May 2, 2012, Goldsboro, NC.

2010/09/01 TO 2011/08/31 1. 1.Parr, M. and Grossman, J. Nitrogen Fixation and Legume Cover Crops in North Carolina. Fifty-Fourth Annual Meeting of the Soil Science Society of North Carolina, January 19-20, 2011 Raleigh, NC. 2. 2.S. Chris Reberg-Horton, Scott Wells, Adam Smith, Julie Grossman, Mary Parr, and George Place, Weed Management Impacts of Roll Killed Cover Crops for Organic Corn and Soybeans, S. Northeast Weed Society Meeting, Jan 3-6, 2011, Baltimore, MD. **SUPPLEMENTARY DATA:** **Institution Type:** SAES **Coop Dept:** Plant Pathology **Region:** 2 **Process Date:** 2010/09/07 **Progress Update:** 2014/03/05 **Program Code:** 112.E

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