ORG Project Details

Award Year 2012

6 Research Projects

PROJECT INDEX

Role of Mixed Crop-livestock Systems in Transitioning to Dryland Organic Farming in the Pacific Northwest

Accession No.	0230470
Subfile	CRIS
Project No.	WNP06412
Agency	NIFA WN.P
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2012-51106-20023
Proposal No.	2012-02965
Start Date	01 SEP 2012
Term Date	31 AUG 2015
Grant Amount	$695,078
Grant Year	2012
Investigator(s)	Reganold, J. P.; Carpenter-Boggs, L.; Huggins, D. R.; Johnson, K. A.; Painter, K. M.; Zakarison, E.
Performing Institution	Crop & Soil Sciences, WASHINGTON STATE UNIVERSITY, PULLMAN, WASHINGTON 99164

NON-TECHNICAL SUMMARY

In April 2012, we established a long-term research project on a commercial grain farm in the Palouse region of eastern Washington State. We are conducting this replicated study on a 2-ha parcel of the Zakarison Farm to measure the sustainability of three different farming systems: transitional certified organic mixed crop-livestock, integrated mixed crop-livestock, and conventional grain systems. Our project is an on-farm, grower/scientist-managed study. Our goal is to improve the competitiveness of organic mixed crop-livestock systems and their potential adoption by growers in a mainstream conventional grain-producing region. Supporting research objectives include measuring sustainability indicators of the three farming systems as follows: analysis of financial performance, based on gross receipts, total costs, net returns, and breakeven points; crop productivity, including crop yield and quality; animal productivity, including weight gain and harvested weight of sheep and feed composition and quality; greenhouse gas emissions, including methane, nitrous oxide, and carbon dioxide from soils and animals; total carbon footprint; nitrogen budgets, including inputs from fertilizers, feeds, and livestock, nitrous oxide and ammonia losses, nitrate leaching, biological nitrogen fixation, and nitrogen mineralization; soil quality assessments, including 27 physical, chemical, and biological measurements, a detailed metagenomic analysis of the soil microbial community, and soil erosion potential. Further objectives are to extend what we learn to growers and consumers and to educate students in the classroom and on the Zakarison Farm. Our research will inform our extension and teaching activities, such as eOrganic webinars and articles, field day and outreach presentations, classroom presentations, and field trips to the study site. This project addresses critical organic agriculture issues and priorities through the integration of research, extension, and teaching activites. Experience gained from our study will contribute to improvements in the production practices of organic and integrated mixed crop-livestock growers and in the ability of conventional grain growers to integrated livestock into their cropping systems. Information that our study adds to the knowledge base of mixed crop-livestock systems will expand economic opportunities for farmers and promote reduced use of agrochemicals. Benefits from our study will contribute to the enhanced sustainability of mixed crop-livestock systems in the United States.

OBJECTIVES

In April 2012, we established a long-term research project on a commercial grain farm in the Palouse region of Washington State. We are conducting this replicated study on a 2-ha parcel of the Zakarison Farm to measure the sustainability of three different farming systems: transitional certified organic mixed crop-livestock, integrated mixed crop-livestock, and conventional grain systems. Our goal is to improve the competitiveness of organic mixed crop-livestock systems and their potential adoption by growers in a mainstream conventional grain-producing region. Supporting research objectives include measuring agroecosystem components of the three farming systems as follows: Objective 1: Examine the economic performance of mixed organic and integrated sheep-wheat farms compared to conventional wheat farms in the Palouse; Objective 2: Compare the total productivity of mixed organic and integrated farms to the productivity of conventional wheat farms, accounting for crops, feed, animal products, and weed management; Objective 3: Quantify total carbon footprint; greenhouse gas (GHG) emissions including methane (CH4), nitrous oxide (N2O), and carbon dioxide (CO2); and ammonia (NH3) emissions from the three systems; Objective 4: Quantify nitrogen budgets for the three systems, including inputs from fertilizers, feeds, and livestock; gaseous losses in the form of N2O and NH3, nitrate leaching, biological nitrogen fixation, and nitrogen mineralization in the soil; Objective 5: Measure chemical, physical and biological changes in soil quality through time for the three systems, including soil organic matter, soil microbial diversity and biomass, and potential for erosion (RUSLE); Objective 6: Disseminate our findings to farmers, consumers, and research and extension agencies through presenting eOrganic webinars, articles, and chat sessions; hosting field days on the Zakarison farm; publishing extension bulletins and articles in popular trade journals; and regularly presenting at extension meetings and regional outreach events; and Objective 7: Use our research findings to teach about novel agroecological concepts in Soils, Crops, and AFS (Agricultural and Food Systems) courses at Washington State University. Long-term systems research, such as ours, is required to understand the complex interactions of agroecosystem components and processes. This project addresses critical organic agriculture issues and priorities through the integration of research, extension, and teaching activites.

APPROACH

(Obj 1): Enterprise budgets will be developed that analyze the annual profitability of the three treatments during the study period. Budgets will be created for the dissemination to the public. (Obj 2): Liveweight of all lambs and ewes will be measured before and after each stage of grazing, as will forage and wheat stubble biomass. Each feed type will be analyzed for crude, acid detergent, and more. Crop yields and wheat quality will be determined. Weed counts and weed seed bank sampling will be performed. (Obj 3): Total carbon footprint will be calculated using the Organic Farming Footprints (OFoot) Life Cycle Analysis (LCA) tool and validated with field measures of footprint components. The USDA-ARS GRACEnet gas sampling protocol will be followed for N2O, CO2, and CH4 measurements. GHG emissions associated with sheep production will be estimated. For ammonia measurements, enclosure methods will be used to account for the heterogeneity of NH3 volatilization from the plots and to minimize across-plot interference. Ammonia volatilization from sheep urine and sheep feces will be measured and ammonia volatilization from fertilizer applications will be assessed. (Obj 4): Anhydrous ammonia fertilizer inputs will be monitored and feed and seed inputs will be analyzed for N concentration. Biological N fixation, soil N pools, and nitrate leaching rates will also be measured. Nitrous oxide and ammonia fluxes will be extrapolated using the OFoot LCA emissions model. Crops will be analyzed for N total N export from crops and sheep tissue will be determined. (Obj 5): We will measure 27 chemical, physical and biological properties to monitor soil quality. Soil erosion will be calculated using RUSLE 2. Ion exchange probes will be used in-field to examine the nutrient dynamics of each system during the course of the study. One detailed metagenomic analysis (pyrosequencing) of the soil microbial community will be undertaken at the end of the project. (Stats): We will apply statistical techniques (e.g., ANOVA, LSD) to investigate how agroecosystem components are integrated within each management system and how these components compare across management systems. (Obj 6): We will subcontract with eOrganic at Oregon State University for outreach support for more efficient project management, communication, and publication. Other ongoing outreach will be provided through a webpage within csanr.wsu.edu and by field days. (Obj 7): We will give guest presentations on our study in courses in the Organic Agriculture Systems Major at WSU. Our study parcel and the Zakarison Farm will provide an excellent site for class field trips in several courses in this major. We will support undergraduate on-farm internships for WSU and University of Idaho undergraduate students. Guest lectures and field trips will also be offered for graduate student courses.

PROGRESS

2012/09 TO 2016/08 Target Audience:Target audiences include farmers, consumers, scientists, and policymakers. Efforts and outcomes with these audiences are described elsewhere. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?One full-time PhD student and two part-time PhD students, four technicians, and four undergraduate students have receivedfield and lab training to accomplish the objectives above. Additionally we participated in the Washington State UniversityUpward Bound Bridge Internship Program in 2015, in which a graduating high school student recieved field and laboratoryexperience as well as academic training. The two Field Days engaged stakeholders (farmers, citizens, faculty, students)interested in the project. Students, staff, and faculty received an education in mixed crop/livestock systems and their potentialdevelopment in the Palouse. How have the results been disseminated to communities of interest?We gave a webinar, two Field Days, several classroom presentations, visiting scientist andfarmer trial tours, and one undergraduate class field trip at WashingtonState University. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2014/09 TO 2015/08 Target Audience: Farmers, consumers, scientists, and policymakers. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?One full-time PhD student and two part-time PhD students, four technicians, and four undergraduate students have received field and lab training to accomplish the objectives above. Additionally we participated in the Washington State University Upward Bound Bridge Internship Program in 2015, in which a graduating high school student recieved field and laboratory experience as well as academic training. The two Field Days engaged stakeholders (farmers, citizens, faculty, students) interested in the project. Students, staff, and faculty received an education in mixed crop/livestock systems and their potential development in the Palouse. How have the results been disseminated to communities of interest?We gave a webinar, two Field Days, several classroom presentations, and one undergraduate class field trip at Washington State University. What do you plan to do during the next reporting period to accomplish the goals?Continue meeting the objectives of the grant proposal.

2012/09 TO 2013/08 Target Audience: Target audiencesfor this project included farmers, WSU graduate and undergraduate students, and other faculty. Efforts:We gave an eOrganic webinar; gave tours of our plots on Zakarison Farm to other farmers and WSU faculty and students; and gave presentations in Soils 101 (Organic Gardening and Farming) and Soils 502 (Graduate seminar). Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? One PhD student, one technician, and three undergraduate students have received field and lab training to accomplish the objectives above. The Webinar engaged stakeholders interested in the project. Students and faculty received an education in mixed crop/livestock systems and their potential developmnt in the Palouse. How have the results been disseminated to communities of interest? We gave one webinar, field tours of the plots, and two classroom presentations. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2012/09 TO 2016/08 What was accomplished under these goals? Objective 1: Economic performance Constructed detailed enterprise budgets for each farming system, including input costs (such as seed and fertilizer), labor costs, costs of machinery use and machinery ownership (lifespan of each piece of equipment, depreciation, and salvage value), land value, and revenues (based on local annual average pricing for grain crop yields, hay yields, and grazed forage). Used annual enterprise budgets to compare the economic performance of the farming systems across the 5 years of the project. Objective 2: Total productivity Measured total yields of grain crops (winter wheat, spring wheat, field peas) by hand-cutting 1m2 samples at a density of 35 samples per acre. Grain quality (moisture, protein, starch, test weight) was determined using a NIR grain analyzer (CropScan1000B). Total carbon and nitrogen were measured on an elemental combustion analyzer (Costech). Measured total hay and forage yields by hand-cutting samples pre- and post- grazing and haying to account for biomass that was not removed. Analyzed hay and forage quality by NDF/ADF (Ankom Technology). Total carbon and nitrogen were measured on an elemental combustion analyzer (Costech). Objective 3: Greenhouse gas and ammonia emissions Designed new large static greenhouse gas measurement chambers that comply with GRACEnet protocols and reduce spatial variability relative to smaller chambers. Performed weekly greenhouse gas measurements on 48 chamber locations for the duration of the growing season (April-October) for 2 years (2015-2016). For each chamber, 3 greenhouse gas samples were taken over 30 minutes and analyzed by gas chromatography (Shimadzu). Created and optimized semi-static ammonia chambers that are designed to trap ammonia emissions cumulatively over time using acid-coated open-cell foam. Performed weekly ammonia loss measurements on 48 chamber locations for the duration of the growing season (April-October) for 2 years (2015-2016). Estimated methane emissions from livestock grazing based on quality and quantity of forage consumed and duration of grazing. Objective 4: Nitrogen budgets Analyzed preseason (March) and postseason (September) soil profile (5-ft) samples for total nitrogen (Costech elemental combustion analyzer) and inorganic nitrogen (Astoria Pacific nitrate and ammonium analyzer) each year for 5 years. Incubated spring soil samples to determine potentially mineralizable N. Estimated biological nitrogen fixation from legumes (Austrian winter peas, field peas, alfalfa) using natural abundance 15N isotope methods (EA-IRMS). Determined plant nitrogen uptake from aboveground plant sampling and nitrogen exports from analysis of crop yields. Due to difficulty of taking detailed measurements of livestock N efficiency, used forage quality and quantity to estimate return of consumed N to the soil via urine and feces. In 4 locations, installed passive capillary lysimeters to a depth of 4 ft (Decagon G3 Drain Gauge). Water quantities and subsamples are extracted weekly in winter/spring and monthly in summer/fall. Water samples are analyzed for inorganic nitrogen (Astoria Pacific nitrate and ammonium analyzer) and total nitrogen (Shimadzu TOC/TN analyzer). Used gaseous nitrogen losses (nitrous oxide and ammonia flux) in Objective 3 to contribute to nitrogen budget estimates. Objective 5: Physical, chemical, and biological changes in soil quality Annually measured soil bulk density. Annually analyzed 5-ft soil profile samples for carbon content (Costech elemental combustion analyzer) as a proxy for organic matter. Annually analyzed surface soil samples for macro- and micronutrient availability using ion exchange membranes embedded in soil incubations (PRS Probes, Western Ag Innovators). In the final year of the project, analyzed surface soil samples for microbial biomass and enzyme activities (urease, beta-glucosidase, phosphatase, and dehydrogenase). Objective 6: Disseminate our findings to farmers, consumers, and research and extension agencies October 2013: E-Organic webinar on \"Integrating Livestock into Dryland Organic Crop Rotations\" (Lynne Carpenter-Boggs (soil scientist), Kate Painter (economist), and Jonathan Wachter (graduate student) October 2014: Field day in collaboration with Washington State University Extension, with presentations by John Reganold (PD), Jonathan Wachter (graduate student), Kate Painter (economist), Lynne Carpenter-Boggs (soil scientist), and Colleen Sanders (graduate student). 40 people in attendance. June 2015: Field day in collaboration with Washington Tilth, with presentations by Jonathan Wachter (graduate student), Rachel Wieme (graduate student), Mary Stewart (undergraduate student), and Eric Zakarison (farmer). 20 people in attendance. Objective 7: Use our research findings to teach novel agroecological concepts in soil science and crop science courses at Washington State University. 2013, 2014, 2015, 2016: Lecture for Soil Science 101 (Organic Gardening and Farming) 2015: Hosted field trip for Crop Science 302 (Forage Crops) **PUBLICATIONS (not previously reported):** 2012/09 TO 2016/08 1. Type: Book Chapters Status: Published Year Published: 2014 Citation: Wachter, J.M., and J.P. Reganold. 2014. Organic agricultural production: plants. In N.K. Van Alfen (ed) Encyclopedia of Agriculture and Food Systems, Vol. 4. Elsevier, San Diego, CA. pp. 265-286. 2. Type: Book Chapters Status: Published Year Published: 2014 Citation: Reganold, J.P., and J.M. Wachter. 2014. Organic agriculture. In Y. Wang (ed) Encyclopedia of Natural Resources, Vol. 1. Taylor & Francis, New York, NY. pp. 1-6. 3. Type: Journal Articles Status: Published Year Published: 2016 Citation: Reganold, J.P. and J.M. Wachter. 2016. Organic agriculture in the 21st century. Nature Plants. 2:e15221. 4. Type: Journal Articles Status: Published Year Published: 2016 Citation: Reganold, J.P. and J.M. Wachter. 2016. Reply to ?Are the claimed benefits of organic agriculture justified?? Nature Plants. 2:e16100. 5. Type: Journal Articles Status: Published Year Published: 2016 Citation: Reganold, J.P. and J.M. Wachter. 2016. Reply to ?Organic farming and deforestation?. Nature Plants. 2:e16101. 6. Type: Other Status: Published Year Published: 2016 Citation: Reganold, J. 2016. Organic is key to help feed the world. UCS Science Network. 3 Feb 2016. . 7. Type: Other Status: Published Year Published: 2016 Citation: Reganold, J. 2016. Can we feed 10 billion people on organic farming alone? Op-Ed, The Guardian. 14 Aug 2016, https://www.theguardian.com/sustainable-business/2016/aug/14/organic-farming-ag riculture-world-hunger 8. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Reganold, J.P. 2015. Moving agriculture into the 21st century. Tilth Producers of Washington Conference Abstracts, Spokane, WA. 9. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Reganold, J.P. 2016. Sustainable agriculture and food systems. International Conference on Promoting Sustainable Development in the DPRK, Ministry of Land and Environment Protection, Pyongyang, North Korea.

2014/09 TO 2015/08 What was accomplished under these goals? Accomplishments included the following: Objective 1: Developed and tracked farm enterprise budgets for all three treatments; Objective 2: Measured the total productivity of the three treatments, accounting for crops, feed, animal products, and weed management; Objective 3: Continued to developed and test methods for field measurements of ammonia and greenhouse gas (methane, nitrous oxide, and carbon dioxide) emissions, and then carried out the methods for the field measurements; Objective 4: Quantified nitrogen budgets for the three systems, including inputs from fertilizers, seed, and, biological nitrogen fixation, pools of inorganic and organic nitrogen, and nitrogen mineralization in the soil and via grazing; Objective 5: Measured chemical, physical and biological soil properties for the three systems; Objective 6: Presented two Field Days at the Zakarison Farm on the project\'s economics and environmental measurements (one in collaboration with the Tilth Producers of Washington) and gave a webinar on mixed crop/livestock systems; and Objective 7: Gave presentations in Soils 101 (Organic Gardening and Farming), Crops/Hort 102 (Introduction to Cultivated Plants), and Hort 425 (Trends in Horticulture), and led a field trip and lecture for Crops 302 (Forage Crops) at Washington State University. **PUBLICATIONS (not previously reported):** 2014/09 TO 2015/08 1. Type: Book Chapters Status: Published Year Published: 2014 Citation: Wachter, J.M., and J.P. Reganold. 2014. Organic agricultural production: plants. In N.K. Van Alfen (ed) Encyclopedia of Agriculture and Food Systems, Vol. 4. Elsevier, San Diego, CA. pp. 265-286. 2. Type: Book Chapters Status: Published Year Published: 2014 Citation: Reganold, J.P., and J.M. Wachter. 2014. Organic agriculture. In Y. Wang (ed) Encyclopedia of Natural Resources, Vol. 1. Taylor & Francis, New York, NY. pp. 1-6. Progress 09/01/13 to 08/31/14 Outputs Target Audience: Farmers, consumers, scientists, and policymakers. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? One PhD student, two technicians, and four undergraduate students have received field and lab training to accomplish the objectives above. The Field Day engaged stakeholders (farmers, citizens, faculty, students) interested in the project. Students and faculty received an education in mixed crop/livestock systems and their potential development in the Palouse. How have the results been disseminated to communities of interest? We gave a webinar, a Field Day, and a classroom presentation at Washington State University. What do you plan to do during the next reporting period to accomplish the goals? Continue meeting the objectives of the grant proposal. Impacts What was accomplished under these goals? Accomplishments included the following: Objective 1: Developed and tracked farm enterprise budgets for all three treatments; Objective 2: Measured the total productivity of the three treatments, accounting for crops, feed, animal products, and weed management; Objective 3: Developed and tested methods for field measurements of ammonia and greenhouse gas (methane, nitrous oxide, and carbon dioxide) emissions; Objective 4: Quantified nitrogen budgets for the three systems, including inputs from fertilizers, seed, and, biological nitrogen fixation, pools of inorganic and organic nitrogen, and nitrogen mineralization in the soil and via grazing; Objective 5: Measured chemical, physical and biological soil properties for the three systems; Objective 6: Presented a Field Day at the Zacharison Farm on the project\'s economics and environmental measurements; and Objective 7: Gave presentations in Soils 101 (Organic Gardening and Farming) at Washington State University. Publications

2012/09 TO 2013/08 What was accomplished under these goals? Accomplishments include the following: Objective 1: Developed and tracked farm enterprise budgets for all three treatments; Objective 2: Measured the total productivity of the three treatments, accounting for crops, feed, animal products, and weed management; Objective 3: Developed and tested methods for field measurements of ammonia and greenhouse gas (methane, nitrous oxide, and carbon dioxide) emissions; Objective 4: Quantified nitrogen budgets for the three systems, including inputs from fertilizers, seed, and, biological nitrogen fixation, pools of inorganic and organic nitrogen, and nitrogen mineralization in the soil and via grazing;Objective 5: Measured chemical, physical and biological soil properties for the three systems; Objective 6: Presented an eOrganic webinar and gave tours of plots; and Objective 7: Gave presentations in Soils 101 (Organic Gardening and Farming) and Soils 502 (Seminar) at Washington State University. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 No publications reported this period.

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Assessing, Modeling, and Maximizing Ecosystem Services in Long-term Organic and Transitioning Farming Systems

Accession No.	0230562
Subfile	CRIS
Project No.	OHO01096-SS
Agency	NIFA OHO
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2012-51106-20008
Proposal No.	2012-02981
Start Date	01 SEP 2012
Term Date	31 AUG 2015
Grant Amount	$749,170
Grant Year	2012
Investigator(s)	Grewal, P. S.; Islam, K. R.; McCoy, E. L.; Kumarappan, S.; Sundermeier, A.
Performing Institution	Entomology, OHIO STATE UNIVERSITY, 1680 MADISON AVENUE

NON-TECHNICAL SUMMARY

Producing healthy food for the expected 9 billion people without harming the environment is one of the society\'s grand global challenges. Ecosystem services provided by the soil food web are the basis of sustainability in all terrestrial ecosystems, but these webs in agroecosystems are degraded, short and dominated by opportunists at the entry level. Organic farming systems enhance soil quality and biodiversity, but data on their impact on environmental outcomes are lacking. Here we propose to fill this knowledge gap by evaluating the impact of a novel combination of no-till, multi-functional cover crops, and organic amendments as tools to reduce greenhouse gas emissions (CO_2, CH_4, and N_2O) and NH_3 volatilization, increase carbon sequestration and N and P accumulation, reduce nutrient losses by soil erosion and leaching, increase soil food web structural and functional diversity, increase energy flow in soil ecosystems, decrease weed and insect pressure, and enhance natural biocontrol activity in a corn-soybeans-spelt rotation on long-term organic farms and transitioning experimental plots fully equipped with run-off and leaching facilities. Multi-functional cover crops will include winter pea and crimson clover (N-fixers), oats and cereal rye (weed suppressors) and oilseed radish (reactive N and P recycler, compaction alleviator, and disease minimizer) and organic amendment will be the mined Zeolite (reactive N trapper). We will also develop tools to measure and model the supporting (nutrient cycling, soil aggregate stability), regulating (biological control, C sequestration), and provisioning (food production) components of the ecosystem services, and (iii) develop and conduct educational programming for farmers.

OBJECTIVES

Specific objectives are: 1) To determine the effects of variable tillage operations, multi-functional cover crops, and mined Zeolite on soil quality, greenhouse gas emissions including ammonia volatilization, C sequestration, N and P accumulation, soil erosion and leaching, cover crop biomass N contribution to crops, weed and pest pressure, belowground biocontrol activity, and yield in certified organic and transitioning farms. 2) To develop suitable tools to measure and model the supporting (nutrient cycling, soil quality), regulating (C sequestration and greenhouse gas emissions, soil erosion and leaching, biological control), and provisioning (food production) components of the ecosystem services provided by organic systems and practices. 3) To develop and conduct educational and outreach programming to provide information and tools for enhancing ecosystem services of organic and transitioning systems. The proposed research will deliver enhanced understanding of the processes and/or mechanisms by which ecosystem services are affected by tillage, crop rotation with cover crops and zeolite in organic and transitioning systems for scientists, farmers, regulators, policy makers, and the general public. We expect that biomass-N contributed from winter pea and crimson clover and nutrient recycling by radish, oats and rye in the corn-soybean-spelt rotation will be economically and environmentally sustainable. The GHG and NH3 emissions will decrease and C, N, and P sink will increase in SOM within 3-yrs of organic farming, as compared to conventional system. It is our expectation that the proposed NT, cover cropped, and zeolite amended organic system will sequester C by 500 to 800 kg/ha/yr within 15 cm soil depth. A substantial reduction in sediment and nutrient loadings from our organic system with cover crops and zeolite is expected. At least a 80% decrease in reactive N and P loss by soil erosion and 50% reduction in leaching of reactive N is expected. Greater retention of C, N, and P in SOM will improve soil quality, support higher production, increase farm income, and enhance overall ecosystem services.

APPROACH

We will test two tillage operations (No-till Vs. Conventional) and three soil amendment levels (0, 50 or 100 lb of mined Zeolite) imposed in our holistic crop rotation with multifunctional cover crops at three different sites across the state of Ohio. The holistic crop rotation will be (1) early maturity corn (95 day rather than 108 day) followed by Daikon radish and annual rye as mixed cover crops, (2) early maturity soybean (2.5 maturity rather than 3) followed by spelt as a grain and cover crop; and (3) and Spelt followed by Alaskan pea, crimson clover, radish and oat as mixed cover crops. Early maturity corn and soybeans will allow about 10 to 14 d earlier harvest and better establishment of fall cover crops. A RCB design with 2 tillage systems x 3 levels of zeolite x 4 rep in factorial arrangement will be established. All the crops will be planted in phases so that each crop will be on the ground each year. Results on numerical values of soil quality will be translated into a simple field test kit (color chart) that would be quick, non-toxic, sensitive to management practices, reliable, and user-friendly, closely related to ecosystems functionality, and able to predict crop yield. The field test kit will identify soil quality as poor, fair, good and excellent ratings; N and P fertility as high, optimum, medium, and low ratings; soil biological activity as high, medium, and low ratings; soil aggregate stability as highly stable, stable, and weak ratings; and greenhouse gas and ammonia emissions as high, medium, and low source or sink ratings Progress 09/01/12 to 08/31/15 Outputs Target Audience: Nothing Reported Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? PD left University, nothing to report. Publications Progress 09/01/13 to 08/31/14 Outputs Target Audience: Organic growers, researchers and students Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Presented results at the Field day at the Ohio Agricultural Research and Development Center (OARDC) in Wooster organized of the Ohio Food and Farming Education and Research (OFFER) program for organic farmers, conducted plot demonstrations and shared project results. How have the results been disseminated to communities of interest? Developed and presented a poster at the NIFA Projector Director\'s Meeting in Washington, DC on October 21-22, 2014. Developed and presented a poster at ESA Annual Conference in Portland, Oregon on December 16-19, 2014. Results were also disseminated to farmers at the OFFER Field day in Wooster, Ohio. What do you plan to do during the next reporting period to accomplish the goals? Continue to collect data on soil quality, greenhouse gas emissions, ammonia volatilization, C sequestration, N and P accumulation, soil erosion and leaching, cover crop biomass N contribution to crops, weed and pest pressure, predator abundance, arthropod diversity, belowground biological control services, soil nematode community, belowground biocontrol activity, and crop yields. Impacts What was accomplished under these goals? Set up field experiments on multifunctional cover crops with two tillage levels and three Zeolite levels at three locations across the state: Piketon (transitioning to organic), West Salem (certified organic), Bowling Green (certified organic). Continued to collect data on soil quality, greenhouse gas emissions, ammonia volatilization, C sequestration, N and P accumulation, soil erosion and leaching, cover crop biomass N contribution to crops, weed and pest pressure, predator abundance, arthropod diversity, belowground biological control services, soil nematode community, belowground biocontrol activity, and crop yields throughout the first two years of the project. Publications

PROGRESS

2012/09 TO 2013/08 Target Audience: Organic growers, researchers and students Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Organized a

Field day at Bowling Green for organic farmers, conducted plot demonstrations, and shared project results Organized a workshop for organic growers at the Ohio Educational Food and Farming Association (OEFFA) meeting and presented research result How have the results been disseminated to communities of interest? Developed and presented a poster at the Ohio Agricultural Research and Development Center's Annual Conference. Results were also disseminated to farmers at the Field day at Bowling Green and at the OEFFA Workshop. What do you plan to do during the next reporting period to accomplish the goals? Continue to collect data on soil quality, greenhouse gas emissions, ammonia volatilization, C sequestration, N and P accumulation, soil erosion and leaching, cover crop biomass N contribution to crops, weed and pest pressure, predator abundance, arthropod diversity, belowground biological control services, soil nematode community, belowground biocontrol activity, and crop yields. Organize additional workshops for growers and present results at a professional meeting.

2012/09/01 TO 2015/08/31 Target Audience: Nothing Reported Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2012/09 TO 2013/08 What was accomplished under these goals? Set up field experiments on multifunctional cover crops with two tillage levels and three Zeolite levels at three locations across the state: Piketon (transitioning to organic), West Salem (certified organic), Bowling Green (certified organic). Collected data on soil quality, greenhouse gas emissions, ammonia volatilization, C sequestration, N and P accumulation, soil erosion and leaching, cover crop biomass N contribution to crops, weed and pest pressure, predator abundance, arthropod diversity, belowground biological control services, soil nematode community, belowground biocontrol activity, and crop yields throughout the year. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 No publications reported this period.

2012/09/01 TO 2015/08/31 What was accomplished under these goals? PD left University, nothing to report.

PUBLICATIONS

2012/09/01 TO 2015/08/31 No publications reported this period.

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Optimizing Cover Crop Selection and Management to Enhance Agronomic and Environmental Services in Organic Cropping Systems

Accession No.	0230906
Subfile	CRIS
Project No.	NYC-145521
Agency	NIFA NY.C
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2012-51106-20116
Proposal No.	2012-02980
Start Date	01 SEP 2012
Term Date	31 AUG 2015
Grant Amount	$676,385
Grant Year	2012
Investigator(s)	Drinkwater, L. E.; Walter, M. T.
Performing Institution	Horticulture, CORNELL UNIVERSITY, ITHACA, NEW YORK 14853

NON-TECHNICAL SUMMARY

Soil management is the foundation of organic farming, and nitrogen-fixing cover crops are a key component of any organic soil fertility management regimen. Biological nitrogen fixation-in which legumes in symbiotic relationship with bacteria known as rhizobia capture atmospheric nitrogen and convert it into a form available to plants-is the major source of new nitrogen in organic agriculture. Composts or animal manures are used in conjunction with legumes to provide the remaining complement of major and minor nutrients. Legumes can provide as much as 300 pounds/acre of nitrogen, although 80-150 pounds/acre is more common. In addition to fixing nitrogen, leguminous cover crops serve multiple functions in organic farming systems. The functions we hear mentioned most often by organic growers are: 1) build soil organic matter 2) suppress weeds, 3) provide habitat for beneficials, 4) suppress disease, 5) improve soil tilth, 6) reduce nitrate leaching, and 7) reduce soil erosion. To increase the probability that a cover crop can achieve these multiple functions, organic farmers often plant mixtures that combine legumes with non-nitrogen-fixing plant species. Grasses, for example, are usually more effective for weed suppression and reducing soil erosion, while brassicas excel at capturing nitrate to reduce leaching losses, particularly in sandier soils. A major challenge faced by farmers who rely on biological nitrogen fixation as the chief source of nitrogen additions is determining how to optimize the process to meet cash crop nutrient requirements while also managing cover crops to deliver other key benefits. The long-term goal of this project is to develop guidelines that can be used by organic farmers to select the best cover crops for grain and vegetable production systems in the northeast. We will pursue questions about how organic management regimes and the resulting soil legacies interact with plant and microbial species to regulate biological nitrogen fixation and other nitrogen cycling processes that govern crop production and environmental impacts. Our approach combines on-farm research with field station experiments, farmer directed cover crop trials, and a suite of integrated outreach activities. The proposed project targets five goals: 1. Conduct research in organic and conventional farms to determine the impact of long-term organic management and specific practices on greenhouse gas emissions and other environmental services. 2. Characterize cover crops in terms of a variety of attributes that impact crop production and environmental services. 3. Improve the Denitrification-Decomposition model to simulate N_2O emissions from organically farmed landscapes in the Northeastern US. 4. Engage in

outreach activities with organic farmers and policy-makers to optimize environmental services in organic farming systems and develop metrics/tools that can be used to implement policies rewarding farmers for these services. 5. Develop and test a course that trains the next generation of agricultural scientists in how to conduct collaborative, agroecological, on-farm research.

OBJECTIVES

Goals: The long-term goal of this project is to develop effective management of C and N cycling processes, particularly biological N fixation and C/N retention pathways so that production and environmental outcomes are optimized. To that end we will pursue questions about how organic management regimes and the resulting soil legacies interact with plant and microbial species to regulate C/N cycling. Our approach combines on-farm research with field station experiments, farmer directed cover crop trials, and a suite of integrated outreach activities. The proposed project targets five goals: 1. We will conduct research in organic and conventional farms to determine the impact of long-term organic management and specific practices on GHG emissions and other environmental services. 2. We will characterize cover crops in terms of a variety of attributes that impact crop production and environmental services (soil mineral N concentrations, biological N fixation, N retention, N2O emissions, weed suppression, biomass contribution and soil P availability). 3. We will improve the Denitrification-Decomposition model to simulate N2O emissions from organically farmed landscapes in the Northeastern US and compare long-term effects of conventional and organic farming practices under different climate situations. 4. We will engage in outreach activities with organic farmers and policy-makers to optimize environmental services in organic farming systems and develop metrics/tools that can be used to implement policies rewarding farmers for these services. 5. We will develop and test a course that trains the next generation of agricultural scientists in how to conduct collaborative, agroecological, on-farm research. Expected outcomes: Goal 1: These on-farm measurements of N2O fluxes will be broadly applicable to temperate organic farming systems and will make a significant contribution to the very limited data that is currently available. The LCA of emissions resulting from different N sources will serve as a starting point to comparing trade-offs of various N sources in terms of input-derived emissions versus environmental emissions occurring in the field. Goal 2: Cover crop experiments will provide information about the performance of three key legume species and can also be used by organic grain and vegetable farmers in the northeast to fine-tune mixture composition and planting densities so that ecosystem services are optimized. Goal 3: The model results will allow us to quantify ecosystem services associated with GHG emissions across a wide range of cropland management systems, which can be used to inform farm managers to improve practices. Goal 4: Our primary outcome with respect to farmer outreach will be the improved dissemination of the latest information to beginning farmers. In addition, we will produce a consensus report that will inform the direction of further research aimed at supporting improved agricultural policy. Goal 5: We will train Cornell graduate students who will be involved in agricultural research in their future careers and publish a paper on this course that can be used by other faculty wishing to teach on this subject.

APPROACH

Experiments and data collection: Research will be conducted on working farms as well as the Cornell research farms. We have established long-term research sites consisting of fields with contrasting management histories. Our earlier detailed characterization of these sites provides the foundation for the studies we will conduct for this project. These field sites represent a gradient that varies in terms of the amount of surplus N added to the system and the proportion of N derived from BNF providing an ideal backdrop for studies aimed at understanding how agroecosystem management shapes the ecosystem processes that ultimately determine the balance between N retention and N loss. Ten experimental fields located on different landscape positions and soil textures will be selected. Each field will divided into four replicate blocks in order to obtain replicate measurements from per field. Input-output N budgets will be constructed based on a combination of grower management information and samples of biomass and crop yields. Cover crop experiments will be conducted in fields with organic and conventional management histories. Legume monocultures and mixtures will be evaluated in terms of total biomass produced, N content of shoots, proportion of N fixed, weed suppression, soil nitrate concentrations, N2O fluxes during growth, dissolved organic C and N, and particulate organic C and N. Our work with the DNDC model will use data from both of these efforts. We will investigate how the inclusion of soil moisture patterns associated with lateral subsurface flows impact DNDC predictions of N2O emissions using data from the on-farm whole field studies. The parameterization will be based on the measurements from the cover crop experiment. We will also explore modifications of DNDC source code to more explicitly accommodate polycultures (e.g., red clover frost-seeded into winter wheat) which requires tracking concurrent growth of legumes and cash crops, and also the mixture of different cover crops based on data from the cover crop experiment. Data analysis: One-way or two-way ANOVAs reveal significant effects of cover crop species, planting density and stand composition.

More sophisticated methods are needed, however, to study complex interactions among multiple correlated phenomena. Accordingly, we will use multivariate techniques like principle components analysis and canonical discriminate analysis to study the interacting effects of multiple variables on one another. In addition, path analysis will be used to untangle complex chains of convergent and divergent interactions - for example, effects of multiple soil variables on N fixation which in turn affect N flows and N2O emissions. Outreach: Our extension efforts will take advantage of the expertise and wisdom of advanced experienced organic farmers by supporting their research efforts and collaborating with them in outreach through meetings and field days. With the help of our Educator Advisory Committee, we will create instructional modules that can be adapted to a variety of learning situations, from week-long workshops to farm visitation days.

PROGRESS

2012/09 TO 2017/08 Target Audience:The target audiences include other researchers, organic and transitioning farmers, farmers considering transitioning to organic, extension educators, and university students. This past year we reached undergraduate students by providing opportunities for them to participate in research. Our collaborating farmers were included in discussions of experimental design and research planning. Lastly we reported our preliminary findings to other researchers and graduate students through our participation in an annual professional conference and soil health training activities targeting extension educators. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Over the course of the project, undergraduate and graduate students as well as early career scientists at the post-doctoral level have received training through their work on this research. The graduate students had the opportunity to develop skills in experimental design, implementing and managing a field experiment, sample collection, and data management. Dozens of undergraduate research assistants learned about how to carry out agricultural research through hands-on experiences managing and sampling field and greenhouse experiments and subsequent processing of these samples. A post-doctoral scientist was trained in systems research approaches and use of stable isotope methods in the course of their work with this project. How have the results been disseminated to communities of interest?Several papers are in preparation and will be published in 2018 to target the research community. The following presentations have been given based on research conducted for this project: Presentations completed Morris, C.K. 2017. Controls on nitrogen losses from agricultural soils and refinements to an earth systems model. Biogeochemistry, Environmental Science and Sustainability Seminar at Cornell University. 10 Feb. Morris, C.K., M.T. Walter, P.G.M. Hess. 2016. Which environmental factors drive denitrification at the global scale? Simulations using the Community Land Model (B51E-0464). 2016 Fall Meeting, AGU, San Francisco, Calif., 12-16 Dec. Reiss, E. Managing Soils for Better Crops, Groundswell Center for Local Food and Farming. Ithaca, NY. May 2016. Reiss, E. The effect of intra- and interspecific diversity of cover crops on ecosystem services in agricultural systems. New York State Producers Expo. Syracuse, NY. January 2016. Reiss, E. How Cover Crops Benefit Soil Health, Cover Crop and Reduced Tillage Workshop for Organic Vegetable Growers, USDA-NRCS Plant Materials Center, Big Flats, NY. October 2015. Reiss, E. How Cover Crops Benefit Soil Health, Soil Health Field Day, Cornell Cooperative Extension of Delaware County. September 2015. Reiss, E. Diversifying your management: incorporating cover crops and crop rotations for improved soil health. Cornell Soil Health Workshop. Ithaca, NY. August 2015. Morris, C. M.T. Walter, E. Reiss, 2015. Winter Cover Crops and Nitrous Oxide Emissions in Early Spring (B34A-03). 2015 Fall Meeting, AGU, San Francisco, Calif., 14-189 Dec. Drinkwater, L.E. Nitrogen Cycling and Soil Ecology overview. Organic Cover Crop Workshop and Tour, USDA-NRCS Plant Materials Program, Cornell Cooperative Extension, and the Northeast Farming Association of New York. October 2013. Morris, C.K., J.R. Barclay, T.R. Anderson, M.T. Walter. 2013. Characterizing denitrification hot spots and hot moments to improve understanding in a mass balance approach to the nitrogen cycle (H13E-1389). 2013 Fall Meeting, AGU, San Francisco, Calif., 9-13 Dec. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2014/09 TO 2015/08 Target Audience:The target audiences include other researchers, organic and transitioning farmers, farmers considering transitioning to organic, extension educators, and university students. This past year we reached undergraduate students by providing opportunities for them to participate in research. Our collaborating farmers were included in discussions of experimental design and research planning. Lastly we reported our preliminary findings to other researchers and graduate students through our participation in an annual professional conference and soil health training activities targeting extension educators. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The graduate student had the opportunity to develop skills in experimental design, implementing and managing a field experiment, sample collection, and data management. At least eight undergraduate research assistants had substantial hands-on experience with field data collection methods and subsequent processing. How have the results been disseminated to communities of interest?At the 2015 Ecological Society of America conference we are scheduled to present some of the initial data in a poster entitled \"The effect of intra- and interspecific diversity of cover crops on ecosystem services in agricultural systems\" Ecological Society of America Annual Meeting, Baltimore, MD, August 2015. Additionally, some of the results were presented to extension educators at the Cornell Soil Health Train-the-Trainer Workshop, also in August 2015. What do you plan to do during the next reporting period to accomplish the goals?In the next year we will finish processing all of the samples collected over the six site years. With this data processed, we can analyze the results with regard to the main objectives of the grant. All of this data combined will be a significant contribution to existing knowledge of nitrogen cycling in organic agricultural systems, and the impact on greenhouse gas emissions.

2013/09 TO 2014/08 Target Audience:The target audiences are other researchers, organic and transitioning farmers, farmers considering transitioning to organic, extension educators, and university students. This past year we reached undergraduate students by providing opportunities for them to participate in research. We also presented the work to an upper level undergraduate class in agroecology. Our collaborating farmers were included in discussions of experimental design and research planning. Lastly we reported our preliminary findings to other researchers and graduate students through our participation in an annual professional conference. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project supports the training of two doctoral students. Also, at least eight undergraduate research assistants had substantial hands-on experience with agroecological field research including data collection methods and sample processing. How have the results been disseminated to communities of interest?We presented some of our initial results from both the field experiment and meta-analysis at the Ecological Society of America Annual Meeting, Sacramento, CA (August 2014) in an invited presentations entitled: \"Can ecological knowledge be used to design cover crop mixtures that provide multiple ecosystem services?\". What do you plan to do during the next reporting period to accomplish the goals?In early September 2014 we planted the second field season of this experiment. While the main design is the same, we made a few changes to improve the conclusions following the data collection. We also added four on-farm sites through collaborations with farmers. These on-farm sites will show how a subset of these cover crop treatments will respond to different environmental conditions, and how that might change the relationship between diversity and ecosystem function. They will also demonstrate the effectiveness of these cover crop options in a real farm setting using typical farm equipment and practices. All cover crop experiments will be sampled for cover crop and weed biomass, total nitrogen content, biological nitrogen fixation, and soil N cycling processes. We will also collect extensive nitrous oxide emissions data on a subset of cover crop treatments and quantify the abundance of microbial groups that carry out key processes governing N2O emissions. In March 2015, we will have a meeting with the Advisory Committee which includes most of the collaborating growers. Lastly, we will continue our review of the published literature that evaluates the value of species diversity for increasing agricultural outcomes. We expect to publish two papers using meta-analysis to quantify the benefits of biodiversity in agricultural systems.

2012/09 TO 2013/08 Target Audience: The target audiences are other researchers, organic and transitioning farmers, farmers considering transitioning to organic, extension educators, and university students. The work is particularly relevant to organic and transitioning grain and vegetable growers. Our findings on fundamental processes and improved modeling capabilities will be broadly applicable to organic and transitioning annual cropping systems in temperate climates. We anticipate that our project will provide new information that will be useful to policy makers who are charged with developing incentive programs to promote environmental services. The work on legume cover crop roles and management tools will be relevant to farmers in the Northeast region of the US. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? This project supports the dissertation research for one graduate student and provides her with training in agroecological research. Undergraduates (2) also have benefited from gaining research experience through assisting with this project. How have the results been disseminated to communities of interest? We have shared our intentions and goals with farmers and extension staff who serve on the Project Advisory Committee, and they have provided us with useful feedback. As this was the first year of the project, we didn't have results to share at this point. What do you plan to do during the next reporting period to accomplish the goals? We will continue our meta-analysis of cultivar mixtures during the winter. In the spring of 2014 we will collect data from the experiment planted in September 2013. We will focus on the resulting environmental services from the different cover crop treatments, as well as on the characteristics of the treatments such as proportion of legumes to non-legumes. Specifically, we will measure soil N status, biological nitrogen fixation, weed suppression, total biomass production, density of legumes and non-legumes in mixture. We will also observe characteristics such as height, flowering time, nodulation status and visual density estimates. We also expect to share our initial results with our research peers as well as farmers. In addition to sharing our results, we will establish collaborations with interested farmers for on-farm trials the following field season. These on-farm sites will provide contrasting environmental conditions allowing us to observe the performance of cover crop mixtures across environmental gradients.

IMPACT

2012/09 TO 2017/08 What was accomplished under these goals? Completed to date: 1\. Extensive research has shown that greater plant community diversity leads to higher levels of productivity and other ecosystem services. Increasing intraspecific diversity with cultivar mixtures is one way to increase diversity in agricultural systems. We examined the relationship between intraspecific diversity and yield in cultivar mixtures using a meta-analysis of 91 studies and \>3600 observations. Additionally, we investigated how environmental and management factors might influence this relationship, and if the yield stability of cultivar mixtures differed from that of monocultures. This practice of mixing cultivars can be used in combination with species mixtures to create cover crop mixtures that can perform well across variable environmental conditions. The results of this meta-analysis are published in Ecological Applications. 2\. The first experiment was conducted for two years and compared the effect of intraspecific and interspecific cover crop diversity on the provision of ecosystem services (hereafter, ES) in randomized, complete block experiments located on the research station. We assessed the performance of six species of cover crops grown as monocultures, cultivar mixtures and species mixtures. We included three species in each of two functional groups, grasses and legumes. We were interested in evaluating the relative strength of intraspecific, interspecific, and functional diversity as well as the variation between cultivars of cover crop species in terms of the outcomes of the associated services. We expected species mixtures, and specifically those including both functional groups, to provide a broader range of ecosystem service outcomes compared to less diverse plantings. We were also interested in testing if the addition of multiple cultivars would improve cover crop performance. Lastly, we hypothesized that more stressful conditions, such as those related to soil fertility, would strengthen the diversity effect on the delivery of these services. Compared to species mixtures, the effect of cultivar mixtures on ES was less significant. There were only a few instances where greater intraspecific diversity increased in ES such as weed suppression and cover crop productivity. Cover crop biomass increased with increasing interspecific diversity for unfertilized grasses and grass legume mixtures, and was positively correlated with the provision of ES such as weed suppression and N supply. Differences in the soil environment, specifically soil N fertility affected ES outcomes, and mixtures moderated these responses compared to grasses and legumes alone, particularly in terms of total N uptake and C/N. Overall, we found that using cultivar mixtures provided some limited improvements in ES, while species mixtures, particularly those that enhanced functional diversity, provided consistent increases in ES. There were no drawbacks to planting cover crops with greater diversity at any level. 3\. We designed a second experiment to investigate the role of environmental variation on the relationship between cover crop diversity and ES outcomes using four farm sites in the Finger Lakes region of New York. Specifically, we tested if there was an interaction between farm and diversity effect on five ES; cover crop productivity, weed suppression, total biomass nitrogen (N), N retention, and long-term N supply via legume fixed N. We evaluated the diversity effect in three ways. With the exception of soil N uptake at one farm, the species mixtures were as good as or better than the best monoculture across all four ES. Similarly, while we did not find a positive effect from increased intraspecific diversity as we expected, we also did not find any negative impacts. We can conclude that while increasing diversity, either through cultivars or species mixtures, may not provide consistent or substantial benefits, there is very little potential risk to such mixtures despite interactions with variable environments. When N fixation is a priority, the mixture of wheat and vetch is a better choice than vetch alone as it produced equivalent fixed N at half the seeding rate of vetch. The cost of wheat seed is less than vetch, so this substitution provides fixed N at a lower cost and has the additional benefits of generally greater biomass and equivalent or better weed suppression compared to the vetch alone. 4\. We conducted a 15N tracer experiment in a long-term organic grain trial in upstate New York to measure the contribution of N from a clover cover crop to N2O emissions. Red clover (Trifolium Pratense) was labeled in situ with 15N-urea using the petiole-feeding technique. Before residue exchange, about one third of the 15N tracers were in belowground sources suggesting that cover crops allocated a significant amount of N to soils. In May 2013, prior to tillage, we exchanged the aboveground biomass in labeled and unlabeled micro-plots so that we could trace the fate of aboveground and belowground N separately. N2O emissions greatly increased after cover crop incorporation with 93% of the total N2O production occurring during the first ten weeks following incorporation. For the first six weeks after incorporation the dominant source of N2O was clover shoot. After week 7, belowground sources (root-derived N and soils) of N2O dominated. The contribution from other shoot-derived including clover litter during spring growth, overwinter biomass and fresh remnants from shoot biomass removal was estimated to be similar to that of fresh clover biomass. We also found that root-derived N (root biomass, exudates & fine root turnover) accounted for 70-85% of clover derived N remaining in the soil suggesting that legume roots play a major role in building soil N reserves. Shoot-derived N accounted for less than 10% of the N acquired by maize, but its contribution to N2O emissions was much greater; approximately 40%. This raises the possibility of harvesting legume shoots as forage prior to incorporation as a strategy to reduce N2O emissions. 5\. Growing concern for understanding the climate impact of several human activities, specifically row crop agriculture, is driving the need for more research into cover crops (hereafter CCs) ability to reduce N2O losses. By studying both leaching and N2O losses, we can understand how CCs might be used to improve N conservation in agricultural systems. We tested two common CC monocultures, wheat and vetch, and a biculture of the two (referred to as a mixture), for their relative performance in minimizing N losses during growth and following tillage (before planting the primary crop). N cycling under CCs can be considered according to their life cycle from planting to cessation by tillage to cash crop planting. In this study, we compared the cumulative N2O production between CC types for each management period (growing and post-tillage periods). This study demonstrated that the climate benefits of CCs depend on the type and period of analysis. Legumes delivered more N2O to the atmosphere post-tillage than our non-legume varieties. Neither crop type, nor a mixture of the two was effective at reducing N2O during the growth phase relative to fallow conditions. Indirect N2O emissions from denitrification of leached NO3 may tip non-legume CCs into the climate-favorable bin. Leaching measurements in the post-tillage period are recommended to assess the wider picture of avoided N2O through reduced leaching. **PUBLICATIONS (not previously reported):** 2012/09 TO 2017/08 1. Type: Journal Articles Status: Awaiting Publication Year Published: 2018 Citation: Reiss, E.R. and L.E. Drinkwater. Cultivar mixtures: a meta-analysis of the effect of intraspecific diversity on crop yield. Ecological Applications. 28:62?77. 2. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Reiss, E.R. and L.E. Drinkwater. Forthcoming. Promoting enhanced ecosystem services from cover crops using intra and interspecific diversity. Submitted to Agriculture, Ecosystems and Environment.

2014/09 TO 2015/08 What was accomplished under these goals? In early September 2014 we planted the second field season of this experiment. While the main design is the same, we added some treatments to allow for more in depth analysis of our question related to cultivar diversity. We also added four on-farm sites through collaborations with farmers. These on-farm sites will show how a subset of these cover crop treatments will respond to different environmental conditions, and how that might change the relationship between diversity and ecosystem function. They will also demonstrate the effectiveness of these cover crop options in a real farm setting using typical farm equipment and establishment practices. With six site-years total, the data we will have collected through this experiment will be very powerful in helping to address our objectives. We also collected more extensive nitrous oxide emissions data (following the trial measurements from last season). We also performed detailed soil sampling and analysis of available nitrogen and internal nitrogen dynamics. In June 2015, we collected aboveground samples to assess cover crop biomass productivity, weed suppression, and nitrogen fixation. While much of the data processing and analysis is still in progress, this second field season results seem to confirm some of the initial results we found the first year. In particular the finding that that weeds are suppressed more in mixtures of two or more cultivars of the same cover crop species compared to just one cultivar. For example, when all five cultivars of hairy vetch were mixed together, they suppressed more weeds than any one cultivar when it was planted alone. This suggests that a simple management change, such as increasing the number of cultivars in a cover crop, can provide additional weed suppression capacity in a cover crop. Additionally, weed biomass declines in mixtures with more species present. **PUBLICATIONS (not previously reported):** 2014/09 TO 2015/08 Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Reiss, E. and L.E. Drinkwater. Can ecological knowledge be used to design cover crop mixtures that provide multiple ecosystem services? Ecological Society of America Annual Meeting, Sacramento, CA, August 2014

2013/09 TO 2014/08 What was accomplished under these goals? In September of 2013 we established a field experiment at the Musgrave Research Farm. This experiment had 45 unique cover crop treatments with monocultures and mixtures of six cover crop species and cultivars along a diversity gradient. With a plus/minus fertilizer treatment across these cover crop treatments, we aimed to examine the relationship between inter and intraspecific diversity, ecosystem services, and environmental conditions. This experiment was harvested in the spring of 2014. We collected data related to cover crop biomass productivity, weed suppression, and nitrogen fixation. Additionally we sampled soil properties related to nitrogen mineralization, dissolved organic nitrogen and carbon, as well as some trial nitrous oxide emissions measurements. While much of the data processing and analysis is still in progress, one of the initial results we\'ve found is that weeds are suppressed more in mixtures of two or more cultivars of the same cover crop species compared to just one cultivar. For example, when all five cultivars of hairy vetch were mixed together, they suppressed more weeds than any one cultivar when it was planted alone. This suggests that a simple management change, such as increasing the number of cultivars in a cover crop, can provide additional weed suppression capacity in a cover crop. This result was consistent across all six cover crop species we used (hairy vetch, winter pea, crimson clover, wheat, rye, and ryegrass). This could increase the effectiveness of cover crops, further reducing the need for herbicides to control weeds in the growing season. We also continued our work on the meta analysis of mixtures of multiple cultivars of the same species grown together. While we had hoped to examine the effect of plant diversity on multiple environmental services, the literature limited us to just productivity, or yield. We compiled data from over 90 studies, resulting in more than 3500 mixtures. Overall, there is statistically significant improvement in the yield of mixtures compared to the component monoculture yields. However, the improvement is very small in an agronomic context, 2.26% increase. While the vast majority (almost 80%) of the observations fall within +/- 10% of the component monoculture yields, we are focusing on the 6% that have substantial yield penalties in mixtures, and the 15% of mixture that show significant yield benefits. Initial results suggest that characteristics the mixture was based on (disease, or physical characteristics), latitude, and fertilizer application, may each have an effect on the success of the mixture. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 No publications reported this period.

2012/09 TO 2013/08 What was accomplished under these goals? Current ecological research suggests that more diverse plant communities are more productive and have better ecosystem functioning (Hooper et al. 2005). We think this theory could help to inform the development of cover crop mixture strategies to maximize the environmental services from cover crops identified by farmers such as, 1) build soil organic matter 2) suppress weeds, 3) provide habitat for beneficials, 4) suppress disease, 5) improve soil tilth, 6) reduce nitrate leaching, and 7) reduce soil erosion. To help inform our understanding of diverse plant community dynamics, we began a quantitative literature review (meta-analysis). We focused on studies in the literature that mixed multiple cultivars of the same species together for cultivation. We restricted our search to major food crops, but we expect that the results will be applicable to cover crops. Our hypothesis is that by increasing the genetic diversity within a species, productivity and other environmental services will also be increased. During the summer of 2013 we designed a trial for implementation at a Cornell research farm to evaluate the characteristics and diversity of cover crops and their relationship to environmental services. This experiment was established in the fall of 2013 (just after this reporting period) with three legume species and three non-legumes in 18 different mixture treatments. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 No publications reported this period. **SUPPLEMENTARY DATA:** **Institution Type:** SAES **Coop Dept:** Biological & Environmental Engineering **Region:** 1 **Process Date:** 2012/08/16 **Progress Update:** 2015/01/06 **Program Code:** 112.E

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Agricultural Greenhouse Warming Potential and Soil Carbon Sequestration in Organic and Long Term Rotational Systems

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NON-TECHNICAL SUMMARY

There is a need to document farming systems effects on greenhouse gas emissions and soil carbon sequestration, especially in organic systems that include long and diverse crop rotations that have been shown to achieve equivalent yields and greater economic efficiency when competing in the economic market against conventional systems. A number of issues stand in the way of evaluating how farming systems perform in terms of sustainability: 1) Measuring soil carbon sequestration requires long-term management in a defined and monitored system experiment or natural experiment on-farm; 2) Measuring greenhouse gases accurately requires standardized methods that are comparable to internationally recognized methodologies; these are labor intensive; 3) Few studies are designed to study biochemically linked carbon and nitrogen in agroecosystems in a combined manner, even though many organic and long rotation farming systems add carbon and nitrogen in biochemically linked forms (green manure, manure, compost); 4) Many models used for extended prediction of soil carbon sequestration and greenhouse gas flux use algorithms that link carbon and nitrogen, but were parameterized based on conventional and short-term rotational agroecosystems in which there are weaker linkages between these cycles. In this research outline we propose a suite of experiments that will utilize unique sites: the Beltsville Farming Systems Project (FSP), the Mixture Injection Trial (MIT), and on-farm evaluation of farming systems to examine performance and ecosystem services provided by a diverse array of realistic long rotation organic farming systems.

OBJECTIVES

The long-term goals of this project are to improve farm management impact on greenhouse gas emissions and soil carbon sequestration in organic grain production systems and to synthesize and disseminate the most current research-based knowledge addressing organic grain production. This work will fill a critical knowledge gap that is not otherwise being met. We have worked with our stakeholders to develop the following four objectives outlined in a conceptual map in figure 3. Objectives: 1) Understand organic till, conventional no-till and organic no-till farming systems with respect to effects of animal manures, fertility timing and placement, cover crop management and tillage on greenhouse gas emissions; 2) Compare how organic farming systems that include diverse and long-term rotation accumulate soil organic carbon and improve soil quality indicators despite often employing frequent tillage and cultivation; 3) Evaluate empirical data collected in realistic crop rotations with models currently used to predict greenhouse gas emissions, soil carbon sequestration and soil health in organic systems where carbon and nitrogen inputs are biochemically linked; and 4) Disseminate the knowledge gained from on-station and on-farm research using on-farm field days, scientific and extension publications and information and webinars via the eOrganic Grain Cropping Systems Community of Practice (COP). We will also facilitate educational outreach focused on agroecological research experience by providing internships to six college and six high school students that have expressed interest in conducting real-world agroecosystems research. Students in the internship programs will be required to pursue a research question within the context of the proposed research and then present their work at the Beltsville Agricultural Research Center Science Competition (poster competition).

APPROACH

Fluxes of N_2O, CO_2, and CH_4 will be measured from 17 FSP and 18 MIT treatments on a weekly basis using standard GRACEnet protocols. Three field replicates will be sampled. Samples will be analyzed for N_2O, CO_2, and CH_4. Soil nitrate, dissolved organic carbon (DOC) and electrical conductivity (EC) will be measured continuously using Decagon data loggers during the growing season from areas near the chambers. We will calculate Global Warming Potential (GWP) using greenhouse gas flux and soil C sequestration data, and published values of CO_2 emissions from agricultural field operations and input manufacturing processes and transportation. Soil carbon sequestration will be addressed using data on soil C and N measured from soil cores taken to a depth of 1 m by subplot in all 68 FSP plots and on-farm in the winter of 2013. Cores will be taken using a Concord hydraulic probe mounted on a pick-up truck. Samples will be divided in increments of 0-10 10-20 20-30, 30-50, and 50-100 cm depth, dried. A similar set of cores will be taken from all on-farm field plots identified by farmers as differing in the history or crop rotation diversity. All soils from farms will be handled similarly to the FSP soils. Our research outcomes will provide empirical values for parameters used in the models We will run the models for each system and compare the modeled results to the empirically measured results and use sensitivity analysis to determine parameters that work well in the model and those that need adjustment when applied to farming systems that use high residue cover crops or alternative farming practices. We will use Akaike Information Criterion (AIC) comparisons to identify model parameters. The AIC is a relative goodness of fit procedure that can be applied to any statistical model. It scores each model based on a ratio of model bias to total variance in the model construction. This approach will allow us to run each ecosystem model (Daycent, DNDC, Roth-C) and identify model parameters that are most sensitive to organic management and those that are most bias when comparing conventional and organic practices. The Cornell Soil Health index will be determined for each site and the data will be used as a baseline for determination of how soils change over time under farming practices that are currently understood to improve soil health. In addition Soil Health Indices will be evaluated in comparison to the ecosystem models being tested. Correlation between Soil Health Indices and ecosystem model predictions will be identified to aid in understanding of how integrated indices such as soil health relate, total soil carbon, ecosystem model estimates of GHG emission and soil organic matter.

PROGRESS

2012/09 TO 2016/08 Target Audience:Final results of our research were shared at national and regional scientific meetings. Specifically three graduate students presented at meetings and shared the results of thier work. We also submitted four manuscripts. Three of those manuscripts are in the process of being revised for resubmission and one is still under review. A fithm manuscript is still in preparation. These research results were also shared at a USDA-ARS Beltsville field day and in a University of Maryland Extension webinar. Changes/Problems:The portion of this research that is still being analyzed is the work done on other farms within the State of Maryland. Although the main experiments took place at the USDA-ARS Beltsville, we had planned to sample a number of farmers\' fields to a depth of 1-m and to compare these microbial comminities and soil health parameters to those observed in our USDA trials. This part of the project proved difficult to accomplish. The farmers that had initially agreed to work with us proved difficult to contact and sampling around their farm schedule proved challenging. As a result, we decided to sample at the University of Maryland Experiment State farms which provided field samples comparable to the private farms we had planned to sample. Those samples were taken in Spring 2016 and are currently being analyzed by a technician that was employed on the project and continues to work for BARC. We plan to prepare a final scientific publication from those results. What opportunities for training and professional development has the project provided?This project supported the training of three master\'s degree students and numerous undergraduates. The three master\'s students all graduated successfully and each have two publications that are in some stage of publication. One of the master\'s students is now a PhD student at Standford University. Another is a current PhD student at UMD. The third student is a tier two technichian at the University of Maryland Baltimore medical school. Over the course of the project there were 13 undergraduates supported. These stufents recieved training in agricutlural science and were given opporutnities to conduct scientific research. At least three of those students are now graduate students. How have the results been disseminated to communities of interest?The results of this work were included in a fact sheet and also shared via two webinars that were hosted by University of Maryland Extension. The general public, particularly school childen were reached via outreach events. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2012/09 TO 2016/08 What was accomplished under these goals? This project accomplished several of the goals that were specified.Using sites within the Long term farming systems project and a Manure Injection Trial, we measured greenhouse gas emissions and combined that with measures of microbial diversity to understand the mechanisms that lead to increased N2O emissions. N2O emissions increased with increasing applicaiton of animal manures and these data were used to build a new model for N2O that more accurately reflects the dynamics of gas production when the crop is grown after a cover crop of rye/vetch as been roller crimped. We found that N2O is emissions are greatest under a cover crop thatch layer that results in increased surface soil moisture. Combined with these measures, we examined the spatial extent of denitrifying communities using quantitiave PCR. We were able to model the spatial variability of the denitrifying and nitrifying communities and establish that there were great populations of these microogranism in the near surface and also surrounding the roots. Part of the manure injection trial also tested subsurface banding of poultry litter in comparison to broadcasting. We observed no difference in the amout of emissions from the subsurface band versus broadcast. We advocate for the use of subsurface banding to maintian more nutrients within the system and have shown that there are no increased deterimental effects. We also examined carbon sequestraiton at the plow layer when crops are grown in long term organic rotations. We characterized the soil microbial communities at these same locaitons. Our research showed that microbial communities differ in the upper soils due to management regime, particularly when diverse cover crop mixes are used. We also showed that carbon did increase at the plow layer when cover crops were used over an 18 year period. These microbial communities drastically changed just above and just below the plow layer suggesting that management can have long term legacy effects. Our last goal was to dissiminate this research to a wide audience and this was accomplished through numerous outlets. **PUBLICATIONS (not previously reported):** 2012/09 TO 2016/08 1. Type: Journal Articles Status: Published Year Published: 2015 Citation: Dlott, G., J. Maul, J. Buyer, S. Yarwood. 2015. Microbial rRNA:rDNA gene ratios may be unexpectedly low due to extracellular DNA preservation in soils. Journal of Microbiological Methods 115: 112-120 2. Type: Journal Articles Status: Under Review Year Published: 2016 Citation: Davis, B., S. Mirsky, B. Needleman, M. Cavigelli, S. Yarwood, J. Maul. Under review. A novel method for estimating nitrous oxide flux from single point flux measurements. Journal of Environmental Quality 3. Type: Journal Articles Status: Other Year Published: 2017 Citation: Bowen, H., J. Maul, H. Poffenberger, S. Mirsky, M. Cavigelli, S. Yarwood. In prep. Spatial patterns of denitrification genes change in agricultural soils in response to fertilizer placement and cover crop species. Applied and Environmental Microbiology 4. Type: Journal Articles Status: Other Year Published: 2017 Citation: Dlott, G., J.E. Maul, J. Buyer, M. Cavielli, D.J. Epp Schmidt?, S. Yarwood. In prep. Legacy and Maintenance of a Soil Plow Layer (Ap Horizon) Affects Dispersal Patterns of Bacteria and Archaea. Soil Biology and Biochemistry 5. Type: Journal Articles Status: Under Review Year Published: 2017 Citation: B.W. Davis, S.B. Mirsky, B.A. Needleman, M.A. Cavigelli, S. Yarwood Manuscript: Nitrous oxide emissions increase exponentially with N rate from cover crops and poultry litter Journal: Nutrient Cycling in Agroecosystems 6. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Michel Cavigelli ?Soil health in organic cropping systems,? Albert Lea Seeds, Albert Lea, MN, Nov. 20, 2015 (all expenses paid) 7. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Understanding agriculture?s role in causing and preventing climate change? PASA Conference, State College, PA, Feb. 5-6 (all expenses paid) 8. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Impact of grain farming on climate change,? Maryland Nutrient Managers Webinar, March 22, 2016 9. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Cover crops and soil health,? Northeast SARE Managing Soil Health with Cover Crops?Beyond the Basics Meeting, Baltimore, MD, March 30, 2016. 10. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Long-term research at the USDA-ARS Farming Systems Project,? University of North Carolina\--Greensboro, April 22, 2016 (all expenses paid). 11. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Soil health in organic cropping systems,? Organic Confluences Conference (The Organic Center), Washington, DC, May 23, 2016. 12. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli

?Organic corn production,? National Corn Grower?s Association Meeting, Washington, DC, July 19, 2016. 13. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Agricultural Research at the Beltsville Agricultural Research Center?Addressing Unprecedented Food Production and Environmental Challenges,? Mishkan Torah Synagogue, Greenbelt, MD, 14. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Michel Cavigelli ?Long-term agroecological research at the USDA-ARS Farming Systems Project, Beltsville, Maryland.? ASA-CSSA-SSSA Annual Meeting, Nov. 15-18, 2015, Minneapolis, MN. 15. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Steven Mirsky University of Maryland, College Park 16. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Steven Mirsky Virginia Tech, Blacksburg, VA 17. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Steven Mirsky ASA, CSSA, & SSSA. St. Paul, Minnesota Agencies, NGO?s, Farmer/Ag. Professional conferences, and Private Sector 18. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Steven Mirsky The Nobel Foundation 19. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Steven Mirsky Organic Trade Association 20. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Yarwood, S. Swedish Agricultural Univeristy (SL?), Ume?, Sweden: August 14, 2015. Title: How does human landuse impact soil microbial commuities? 21. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Yarwood, S. Villanova University, Villanova, PA: November 3, 2016. Title: Shaping the soil microbiome: How do humans impact microbes and can we use that knowledge for good? 22. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Bowen, H., H. Poffenbarger, J. Maul, S. Mirsky, S. Yarwood. Ecological Society of America MidAtlantic Chapter, College Park, MD: March 29, 2014. Title: Analysis of the microbial controls on nitrogen movements and tranformation in agricultural sol. 23. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Bowen, H., H. Poffenbarger, J. Maul, S. Mirsky, M. Cavigelli, S. Yarwood. University of Maryland AGNR Open House, Clarksville, MD: October 11, 2014. Title: Spatial distribution of nitrogen cycling microorganisms in agricultural soil 24. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Dlott, G., D. J. Epp Schmidt, J. Maul, M. Cavigelli, J. Buyer, S. A. Yarwood. University of Maryland AGNR Open House, Clarksville, MD: October 11, 2014. Title: Tillage effects persist long after no-till conversion: Carbon and microbial community evidence. 25. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Davis, B., S. Mirsky, B. A. Needelman, M.A. Cavigelli, J. Maul, S.A. Yarwood. Soil Science Society of America, Long Beach, CA: November 3, 2014. Title: Nitrous oxide emissions from subsurface banded poultry litter in a cover crop-based corn system. 26. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Dlott, G.A., D. Epp Schmidt, J. Maul, M.A. Cavigelli, J.S. Buyer, S.A. Yarwood. Soil Science Society of America, Long Beach, CA: November 3, 2014. Title: Microbial communities and carbon dynamics across a depth profile in an organic and conventionally managed agricultural soil. 27. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Bowen, H., J. Maul, S. Mirsky, M.A. Cavigelli, S.A. Yarwood. Soil Science Society of America, Long Beach, CA: November 4, 2014. Title: Spatial analysis of the nitrogen cycling microbial communities in agricultural soils. 28. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Dlott, G., D. J. Epp Schmidt, J. Maul, M. Cavigelli, J. Buyer, S. A. Yarwood. UMD?BARC symposium, National Agricultural Library, Beltsville, MD: November 13, 2014. Title: Tillage effects persist long after no-till conversion: Carbon and microbial community evidence. 29. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Bowen, H., H. Poffenbarger, J. Maul, S. Mirsky, M. Cavigelli, S. Yarwood. University of Maryland AGNR Open House, Clarksville, MD: November 13, 2014. Title: Spatial distribution of nitrogen cycling microorganisms in agricultural soil. 30. Type: Conference Papers and Presentations Status: Other Year Published: 2012 Citation: Jude Maul, 2012, poster, BARC-UMD symposium, Soil Denitrification Potential and Gene Diversity of Nirk, Nirs and Nosz; Field Scale Comparisons Across Farming Systems. 31. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Jude Maul, 2013, webinar, UMD extension, Biological Nitrogen Fixation 101. 32. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Jude Maul 2013, invited talk, Purdue University, Soil Denitrification Potential; Field Scale Comparisons Among Diverse Farming Systems 33. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Jude Maul 2013, invited talk, USDA-Ft. Pierce, Soil Denitrification Potential and Gene Diversity of Nirk, Nirs and Nosz; Field Scale Comparisons Across Farming Systems. 34. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Jude Maul 2014, poster, Argonne National Lab Soil Metagenomics meeting, Microbial communities and carbon dynamics across a depth profile of organic and conventionally managed agricultural systems in the Mid-Atlantic region 35. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Jude Maul 2015, invited talk, USDA-NIFA, How Research on Organic Farming, The Original Multifunctional Agriculture, Can Inform Scientific Progress.

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Improving Soil Quality, C Sequestration, and Mitigating Greenhouse Gas Emission in Organic Rice Production

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Subfile	CRIS
Project No.	TEX09552
Agency	NIFA TEX
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Contract / Grant No.	2012-51106-20137
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Investigator(s)	Dou, F.; Hons, F. M.; Wight, J. P.; Torbert, H. A.
Performing Institution	Beaumont-TAMU Agr Res Cntr, TEXAS A&M UNIVERSITY, 750 AGRONOMY RD STE 2701

NON-TECHNICAL SUMMARY

Organic rice farming may have greater potential for soil carbon (C) sequestration, but may also result in greater greenhouse gas (GHG) emissions because of greater input of organic matter (C is a main component) compared to conventional rice production. Our project will integrate the use of cover crops, organic soil amendments, and choice of cultivar to improve soil quality, reduce losses from disease and increase yield and milling quality. This proposed research will also utilize life cycle assessment (LCA) to help optimize environmental services and the climate change mitigation capability of organic rice farming systems. In previous independent studies to develop management practices for organic rice farming, we demonstrated: 1) ryegrass and clover had better performance than other winter cover crops on clay soil; 2) two organic soil amendments, Nature Safe and Rhizogen, significantly increased rice yield and milling quality over other organic fertilizers; and 3) cultivar significantly affected the yield of organically produced rice. Information is lacking on the integrated effects of these organic rice production practices and their economic and ecological benefits. To accomplish our goals, we will quantify the effects of cover crops, organic soil amendments, and cultivar on rice yield, milling quality, soil quality, soil C sequestration, and GHG emissions in integrated studies conducted in Texas. We conducted a stakeholder survey to prioritize research goals and consulted with an established advisory committee involving growers, millers, consultants, and end-users to guide our research approach and delineate technology transfer programs needed to implement these organic rice systems.

OBJECTIVES

1) Quantify the combined effects of cover crop, organic soil amendments, and variety selection on rice yield and milling quality in field trials conducted on certified organic land in conjunction with an established stakeholder research and outreach advisory board. 2) Determine ecological services (enhanced C sequestration, GHG abatement, increased N retention and cycling, and water quality improvement) provided by organic rice farming using the proposed integrated practices. 3) Conduct a LCA to identify sustainable management practices for organic rice in terms of grain yield, net income, soil quality, C sequestration, and GHG emissions. 4) Implement

field demonstrations and provide information to growers, researchers, county agents, natural resource managers, and regional public officials on the production potential, financial viability, and ecological impacts of organic rice cropping systems.

APPROACH

We propose to expand upon a set of field studies that were initiated in 2008 and are continuing near Beaumont, TX, on organic land that has been maintained as fallow or seeded to clover for two years prior to the proposed study. Three main experimental factors are: cover crop (fallow control, white clover, and rye grass), organic soil amendments with three levels, and rice variety. Agronomic traits will be determined for the two cultivars including: plant height, days to flowering and harvest, aboveground biomass, root biomass, and root distribution. Total aboveground biomass will be determined by manually sampling 1.15m-2 of each plot at maturity. Biomass, N and lignin content of cover crops at termination will be measured. A two-week aerobic incubation following anaerobic incubation will be used to quantify N supply from cover crop and soil amendments. Soil from the field studies will be sampled prior to planting and after harvest and archived samples from previous clover, ryegrass, and fallow cover crop organic trials will be used to determine changes in soil physical, chemical, and biological properties as a result of cover cropping and organic practices. Soil samples from an adjacent long-term conventional rice trial will be collected to estimate baseline soil C sequestration in conventional production for comparison with the organic system. Soil organic C and N sequestration will be quantified using aggregate size and density fractionation techniques. Floodwater samples during organic and conventional rice production will be collected periodically to describe water quality associated with the various treatments. Gas samples will be collected using static chambers. Cumulative fluxes will be calculated by trapezoidal integration of measured daily gas fluxes between sampling events with the assumption that mean daily fluxes change linearly between each sampling event/date. When daily, seasonal, and cumulative gas fluxes are combined with previously described soil and crop analyses, the majority of C and N pool fluxes can be quantified. Data collected from the split-split plot field study will be analyzed to assess the effects of cover crop, soil amendment, and rice cultivar on rice yield, yield components, milling quality, soil C sequestration, and water quality using the GLM procedure of SAS 9.2. LCA will be used to assess environmental performance of organic and conventional systems in their totality- from production of inputs to crop production and through the sale of the finished product. Cropping, soil, and GHG results from objectives 1 and 2 will be combined with production input data to delineate treatment effects on the economics and net energy and C balances of organic rice production, to provide \"cradle to market\" assessments of products and processes involved in production. Through our established field days, routine participation in county extension meetings, extension newsletters and websites, we have access to a wide range of venues to translate our research findings to an audience that includes producers, agribusiness leaders, water providers and regulators, as well as local and regional public officials.

PROGRESS

2012/09 TO 2016/08 Target Audience:Organic rice producers, high school students, undergraduate students, industry consultants, county agents, scientists, and media reporters Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Providing training for young scientists including four postdoctoral research associate (Dr. Jason Wight, Dr. Joe Storlien, Dr. Jingqi Guo, and Dr. Xiufen Li), two M.S. students (Mariana Valdez Velarca, and Aditi Pandey), a junior research scientist, and five undergraduate students (Justin Floyd, Garrett, Floyd, Williams Tarpley, Bethany Stanton, and Tommy Tan). In addition, we are hosting five international visiting scientists, Drs. Youzhong Lang, Ganghua Li, Xiaoyin Bi, Shu Wang, and Qiong Wu to work on this project, too. How have the results been disseminated to communities of interest?We have continuously held an annual workshop on organic rice production for the advisory board either separately or conjunct with our annual field day at Beaumont Center since 2012. More than 200 audiences including organic rice producers, county agents, industry consultants, and scientists in the region attended. Also, four field tours were hold for producers and scientists who were interested in organic rice production or research. Some of the results have been presented at the international scientific conferences like 2013, 2014, 2015, and 2016 ASA-SSSA-CSA annual meetings. In March 2016, we hosted an organic rice symposium during the 2016 Rice Technical Working Group (RTWG). Four invited speakers updated the progresses in organic rice production including: 1) Nitrogen, variety, cover crop, and seeding rate in organic rice production; 2) Organic rice diseases and their management; 3) Arsenic uptake in organic rice production systems, and 4) Factors affecting the economics of organic rice production. More than forty audiences attended this symposium. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2013/09 TO 2014/08 Target Audience: Organic rice producers, industry consultants, county agents, scientists, and media reporters. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Providing training for young scientists including a postdoctoral research associate (Dr. Joe Storlien), a Ph.D. student (Yong Wang), a junior research scientist, and an undergraduate student. In addition, we are hosting three international visiting scientists, Drs. Youzhong Lang, Ganghua Li, and Shu Wang, to work on this project, too. How have the results been disseminated to communities of interest? We held a workshop on organic rice production for the advisory board on July 10, 2014. Approximately 45 participants included organic rice producers, county agents, industry consultants, and scientists in the region. Also, a field tour was hold for producers and scientists who were interested in organic rice production or research. Some of the results have been presented at the international scientific conferences like 2013 ASA-SSSA-CSA annual meeting in Tempa, FL and 2014 Rice Technical Working Group in New Orleans, LA. Each presentation had more than 30 audiences. What do you plan to do during the next reporting period to accomplish the goals? We will implement the research activities and work toward achieving the research objectives we have proposed as listed in the objective section including continuing cover crop and organic rice trials, on-farm demonstration studies, and soil, water, gas, and plant tissue sampling. Delivering our discoveries to communities through workshops, field tours, presentations at scientific and extension meetings, publications in scientific outlets and the general media. Also we will train junior scientists through our research project.

2012/09/01 TO 2013/08/31 Target Audience: Organic rice producers, industry consultants, county agents, scientists, and media reporters. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Providing training for young scientists including a postdoctoral research associate, a Ph.D. student, a junior research scientist, and a high school student. In addition, we are hosting an international visiting scientist, Dr. Youzhong Lang, to work on this project, too. How have the results been disseminated to communities of interest? So far, we have held a workshop on organic rice production. Participants included organic rice producers, county agents, industry consultants, and scientists in the region. Also, our research activities have been reported by media including AgriLife Today and Science Business. We will host a field tour and another workshop to introduce our projects to producers and communities of interest. What do you plan to do during the next reporting period to accomplish the goals? We will implement the research activities and work toward achieving the research objectives we have proposed as listed in the objective section including continuing cover crop and organic rice trials, on-farm demonstration studies, and soil, water, gas, and plant tissue sampling. Delivering our discoveries to communities through workshops, field tours, presentations at scientific and extension meetings, publications in scientific outlets and the general media. Also we will train junior scientists through our research project.

IMPACT

2012/09 TO 2016/08 What was accomplished under these goals? Cover crop production: Two selected winter cover crops, Durana white clover and ryegrass, were planted on November 1, 2011, October 12, 2012, November 6, 2013, and October 21, 2015, and they were terminated on April 14, 2012, March 7, 2013, March 14, 2014, and May 5, 2016, respectively. The amount of dry biomass at termination in 2012 was 5,175 and 5,693 kg/ha for clover and ryegrass, respectively. The amount of dry biomass at termination in 2013 was 4,380, 4,837 and 5,907 kg/ha for fallow, clover and ryegrass, respectively. The amount of dry biomass at termination in 2014 was 4,525 and 5,152 kg/ha for clover and ryegrass, respectively. The amount of dry biomass at termination in 2016 was 4,398, 5,592, and 5260 kg/ha for fallow, clover and ryegrass, respectively. Organic rice production: In the 2012, 2013, and 2014 field trials, we examined cover crops (Durana white clover, ryegrass, and fallow), soil amendments (Nature Safe vs. Rhizogen) with three levels (untreated control, 150 kg N/ha, and 210 kg N/ha, and two rice varieties (Tesanai - high yield, used for flour market vs. Presidio - superior long grain quality) on rice production. Winter cover crop treatments served as main plots with rice varieties as sub-plots. Soil amendment treatments were applied as sub-sub-plots. The grain yield of Tesanai was 75% higher than that of Presidio. Similar to cover crops, soil amendments did not have significant effect on rice grain yield. The grain yield using Nature Safe was similar to that with Rhizogen, indicating that both were equally effective in providing nutrients for organic rice production. However, the application rate of soil amendments significantly affected rice grain yield. Compared to the control (0 applied), both the 150 kg N/ha and 210 kg N/ha soil amendment application rate increased rice grain yields by 11%. There was no difference in rice grain yields between the two N rates, indicating that 150 kg N/ha was sufficient for organic rice production in terms of N supply.Both cover crop and variety did not affect rice seedling establishment. The weed density under Presidio was greater than that under Tesanai, indicating that greater weed competition with Presidio. Compared to the control, application of soil amendments significantly increased aboveground biomass. Also, the aboveground biomass was highly correlated with the corresponding grain yield. Rice milling yield was significantly affected by cover crop and rice variety. Presidio had higher milling quality than Tesanai. In the 2015 field trials, we tested the effects of different rice seeding rate on organic rice production. Two factors were seeding rate (108, 161, 215, 269, 323, 376, and 431 seeds m-2) and variety (Presidio vs. XL753). Seeding rate had significant effects on plant density (p \< 0.0001) and dry biomass (p \< 0.05) with positive linear correlations (R2 \> 0.84); while, its effect on plant height was insignificant. Seeding rate linearly increased the grain yield but insignificantly influenced the number of filled grains per panicle and 1,000-grain weight. Of the two varieties, hybrid XL753 produced significantly higher grain yield over inbred Presidio, and had a significantly (p \< 0.0001) higher plant density, height, biomass, number of spikelet and full grain per panicle, and percentage of total grain. In organic rice system, seeding rate of 431 seedlings m-2 (94 kg ha-1 for XL753, 106 kg ha-1 for Presidio) or higher was needed to achieve high grain yield but not significantly affect harvest index or milling quality. Soil organic carbon (SOC), soil total nitrogen (STN), and life cycle assessment (LCA): Soil samples were collected from continuous organic rice blocks to determine the effects of cover crop, rice variety and nitrogen rate on SOC. Two soil sample cores were collected from each plot at an increment of depth from 0-5, 5-20, and 20-40 cm. Statistical analysis indicated that only cover crop and soil depth had significant effects on SOC and STN. For SOC, soil under clover was greater than that under fellow at both 0-5 and 5-20 cm depths. Compared the depth of 5-20 cm, surface soil at 0-5 cm had greater SOC concentration. The effect of cover crop on SOC at the depth of 20-40 cm was minimal. Soil total nitrogen had a similar pattern as SOC as being affected by the treatments. Our selected LCA indicated that the treatment of XL753 with 150 kg N/ha of Nature Safe under clover had the greatest potential in emitting of new greenhouse gases with lowest the treatment of Presidio received 150 kg N/ha of Rhizogen under clover. Water quality: In the 2014 rice season (April-August), impacts of winter cover crop (ryegrass vs. fallow), nitrogen rate (0, 150 kg N/ha with split, and 150 kg N/ha single application), and cropping system (organic vs. conventional rice system) on water quality \electronic conductivity (EC), pH, dissolved organic carbon (DOC) and dissolved total nitrogen (DTN), and water soluble inorganic phosphorus (P)\ were evaluated. Our results indicated that there were no significant differences in water quality between organic and conventional rice systems and the winter cover crop and N rate had minimal effects on water quality. Greenhouse gas emissions: The effects of the proposed treatments of winter cover crop, N rate and splitting, and cropping system were also determined for the greenhouse gas emissions during 2013 and 2014 rice seasons. As anticipated, N2O emissions remained low to nondetectable under the anaerobic conditions during this time period. Across all production scenarios, cumulative CO2 and CH4 emissions averaged 133 g CO2-C m-2 and 12 g CH4-C m-2, respectively. While CH4 emissions were much smaller than CO2 directly, they were the most dominant GHG when their global warming potential was considered (\~360 g CO2-eq m-2). A temporal trend in flux rates between CO2 and CH4 was observed when CH4 fluxes peaked (\~13 mg CH4-C m-2 h-1) in mid-June, while CO2 fluxes peaked (\~140 mg CO2-C m-2 h-1) in mid-July. Nitrogen source had the largest impact on CO2 and CH4 emissions; Rhizogen fertilizer increased emissions compared to Nature Safe fertilizer. Nearly double the mass of Rhizogen fertilizer was applied to supply the same amount of N as the Nature Safe fertilizer, which may partially explain the differences observed in GHG emissions. In 2014, we continued our GHG trials using the same sampling and analysis methods. The cumulative CO2 emission under ryegrass was 244% higher than that under fallow, indicating that extra fresh biomass input after ryegrass plowdown was a main source of CO2 emission. Methane emission was significantly affected by cover crop, N rate, and rice variety. Similar to CO2, the amount of cumulative CH4 under ryegrass was higher than that under fallow. Also, Tesanai field emitted the most CH4 with the lowest with Presidio field. Compared with the control, N application also increased CH4 emission. SimilFar as 2013, only a few low, sporadic fluxes of N2O were observed during the rice season. Economic analysis: Our economic analyses were based on the data collected from field operation records, farmer visiting, phone contact with producers, and published information. Production costs are not as much of an issue with organic rice (\$586/ha) as with conventional rice (\$962/ha). Producers are already using fewer costly inputs with organic rice. Profitability depends largely on the presence of two key necessary components: 1) the guarantee of a monetary premium for organic rice and Availability and 2) good control of water. Using Organic Economic Optimum Seeding Rates analysis, our results indicated that the optimal seeding rates for Presidio and XL753 were 78 and 47 kg/ha, respectively. The corresponding optimal seeding rates under conventional rice system were 77 and 30 kg/ha, respectively. The interaction between cropping system and variety suggested that hybrid had advantage by increasing seeding rate under organic production. **PUBLICATIONS (not previously reported):** 2012/09 TO 2016/08 1. Type: Other Status: Published Year Published: 2013 Citation: Dou, F., A. McClung, and X. G. Zhou. 2013. Integrating choice of variety, soil amendments and cover crops to optimize organic rice production. Texas Rice Special Section. 2. Type: Other Status: Published Year Published: 2013 Citation: Dou, F. 2013. Improving soil quality to increase yield and reduce diseases in organic rice production (oral presentation). 2013 Organic Rice Workshop, Houston, TX. 3. Type: Other Status: Published Year Published: 2013 Citation: Dou, F. 2013. Improving soil quality to increase yield in organic rice production (poster). Field Day. Eagle Lake, TX. 4. Type: Other Status: Published Year Published: 2013 Citation: Dou, F. 2013. Improving soil quality to increase yield in organic rice production (poster). Field Day. Beaumont, TX. 5. Type: Other Status: Published Year Published: 2013 Citation: Garrett, T.F. and F.

Dou. 2013. SARE. Learning experience of organic rice production. 2013 Southern SARE Young Scholar Enhancement Program. 6. Type: Other Status: Published Year Published: 2013 Citation: Zhou, X. G., Dou, and A. M. McClung. 2013. Effects of cover crops, fertility, cultivars, and biocontrol agents on organic rice diseases. Organic Rice Advisory Meeting. Mar. 20. 2013. Houston, Texas, USA. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Dou, F., X. G. Zhou, A. McClung, J. Storlien, Y. Lang, A. Torbert, F. Hons, B. Ward, S. Kresovich, and J. Wight. 2014. Cover crop, soil amendments, and variety effects on organic rice production in Texas (oral presentation). 35rd Rice Technical Working Group Meeting. New Orleans, LA. February, 2014. 8. Type: Other Status: Published Year Published: 2014 Citation: Zhou, X. G. 2013. Organic rice disease management. Pages 56-59. 2014 Texas Rice Production Guidelines. Texas AgriLife Research and Texas AgriLife Extension. B-6131. https://beaumont. tamu.edu/eLibrary/Bulletins/2014 Rice Production Guidelines. pdf. 9. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Dou, F., X. G. Zhou, A. M. McClung, J. Storlien, Y. Lang, A. Torbert, F. Hons, B. Ward, S. Kresovich, and J. Wight. 2014. Cover crop, soil amendments, and variety effects on organic rice production in Texas. 35rd Rice Technical Working Group Meeting. New Orleans, Louisiana, USA. Feb. 18-21, 2014. P. 119-120. 10. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Dou, F. 2014. Summary of 2013 organic rice production. Presentation made at the Organic Rice Workshop of the 67th Annual Beaumont Field Day. Beaumont, TX, July 10, 2014. 11. Type: Other Status: Published Year Published: 2014 Citation: Zhou, X. 2014. Effects of cover crops, fertility, and cultivars on organic rice diseases. Presentation made at the Organic Rice Workshop of the 67th Annual Beaumont Field Day. Beaumont, TX, July 10, 2014. 12. Type: Other Status: Published Year Published: 2014 Citation: McClung, A.M. 2014. Impact of variety and organic production methods on yield, quality, and grain arsenic. Presentation made at the Organic Rice Workshop of the 67th Annual Beaumont Field Day. Beaumont, TX, July 10, 2014. 13. Type: Other Status: Published Year Published: 2014 Citation: Watkins, K.B. 2014. Economics of organic rice production. Presentation made at the Organic Rice Workshop of the 67th Annual Beaumont Field Day. Beaumont, TX, July 10, 2014. 14. Type: Other Status: Published Year Published: 2014 Citation: Ward, B. 2014. System of Rice Intensification Cultivar Trials 2014. Presentation made at the Organic Rice Workshop of the 67th Annual Beaumont Field Day. Beaumont, TX, July 10, 2014. 15. Type: Other Status: Published Year Published: 2014 Citation: Dou, F., X. Zhou, F. Hons, A.M. McClung, S. Wang, Y. Lang, G. Li, J. Storlien, J. Wight, K. Landry, and G. Liu. Improving organic rice production through combining cover crop, soil amendment, and variety selection. The 67th Annual Beaumont Field Day. Beaumont, TX July 10, 2014. 16. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Dou, F., F. Hons, X. Zhou, A. McClung, S. Wang, A. Torbert, Y. Lang, G. Li, J. Storlien, and J. Wight. 2014. Effects of cover crop and soil amendment on organic rice production. Annual Meeting of the Soil Science Society of America. Long Beach, CA. November 2014. 17. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: McClung, A.M., Gerads, R., Chaney, R.L., Dou, F., Zhou, X., Duke, S.E. November 2-5, 2014. Organic rice production: minimizing exposure to grain arsenic. ASA-CSSA-SSSA Annual Meeting Abstracts, Long Beach, CA. 61-4. 18. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Storlien, J., F. Dou, G. Liu, and F. Hons. 2014. Organic rice management effects on greenhouse gas emissions in southeast Texas. Annual Meeting of the Soil Science Society of America. Long Beach, CA. November 2014. 19. Type: Journal Articles Status: Published Year Published: 2015 Citation: Chen M.H., McClung A.M. (2015) Effects of Cultivars, Organic Cropping Management, and Environment on Antioxidants in Whole Grain Rice. Cereal Chemistry 92:364-369. DOI: 10.1094/cchem-11-14-0240-r. 20. Type: Other Status: Published Year Published: 2015 Citation: Watkins, K.B. and R. Mane. 2015. Organic Rice Production in Arkansas. Presentation made at the Organic Rice Workshop of the 68th Annual Beaumont Field Day. Beaumont, TX, July 9, 2015. 21. Type: Other Status: Published Year Published: 2015 Citation: Tan, Tommy and Fugen Dou. Internship with Organic Rice Production. 2015. 22. Type: Theses/Dissertations Status: Published Year Published: 2016 Citation: Valdez Velarca. 2016. EFFECTS OF NITROGEN FERTILIZATION ON ORGANIC RICE PRODUCTION. Thesis. 23. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Dou, F., Valdez Velarca, A. McClung, X-G. Zhou, and F. Hons. 2016. Nitrogen, variety, cover crop, and seeding rate in organic rice production. 36th Rice Technical Working Group Meeting. Galveston, TX. March, 2016. 24. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: McClung, A., S. Duke, F. Dou, X-G. Zhou, R. Chaney, and R. Gerads. 2016. Arsenic uptake in organic rice production systems. 36th Rice Technical Working Group Meeting. Galveston, TX. March, 2016. 25. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Valdez Velarca, M., F. Dou, J. Guo, T. Gentry, F. Hons, and A. Torbert. 2016. Effect of N source and rate on greenhouse gas emissions in organic rice production. 36th Rice Technical Working Group Meeting. Galveston, TX. March, 2016. 26. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Zhou, X-G., F. Dou, and A. McClung. 2016. Organic rice diseases and their management. 36th Rice Technical Working Group Meeting. Galveston, TX. March, 2016. 27. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: 53. Li, X. and F. Dou. 2016. Effect of seeding rate on plant growth, grain yield, yield components, milling quality and weed density of organic rice. Annual Meeting of the Soil Science Society of America. Phoenix, AZ. November 2016. 28. Type: Journal Articles Status: Under Review Year Published: 2016 Citation: Xiufen Li, Fugen Dou, and Shu Wang. Effect of seeding rate on plant growth, grain yield, yield components, and weed density of organic rice.

2013/09 TO 2014/08 What was accomplished under these goals? Organic rice production (summary of April-August, 2013 which is not previously reported): In the 2013 Beaumont field trials, we examined cover crops (Durana white clover, ryegrass, and fallow), soil amendments (Nature Safe vs. Rhizogen) with three levels (untreated control, 150 kg N/ha, and 210 kg N/ha), and three rice varieties (Tesanai -- high yield, used for flour market, Presidio -- superior long grain quality, and XL723 - high yield, new released hybrid that was suggested by the Organic Rice Production Advisory Board) on rice production. Winter cover crop treatments served as main plots with rice varieties as sub-plots. Soil amendment treatments were applied as sub-sub-plots. Each treatment had four replications. Cover crops were managed as in the previous section. Soil amendments were broadcast by hand and incorporated just after planting using a rake in the drill-seeded plots that were approximately 5 m-2. Plots were flush irrigated to encourage uniform germination and after stand establishment were maintained under a flood until harvest to help with weed control. In addition, we treated all the seed with OMRI certified gibberellic acid (GA) to promote seed germination. Organic rice was drill seeded on April 22, 2013 using a high seeding rate (160 kg/ha for Presidio and Tesanai, and 80 kg/ha for XL723 which is double the recommended rate for hybrids). Although the three varieties emerged on the same date, compared to Presidio and XL723, Tesanai had longer growth duration and matured two or more weeks later. All plots were harvested by hand as they came to maturity, in early August for Presidio and XL723 and in late August for Tesanai. The winter cover crops when averaged over all soil amendment treatments did not significantly affect the main crop (MC) grain yields in 2013. The average MC grain yields were 7443, 7292, and 7312 kg/ha for clover, ryegrass, and fallow treatments, respectively. Rice variety had a significant effect on MC grain yield. Tesanai had higher MC yield than XL723 and Presidio. Grain yield using Nature Safe was similar to that with Rhizogen, indicating that both were equally effective in providing nutrients for organic rice production. However, the application rate of soil amendments significantly affected rice grain yield. Compared to the control (0 applied), both the 150 kg N/ha and 210 kg N/ha soil amendment application rate increased rice grain yields by 6%. There was no difference in rice grain yields between the two N rates, indicating that 150 kg N/ha was sufficient for organic rice production in terms of N supply. Plant height decreased in the order of Tesanai, XL723, and Presidio. Although taller varieties would be expected to have an advantage in weed competition, the weed density was very low in 2013 organic rice trials. Rice milling yield of MC was significantly affected by cover crop and rice variety. Higher milling quality (whole grain yield) was observed with the ryegrass treatment than with clover and fallow. Also, the highest milling yield was with Presidio and lowest with Tesanai. Greenhouse gas emissions: During the first growing season (May -- July, 2013), impacts of rice variety (Presidio, XL723, and Tesanai), nitrogen source (Rhizogen and Nature Safe), and nitrogen application rate (0, 150, and 210 kg N ha-1) on greenhouse gas (GHG) emissions were evaluated within three different fallow systems \ryegrass (Lolium multiflorum L.), clover (Trifolium repens L.), and weedy fallow\. Rice variety and N rate had little impact on GHG emissions during the first growing season. Nitrogen source significantly (P \< 0.005) impacted CH_4 emissions, where Rhizogen lost 38% more CH_4 than Nature Safe. This may be partially explained by the fact that nearly twice as much Rhizogen (7-2-1) was applied to achieve the same N rate as Nature Safe (13-0-0). When converted to CO_2-equivalents, CH_4 accounted for 49% of the cumulative CO_2-eq (CO_2 + CH_4) emissions from Rhizogen treatments compared to 42% from Nature Safe treatments. Additionally, cumulative CO_2 emissions from each of the fallow systems were different from each other with ryegrass losing the most CO_2 followed by clover and then fallow. Only a few low, sporadic fluxes of N_2O were observed during the first growing season. Following the initial harvest in July 2013, the impacts of N application rate and residue management (with or without straw returned) on GHG emissions were evaluated on a ratoon crop from September to November 2013. Similar to the first growing season, N rate had no impact (P = 0.474) on GHG emissions from the rice plots. Returning rice straw to the plots had no effect on CH_4, but caused a marginal increase (P = 0.071) in CO_2 emissions, with higher CO_2 emissions from plots with straw returned compared to those without. Cumulative emissions of CO_2 and CH_4 were higher during the second growing season than the first, potentially due to greater C mineralization following the first cropping season (May -- July). Methane accounted for 57% of the cumulative CO_2-eq emissions in treatments without straw returned during the second cropping, while CH_4 accounted for only 33% of the cumulative CO_2-eq emissions in treatments with 100% of straw returned. Similar to the first growing season, almost no N_2O fluxes were observed while soils were flooded, likely due to highly anaerobic conditions. Finally, the impacts of winter cover crop on GHG emissions were evaluated from February to March 2014. Fluxes of CH_4 and N_2O remained low over the winter, likely due to aerobic soil conditions and relatively low temperature. The aerobic conditions may have enhanced microbial decomposition of organic matter, as CO_2 emissions were higher over the winter fallow season than the flooded rice growing seasons. The highest CO_2 emissions came from the clover cover crop followed by ryegrass and fallow. The fallow and ryegrass treatments had 81% and 43% lower cumulative CO_2 emissions than clover treatments, respectively. The first year of GHG data from the organic rice production project were vital to guiding ongoing research efforts and improving the efficiency of overall research efforts. This work provided important preliminary information on GHG emissions from organic rice production and will continue as an ongoing effort to identify management practices which maximize rice yield while simultaneously minimizing GHG emissions. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Dou, F., A. McClung, and X.G. Zhou. 2013. The impacts of soil amendments on organic rice production (oral presentation). Annual Meeting of the Soil Science Society of America. Tampa, FL. November 2013. 2. Type: Other Status: Published Year Published: 2013 Citation: Zhou, X.G. 2013. Organic rice disease management. Pages 56-59. 2014 Texas Rice Production Guidelines. Texas AgriLife Research and Texas AgriLife Extension. B-6131. https://beaumont. tamu. edu/eLibrary/Bulletins/2014 Rice Production Guidelines. pdf. 3. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2014 Citation: Dou, F., X.G. Zhou, A. McClung, J. Storlien, Y. Lang, A. Torbert, F. Hons, B. Ward, S. Kresovich, and J. Wight. 2014. Cover crop, soil amendments, and variety effects on organic rice production in Texas (oral presentation). 35rd Rice Technical Working Group Meeting. New Orleans, LA. February, 2014. 4. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2014 Citation: McClung, A.M., Duke, S., and Chaney, R.L. 2014. Impact of Organic Production Management on Variety Yield and Grain Arsenic Accumulation. 35rd Rice Technical Working Group Meeting. New Orleans, LA. February, 2014. 5. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2014 Citation: Storlien, J. O., F. Dou, Y. Lang, A. Torbert, F. Hons, and J. Wight. 2014. Cover crop, nitrogen, and variety effects on greenhouse gas emissions from organic rice production in east Texas. 35th Rice Technical Working Group Meeting. New Orleans, LA. February, 2014. 6. Type: Other Status: Published Year Published: 2014 Citation: Dou, F., J.O. Storlien, Y. Lang, G. Li, S. Wang, G. Liu, and K. Landry. 2014. Organic rice management affects greenhouse gas emissions. Texas Rice Special Section. 7. Type: Other Status: Other Year Published: 2014 Citation: Dou, F., X.G. Zhou, F. Hons, A. McClung, S. Wang, Y. Lang, G. Li, J. Storlien, J. Wight, and G. Liu. 2014. Improving organic rice production through combining cover crop, soil amendment, and variety selection. The Field Day of Texas A&M AgriLife Research Center at Beaumont (poster). 8. Type: Other Status: Other Year Published: 2014 Citation: Storlien, J., F. Dou, F. Hons, J. Wight, H. Torbert, Y. Lang, G. Li, S. Wang, K. Landry, and G. Liu. 2014. Organic rice management influences carbon dioxide and methane emissions. The Field Day of Texas A&M AgriLife Research Center at Beaumont (poster). 9. Type: Other Status: Other Year Published: 2014 Citation: Storlien, J., F. Dou, F. Hons, J. Wight, H. Torbert, Y. Lang, G. Li, S. Wang, K. Landry, and G. Liu. 2014. Organic rice management influences carbon dioxide and methane emissions. The Eagle Lake Field Day of Texas A&M AgriLife Research (poster). 10. Type: Other Status: Other Year Published: 2014 Citation: Brad Watkins. 2014. Economics of organic rice production. Organic Rice Workshop, Beaumont, TX (oral presentation). 11. Type: Other Status: Other Year Published: 2014 Citation: Dou, F., Y. Lang, G. Li, S. Wang, S. Zhou, A. McClung, F. Hons, J. Storlien, and A. Torbert. 2014. A combined effect of cover crop, soil amendment, and variety on organic rice production and greenhouse gas emissions. Organic Rice Workshop, Beaumont, TX (oral presentation). 12. Type: Other Status: Other Year Published: 2014 Citation: Zhou, X.G., F. Dou, and A. McClung. 2014. Organic rice disease management. Organic Rice Workshop, Beaumont, TX (oral presentation).

2012/09/01 TO 2013/08/31 What was accomplished under these goals? Winter cover crops, Durana White Clover and Ryegrass, were planted on October 12, 2012 and plowed down on March 08, 2013. The winter cover crop samples were harvested prior to termination and the average dry biomass yields were 4837 and 5907 kg/ha for clover and ryegrass, respectively. The water contents of biomass samples were 76% and 73% for clover and ryegrass, respectively. Biomass samples were oven dried and are ready for incubation. Soil samples were taken prior to winter cover crop planting in fall 2012 and prior to organic rice planting in April, 2013. Samples are being analyzed for soil quality parameters including total organic and inorganic carbon and nitrogen, residual nitrate and Mehlich III extractable nutrients. Also, soil samples have been collected for laboratory incubation to estimate N mineralization and N release from soil amendments. Organic rice was drill-seeded on April 22, 2013. All the soil amendments have been applied after planting. Currently, rice has a good stand. Plant density and leaf chlorophyll content have been measured. Greenhouse gas samples are being collected weekly using a static chamber. Collected gas samples are being analyzed by a GC. All plots will be sampled till harvesting. Floodwater samples are being sampled weekly, too. Flashing chambers have been installed in selected plots. Water samples will be filtered after sampling and stored in a refrigerator for later analysis. Water samples will be taken till field water drainage shortly before harvest. Data is being collected by Co-PIs to conduct an LCA for organic rice production. Information used for the LCA will include both direct, such as plant and soil carbon and GHGs, and indirect sources of carbon, such as equipment and fertilizer manufacture, diesel usage, etc. The GREET model will be utilized for the analysis. A stakeholder research and outreach advisory board has been established and our first board meeting was completed at the US Rice Producers Association meeting in Houston on March 22, 2013. During this meeting, we reported our previous results and reviewed future research plan with rice producers, county agents, organic rice consultants, and researchers. Project directors began to inform producers of their results through an article in the 2013 Beaumont Field Day research highlights and poster presentations to the Texas Rice Field Days at Eagle Lake and Beaumont. Also, we will offer a field tour and workshop during the field days. Therefore, rice producers, county agents, consultants, and other stakeholders will benefit from our research and extension activities. In addition, our research efforts have been reported by media including AgriLife Today, Science Business,and Spirit, the Texas A&M Foundation magazine. Science Business is an online news service created for researchers, administrators, business people, government officials, and observers interested in what it takes to convert scientific knowledge into marketable products and services. Early findings will be shared with the scientific community through a presentation to be given at the ASA/CSSA/SSSA International Annual meetings in November, 2013, in Tampa, FL. At least two on-farm field demonstration trials have been planned and will be conducted in 2014.

PUBLICATIONS

2012/09/01 TO 2013/08/31 No publications reported this period.

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Assessing the Greenhouse Gas Mitigation Potential of Organic Systems in the Southeast

Accession No.	0230561
Subfile	CRIS
Project No.	NC09248
Agency	NIFA NC.
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2012-51106-20332
Proposal No.	2012-02978
Start Date	01 SEP 2012
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Grant Year	2012
Investigator(s)	Hu, S.; Reberg-Horton, C.; Schroeder-Moreno, M.; Cardoza, Y.; Grossman, J.; Robarge, W.; Eveman, W.
Performing Institution	Plant Pathology, NORTH CAROLINA STATE UNIV, RALEIGH, NORTH CAROLINA 27695

NON-TECHNICAL SUMMARY

Agricultural lands provide potential opportunities for climate change mitigation through promoting soil C sequestration and reducing N2O emissions. Agriculture is one of the few economic sectors that can be adapted to have a net negative impact on greenhouse gas emissions. It is assumed that high organic inputs in organic systems provide best opportunities for C sequestration and N retention in the Southeast coastal plains. Still, the relative scarcity of field data makes any generalizations across organic systems and regions difficult. The key to understanding how agriculture will both adapt to climate change and mitigate greenhouse gas emissions is to understand how cropping systems impact the C and N cycles and identify management regimes that are not only profitable, but also optimize soil C sequestration and reduce N losses. The long-term goal of this integrated research, education and extension project is to understand the impact of organic systems in the Southeastern US on greenhouse gas emissions and educate stakeholders and students about maximizing the mitigation potential of these systems. Our supporting objectives are to 1) investigate how organic systems affect soil carbon (C) and nitrogen (N) dynamics and greenhouse gas emissions, 2) examine how tillage practices and cover crops can be integrated to enhance C sequestration and reduce N2O emissions, and 3) educate next generation of organic researchers and farmers through student training and various outreach activities. We propose that organic systems with reduced tillage may provide the best opportunities to increase soil C sequestration and reduce soil N2O emission in the sandy soils of the warm and humid Southeastern USA. Our central hypothesis is that integration of high organic matter inputs and reduced tillage is the key to tighten C and N cycles and reduce N2O emission. We plan to utilize three certified organic systems and three parallel conventional systems at our existing long-term site at Goldsboro, NC to conduct a series of field experiments to quantify the CO2 and N2O emissions and to identify potential mechanisms underlying the C and N stabilization in soil. We also plan to develop new curricula on greenhouse gases and agriculture for student training and stakeholders. Outcomes of this project would provide essential data necessary for developing organic practices that reduce soil N2O emissions while increasing C sequestration.

OBJECTIVES

Goals/Objectives: The long-term goal of this integrated research, education and extension project is to understand the impact of organic systems in the Southeastern US on greenhouse gas emissions and educate stakeholders and students about maximizing the mitigation potential of these systems. Our supporting objectives are to 1) investigate how organic systems affect soil carbon (C) and nitrogen (N) dynamics and greenhouse gas emissions, 2) examine how tillage practices and cover crops can be integrated to enhance C sequestration and reduce N2O emissions, and 3) educate the next generation of organic agriculture researchers and farmers through student training and an active, multi-pronged outreach program. Our interdisciplinary team will approach five specific objectives through experiments and field demonstration on farm-scale, replicated certified organic plots at our existing long-term experimental site at Center for Environmental Farming, Goldsboro, NC. Objective 1: Quantify the greenhouse gas emissions and soil C and N in three organic and tillage management regimes and three paralleled conventional systems. Objective 2: Determine the impact of invertebrates on residue decomposition and soil C stabilization. Objective 3: Assess the effects of AM fungi on soil aggregation and N retention in organic systems. Objective 4: Ascertain the role of cover crops and weeds in mediating soil N availability Objective 5: Education and outreach through developing new curricula on greenhouse gases and agriculture for student training and stakeholders. Expected Outputs: This project will create knowledge on the differences in C and N cycling between organic and conventional systems and elucidate which biological factors are primarily responsible for those differences. In addition we hope to have short term and longer term impacts in several sectors. The educational curriculum developed will be used throughout the region and will serve as a model for others. Our research group has excellent ties with the regional NRCS training center located in Greensboro, NC that serves 22 states. CEFS data has been used in previous updates to the RUSLE2 model that guides how NRCS field offices share costs with farmer for soil conserving processes. During our training events with NRCS, we will engage them on how this information could be incorporated in their \"Greenhouse Gas Emissions Resource\" metric which they have deployed as part of their online \"Fieldprint Calculator\". This tool calculates a farms direct and embedded impact on greenhouse gas emissions. N2O emissions are only projected for rice systems. Our data could be used to expand the N2O projections to other crops based on organic versus conventional status, the amount of tillage involved, and the length of the rotation. This tool will also be the likely arbiter of any greenhouse gas payments to farmers that have been discussed by USDA.

APPROACH

We will conduct a series of experiments and education programs using our existing long-term field site based at the Center for Environmental Farming Systems near Goldsboro, North Carolina to achieve five specific objectives. Objective 1: Quantify the greenhouse gas emissions and soil C and N in three organic and tillage management regimes and three paralleled conventional systems. We will quantify the C and N distribution across the soil profile and monitor the temporal dynamics of labile N pools. Intensive measurements of N2O and CO2 will be conducted. We will also quantify soil and microbial parameters to understand the possible links among soil and microbial properties, GHG emissions, soil C and N dynamics, and plant N utilizations. Objective 2. Determine the impact of soil invertebrates on residue decomposition and soil C stabilization. To evaluate invertebrate impacts on cover crop litter decomposition and nutrient cycling, litter will be placed in bags deployed in the experimental plots. Objective 3. Characterize mycorrhizal effects on soil aggregation and plant N acquisition. We will use a mycorrhizal bioassay to assess mycorrhizal-mediated plant N uptake both in field and greenhouse experiments. We will also quantify the soil aggregates fractions through wet-sieving into aggregates of different size and assess AM fungal contribution of soil N translocations in field with root and mycorrhizal hyphal ingrowth cores. Objective 4. Assess the impact of cover crops and weeds on soil C and N sequestration and soil GHG emissions. Weeds and cover crops will be intensively sampled to assess their capacity for N retention and organic C inputs. Objective 5. We will approach our education and outreach goals through a) developing an extension curriculum on greenhouse gases and agriculture to deliver to local and national audiences, and b) developing education curricula on agriculture and climate change for undergraduate and graduate student training. Result synthesis and evaluation: Results obtained will be synthesized to assess how different soil amendments (either cover crops or other organic materials) affect soil C sequestration and N2O emissions. Our proposed experiments should: 1) determine if tightening nutrient cycling through organic inputs and cover cropping favor C sequestration and biological N retention to reduce N2O emissions, and 2) determine if enhancement of microbial biomass and activities and soil biodiversity through cover crops and soil amendments improves soil quality (aggregation) and soil C stabilization. Results from this work and our protocols will also be evaluated through the scientific review process when we submit publications and when we present at scientific meetings. Also, results will be delivered to growers and other related stakeholders through our extension talks and written and electronic materials. In addition, we are members of the Center for Environmental Farming

Systems at NCSU team and as such we have an internal evaluation process among the main faculty members and with stakeholders.

PROGRESS

2012/09 TO 2016/08 Target Audience:Students: Three graduate students received supports or partially supports from this project to conduct field and lab experiments to assessing the effects of different organic management practices on soil C and N dynamics and greenhouse gas emissions. Multiple visiting scientists, including one visiting postdoctoral scholar, were also involved and got trained through this project, although they did not receive financial supports from this project. The scientific community in general, particularly ecologists, soil scientists, and biologists and graduate and undergraduate students. Our project was presented at the \"French-American Climate Change Symposium\" (Raleigh, NC, August 27, 2015. 220 attendees). Our graduate students presented multiple talks at regional and national meetings (for example, ASA-CSSA-SSSA International Annual meetings in Minneapolis, November, MN 2015, and Phoenix, AZ, November 2016). Oral Presentation. Nov 2016. Scientists from multiple countries (including a delegate from Nanjing Agricultural University, Nanjing, China) visited our field project and the automatic detection systems for N2O at the Center for Environmental Farming Systems (CEFS, Goldsboro, NC). Farmers and land managers. Co-PIs and students made multiple presentations at the field days. On the Field Day, farmers and land managers visited our field project for automatic N2O measurement. ? Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Six graduate students were trained: This project provided funding fully or partially supporting the research for three PhD (Alexandra Knight, Crop Science; Sean Bloszies, Soil Ecology; Yunpeng Qiu, SoilEcology) and three MS students (Paul Adams, Entomology; Natalie Ross, Soil Science; Peyton Ginakes, Soil Science). Two exchange PhD students were actively involved and conducted experiments associated with this project (Yi Zhang and Keke Wu, both in Plant Pathology Dept., North Carolina State University). Three visiting scientists received training through participating in field sampling and conducting independent research (Dr. Xuelin Zhang, Henan Agricultural University, China; Dr. Bhoopander Giri, University of Delhi, India; Jinping Wang, Central China Agricultural University, China). Fifteen graduate students taught: Six graduate students at NCSU were enrolled in our Climate Change and Agriculture course from 4 NC State academic departments. Nine graduate students were enrolled in our Ecology of Soil Ecosystems course from five NCSU academic departments. Many visiting faculty also regularly attended our courses. Farmers: Farmers were directly impacted by the presentations at our annual Field Days at CEFS, Goldsboro and a special farmer-researcher event \"Soil Bration\" on October 17, 2014, as well as by presentations listed under \'Products - Publications\' and \'Products - Events\', with eight presentations geared toward farmers or extension personnel presented over the life of the project.? How have the results been disseminated to communities of interest?Results of this project have been disseminated in multiple diverse ways. First, two peer-reviewed manuscripts and four thesis/dissertations have been published or submitted. Four other manuscripts have been either submitted or under review for peer-reviewed journals and six more are under preparation for publication. Over twenty presentations (posters or talks) have been given at a national or regional level to reach scientific audiences at different scientific meetings (such as International Annual of ASA-CSSA-SSSA and Annual meeting of Ecological Society of America). Also, our project and results of our work were shared at our annual Field Day at CEFS, Goldsboro, NC. It was shared and extensively discussed at the Soil Bration on October 17, 2014, an event organized by the Center for Environmental Farming Systems and the USDA Natural Resources Conservation Service. Over 300 farmers, land managers, and scientists attended this event. We also shared our research at the \"Sustaining agriculture in a changing climate. French-American Climate Change Symposium\" (Raleigh, NC, August 27, 2015. 220 attendees). What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2014/09 TO 2015/08 Target Audience:Students: Five graduate students received supports or partially supports from this project to conduct field and lab experiments to assessing the effects of different organic management practices on soil C and N dynamics and greenhouse gas emissions. Multiple visiting scientists were also involved and got trained through this project, although they did not receive financial supports from this project. The scientific community in general, particularly ecologists, soil scientists, and biologists and graduate and undergraduate students. Co-PI, Chris Reberg-Horton, co-organized the symposium \"Sustaining agriculture in a changing climate. French-American Climate Change Symposium\". (Raleigh, NC, August 27, 2015. 220 attendees). Our graduate students presented multiple talks at regional and national meetings. Farmers and land managers. Co-PIs made multiple presentations at the field days. PI (Hu), multiple graduate students and technicians presented their projects in field for \"SOILbration: 20th anniversary for the Center for Environmental Farming Systems\" (October 17, 2014. 300 attendees). Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Over the last 12 months, our project provides opportunities to five graduate students: Miss Alexandra Knight (Crop Science) has been assessing the effects of weed growth and herbicides on N cycling and N2O emission. Mr. Paul Adams (Entomology) investigated the effects of farming practices on the soil arthropod community and foliar arthropods. Miss Natalie Ross (Soil Science) is exploring a new approach for measuring N2O emissions using a new continuously measuring method in field. Sean Blosvies (Soil Ecology) and Yunpeng Qiu (Soil Ecology) have been examining the linkages among soil microbial biomass and activities, soil labile C and N, and soil CO2 and N2O emissions through incubation experiments. Also, Dr. Xuelin Zhang (a visiting scholar from Henan Agricultural University, China) receives training in N2O emissions as influenced by labile C and N in organic and conventional corn systems. In addition, Dr. Cong Tu is coordinating the field execution of the project and the trace gas emission measurements. Ms. Dolly Watson and Dr. Bhoopander Giri (a visiting scholar from University of Delhi, India) examined the effect of mycorrhizal fungi on soil residue decomposition and N transfer. Two technicians (Mr. Tomas Moreno and Mr. Evan Taylor), who are financially supported by North Carolina Department of Agriculture, also received training in field experimental design and greenhouse gas sampling. Finally, multiple undergraduate students participated in this project through working on sample analyses in lab and/or field management or soil and plant sampling. How have the results been disseminated to communities of interest?Our project and results of our work were shared at the Soil Bration on October 17, 2014, an event organized by the Center for Environmental Farming Systems and the USDA Natural Resources Conservation Service. Over 300 farmers, land managers, and scientists attended this event. We also shared our research at the \"Sustaining agriculture in a changing climate. French-American Climate Change Symposium\". (Raleigh, NC, August 27, 2015. 220 attendees). We have presented our results at six different scientific meetings and more results will be presented at the ASA, CSSA, and SSSA annual meetings in Minniapolis, MN in this coming November. In addition, the Project Director attended the Annual Project Director meeting in DC in October, 2015 and had an oral presentation that highlighted the project progress. In summary, one thesis and seven meeting abstracts were published. What do you plan to do during the next reporting period to accomplish the goals?Research & Education Program: We have requested one-year no-cost extension for our project. We are in the process analyzing results from our multiple experiments that addressed our three long-term goals in understanding the effects of organic systems, cover crops and tillage on soil C and N dynamics and greenhouse gas emissions. In particular, we will carefully build the linkages among soil C and N, microbial activities and soil N2O and CO2 emissions. Using stable isotope techniques, we will finish an ongoing greenhouse experiment that assesses mycorrhizal effects on N2O emissions from conventional and organic soils. We will strive to construct a conceptual model based on a large dataset of N2O emissions as influenced by fertilization practices, tillage and soil physiochemical and biological factors. Five manuscripts for peer-reviewed journals are in internal review or in preparation and will be submitted in this coming winter or Spring, 2016. We will continue to train four graduate students. We will also introduce this project to students to the Soil Ecology class the PD will teach in Spring, 2016. Six to eight manuscripts will be submitted to peer-reviewed journals. Outreach program: We will use the Field day at the CEFS in July 2016 as a platform to show the significance of farming practices in controlling soil C and N dynamics and greenhouse gas emissions. This is one of our major field events and attracts ca. 300 participants. Also, results of our work will continue to be again shared at the annual Organic Grains Field Day on July 30th and the annual Organic Commodities and Livestock Conference held each February. We will present our results at the ASA, CSSA, and SSSA annual meetings (November 2016) and at the Ecological Society of America annual meeting (August, 2016).

2013/09 TO 2014/08 Target Audience: 1. The scientific community in general, particularly ecologists, soil scientists, and biologists 2. Graduate and undergraduate students in agriculture- and environment-related areas. 3. Farmers and land managers. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Over the last 12 months, our project provides opportunities to six graduate students: Miss Alexandra Knight (Crop Science) has been assessing the effects of weed growth on N cycling and N2O emission. Mr. Paul Adams (Entomology) is working on soil arthropod community. Miss Natalie Ross (Soil Science) is exploring a new approach for measuring N2O emissions using a new continuously measuring method in field. Sean Blosvies (Soil Ecology), Peyton Ginakes (Soil Sciences) and Yunpeng Qiu (Soil Ecology) have been examining the linkages among soil microbial biomass and activities, soil labile C and N, and soil CO2 and N2O emissions. Also, Dr. Xuelin Zhang (a visiting scholar) receives training in N2O emissions as influenced by labile C and N in organic and conventional corn systems. In addition, Dr. Cong Tu is coordinating the field execution of the project and the trace gas emission measurements. Ms. Dolly Watson is working on mycorrhizal fungi and soil aggregation. Two technicians (Mr. Tomas Moreno and Mr. Evan Taylor), who are financially supported by North Carolina Department of Agriculture, also received training in field experimental design and greenhouse gas sampling. Finally, multiple undergraduate students participated in this project through working on sample analyses in lab and/or field management or soil and plant sampling. How have the results been disseminated to communities of interest? Our project and results of our work were shared at the annual Organic Grains Field Day on July 30th, 2014 and the annual Organic Commodities and Livestock Conference held in February, 2014. We have presented our results atfour different scientific meetings and more results will be presented at the ASA, CSSA, and SSSA annual meetings in Minniapolis, MN in this coming November. We will show our field project to the participants of the Soil Bration on October 17, 2014, an event organized by the Center for Environmental Farming Systems and the USDA Natural Resources Conservation Service. About 500 farmers, land managers, and scientists will attend this event. In summary, one paper andfour meeting abstracts were published andanother meeting abstracthas beenaccepted. What do you plan to do during the next reporting period to accomplish the goals? Research Program: We will continue to carry out the multiple experiments to address our three long-term goals in understanding the effects of organic systems, cover crops and tillage on soil C and N dynamics and greenhouse gas emissions. In particular, our team will carefully approach all the five specific objectives listed in our proposal and conduct experiments to identify the underlying mechanisms that mediate the effects of soil C and N and microbial activities on soil N_2O and CO_2 emissions. Using stable isotope techniques, we are in the process of designing or carrying out both lab incubation and greenhouse experiments to assess N_2O emissions from conventional and organic soils. We plan to manipulate arbuscular mycorrhizal fungi to determine their impact on N_2O emissions via two potential contrasting mechanisms, labile C inputs or N removal. So far, we have generated a large dataset of N_2O emissions as influenced by fertilization practices, tillage and soil physiochemical and biological factors. We plan to publish these data in multiple manuscripts for peer-reviewed journals. Outreach program: We will use the Soil Bration event in October as a platform to show the significance of farming practices in controlling soil C and N dynamics and greenhouse gas emissions. Also, results of our work will continue to be shared at the annual Organic Grains Field Day on July 30th and the annual Organic Commodities and Livestock Conference held each February. We will present our results at the ASA, CSSA, and SSSA annual meetings and at the Ecological Society of America annual meeting. We will introduce our project and share our results to the participants of the annual CEFS Field Day, an event that regularly attracts ca. 300 participants.

2012/09/01 TO 2013/08/31 Target Audience: The scientific community that includes agronomists, soil scienctists, ecologists, and researchers in the related areas; The organic community that includes organic growers, students and the public who are interested in organic production of foods. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? We have quickly assembled a strong team for the project through which multiple technicians and graduate students have received training. Dr. Cong Tu is coordinating the field execution of the project and the trace gas emission measurements. Ms. Dolly Watson is working on mycorrhizal fungi and soil aggregation. Two technicians (Mr. Tomas Moreno and Mr. Evan Taylor), who are financially supported by North Carolina Department of Agriculture, have joined the team and managed the field plots. Two highly motivated graduate students have joined the team: Miss Alexandra Knight is responsible for assessing the effects of weeds on N cycling and N_2O emission. Mr. Paul Adams is working on soil arthropod community. A third graduate student, Miss Natalie Ross, will join the team in this coming August to determine soil microbial biomass and activities, and soil labile C dynamics. Multiple undergraduate students have been involved. How have the results been disseminated to communities of interest? Our team co-sponsored the event "Farming Strategies in Today's Changing Climate" in Pittsboro, NC on February 8, 2013. Chris Reberg-Horton led the session on annual crop vulnerabilities in the Southeast and how researchers are responding to climate change. We had over 150 farmers and other agricultural professionals attend the event and participate in the discussion sessions. What do you plan to do during the next reporting period to accomplish the goals? Research Program: We will continue to carry out the multiple experiments initiated recently to address our three long-term goals in understanding the effects of organic systems, cover crops and tillage on soil C and N dynamics and greenhouse gas emissions. In particular, our team will carefully approach all the five specific objectives listed in our proposal and conduct experiments to identify the mechanisms that regulate C and N cycling and retention in organic systems. Outreach program: One outgrowth from the recent climate change conference in NC is a proposed climate response tour. This will be a tour of farms with successful adaptation practices for next summer. Also, results of our work will be shared at the annual Organic Grains Field Day on July 30th and the annual Organic Commodities and Livestock Conference held each February. We will present our results at the ASA, CSSA, and SSSA annual meetings (November, 2014; Long Beach, FL) and at the Ecological Society of America annual meeting (August, 2014; Sacramento, CA). In addition, we plan to submit 2-3 manuscripts for peer-reviewed journals based on results obtained from this project.

IMPACT

2012/09 TO 2016/08 What was accomplished under these goals? Summary of overall project: This project assessed soil N_2O emissions in the coastal Southeast US plain, using six conventional (3) and organic (3) systems that have been under contrasting tillage and cover cropping practices over the last 15 years, and examined the relationships between the N_2O emissions and soil C, N and microbial parameters. One of our most striking findings was that regardless of conventional or organic systems, small changes in management practices can have large impacts on greenhouse gas emissions from soil. In particular, tillage and fertilizer placement were found to have major impacts on N2O emissions. Another surprising finding was that applications of some herbicides significantly affected N2O emissions. Also, arbusular mycorrhizal fungi were shown to have high C use efficacy in reducing N2O emissions and transferring soil N to host plants. In addition, our project provided unique opportunities for student training. It provided partially financial supports for three PhD and three MS students, and created a platform in which two exchange PhD students and multiple visiting scholars actively participated. The project and results obtained were timely incorporated into two courses for graduate students (Ecology of Soil Ecosystems; Agriculture and Climate Change). The field project was also presented extensively to diverse audiences of farmers and land managers as well as the scientific community in general. Objective 1: Quantify the greenhouse gas emissions and soil C and N in three organic and tillage management regimes and three paralleled conventional systems. We conducted four sets of field, greenhouse and lab experiments examining N2O emissions from organic and conventional systems located at the Center for Environmental Farming Systems, Goldsboro, NC. First, we monitored N2O emissions following every rainfall event for three years (from early 2013 to later 2015), using the static chamber method, and for the first time, generated a comprehensive long-term dataset of N2O emissions in the coastal Southeast US plain; Second, we examined whether weed growth in the early growth season suppressed N2O emissions and assessed whether and how applications of herbicides (18 chemicals) affected soil N2O emissions (Knight, 2016, PhD Dissertation, North Carolina State University). Third, we conducted a greenhouse experiment assessing the impact of corn roots and their associate mycorrhizal fungi on soil N2O emissions in both organic and conventional soils (Zhang et al. 2016). Fourth, multiple incubation experiments were carried out to quantify the N2O and CO2 emissions from organic and conventional soils as influenced by different C and N availability following cover crop incorporation or crop harvesting (Sean Bloszies, 2016, PhD Dissertation, North Carolina State University). Fifth, we have developed a simple robust continuous monitoring system for N2O emissions to assess the temporal variability in emissions (Ross, 2016, MS Thesis, North Carolina State University). Objective 2: Determine the impact of invertebrates on residue decomposition and soil C stabilization. Field pitfall traps were installed in April 2013 and soil arthropods had been collected continuously for two years. Overall, the abundances and diversity of arthropods decreased with the increasing perturbation intensity and frequencies, leading to highest arthropod abundance and diversity in the organic reduced-till system and lowest in the conventional clean-till one (Adams, 2015, MS thesis, North Carolina State University). These data were also correlated well with microbial biomass and activities. Objective 3: Assess the effects of AM fungi on soil aggregation and N retention in organic systems. We found that mycorrhizal infection of both corn and soybean roots tended to be lower in organic than conventional soils. However, a greenhouse experiment that assessed mycorrhizal effects on N2O emissions showed that mycorrhizal fungi significantly reduced N2O emissions in organic soils but had no effects in conventional soils with high N inputs (Zhang et al. 2016), suggesting that infection rate may have underestimated the contribution of mycorrhizal fungi in N retention. In addition, our results showed that mycorrhizal fungi used marginal organic carbon to significantly enhanced plant N uptake and reduced denitrification, demonstrating their high energy use efficacy. Objective 4: Ascertain the role of cover crops and weeds in mediating soil N availability: We found that cover cropping critically modulated soil N availability. Both the type and the biomass of cover crops significantly affected the soil N and cover crop biomass N that would subsequently be available for the major crop. Also, we examined whether weed growth in the early growth season suppressed N2O emissions and assessed whether and how applications of herbicides (18 chemicals) affected soil N2O emissions (Knight, 2016, PhD Dissertation, North Carolina State University). Our results showed that weeds can substantially retain N in their biomass at the very early stage of crop growing season. What was really surprising was that applications of several herbicides significantly affected soil N transformations and N-transforming microbes. The exact mechanisms are unclear but we will continue to explore the underlying mechanisms. Objective 5: Education and outreach through developing new curricula on greenhouse gases and agriculture for student training and stakeholders. Please below \"opportunities provided for training and professional development\". **PUBLICATIONS (not previously reported):** 2012/09 TO 2016/08 1. Type: Theses/Dissertations Status: Published Year Published: 2016 Citation: Knight, Alexandra Marie. 2016. Greenhouse Gas Emissions in Long Term Agricultural Production Systems. Ph.D., NORTH CAROLINA STATE UNIVERSITY, 2016, 104 pages; 10289909. gradworks.umi.com 2. Type: Theses/Dissertations Status: Submitted Year Published: 2016 Citation: Blosvzies, Sean A. 2016. Soil Microbial Activity and Organic Carbon Dynamics in Low Input Agroecosystems. PhD dissertation. North Carolina State University. 3. Type: Journal Articles Status: Submitted Year Published: 2016 Citation: Bloszies, S. A., J. Grossman, J. Heitman, S. Hu. 2016. Effects of legume cover crops and spring termination practices on soil C dynamics in an organic system in the Southeastern U.S.. Soil & Tillage Research. 4. Type: Journal Articles Status: Accepted Year Published: 2016 Citation: Wu, K.K., D. M. Chen, C. Tu, Y. P. Qiu, K. O. Burkey, S. C. Reberg-Horton, S. L. Peng, Shuijin Hu. 2016. CO2-induced alterations in plant nitrate utilization and root exudation stimulate N2O emissions. Soil Biology & Biochemistry. 5. Type: Journal Articles Status: Under Review Year Published: 2016 Citation: Zhang, X. L., C. Tu, Y.P. Qiu, S.C. Reberg-Horton and S. Hu. 2016. High carbon use efficiency in arbuscular mycorrhizal fungi for reducing soil N2O emissions. Global Change Biology. 6. Type:

Journal Articles Status: Under Review Year Published: 2016 Citation: Knight, A. M., W. J. Everman, S. Chris Reberg-Horton, C. Tu, W. Robarge, N. Ross, S. Bloszies, M. A. Cavigelli, Y. P. Qiu. M. Schroeder-Moreno, S. Hu. 2016. Greenhouse gas emissions in long-tern conventional and organic farming systems in Southeast US. Global Change Biology. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloszies, S.A., C. Reberg-Horton, S. Hu. Effects of Alternative Farming Systems on Soil Organic Matter Pools and Nitrous Oxide Emissions. International Annual meeting of ASA-CSSA-SSSA, Phoenix, AZ. Oral Presentation. Nov 2016. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Qiu YP, Y. Jiang, K.O. Burkey, R. W. Zobel, H.D. Shew, S. Hu. 2016. Effects of arbuscular mycorrhizal fungi on organic carbon decomposition under elevated temperature and ozone conditions. The 101th Ecological Society of America Annual Meeting, August 11, 2016. Fort Lauderdale, FL, USA 9. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Knight, A.M., S. Reberg-Horton, W.J. Everman, S. Hu, D.L. Jordan, and N. Creamer. Nitrous oxide Emissions in long term cropping systems. 2015. ASA-CSSA-SSSA. 342-15. 10. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Knight, A.M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan, and N. Creamer. 2016. Nitrous oxide Emissions in long term cropping systems. Northeastern Plant, Pest, and Soils Conference. 1(70). 11. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Knight, A.M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan, and N. Creamer. 2016. Herbicide and nitrogen applications impact nitrous oxide emissions. Northeastern Plant, Pest, and Soils Conference. 1(156). 12. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Knight, A.M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan, and N. Creamer. 2016. Herbicide and nitrogen applications impact nitrous oxide emissions. WSSA. 56(69). 13. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Knight, A.M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan, and N. Creamer. 2016. Impact of weed management systems on nitrous oxide emissions. SWSS. 69(283).

2014/09 TO 2015/08 What was accomplished under these goals? In the last 12 months, we continued multiple field, greenhouse and incubation experiments to approach the objectives of our research project. Trace gas emissions: Continuous measurements of nitrous oxide (N2O) emission study were performed in six different farming systems with three replicates at Center for Environmental Farming Systems (CEFS), Goldsboro, NC. These systems include Organic clean-till, Organic reduced-till, Organic long-rotation, Conventional clean-till, Conventional no-till, and Conventional long-rotation. A static gas chamber technique was employed to collect N2O emitted from soils. Gas sampling started right after corn seeds were sowed, and takes place 24-48 hours after every rainfall event greater than 0.5 inch within 24 hours. In general, N2O flux rates tended to be higher in the conventional clean-till system than conventional no-till and organic-reduced till systems, with the N2O emission rate being nearly twice much in the former than in the two systems. We also measured the direct effect of multiple herbicides on N2O emissions in incubation experiments. In addition, Co-PI, Wayne Robarge, and his graduate student, Natalie Gross, established a continuous N2O measurement system in the field at CEFS. Soil carbon and nitrogen dynamics: We continued analyzing soil samples collected before planting and during the growing season to monitor the soil C and N dynamics, in particular, the labile C and extractable N. In general, organic C, particularly labile C was higher in organic than conventional systems, but extractable N was strongly affected by organic or mineral N inputs, which was closely related to N2O emissions. The duration of each farming practice also affected the dynamics of soil labile C and N and microbes. Soil C dynamics and mycorrhizal fungi: We found that mycorrhizal infection of both corn and soybean roots tended to be lower in organic than conventional soils. However, a greenhouse experiment that assessed mycorrhizal effects on N2O emissions showed that mycorrhizal fungi significantly reduced N2O emissions in organic soils but had no effects in conventional soils with high N inputs, suggesting that infection rate may have underestimated the contribution of mycorrhizal fungi in N retention. The soil arthropod community structure: field pitfall traps were installed in April 2013 and soil arthropods have been collected continuously since. Overall, the abundances and diversity of arthropods decrease with the increasing perturbation intensity and frequencies, leading to highest arthropod abundance and diversity in the organic reduced-till system and lowest in the conventional clean-till one. These data were also correlated well with microbial biomass and activities. **PUBLICATIONS (not previously reported):** 2014/09 TO 2015/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Bloszies, S.A., Grossman, J.M. and Hu, S. Effect of legume cover crops and spring termination practices on soil C dynamics in an organic system. 2014 Soil Science Society of America Annual Meeting. Long Beach, CA (Nov 4, 2014). 2. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Bloszies, S.A., Ginakes, P., and Hu, S. Soil conservation and greenhouse gas emissions: The role of reduced tillage and organic agriculture in soil nitrous oxide production. 2015 Soil and Water Conservation Society Conference. Greensboro, NC (July 28, 2015). 3. Type: Conference Papers and Presentations Status: Accepted Year Published: 2015 Citation: Bloszies, S.A. Reberg-Horton, S.C., and Hu, S. The Role of Reduced Tillage and Organic Agriculture in Soil Nitrous Oxide Emissions. 2015 Soil Science Society of America Annual Meeting. Minneapolis, MN (November 15, 2015). 4. Type: Theses/Dissertations Status:

Published Year Published: 2015 Citation: Paul R. Adams III. 2015. Soil and foliar arthropod abundance and diversity in five cropping systems in the Southeastern United States. MS Thesis. North Carolina State University. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Knight, A. M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan and N. Creamer. 2014. Impact of Long Term Production Systems On Greenhouse Gas Emissions. Proc. of Amer. Soc. of Agron. 61:15. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Knight, A. M., S. Reberg-Horton, W.J. Everman, S. Hu, D.L. Jordan and N. Creamer. 2015. Nitrous Oxide Emissions in Long Term Cropping Systems. Proc. of Amer. Soc. of Agron. 342: 15. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Knight, A. M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan and N. Creamer. 2015. Nitrous Oxide Output Based on Weed Management Systems. Proc. Weed Sci. Soc. of Amer. 55:119. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Knight, A. M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan and N. Creamer. 2015. Nitrous Oxide Emissions Impacted by Weed Management. Southern Weed Sci. Soc. 68: 133. 9. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Knight, A. M., W.J. Everman, S. Reberg-Horton, S. Hu, D.L. Jordan and N. Creamer. 2015. Effect of Weed Management on Nitrous Oxide Emissions in North Carolina Cropping Systems. Proc. NorthEastern Weed Sci. Soc. 69:44.

2013/09 TO 2014/08 What was accomplished under these goals? In the last 12 months, we conducted multiple field, greenhouse and incubation experiments to approach the objectives of our research project. Trace gas emissions: Nitrous oxide (N2O) emission study was performed in six different farming systems with three replicates starting in April, 2013 at Center for Environmental Farming Systems (CEFS), Goldsboro, NC. These systems include Organic clean-till, Organic reduced-till, Organic long-rotation, Conventional clean-till, Conventional no-till, and Conventional long-rotation. A static gas chamber technique was employed to collect N2O emitted from soils. Gas sampling started right after corn seeds were sowed, and takes place 24-48 hours after every rainfall event greater than 0.5 inch within 24 hours. From April 2013 toAugust 2014, we have sampled45 times.In general, N2O flux rates tended to be higher in the conventional clean-till system than conventional no-till and organic-reduced till systems, with the N2O emission rate being nearly twice much in the former than in the two systems. We also examined whether application of herbicides affect weedy growth and the N2O emission. Following application of PRE herbicides, no significant differences were observed in N2O emissions between the weedy versus weed free plots both in 2013 and 2014, likely due to the lack of significant weed growth. Soil carbon and nitrogen dynamics: We collected soil samples right before planting and continued the sampling periodically to monitor the soil C and N dynamics, in particular, the labile C and extractable N. In general, organic C, particularly labile C was higher in organic than conventional systems, but extractable N was strongly affected by organic or mineral N inputs. The duration of each farming practice also affected the dynamics of soil labile C and N and microbes. Weed treatments through herbicides did not significantly affect soil extractable and mineralizable N. In addition, a lab incubation experiment showed that soil N2O emissions were higher in the conventional till system than other ones. Soil C dynamics and mycorrhizal fungi: Soil, and corn and soybean root samples have been collected for measurement of external fungal hyphal, root colonization and soil aggregate stability measurements from the first two sampling times of 4 weeks and 8 weeks post corn germination. Surprisingly, mycorrhizal infection of both corn and soybean roots tended to be lower in organic than conventional soils. However, a greenhouse experiment that assessed mycorrhizal effects on N2O emissions showed that mycorrhizal fungi significantly reduced N2O emissions in organic soils but had no effects in conventional soils with high N inputs. The soil arthropod community structure: field pitfall traps were installed in April 2013 and soil arthropods have been collected continuously since. Interestingly, arthropod abundance was highest in the conventional no-till system and lowest in the conventional-clean till one. The exact implications of these data are unclear and we plan to examine how these differences in abundance affect residue decomposition in this coming year. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: A.M. Knight, W.J. Everman, S. Reberg-Horton, and S. Hu. 2014. IMPACT OF WEED MANAGEMENT SYSTEMS ON GREENHOUSE GAS EMISSIONS. Proc. NorthEastern Weed Sci. Soc. 68:32. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: A.M. Knight, W.J. Everman, S. Reberg-Horton, and S. Hu. 2014. IMPACT OF WEED MANAGEMENT SYSTEMS ON GREENHOUSE GAS EMISSIONS. Proc. South. Weed Sci. Soc. 67:47. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: A.M. Knight, W.J. Everman, S. Reberg-Horton, and S. Hu. 2014. IMPACT OF WEED MANAGEMENT SYSTEMS ON GREENHOUSE GAS EMISSIONS. Proc. Weed Sci. Soc. Amer. 54:300. 4. Type: Conference Papers and Presentations Status: Accepted Year Published: 2014 Citation: A.M. Knight, W.J. Everman, S. Reberg-Horton, and S. Hu, D.L. Jordan and N. Creamer. 2014. IMPACT OF LONG TERM PRODUCTION SYSTEMS ON GREENHOUSE GAS EMISSIONS. Proc. of Amer. Soc. of Agron. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: X.L. Zhang, C. Tu, Y.P. Qiu, S.C. Reberg-Horton and S. Hu. 2014. Arbuscular mycorrhizal fungi markedly reduce N2O emissions from an organic soil. 99th Annual meeting of

Ecological Society of America. Sacramento, August 10-15, 2014. 6. Type: Journal Articles Status: Published Year Published: 2014 Citation: Y. Wang, Wen Xia Duan, C. Tu, S. Washburn, L Cheng and S. Hu. 2014. Soil carbon, nitrogen and microbial nynamics of pasturelands: Impacts of grazing intensity and planting systems. Pedosphere 24: 408-416.

2012/09/01 TO 2013/08/31 What was accomplished under these goals? In the first eight months of the project, we prepared our field plots, adjusted the crop rotation and have initiated multiple experiments to approach our objectives: Plot preparation: In fall 2012, we made adjustments in winter crops with different types of cover crops/mixes depending on the treatment: all conventional treatments with wheat, both the organic clean-till and the organic long-rotation with clover and vetch, and the organic reduce-till with clover, vetch, and rye. In the spring of 2013, cover crops were killed about three weeks before planting the corn. Corn planting and fertilization: All treatments were planted with corn on April 17th (organic treatments) and April 18th (conventional plots). All organic treatments received 5 T of chicken litter per acre before planting. The conventional treatments received approximately 75 lb N, 30 lb P, and 50 lb K per acre when corn was planted. Additional 75 lb N per acre was applied to the conventional plots when the corn was 6 weeks old. Field experiments: a. Trace gas emissions. We have collected gas samples six times since the chambers were installed on the day of planting. We used plastic chambers composed of two main parts: the anchor (bottom part, 29 cm dia) and the top cover, and are water sealed. All chambers anchors were placed in the field the day of planting, ready for the first rain event after planting for the gas sampling. A total of 36 chambers were place in the field, two per plot. Chambers needed to be removed every time machinery for weed control was used in the organic treatments and when N was applied in the conventional treatment. In addition, soil moisture/temperature sensors were installed at 3 and 6 inches deep in all treatments. The field setup of gas chambers for greenhouse gas emissions was an important milestone that allowed us to quantify the emissions of all three greenhouse gases (CO2, CH4 and NO) from the very beginning of the growing season. Also, we set up the gas chromatograph in a lab near the field plots in Goldsboro, NC, which provided convenient access for determinations of GHG gases. b. Soil carbon and nitrogen dynamics: We collected soil samples right before planting and continued the sampling monthly to monitor the soil C and N dynamics, in particular, the labile C and extractable N. Weed treatments have also been established to examine soil extractable and mineralizable N. c. Soil C dynamics and mycorrhizal fungi: Soil and corn root samples have been collected for measurement of external fungal hyphal, root colonization and soil aggregate stability measurements from the first two sampling times of 3 weeks and 7 weeks post corn germination. d. The soil arthropod community structure: field microcosms have been installed and used to collect the soil insects with an objective to build the linkages between soil insects, residue decomposition and N cycling.

PUBLICATIONS

2012/09/01 TO 2013/08/31 No publications reported this period.

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