OREI Project Details

Award Year 2010

23 Research Projects

PROJECT INDEX

18. Holistic Integration of Organic Strategies and High Tunnels for Midwest/great Lakes Fruit Production
Grant No: 2010-51300-21395

19. A Systems Approach to Control Gastrointestinal Nematodes in Organic Small Ruminant Production
Grant No: 2010-51300-21641

20. Organic Blackberry Production Systems for Improved Yield, Fruit Quality, and Food Safety in Fresh and Processed Markets Grant No: 2010-51300-21264

21. Tools for Organic Transition: Financial Data and Educational Resources for Farmers and Agricultural Professionals Grant No: 2010-51300-21401

22. Organic Dry Bean Production Systems Grant No: 2010-51300-21224

23. Using Winter Cover Crops to Enhance the Organic Vegetable Industry in the Mid-atlantic Region
Grant No: 2010-51300-21412

Strategies of Pasture Supplementation on Organic and Conventional Grazing Dairies: Assessment of Economic, Production and Environ. Outcomes

Accession No.	0220749
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Agency	NIFA WIS
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Investigator(s)	Cabrera, V. E.; Wattiaux, M. A.; Combs, D. K.; Gildersleeve, R. R.
Performing Institution	Dairy Science, UNIV OF WISCONSIN, 21 N PARK ST STE 6401

NON-TECHNICAL SUMMARY

The dairy production standards from USDA National Organic Program stress integration of pastures as part of farm feeding strategies. Managed pastures provide abundant, high quality forage, but also present challenges when balancing dairy rations. Organic farms may have additional economic, production and environmental challenges when growing or purchasing supplemental feeds for grazing dairy herds. We will investigate the impacts of pasture supplementation decisions made on Wisconsin organic and conventional grazing dairies. Results will be used to develop outreach materials and decision aids for farmers and extension agents or other agricultural professionals as they assist organic, transition, beginner or grazing dairy producers with farm planning and risk management decisions. This project addresses national Organic Agriculture Research and Extension Initiative goals by facilitating farm level production decisions on organic dairy feed management, evaluating economic benefits to organic producers, and identifying optimal environmental outcomes from appropriate pasture supplementation strategies.

OBJECTIVES

This project will conduct integrated, long-term research and extension work with the overall goal of investigating the impacts of pasture supplementation decisions made by Wisconsin organic and conventional grazing dairies on selected economic, production and environmental variables. The information gained will be utilized to develop outreach materials and decision aids that will be useful to farmers and extension professionals or other agricultural professionals as they assist organic, transition, beginner or grazing dairy producers with farm planning and risk management decisions. Our specific objectives are: (1) Identify farm level factors contributing to pasture supplementation decisions on organic and comparable conventional dairy grazing farms. (2) Evaluate the economic, production, and environmental outcomes of pasture supplementation strategies used on organic and comparable conventional grazing dairy farms. (3) Develop sustainability indexes to compare within and between organic and conventional grazing dairies. (4) Create decision support aids and consult one-to-one participating farms with research results to assess long-term production, economic, and environmental sustainability. (5)

disseminate extension information and assess effectiveness of outreach methods and impacts of changes to supplementation strategies made by organic, transition or grazing dairy producers on whole farm planning and risk management to optimize human, land, and capital resources for long-term farm sustainability.

APPROACH

Study Design: Prospective cross-sectional stratified random sampling of organic and comparable grazing dairies in the state of Wisconsin. To ensure a wide cross-section of farms interested in participation in the project, we will work with a number of stakeholders to develop an invitational mailing, including GrassWorks, the statewide grazing farm organization, approximately 15 networks local grazing networks, organic dairy cooperatives such as Organic Valley, other interested farm groups, and the state Department of Ag, Trade & Consumer Protection organic & grazing specialist. Number of herds to be studied: 50 organic and 50 grazing dairies. Herd selection criteria and characteristics: Dairy herds that have been utilizing management intensive grazing and shipping milk for at least 3 years will be eligible and invited to participate in the study and further categorized as organic or grazing. Once enrolled, all farms will be asked to define their preferred pasture supplementation strategy by peer category (no grain, grain on farm sources, or grain off farm sources). These criteria will be applied to categorize groups of farms to study in order to reduce farm to farm variability due to grazing management experience. Data collection: Trained staff will collect relevant data on selected economic, production, and environmental variables during 6 scheduled visits over two grazing seasons (2010 and 2011). Data will be collected using a combination of questionnaires and physical samples collection, depending on the variable of interest. Sample collection and analysis: All sample collection and analysis will be coordinated through the Extension Dairy Management Lab in the University of Wisconsin Dairy Science Department. Analysis of concentrates, forage, soil, and manure samples will be conducted by the University of Wisconsin Forage, Plant & Soil Testing Labs at Marshfield and Madison as appropriate using standard analytical procedures for each sample category. Effectiveness of dissemination methods and adoption of practices will be facilitated through a variety of methods, including producer meetings, newsletters, magazine articles, Cooperative Extension websites, scientific manuscripts, and web-based interactive tools in addition to the leadership role model of participant farmers. Data on receptiveness and behavioral change will be collected to identify the most valuable dissemination methods that will reach and promote management changes among organic, grazing, or transitional producers regarding feed supplementation strategies. Each year of the project, a survey will be randomly assigned to a group of 30 participants and non-participating peers to (1) assess the effectiveness of the delivery methods and (2) document adoption practices based on project on-going results. During the final 6 months of the project, a post-evaluation survey will also be solicited from all participant farmers and a random group of 100 non-participating organic, grazing, and transitional dairy producers to assess the effectiveness of delivery of project outcomes to participants and their peers and document adoption of different feeding strategies due to project results. **Progress** 01/15/10 to 01/14/15 **Outputs** Target Audience: This project targeted dairy farmers as the main audience to serve. Within this audience, it better served disadvantaged, minority, and traditionally underserved (educationally and sometimes economically) grazing and organic dairy production system farmers. The project reached a group of at least 1000 farmers throughout the seminars, conferences, and workshops executed. Along with the farmers, UW Extension agents who are in close contact with these producers were important secondary target audiences of the project and at least 20 agents in Wisconsin were made aware andfollowed and transmitted results of the project. Other target audiences were on-farm consultants including nutritionists, veterinarians, commercial agricultural lenders, and government agency personnel (USDA-NRC-FSA) working with farmers. All publications, presentations, and decision support tools developed as part of this project are available at the University of Wisconsin Dairy Management Website: DairyMGT.info. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Students: M.S. Claudia Hardie and Ph.D. Marion Dutreuil both sucessfully completed successfully their degrees from this project. The project also supported the training of enumerators (survey data collectors) from the Wisconsin Department of Agriculture. Support also gave direct and indirect training to dairy producers through a number of local, national, and international extension programs. How have the results been disseminated to communities of interest? All project materials and results have been posted and updated at the University of Wisconsin Dairy Management Website, the most used web portal in the State of Wisconsin dealing with this subject matter. Results of the project were presented at high profile extension meetings (e.g., Midwest Organic and Sustainable Education Service Conference, the American Dairy Science Annual meeting, or the University of Extension Grazing Conference)at least once during the last 3 years of project. The University of Wisconsin-Extension grazing specialist and co-PI R. Gildersleeve have prepared a number of fact sheets based on the project\'s results, which have been used in a number of extension meetings across Wisconsin in the last 2 years of the project. This is currently an ongoing effort. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **Impacts** What was accomplished under these goals? Results from the project describe the farm characteristics and management strategies contributing to performing pasture supplementation on organic and

grazing dairy farms in Wisconsin. Results from this project have also clearly delineated production, economic and environmental outcomes related to pasture supplementation strategies of organic and grazing dairy operations in Wisconsin. Results and extensive data collected through comprehensive survey questionnaires and personal interviews have been accommodated into decision support toolsthatinclude proxy variables of sustainability indexes to help farmers and farm advisors with optimal decision-making. The tools developed within the project are listed on the tools section of the University of Wisconsin Dairy Management Website (http://DairyMGT.info -\> Tools). Our main findings indicate: 1)Wisconsin\'s organic dairy farms differ significantly in size, feeding management, productivity, and income over feed cost. Organic farms having predominantly Holstein cows and relying on a greater variety of feed ingredients and greater amounts of nonpasture feeds had the largest production and productivity and thehighest income over feed costs (andlikelyhigher overall profitability) compared with farms using predominantly non-Holstein breeds and relying more heavily on grass-based diets. 2)Feeding management changes can be made to reduce greenhouse gas emissions on Wisconsin conventional, grazing, and organic dairy farms, and in some cases, those changes can improve profitability. Specific positive management strategies include increase grazing feeding on conventional farms and increase the level of concentrate in feed rations in organic and grazing dairy farms.In contrast, changes in manure management to reduce green house gases emission were possible, but these changes had a negative effect on profitability. The evaluation and the implementation of green house gases mitigation strategies and their impact in profitability should be based on farmspecificcharacteristics and using data from site-specific farm conditions. **Publications** - Type: Journal Articles Status: Published Year Published: 2014 Citation: Dutreuil, M., M. Wattiaux, C. A. Hardie, and V. E. Cabrera. 2014. Feeding strategies and manure management for cost effective mitigation of greenhouse gas emissions from dairy farms in Wisconsin. Journal of Dairy Science 97:5904-5917. - Type: Journal Articles Status: Published Year Published: 2014 Citation: Hardie, C., M. Wattiaux, M. Dutreuil, R. Gildersleeve, N. Keuler, and V. E. Cabrera. 2014. Feeding strategies on certified organic dairy farms in Wisconsin and their impact on milk production and income over feed costs. Journal of Dairy Science 97:4612-4623. - Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Cabrera, V. E., and M. Dutreuil. 2014. Implementation of greenhouse gas mitigation strategies on organic, grazing and conventional dairy farms. In Proceedings 11th European International Farming System Association Symposium of the Farming and Rural Systems. Berlin, Germany. 1-4 April 2014. - Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Hardie, C. 2013. M. S. Thesis. University of Wisconsin, Madison, Wisconsin. General Management and Feeding Strategies on Wisconsin Organic Dairy Farms. - Type: Theses/Dissertations Status: Awaiting Publication Year Published: 2015 Citation: Dutreuil., M. 2015. Ph. D. Thesis. Comparison of farm management practices on conventional grazing and organic dairy farms in Wisconsin, and their impacts on economics and environment. - Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Dutreuil, M., M. Wattiaux, R. Gildersleeve, and V. E. Cabrera. 2014. Modeling the impact of feeding and manure management strategies on Wisconsin organic, conventional and grazing farms to mitigate greenhouse gas (GHG) emissions. In Proceedings The Midwest Organic and Sustainable Education Service Conference. La Crosse, WI. 27 February to 1 March 2014. - Type: Other Status: Published Year Published: 2014 Citation: Gildersleeve, R., C. A. Hardie, M. Dutreuil, M. Wattiaux, and V. E. Cabrera. 2014. Feeding Strategies on Wisconsin Dairy Farms: Economic, Production, and Environmental Outcomes. http://dairymgt.info/publications/extension_publications/FS1%20Project%20Overview.pdf - Type: Other Status: Published Year Published: 2014 Citation: Gildersleeve, R., C. A. Hardie, M. Dutreuil, M. Wattiaux, and V. E. Cabrera. 2014. Farm characteristics of surveyed farms. <http://dairymgt.info/publications/extension_publications/FS1%20Project%20Overview.pdf>.

PROGRESS

2013/01 TO 2014/01 Target Audience: Project\'s main target audience is dairy farmers. Within this audience, it better serves disadvantaged, minority, and traditionally underserved(educationally and sometimes economically) grazing and organic dairy production systems. During 2013 the project reached agroup of at least 400 farmers through conferences and seminars. Along with farmers, UW Extension agents who are in closecontact with these producers are important secondary target audiences of the project, as are other on-farm consultants including nutritionists, veterinarians, commercial agricultural lenders, and government agency personnel (USDA-NRCS-FSA) working with these farmers. All publications, presentations, and decision support tools developed as part or in leverage with this project are available at the University of Wisconsin Dairy Management Website: DairyMGT.info. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? M.S. Claudia Hardie complete succesfully her degree with this project support. Ph.D. Dissertor Marion Dutreuil passed her Ph.D. examination and is planned to defend her dissertation project in summer or fall 2014. How have the results been disseminated to communities of interest? Extension presentations in Wisconsin had been the mean means of dissemination so far. Our partner UW-Extension Fcaulty Rhoda Gildersleeve is working on putting together a number (10) fact sheets based on results of our project.

These practical take home messages will be widely disseminated across Wisconsin dairy industry community. What do you plan to do during the next reporting period to accomplish the goals? Here it is a tentaive plan of activities for 2013-2014: Revision article organic dairy farms cluster analysis (Hardie) January 2014 Submission article profitability and green house gasses (Dutreuil) February 2014 Decision support tool about grain/concentrate supplementation completed March 2014 Submission article regression explaining profitability (Dutreuil) April 2014 Submission article manure management and indices (Dutreuil) June 2014 Decision support tool about income over feed cost completed June 2014 Ph.D. student defense (Dutreuil) summer/fall 2014 Decision support tool about environmental impacts completed September 2014 Dissemination of decision support tools March 2014-January 2015 Production and dissemination of 10 fact-sheets (UW-Extension) March 2014-January 2015 Extension seminars and workshops June 2014-January 2015

2012/01/15 TO 2013/01/14 OUTPUTS: During the period January 2012 through January 2013, the two students involved in this project, Marion Dutreuil (PhD) and Claudia Hardie (MS), worked on the design, data entry and implementation of the project\'s main database containing comprehensive information on 131 dairy farms previously surveyed. Seventy farms are organic, 30 are grazing (non-organic), and 31 are non-grazing, non-organic Wisconsin dairy farms. The database has been completed and it is being used for scientific analysis. Main results of scientific analyses that included a description of Wisconsin dairy farms\' profitability, green house gas emissions, and profiles of organic dairy farms in Wisconsin were presented at the Joint Annual Meeting of the Animal Sciences and the American Dairy Science Association in Phoenix, Arizona in July 2012. Results were also presented in more producer- and practitioner-oriented settings. Two presentations were made to Extension and other agency partners during the University of Wisconsin Extension Grazing Teaching and Technology Conference held at the U.S. Dairy Forage and Research Center (August 2012) on \"factors affecting profitability on Wisconsin dairy farms\" and \"characterization of certified organic dairy farms in Wisconsin.\" At the annual World Dairy Expo Grazing Seminars (October 2012) \"supplementation on pasture dairy farm systems\" was presented to an audience that included producers, agency staff, and allied ag industry interests. Consulting with statisticians and definition of further analysis continued during the remainder of 2012. Expected continued work includes: application of the Integrated Dairy Farm System Model to 3 defined dairy farm systems to study their economic, production, and environmental outcomes; use of cluster analyses to study manure management practices on Wisconsin dairy farms; application of cluster analysis to study factors affecting farm profitability; research of grazing practices\' impacts on dairy farm performance; and studies of farmer satisfaction according to dairy farm characteristics. PARTICIPANTS: Individuals (PIs/PDs) and main role/expertise: Victor E. Cabrera: General project leadership, economic decision-making related to dairy feed supplementation. Rhonda Gildersleeve: Dairy pasture management, grazing activities, and overall dairy grazing and organic production systems. Michel Wattiaux: Dairy cattle nutrition, crop systems, and nutrient management. David Combs: Dairy cattle nutrition combined with grazing systems. Individuals (Students) and roles: Marion Dutreuil (PhD): Survey instrument development, field data collection, data entry and database development, statistical analyses, and research and extension publications. Claudia Hardie (MS): Sample determination, field data collection, data entry, statistical analyses, and research and extension publications. Statistical support: Nick Keuler, Associate Researcher at Computer & Biometry, University of Wisconsin-Madison College of Agricultural & Life Sciences. Erik Nordheim, Professor in the Statistics Department, University of Wisconsin-Madison College of Letters. TARGET AUDIENCES: This project\'s main target audience is dairy farmers. Within this audience, it better serves disadvantaged, minority, and traditionally underserved (educationally and sometimes economically) grazing and organic dairy production systems. During 2012 the project reached a group of at least 500 farmers through conferences and seminars. Along with farmers, UW Extension agents who are in close contact with these producers are important secondary target audiences of the project, as are other on-farm consultants including nutritionists, veterinarians, commercial agricultural lenders, and government agency personnel (USDA-NRCS-FSA) working with these farmers. All publications, presentations, and decision support tools developed as part or in leverage with this project are available at the University of Wisconsin Dairy Management Website: DairyMGT.info. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2011/01/15 TO 2012/01/14 OUTPUTS: During the period January 2011 and January 2012, the two students involved in this project: Marion Dutreuil (PhD) and Claudia Hardie (MS) devoted great effort and time on selecting, recruiting, and interviewing organic and grazing dairy farmers across Wisconsin. They used the 50-page (5-hour) survey developed in the previous year as the instrument for data collection. In total, they collected in-depth information from more than 120 dairy farms. The data collection (interview) part of the project is now completed. Preliminary results of subsets of data collected through the interviews were presented to the Midwest Organic and Sustainable Education Service Conference (February 2011), Organic Farming Systems Research (March 2011), and in the National Joint Annual Meeting of the Animal Sciences (that includes the American Dairy Science Association) (July 2011). Several database, statistical, and methodological analyses packages to be

used with the data collected are being explored. A database standard for the survey was created and is being used to enter the collected data. Several methodological statistical frameworks were explored and are still being analyzed. These include descriptive statistical analyses, principal component analyses, factor analyses, cluster analyses, Delphi method, etc. The Integrated Farm System Model, which is a whole dairy farm simulation model has also been studied and selected as a tool to describe and perform predictions and scenario analyses with the data collected in the surveys. A benchmarking decision support online tool (DairyMGT.info: Tools: Dairy Extension Feed Cost Evaluator) has been prepared to receive data from the surveys and perform seasonal analyses on the studied farms of income over feed costs and their relationships with feed supplementation. Farmers, whether they are participating in the study or not, have free access to it. An increasing group of farmers are using this tool for practical decision-making. PARTICIPANTS: Individuals (PIs/PDs) and main role/expertise: Victor E. Cabrera: General project leadership. Economic decision-making related to dairy feed supplementation. Rhonda Gildersleeve: Dairy pasture management, grazing activities, and overall dairy grazing and organic production systems. Michel Wattiaux: Dairy cattle nutrition, crop systems, and nutrient management. David Combs: Dairy cattle nutrition combined with grazing systems. Individuals (Students) and role: Marion Dutreuil (PhD): Survey instrument development, field data collection, data entry and database development, statistical analyses, and research and extension publications. Claudia Hardie (MS): Sample determination, field data collection, data entry, statistical analyses, and research and extension publications. TARGET AUDIENCES: This project targets dairy farmers as the main audience to serve. Within this audience, it better serves disadvantaged, minority, and traditionally underserved (educationally and sometimes economically) grazing and organic dairy production systems. During 2011, the project reached a group of at least 1,000 farmers throughout the survey process. Although not all of them participated or will participate in the study (a group of 120+ farmers were interviewed during 2011), all of them were exposed to the concepts of the project. Along with the farmers, UW Extension agents who are in close contact with these producers are important secondary target audiences of the project, as are other on-farm consultants including nutritionists, veterinarians, commercial agricultural lenders, and government agency personnel (USDA-NRC-FSA) working with these farmers. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/01/15 TO 2011/01/14 OUTPUTS: Project\'s team (http://dairymgt.uwex.edu/projects/orei.php) conducted a series of focus groups with dairy farmers and extension agents around the State of Wisconsin, including a special session in the 2010 Grazing Conference in Wisconsin Rapids. During the focus groups, feedback was solicited from participants regarding the project. A document summarizing the most important findings from more than 50 people is being used for project\'s next steps. In collaboration with survey experts at the University of Wisconsin-Madison (Prof. B. Barham) and with the participation of students involved in the project, the project\'s team developed a highly interdisciplinary and comprehensive survey instrument. The goal of this 50-page questionnaire is to collect very detailed information from dairy farms with regard to: A) Farm business structure and decision makers; B) people working on the farm; C) dairy herd and management; D) feeding management; E) pasture management; F) land management and cropping operation; G) manure and nutrient management; H) farmer to farmer interactions; I) economic information; and J) assessment of farm management and satisfaction. During the final stages of survey instrument development, the questionnaire was extensively reviewed, commented, and analyzed by technical personnel from the USDA\'s National Agricultural Statistical Service, Wisconsin Field Office (WASS) with the endorsement of its Director (R. Battaglia) and improved based upon their feedback. The questionnaire was then tested with 5 farm operations and further improved. A survey manual document was developed to define each and every major concept to help enumerators collect consistent data in the field. In September 2010, the project\'s team conducted a two-day training workshop in Richland Center, WI, with the attendance of 8 enumerators hired to conduct the survey in South West Wisconsin counties. Six of the enumerators were from WASS and 2 of the enumerators were free-lance, local individuals with farm background and interest to conduct the survey. A random sample of 100 dairy farmers (50 conventional graziers, and 50 organic) was defined and distributed among the enumerators, who are currently performing the interviews. As an additional deliverable leveraged by this project was the inclusion of additional 100 non-grazier conventional farmers in this sample frame within the collaboration with Prof. B. Barham and his NSF project. Before starting, a press release and letters to county extension offices were distributed to alert and invite them in our efforts. The team defined a protocol for enumerators that included to mail a personal letter, visit in person selected farms, make appointments with accepting farmers, ask farmer to sign the project\'s approved IRB consent form, perform survey, and provide a summary benchmarks later. Marion Dutreul, Ph.D. student is developing a database with the survey data and the framework for data analyses. A phase II of the survey to include all other counties not included in Phase I is currently under development. Claudia Hardie, M.S. student, will perform personal interviews for Phase II of survey. PARTICIPANTS: Individuals (PIs/PDs) and main role/expertise: Victor E. Cabrera: General project leadership. Economic decision-making related to dairy feed supplementation. Rhonda Gildersleeve: Dairy pasture management, grazing activities, and overall dairy grazing and organic production systems. Michel Wattiaux: Dairy cattle nutrition, crop systems, and nutrient management. David Combs: Dairy

cattle nutrition combined with grazing systems. Individuals (Students) and role: Marion Dutreuil (PhD): Survey instrument development, data entry and database development, lineaments of analyses. Claudia Hardie (MS): Plan and application of developed survey (Phase II) to all Wisconsin, except the South West counties. Individuals (Enumerators) and role: Stephanie Eastwood: Interview surveys in the South West Wisconsin. Allen Moody: Interview surveys in the South West Wisconsin. Partner organizations: Program on Agricultural Technology Studies (PATS) and the Department of Agricultural and Applied Economics at the University of Wisconsin-Madison. We joined forces with Brad Barham, recipient of a NSF grant, to leverage resources in the development of a more comprehensive survey in scope and content. The PATS provided expertise in the development of survey research through the individuals of Brad Barham (Senior Faculty Associate), Alan Turnquist (Outreach Specialist), and Caroline Brock (Outreach Specialist). USDA\'s National Agricultural Statistical Service, Wisconsin Field Office (WASS). The WASS office provided comprehensive feedback in the survey instrument and survey planning through several functionaries: Robert Battaglia (Director), Heidi Woodstock (Officer), Andrew Dau (Officer), and Audra Hubbell (Officer). Moreover, the WASS office committed 6 field enumerators to perform part of the project survey in the South West Wisconsin. North American Network on Sustainable Dairy Systems A group of \~20 scientists from 4 universities in Mexico, the University of Laval in Canada, and 2 co-PIs/PDs of this project (Wattiaux and Cabrera) are collaborating within the main thrust of dairy farm sustainability. As part of such collaboration, resources would be leveraged to perform comparative studies on feed supplementation on representative systems in different locations in Canada, the US, and Mexico. Training or professional development Two-day training workshop in Richland Center, WI, with the attendance of 8 enumerators hired to conduct the survey in South West Wisconsin counties: Crawford, Grant, La Crosse, Lafayette, Monroe, Richland, Sauk, and Vernon. TARGET AUDIENCES: This project targets dairy farmers as the main group to serve. Inside this group, it better serves disadvantaged, minority, and traditionally underserved (educationally and sometimes economically) grazing and organic dairy production systems. During 2010, the project reached a group of at least 50 organic, 50 grazing, and 100 comparable (small) conventional dairy farms throughout the process of survey. Although not all of them participated or will participate in the study, all of them were exposed to the concepts of the project. Along with the farmers, extension agents who are in close contact with these producers are important target audiences of the project together with farm consultants including nutritionists and veterinarians working with these farmers. With the aim of helping in the process of farmers making better informed decisions and in preparation of the data analysis and further follow up with farmers, project\'s team has developed a web-based, log-in tool (http://dairymgt.uwex.edu/iofscdb/login.php) to benchmark and evaluate feed cost supplementation and income over feed cost among a group of farms. Data from surveys will be entered in this database in order to record trends and collect results of feeding supplementation practices. Farmers, whether they are participating in the study or not, have free access to it. An increasing group of farmers are using this tool for practical decision making. Better informed farmers are making better feed supplementation decisions and consequently improving overall farm sustainability. The project is currently undergoing and additional extension outreach activities are planned when data are available. PROJECT MODIFICATIONS: Due to extremely economic hardship during the last 2 years (several times expressed by farmers to enumerators) and because the level of detail pertained in the survey instrument (4 hours of interview on average), a rate of response lower than expected to survey participation is occurring. The rate of participation is being around 20% and we expected 40%. Leverage performed with another project allowed to increase our sample size, which is helping to reach our goal of completed surveys. Nonetheless, in order to assure a number of participants higher than the target of 50 organic and 50 graziers, the project team has agreed to hire additional enumerators and offer a compensation of \$100 to participating dairy producers.

IMPACT

2013/01 TO 2014/01 What was accomplished under these goals? Active research to evaluate supplementation decisions and their economic, production, and environmental outcomes was performed during 2013. M.S. student Claudia Hardie defended her thesis successfully in June and as part of it a paper that deals with supplementation practices in organic farms has been submitted and s being reviewed in the Journal of Dairy Science. Ph.D. student Marion Dutreuil has outlined her dissertation and as part of it 4 major research accompishments with survey collected data are being developed: 1) whole farm environemtal and economic outcomes using the Integrated Farm System Model (paper almost ready to be submitted), 2) regression analysis of feeding strategies, and 3) manure management strategies. Under project objective 3, Marion is working on a research to use all previous collected information and analyses to develop sustainability indices. Under objectives 4 and 5 of project, a number of online decision support tools have been developed or adapted (please see Products section) and at least 4 extension presentations have been performed in Wisconsin with preliminary results. **PUBLICATIONS (not previously reported):** 2013/01 TO 2014/01 1. Type: Conference Papers and Presentations Status:

Published Year Published: 2013 Citation: Hardie, C. A., M. Dutreuil, R. Gildersleeve, M. Wattiaux, N. S. Keuler, and V. E. Cabrera. 2013. Impact of feeding strategies on milk production and profitability on Wisconsin organic dairy farms. Journal of Animal Science 91 (E-Suppl. 2):TH378. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Hardie, C. A., M. Dutreuil, R. Gildersleeve, and V. E. Cabrera. 2013. A comparison of feeding strategies on Wisconsin organic dairy farms. In Proceedings The Midwest Organic and Sustainable Education Service Conference. La Crosse, WI. 23 February 2013. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Hardie, C. A., V. E. Cabrera, M. Dutreuil, and R. Gildersleeve. 2012. Characterization of certified organic Wisconsin dairy farms: Management practices, feeding regimes, and milk production. In Proceedings UW-Extension Grazing, Teaching, and Technology Conference. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Dutreuil, M., V. E. Cabrera, R. Gildersleeve, and C. A. Hardie. 2012. Factors affecting profitability on Wisconsin dairy farms. In Proceedings UW-Extension Grazing, Teaching, and Technology Conference. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012. 5. Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Hardie, C. 2013. M. S. Thesis. General Management and Feeding Strategies on Wisconsin Organic Dairy Farms. University of Wisconsin, Madison, Wisconsin.

2012/01/15 TO 2013/01/14 As previously described, a large number of scientists and dairy farmers or dairy farmer practitioners have increased their awareness of a series of new applicable and relevant information gained through the present project. Below is a synopsis of these major knowledge gains. A wide range of intersected profitability levels exists among dairy farms regardless of the dairy production system: conventional, grazing, or organic. More important than the system type are the management strategies that farmers choose to exercise within their farming system, which account for most of the economic difference among dairy farms. The impact of animal density on estimated green house gas emissions depends on the farm management more than the type of the system (conventional, grazing, or organic). Combining farm data with model-based prediction is a powerful and useful framework to perform critical decision-making on dairy farms. Certified organic dairy farms in Wisconsin have tremendous variations regarding herd performance characteristics and feeding regimes. Increased awareness and understanding of the general structure of this broad range of on-farm resources and conditions should help design and implement Extension programs and agricultural publications better suited to meet the educational needs of this dairy sector.

2011/01/15 TO 2012/01/14 Our project\'s team emphasizes that the process of performing and applying a large, comprehensive, and detailed survey has provided an opportunity for the farmer being interviewed to reflect, learn, and possibly take actions about their operation\'s management. Interviewed farmers have indicated that they usually do not take time or have not thought before about all the integrated factors and potential impacts of feeding supplementation practices on the performance of the whole integrated dairy farm operation. Farmers exposed to the survey during 2011 have experienced a change in knowledge that may lead to changes in actions such as improved feeding management strategies, pasture utilization, feed supplements purchase, or feed price risk management. We are planning to summarize take home messages found with the surveys, send those with custom analyses to participating farmers, and distribute the main results widely throughout Wisconsin. We envision that results will lead to improved dairy farm sustainability, especially for organic, grazier, or transition farmers. Improved sustainability is projected because these farmers will make better decisions on feeding supplementation regarding their economic, productive, and environmental outcomes based on-farm data collected through this project. At the moment, similar data are very limited or non-existent. Knowledge gained and an improved understanding of on-farm production situations can be summarized in some initial assessments described below. Preliminary analyses suggest that Wisconsin organic producers have a large size range between 12 and 650 cows, pasture area between 6 and 146 ha, production average between 2,350 and 10,270 kg/cow per year, feed consumption between 11.8 and 25.6 kg of dry matter /cow per day, and grazing time between 122 and 244 days/year. Awareness of these extreme variations should help design Extension programs and agricultural publications better suited to meet the educational needs of this growing dairy sector. An initial cluster analysis using complete linkage on 4 organic, 4 grazing, and 12 conventional interviewed dairy farms regarding their milk income over feed cost yielded 3 clusters. Each of the 3 clusters contained farms from different systems indicating that management system was not a major descriptor of income over feed cost. Moreover, it suggested that income over feed cost was associated with quantity and quality of milk, percentage of milk withheld, feeding strategy and age of the farmer, in spite of the farm being classified as organic, grazing, or conventional. An analysis of 3 representative dairy farms (one organic, one grazing, and one conventional) studied with the aim to test the impact of animal density on predicted greenhouse gas emission using the Integrated Farm System Model suggested that increasing animal density would have a lesser impact on the predicted greenhouse emission per unit of milk production on the grazing farm than on the organic or

conventional farm. Within the scope of the farms analyzed, the grazing farm would be able to support more cows than the organic and conventional farms when looking to minimize greenhouse gas emissions.

2010/01/15 TO 2011/01/14 Project\'s team emphasizes that the process of performing and applying a large, comprehensive, and detailed survey, as previously described, also provides an opportunity for the farmer being interviewed to reflect, learn, and possibly take actions about the operation\'s management. Farmers being interviewed indicate that they usually do not take time or have not thought before about all the integrated factors and potential impacts of feeding supplementation practices on the performance of whole integrated dairy farm operation. Farmers exposed to the survey have certainly experienced a change in knowledge that may lead to changes in actions such as improved feeding management strategies, pasture utilization, purchase of feed supplements, or feed price risk management. The interdisciplinary team of scientists and students involved in the process of developing the survey instrument and designing and planning the survey learnt a great deal from each other and from the target public to be interviewed during the process. Actions were changed and adjusted after a better understanding of the integrated concepts and the farmers to be interviewed. It is early in the project to measure impacts as the collection data is still underway, but we envision that results from project\'s research and extension will lead to improved dairy farm sustainability, especially for organic, grazier, or transition farmers. Improved sustainability is projected because these farmers will make better decisions on feeding supplementation regarding their economic, productive, and environmental outcomes based on-farm data collected through this project. At the moment, similar data are very limited or non-existent. Preliminary analyses are showing that compared to conventional, organic and grazier dairy farms have a lower feed efficiency (milk/dry matter intake), lower feed cost, and lower dry matter intake. However, organic farms could have a higher income over feed cost because of substantial milk price premium and lower pasture feed costs. Given 2010 prices, organic farms could be as much sustainable as conventional or grazing systems when including the USDA organic dairy production standards. Details of final results will be critical to help dairy producers change in actions, which will lead to change in conditions. With the aim of helping in the process of farmers making better informed decisions and in preparation of the data analysis and further follow up with farmers, project\'s team has developed a web-based, log-in tool (http://dairymgt.uwex.edu/iofscdb/login.php) to benchmark and evaluate feed cost supplementation and income over feed cost among a group of farms. Data from surveys will be entered in this database in order to record trends and collect results of feeding supplementation practices. Farmers, whether they are participating in the study or not, have free access to it. An increasing group of farmers are using this tool for practical decision-making. Better informed farmers are making better feed supplementation decisions and consequently improving overall farm sustainability.

PUBLICATIONS

2012/01/15 TO 2013/01/14 1. Cabrera, V. E., M. Dutreuil, C. Hardie, R. Gildersleeve, M. Wattiaux, and D. Combs. 2012. Strategies of pasture supplementation on organic and conventional grazing dairies: Assessment of economic, production and environmental outcomes. Pp. 27-30 in Proceedings USDA Institute of Food Production and Sustainability, Organic Programs Project Directors Meeting. Washington DC. 3-4 October 2012. 2. Dutreuil, M., Gildersleeve, R., and V. E. Cabrera. 2012. Dealing with high feed cost: Supplementation on pasture. In Proceedings 4th Annual World Dairy Expo Grazing Seminars. Alliant Energy Center, Madison, WI. 5 October 2012. 3. Hardie, C. A., V. E. Cabrera, M. Dutreuil, and R. Gildersleeve. 2012. Characterization of certified organic Wisconsin dairy farms: Management practices, feeding regimes, and milk production. In Proceedings UW-Extension Grazing, Teaching, and Technology Conference. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012. 4. Dutreuil, M., V. E. Cabrera, R. Gildersleeve, and C. A. Hardie. 2012. Factors affecting profitability on Wisconsin dairy farms. In Proceedings UW-Extension Grazing, Teaching, and Technology Conference. US Dairy Forage Research Center, Prairie du Sac, WI. 28 August 2012. 5. Hardie, C. A., V. E. Cabrera, M. Dutreuil, R. Gildersleeve, and M. Wattiaux. 2012. Characterization of certified organic Wisconsin dairy farms: Management practices, feeding regimes, and milk production. Journal of Animal Science 90 (E-Suppl. 3):M239. 6. Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. 2012. Impact of animal density on predicted greenhouse gas emission on selected conventional, organic, and grazing dairy farms in Wisconsin. Journal of Animal Science 90 (E-Suppl. 3):777. 7. Dutreuil, M., V. E. Cabrera, R. Gildersleeve, C. A. Hardie, and M. A. Wattiaux. 2012. A cluster analysis to describe profitability on Wisconsin dairy farms. Journal of Animal Science 90 (E-Suppl. 3):M119. 8. Hardie, C. A., V. E. Cabrera, M. Dutreuil, and R. Gildersleeve. 2012. Characterization of certified organic WI dairy farms: Management, feeding regimes, and milk production. Pp. 20. Midwest Forage Association Forage Focus. December 2012.

2011/01/15 TO 2012/01/14 1. Cabrera, V.E., R.R. Gildersleeve, M.A. Wattiaux, D.K. Combs, M. Dutreuil and C. Hardie. 2011. Strategies of pasture supplementation on organic and conventional grazing dairies: assessment of economic, production, and environmental outcomes. USDA ERS Organic Farming Systems Research Conference, Washington, DC, 16-18 March 2011. 2. Dutreuil, M., Wattiaux, M., Gildersleeve, R., Barham, B., Cabrera, V.E. 2011. Impact of feeding strategies on milk production and income over feed cost: A case study of organic, grazing, and conventional Wisconsin dairy farms. J. Anim. Sci. 89 (E-Suppl. 1): 313. 3. Dutreuil, M., Wattiaux, M., Cabrera, V.E. 2011. Impact of feeding strategies on milk production and milk income over feed cost: A case study of organic, grazing, and conventional Wisconsin dairy farm. The Midwest Organic and Sustainable Education Service Conference, La Crosse, WI, 24-26 February 2011.

2010/01/15 TO 2011/01/14 No publications reported this period

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Low Energy Agro-ecological Farming (leaf)

Accession No.	0222315
Subfile	CRIS
Project No.	GEO-2010-01927
Agency	NIFA GEO
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21262
Proposal No.	2010-01927
Start Date	15 AUG 2010
Term Date	14 AUG 2012
Grant Amount	$45,713
Grant Year	2010
Investigator(s)	Schramski, J. R.; Gattie, D. K.
Performing Institution	Miscellaneous, UNIVERSITY OF GEORGIA, 110 RIVERBEND ROAD

NON-TECHNICAL SUMMARY

This OREI Research and Extension Planning Proposal will develop a comprehensive OREI Integrated Project Proposal addressing energy in organic farming. Both organic farming and the global energy crises are fundamentally related to all sustainability efforts. Yet, energy (for example, required energy inputs, expected caloric outputs, policies, long-term goals, etc.) in organic farming remains a primitive area of understanding and discussion. A core group of critical stakeholders (for example, including but not limited to farmers, suppliers, processors, buyers, researchers, etc.), will be identified and assembled on University of Georgia\'s campus to facilitate the current state of energy as it pertains to organic farming. The salient research questions and outreach needs, as elicited from the stakeholders engaged in this workshop, will be organized by the Program Staff into an USDA OREI Integrated Project Proposal.

OBJECTIVES

The goal of this Research and Extension Planning Proposal is to develop a comprehensive OREI Integrated Project Proposal addressing energy in organic farming. A core group of critical stakeholders (for example, including but not limited to farmers, suppliers, buyers, researchers, processors, etc.), will be identified and assembled on UGA\'s campus to discuss the current state of energy as it pertains to organic farming. Outreach program development and research question development will be the two primary outcomes from the proposed stakeholder\'s workshop. In particular, with regard to outreach, what information regarding energy in organic farming is needed, by whom, and how will it be disseminated The salient research questions and outreach needs, as elicited from the stakeholders engaged in this workshop, will be organized by UGA\'s Program Staff into an OREI Integrated Project Proposal.

APPROACH

This Research and Extension Planning Proposal will first identify key stakeholders with regard to both organic agriculture and corresponding energy systems related operations, policies, and technologies. This process will involve but not be limited to specific governmental agencies, farmers, researchers, processors, and buyers.

These stakeholders will be invited to convene a collaborative workshop on UGA\'s campus to formulate the outstanding issues with regard to energy use in the greater organic farming enterprise. Specific goals and objectives with regard to energy use in organic farming will be identified, synthesized, and organized into a comprehensive OREI Integrated Project Proposal by UGA\'s program staff. The original stakeholders engaged for the proposal development will also be engaged as an advisory panel to monitor the final OREI grant progress.

PROGRESS

2010/08 TO 2012/08 OUTPUTS: 1. Dr\'s Schramski and Gattie organised and chaired a full day colloquium on energy in organic agriculture comprised 22 individuals from vegetable and grazing farms, nonprofits, organic suppliers, corporations, small colleges, and university researchers and extension agents. 2. The Planning Proposal funding and the energy in organic agriculture colloquium generated an OREI funding proposal (submitted 2/11) titled \"Energy in Sustainable Agriculture: Modeling and Case Studies for Research and Extension\" for \$1,783486 that was not funded and received a Medium Recommendation for Funding. 3. The OREI proposal was revised and resubmitted 2/12 titled \"Energy in Organic Agriculture: Modeling and Case Studies for Research and Extension\" for \$1,980,123 that was not funded and received a High Priority Recommendation for Funding. 4. The Planning Proposal funding and the energy in organic agriculture colloquium generated an USDA AFRI Food Security funding proposal (submitted 2/12) titled \"Sustainability of Scale: Identify Secure Food Delivery Systems in the Southeast Through Integrated Life Cycle, Market, Land-Use, and Social Network Analysis (Integrated-FDS)\" for \$4,888,598 that was not funded and received a High Priority Recommendation for Funding. PARTICIPANTS: 1. Energy in Sustainable Agricutlture Colloquium Participants: Josh Egenolf (Sustainable Cattle Rancher, Illinoi), Anthony Flaccavento (Executive Director of Appalachian Sustanable Agriculture), Krista Jacobson (Hortoculture Faculty University of KY), Paul Hirsch (Environmental Policy Faculty, Syracuse University), Bill Hodge (Sustainable Cattle Rancher, Georgia), Kenneth Mulder (Farm Manager and Faculty, Green Mountain College, Vermont), Alex Rilko (Purchasing Manager Whole Foods), Alice Rolls (Executive Director Georgia Organics), Mike Smith (Business Owner, Longwood Plantation, Organic Composter), Robert Tate (Horticulturist and Farm Manager , University of Georgia) , David Gattie (Agricultural Engineering Faculty, University of Georgia, John Schramski (Environmental Engineering Faculty, University of Georgia), and Jason Mann (Owner, multiple sustainable farms and restaurants). 2. USDA OREI 2011 Proposal Partners: John Schramski (University of Georgia), David Gattie (University of Georgia), Sue Hawkins (University of Vermont), Krista Jacobsen (University of Kentucky), Caner Kazanci (University of Georgia), Ke Li (University of Georgia), Jason Mann (Full Moon Cooperative), Kenneth Mulder (Green Mountain College), Alexandra Stone (Organic State University), Mark Williams (University of Kentucky) 3. USDA OREI 2012 Proposal Partners: John Schramski (University of Georgia), David Gattie (University of Georgia), Sue Hawkins (University of Vermont), Krista Jacobsen (University of Kentucky), Caner Kazanci (University of Georgia), Ke Li (University of Georgia), Kenneth Mulder (Green Mountain College), Michael Bomford Michael (Kentucky State University), Julia Gaskin (University of Georgia), Erika Styles (Fort Valley State University) 4. USDA AFRI 2012 Proposal Partners: John Schramski (University of Georgia), David Gattie (University of Georgia), Krista Jacobsen (University of Kentucky), Caner Kazanci (University of Georgia), Ke Li (University of Georgia), Kenneth Mulder (Green Mountain College), Michael Bomford Michael (Kentucky State University), Julia Gaskin (University of Georgia), James Brown (Fort Valley State University), Faidra Papavasiliou (Georgia State University), Carrie Furman (University of Georgia), Xuanli Liu (Fort Valley State University), George Boyhan (University of Georgia) TARGET AUDIENCES: Not relevant to this project. PROJECT MODIFICATIONS: Not relevant to this project.

2010/08/15 TO 2011/08/14 OUTPUTS: A comprehensive Integrated Project Proposal addressing energy in organic farming was created and submitted for the USDA\'s OREI RFP. To assure that this proposal was stakeholder inspired, a workshop was held at the University of Georgia comprised of individuals from vegetable and grazing farms, nonprofits, organic suppliers, corporations, small colleges, and university researchers and extension agents. The submitted proposal outlined an integrated response to these stakeholder conclusions through the development of educational videos, webinars, technical publications, a diverse representation of on-farm data collection programs, and a comprehensive web-based energy modeling and assessment tool for farmers, extension agents, and researchers. PARTICIPANTS: PI, John Schramski, University of Georgia, jschrams@uga.edu. Dr. Schramski organized a three day workshop of stakeholders to identify the main research objectives and associated research questions for the submitted Integrated Proposal. The workshop participants represented a wide variety of organizations with diverse concerns associated with energy in organic agriculture including but not limited to the University of Kentucky, Hodge Ranch Organics, Georgia Organic, Green Mountain College, The Appalachian Sustainable Development, Whole Foods Inc., Full Moon Cooperative, MoonShine Meats, and Syracuse University. The following Individuals were partners in the final OREI Integrated Proposal that was ultimately submitted: David Gattie, University of Georgia, dgattie@engr.uga.edu Jason Mann, Owner

Moonshine Meats and Full Moon Cooperative, jmdedalus@earthlink.com Susan Hawkins, University of Vermont, susan.hawkins@uvm.edu Krista Jacobsen, University of Kentucky, klja223@uky.edu Caner Kazanci, University of Georgia, caner@uga.edu Ke Li, University of Georgia, keli@engr.uga.edu Kenneth Mulder, Green Mountain College, mulderk@greenmtn.edu Alexandra Stone, Oregon State University, alexandra.g.stone@gmail.com Mark Williams, University of Kentucky, mark.williams@uky.edu TARGET AUDIENCES: Not relevant to this project. PROJECT MODIFICATIONS: Not relevant to this project.

IMPACT

2010/08 TO 2012/08 This Proposal Planning grant generated one comprehensive colloquium covering energy in sustainable agriculture with 22 individuals from vegetable and grazing farms, nonprofits, organic suppliers, corporations, small colleges, and university researchers and extension agents. This planning effort generated 3 USDA proposals addressing energy in sustainable and organic agriculture. This is an area increasing acknowledged to be critical to the future of sustainable agriculture. **PUBLICATIONS (not previously reported):** 2010/08 TO 2012/08 No publications reported this period

2010/08/15 TO 2011/08/14 The comprehensive Integrated Project Proposal received a Medium Recommendation from the USDA OREI review panel. Guidance was provided by the reviewers as to how the proposal can be improved sufficiently for the next submittal. The Proposal\'s Integrated team is already working on these improvements.

PUBLICATIONS

2010/08/15 TO 2011/08/14 No publications reported this period

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Host Plant Choice of Colorado Potato Beetle and Variation in Defoliation and Yield Losses Among Organically Grown Commercial Potato Varietie

Accession No.	0222366
Subfile	CRIS
Project No.	IDA01001-CG
Agency	NIFA IDA
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21285
Proposal No.	2010-01943
Start Date	01 SEP 2010
Term Date	31 AUG 2013
Grant Amount	$108,815
Grant Year	2010
Investigator(s)	Wenninger, E. J.; Olsen, N.; Painter, K.
Performing Institution	Plant Soil & Entomological Sci, UNIV OF IDAHO, 875 PERIMETER DRIVE

NON-TECHNICAL SUMMARY

The Colorado potato beetle (CPB) is one of the most important pests of potato production in the United States. Given the limited insecticide options for organic producers, high expense of organic insecticides, and well-founded concerns over development of insecticide resistance in CPB, sustainable management tools for organic potato producers are sorely needed. The primary objective of this project is to clarify differences among commercial potato varieties in regard to CPB preferences and defoliation rates in order to establish the relative susceptibility of commonly grown commercial potato cultivars to CPB damage. Field experiments will be conducted at the University of Idaho Kimberly Research & Extension Center (Kimberly, ID) comparing the abundance of different life stages of CPB (eggs, small larvae, large larvae, and adults) and defoliation rates over time among different commercial potato varieties. A total of at least ten different varieties will be used. The results will allow for evaluation of host preference of CPB and the importance of beetles on defoliation and yield within each variety. Variety-specific defoliation and yield data will allow economic analysis of potential returns and risks of organic versus commercial potato production in this region. This project will contribute to the development of sustainable organic potato production in several ways: (1) growers could produce less preferred varieties to limit CPB damage with fewer insecticide applications or (2) tailor a CPB management strategy to a variety\'s susceptibility; (3) reduced insecticide use would satisfy consumer demand for environmentally responsible production, (4) mitigate against insecticide resistance development, and (5) reduce input costs; moreover, (6) varieties that are particularly attractive to CPB ultimately could be used in a trap cropping program. The use of more tolerant or less preferred varieties could be part of an overall integrated pest management strategy to reduce insecticide use and environmental risks while increasing yields and contributing to the long-term sustainability of organic potato production.

OBJECTIVES

The Colorado potato beetle (CPB; Leptinotarsa decemlineata) is a serious pest of potatoes nationwide. Efforts to develop host resistance to CPB have yet to produce commercially acceptable varieties; however, CPB host

preference, survival, reproduction, and defoliation vary among wild potato, its cultivated relatives, and some commercial potato varieties. In a pilot study, we recorded as high as nine-fold differences in defoliation rates among ten organically produced potato varieties. We will conduct a more detailed investigation into variation among commercial potato varieties in regard to CPB host preference and susceptibility to defoliation and yield loss from CPB feeding damage. Variety-specific defoliation and yield data will allow economic analysis of potential returns and risks of organic versus commercial potato production in this region. This project will contribute to the development of sustainable organic potato production in several ways: (1) growers could produce less preferred varieties to limit CPB damage with fewer insecticide applications or (2) tailor a CPB management strategy to a variety\'s susceptibility; (3) reduced insecticide use would satisfy consumer demand for environmentally responsible production, (4) mitigate against insecticide resistance development, and (5) reduce input costs; moreover, (6) varieties that are particularly attractive to CPB ultimately could be used in a trap cropping program. The use of more tolerant or less preferred varieties could be part of an overall integrated pest management strategy to reduce insecticide use and environmental risks while increasing yields and contributing to the long-term sustainability of organic potato production. The outreach plan is comprised of a coordinated effort among the University of Idaho (UI) Extension system, the Idaho Potato Commission, and the Northwest Coalition for Alternatives to Pesticides (NCAP; Eugene, OR). Specific extension activities will include several annual organic field days during the growing season that will focus on management of Colorado potato beetles and allow attendees to observe our research plots; workshops and presentations at the highly attended Idaho Potato Conference; publication of results and recommendations through the UI Extension system, NCAP network, national trade journal magazines (e.g., Spudman and Potato Grower), and eXtension and eOrganic Community of Practice; and dissemination of findings to the scientific community via journal publications and scientific meeting presentations.

APPROACH

Objective 1: Compare the abundance of different life stages of CPB and defoliation rates among commercial potato varieties with and without organic insecticide treatments. A field experiment will be conducted at the University of Idaho Kimberly Research & Extension Center (Kimberly, ID) comparing the abundance of different life stages of CPB (eggs, small larvae \first and second instar\, large larvae \third and fourth instar\, and adults) and defoliation rates over time among different commercial potato varieties and two insecticide treatments (untreated and organic insecticide program). A total of at least ten different varieties will be selected from each of the following groups: Russets, Reds, Blues/Purples, Yellows, and Chipping/Whites. Three-row plots will be arranged in a randomized complete block design and will be replicated at least five times. The numbers of CPB of each life stage per plant as well as percent defoliation will be compared among treatments over time using repeated measures Analysis of Variance (ANOVA). Potato emergence rates, vigor, late-season senescence, and yield parameters (total yield, grade and size profiles, and specific gravity) within the center row of plots will be compared among treatments using ANOVA or repeated measures ANOVA as appropriate. Objective 2: Compare CPB performance and defoliation rates on commercial potato varieties in no-choice assays on caged plants in the field. The same varieties used in Objective 1 will be grown in the field, infested with CPB eggs, and caged to prevent further colonization of beetles. Potatoes will be grown without insecticides in hand-planted, one-plant plots that will be caged in the field before immigration of adults. The plots will be arranged in a randomized complete block design and will be replicated 6-8 times. The number of individuals of each life stage as well as percent defoliation on each plant will be recorded weekly and compared among treatments using repeated measures ANOVA as described for Objective 1. Objective 3: Develop enterprise budgets that will compare costs and returns associated with organic potato production for different varieties and pesticide treatments in the region, and compare them to commercial potato production with various pesticide scenarios. We will organize organic stakeholder meetings with organic potato growers and other stakeholders in order to discuss and develop enterprise budgets for various organic potato varieties and pesticide scenarios. Growers will provide expert opinion regarding which organic insecticides are typically used against CPB, including application rates and the typical number of applications per season. Cost of production data will be used to create enterprise budgets by variety and by pest management practices. Objective 4: Provide research findings from Objectives 1-3 to producers, peers, and other stakeholders in a timely manner through presentations, workshops, field days, newsletters, bulletins, web sites, and other appropriate means.

PROGRESS

2010/09 TO 2013/08 Target Audience: Target audiences included growers, industry representatives, and other attendees of the Snake River Pest Management Research Tour during June 2011, the Idaho Potato Conference during January 2012, a "Grower's Own" organic conference during January 2012, and an Organic Field Day at U-

Idaho Kimberly during July 2012. A forthcoming publication will target fellow scientists. Changes/Problems: The no-choice caged field experiment was compromised due to the high infestation levels of beetles surrounding the cages; large numbers of newly eclosed adult beetles from the second generation surfaced within cages. Unfortunately, this aspect of the project had to be abandoned. What opportunities for training and professional development has the project provided? Approximately seven undergraduate technicians were involved in assisting with data collection during the life of the project, which provided training for these students in carrying out agricultural field research. How have the results been disseminated to communities of interest? Results were presented togrowers, industry representatives, and other attendees of the Snake River Pest Management Research Tour during June 2011, the Idaho Potato Conference during January 2012, a "Grower's Own" organic conference during January 2012, and an Organic Field Day at U-Idaho Kimberly during July 2012. A forthcoming publication will target fellow scientists. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2010/09/01 TO 2011/08/31 OUTPUTS: The two field experiments described in the proposal were conducted - an open choice experiment in which Colorado potato beetle responses to ten potato varieties were examined (with and without organic insecticides) and a no choice experiment in which individual caged plants each were infested with the same number of eggs. In addition to collecting data on all life stages of beetles on each plot, data were also collected on plant emergence, tuber yield and quality at harvest, and wireworm damage to harvested tubers. Preliminary analysis of data was conducted. Plots were shown to growers, industry representatives, and other attendees of the Snake River Pest Management Research Tour during June 2011. PARTICIPANTS: Erik Wenninger (PI): directed the entomological portions of the project, including all insect sampling, building and deployment of beetle cages, and spraying of insecticides. Nora Olsen (co-PI): directed planting and harvesting of research plots and fertility and irrigation requirements. Neyle Perdomo (technician): assisted with insect sampling. Mary Jo Frazier (technician): obtained all potato seed, developed plot layout, and organized harvest activities. Kathleen Painter (co-PI): work on the project will commence during the next reporting session. Jennifer Miller (cooperator): work on the project will commence during the next reporting session. Paul Patterson (cooperator): work on the project will commence during the next reporting session. TARGET AUDIENCES: Target audiences included growers, industry representatives, and other attendees of the Snake River Pest Management Research Tour during June 2011. PROJECT MODIFICATIONS: The no choice experiment was compromised due to the high infestation levels of beetles surrounding the cages. Large numbers of mature larvae from the first generation dropped to the soil surrounding the cages to pupate, and newly eclosed adult beetles from the second generation emerged from the soil inside of cages. The no choice experiment will be established using caged plants in a greenhouse during 2012 and/or on a field site that does not have such heavy beetle pressure.

IMPACT

2010/09 TO 2013/08 What was accomplished under these goals? A two-year field study was conducted at the University of Idaho Kimberly Research & Extension Center (Kimberly, ID) comparing tuber yields and the abundance of different life stages of CPB over time among different commercial potato varieties and two insecticide treatments (untreated and organic insecticide program). Ten different varieties were selected: 'Russet Burbank,' 'Classic Russet,' 'Defender Russet,' 'Yukon Gold,' 'Yukon Gem,' 'Dark Red Norland,' 'Red Lasoda,' 'Purple Viking,' 'All Blue,' and 'King Harry' (a variety bred for tolerance to CPB and other insect pests). The insecticide-treated plots were treated with two applications of spinosad (Entrust) against the first generation of CPB and neem-based and/or pyrethrin insecticides as necessary thereafter for the second generation. Comparisons between the untreated and insecticide-treated plots allowed for evaluation of the importance of CPB on defoliation and yield within each variety. Three-row plots were arranged in a randomized complete block design replicated five times. At weekly intervals beginning at the onset of natural infestation of adults onto plots and continuing about ten weeks, all CPB life stages (eggs, small larvae \first and second instar\, large larvae \third and fourth instar\, and adults) were counted on five plants within the center row of each plot and estimates of the percent defoliation on the same plants were made. The numbers of CPB of each life stage per plant as well as percent defoliation were compared among treatments over time using repeated measures Analysis of Variance (ANOVA). Yield parameters (including total yield, grade and size profiles, and specific gravity) within the center row of plots were compared among treatments using ANOVA. Yields differed significantly between insecticide treatments and among varieties during both years for most grade profiles (total, USDA #1, USDA #2, and culls). Not surprisingly, yields were higher for insecticide-treated plots. King Harry, which was bred for resistance to several insect pests, exhibited higher yields than most other varieties; other high-yielding varieties included Purple Viking, Yukon Gold, and Dark Red Norland. Russet Burbank yielded well the second year, but not the first. All Blue and Classic Russet tended to yield poorly during both years. King Harry produced the most

tubers per ha in both years; Purple Viking produced tubers with the highest mean mass in both years. Classic Russet produced the fewest tubers per ha in both years; All Blue exhibited the lowest mean tuber mass in both years. As the field was colonized by adult beetles, initial "preferences" for certain varieties were observed; however, these preferences shifted from week to week and were not entirely consistent between years. Egg abundance tended to reflect adult preferences, but also shifted, which is consistent with females preferring to lay eggs on less infested plants. Differences among varieties in regard to larval abundance and defoliation rates were weak; however, certain varieties tended to show smaller differences in yield between insecticide-treated and untreated plots. For example, during 2012 both Dark Red Norland and Red Lasoda showed similar yields whether treated with insecticide or not, despite exhibiting significantly heavier defoliation when not treated. Other varieties (notably Classic Russet) showed 2-4 fold higher yields when treated with insecticides. Though not part of the proposed project, we rated harvested tubers for wireworm damage. Significant differences were observed among varieties, with at least four varieties exhibiting relatively low damage compared to the other six varieties. Wireworm damage was generally higher on insecticide-treated plots, which was likely a reflection of a greater mass of tubers to attract wireworms. These results, not detailed further here, will be further investigated in future studies. **PUBLICATIONS (not previously reported):** 2010/09 TO 2013/08 No publications reported this period.

2010/09/01 TO 2011/08/31 Responses of beetles to the different varieties in the open choice experiment were dynamic from week to week. No one variety was consistently attractive or unattractive to adult beetles, but rather beetles were significantly more abundant on different varieties each week, at least up until the fifth week of sampling when there were no longer any differences in preference observed. Abundance of eggs showed similar shifts that appeared to reflect preferences of adults. Differences among varieties in abundance of larvae and defoliation rates were small, possibly due in part to the very high abundance of beetles overall. During the second year of the experiment, we plan to take more frequent beetle counts and defoliation ratings during critical times (e.g., when adults are first infesting plots and when larvae are starting to defoliate plants), which may help to clarify more subtle differences among varieties. The no choice experiment was compromised due to the high infestation levels of beetles surrounding the cages; large numbers of newly eclosed adult beetles from the second generation emerged within cages. The no choice experiment will be established using caged plants in a greenhouse during 2012. Yield data are still being analyzed, but overall insecticide treatment improved yields across all varieties except King Harry which was bred for resistance to Colorado potato beetles. As expected, yields were generally higher for varieties that were earlier emerging. Wireworm damage differed significantly among varieties, with at least four varieties exhibiting relatively low damage compared to the other six varieties. Wireworm damage was generally higher on insecticide-treated plots, which was likely a reflection of a greater mass of tubers to attract wireworms.

PUBLICATIONS

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

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Farmers Legal Action Group Production of an Organic Farmers Guide to Contracts

Accession No.	0222332
Subfile	CRIS
Project No.	MINW-2010-01899
Agency	NIFA MINW
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21445
Proposal No.	2010-01899
Start Date	01 SEP 2010
Term Date	31 AUG 2012
Grant Amount	$109,200
Grant Year	2010
Investigator(s)	Hayes, L. A.; Hayes, L.
Performing Institution	FARMER'S LEGAL ACTION GROUP, 360 ROBERT STREET NORTH, SUITE 500, ST. PAUL, MINNESOTA 55101-1589

NON-TECHNICAL SUMMARY

Contracts play an increasingly important role in the lives of all farmers, but particularly those in organic farming. While these contracts can provide welcome risk management for some producers, they can also impose legal complexities that can affect issues ranging from required investments to the conditions under which agricultural products can be produced and delivered. For more than 20 years, FLAG has approached the legal needs of farmers in the belief that sound, independent, accessible information benefits everyone in the agricultural marketplace. Good contracts are those that share risks and benefits evenly. We have been proud, for example, that one of our most popular farmer guides, Understanding Farmers\' Market Rules, is used by both farmers and market managers. And farmers and developers alike order copies of FLAG\'s popular 293-page Farmers\' Guide to Wind Energy. We believe that an Organic Farmers\' Guide to Contracts, produced in an objective, concise, and accessible form, and distributed through NIFA extension offices, online through the eXtension library and FLAG\'s website, along with FLAG\'s network of organic communities and organizations, would find a similarly wide audience among producers, as well as distributors, processors, and retailers. We have at least anecdotal evidence that, in addition to farmers, some processors, retailers, and distributors in the organic trade are genuinely searching for contract language that would apportion risks fairly. Expected outcomes from the project are that FLAG will create a resource produced by research and outreach to organic producers that will provide organic farmers with knowledge of their rights and responsibilities in marketing contracts that will allow them to solve critical legal agricultural issues, priorities, and problems, agricultural professionals will have a greater knowledge of farmers\' rights and responsibilities in contracts, and be in a position to share that knowledge with wider populations of organic producers, more organic farmers will negotiate and sign contracts that evenly share risks and opportunities with processors, distributors, and retailers, and more organic producers will successfully grow and market high-quality organic agricultural products.

OBJECTIVES

Farmers\' Legal Action Group, Inc. (FLAG), with a two-year, \$109,200 grant from the USDA/NIFA Organic Agriculture Research and Extension Initiative (OREI), will research, write, produce, distribute, and provide outreach for a farmer-friendly legal guide, Organic Farmers\' Guide to Contracts. This Integrated Project Proposal will provide current and transitioning organic farmers with a critical, concise, and accessible guide to the interpretation and management of the legal contracts with the processors, distributors, and retailers that increasingly dominate farmers\' ability to market organic agricultural products successfully. The organic sector uses contracts at a much higher rate than the conventional sector. There is, however, little independent, reliable legal information available to the nation\'s 20,000 organic farmers when they are presented with or hope to propose a production or marketing contract. This project\'s goal is to develop and demonstrate education tools for best practices that will enhance the ability of agricultural producers to make informed decisions and manage their risks when agreeing to contracts for the sale of their organic agricultural products; and to encourage a marketing system in which producers, as well as processors, distributors, and retailers, can thrive.

APPROACH

The first six months of the project\'s projected timeline include research and outreach to producers and producer groups to ascertain trouble areas in contracts and to obtain sample contracts; the second six months will include research, writing, and review by the advisory panel, farmers, and farm organizations; and the first six months of the second year will include design, publication, and initial outreach and distribution; and the last six months will include outreach and farmer contacts. To create this first edition of Organic Farmers\' Guide to Contracts, FLAG will review relevant federal and common laws and regulations that govern production and marketing contracts in organic agriculture, solicit sample contracts through our networks, and maintain the confidentiality of producers who share the contracts with us, review the contracts that distributors, processors, and retailers are offering farmers, consult our review panel and collaborating organizations for their guidance to make sure that the publication will be as helpful as possible for the largest numbers of organic farmers, write the guide with an intention to use approachable, straightforward language, publish and strategically distribute the guide in paper and electronic versions that will be available to farmers and agricultural professionals without charge (online) or for costs of shipping (paper).

PROGRESS

2010/09 TO 2012/08 OUTPUTS: FLAG attorneys completed the research, writing, production, distribution, and outreach for a farmer-friendly legal guide, \"Farmers\' Guide to Organic Contracts,\" that will provide current and transitioning organic farmers with critical, concise, and accessible guidance to the interpretation and management of the legal contracts with the processors, distributors, and retailers that increasingly dominate farmers\' ability to market organic agricultural products successfully. The project\'s work included legal research; interviews with organic farmers and handlers; compilation of an organic contracts database; drafting and two rounds of edits by internal staff, and two rounds of peer review by a notable advisor panel (see below). The \"Farmers\' Guide to Organic Contracts\" was written to help farmers make informed decisions at every stage of their contract relationships. This accessible new legal guide includes: 1. An overview of contract laws important to farmers; 2. A Quick Organic Contract Checklist and practical toolkit farmers can use to review and negotiate contract offers; 3. Highlighted sections illustrating how federal organic regulations interact with organic contracts; 4. Examples and discussion of over 100 types of organic contract provisions; and 5. Detailed information about solving the types of contract disputes that commonly arise in the organic market. The \"Farmers\' Guide to Organic Contracts\" will assist farmers with all types of agricultural contracts, but the guide\'s primary purpose is to serve farm operations certified as organic under U.S. Department of Agriculture (USDA) and National Organic Program (NOP) regulations. Specific suggestions and information for certified organic operations are highlighted throughout the guide, which features a color-coded symbol system designed to enhance reader understanding. PARTICIPANTS: Principal author/investigator: Amanda N. Heyman, FLAG Staff Attorney. Role: Interviewed stakeholders and worked with advisor panel to decide on the scope and content of the book; conducted extensive outreach to collect organic contract samples; reviewed and analyzed contract samples; conducted legal research; created the structure, content, and outline of the book; drafted all of the chapters; worked with peer reviewers, discussing and incorporating where appropriate their input; revised drafts based on peer reviewers\' and FLAG senior staff attorney reviewers\' feedback; finalized guide; worked on layout, publication, and distribution; and presented information from the guide at conferences, workshops, and trainings. Advisory panel: Jim Riddle, the Organic Outreach Coordinator for the University of Minnesota Southwest Research and Outreach Center, is the founding chair of the Independent Organic Inspectors Association (IOIA), and former chair of the Minnesota Department of Agriculture\'s Organic Advisory Task Force; Michael Sligh, the Sustainable Agriculture Program Director at Rural Advancement Foundation International-USA (RAFI), is a farmer, author, and founding chair of USDA\'s National

Organics Standards Board; and Ed Maltby, the Executive Director of Northeast Organic Dairy Producers Alliance (NODPA), one of the nation\'s largest grassroots organizations of organic dairy producers. Roles: Participated in several conference calls to discuss scope and content of the book; assisted with outreach to collect contract samples; provided individualized advice where appropriate; conducted two rounds of in-depth edits on the entire book. Supervising editor: Lynn Hayes, FLAG Program Director and Senior Staff Attorney. Role: Oversaw each step in the development and publication of the guide. Editor: Karen Krub, FLAG Senior Staff Attorney. Role: Edited all chapters. TARGET AUDIENCES: The Target Audience of this project is the growing community of current and transitioning organic farmers whose operations require the understanding and management of legal contracts with the processors, distributors, and retailers that increasingly dominate the farmers\' ability to market organic agricultural products successfully. The organic sector uses written contracts at a much higher rate than the conventional agricultural sector (68 percent of the transactions of organic handlers use either written or verbal contracts), but the market has previously lacked an independent, reliable source of legal information for organic farmers to use when presented with, or when proposing, a marketing contract for organic crops, dairy, livestock, or other organic farm products. Over the years, FLAG has received contract-related calls from organic producers from Florida to Idaho, who are growing everything from watermelons to potatoes. Producers have asked questions about their legal recourse when a buyer rejects a perishable crop after it has been shipped hundreds of miles, or when a buyer \"changes its mind\" after committing to buy all of a crop the farmer can produce. And producers of organic grains have had questions about whether they must agree to testing for the presence of genetically modified organisms, pesticides, and other prohibited substances (and who should pay for the tests). Our collaborating organizations tell us that those kinds of examples are common across the country. The \"Farmers\' Guide to Organic Contracts,\" produced under this grant, will provide the legal information on contracts so that organic farmers can fully understand the implications of the contracts they are signing and other options that are available to them. The guide will be a useful resource to organic farmers contemplating a new contract, as well as to farmers searching for information and support after a dispute arises. PROJECT MODIFICATIONS: This project is now complete.

2010/09/01 TO 2011/08/31 OUTPUTS: Attended and conducted research and obtained input and resources at the 2011 Minnesota Organic Conference and the conference of the Midwest Organic and Sustainable Education Service (MOSES). Reviewed and analyzed a wide range of contracts involving many types of organic commodities. Conducted interviews with approximately 10 organic farmers and handlers. Constructed a contacts database of approximately 50 organic farmers and handlers. Completed research for and drafting of 85 percent of the guide, \"Organic Farmers\' Guide to Contracts,\" including Chapter 1 on Contract Basics (20 pages); Chapter 2 on Reviewing an Organic Contract (90 pages); and Chapter 3 on Problem Solving (20 pages); for a total of 130 pages. This draft has been through two rounds of edits by internal staff and is being prepared for submission to the project\'s adviser panel for the first of two rounds of adviser review. Drafted a checklist for farmers to use when reviewing organic contracts. PARTICIPANTS: Lynn A. Hayes was a founding attorney at FLAG. After 16 years, she left FLAG in the spring of 2002 to move to Pittsburgh, Pennsylvania. In early 2006, FLAG welcomed Lynn back as senior staff attorney and, beginning September 2006, she began serving again as FLAG\'s program director. Lynn worked for the Office of the Monitor for three years, reviewing African-American farmers\' claims in the racial discrimination case against USDA, Pigford v. Veneman. During her tenure at FLAG, Lynn was lead or co-counsel in several lawsuits, including Coleman v. Lyng (national class action lawsuit against the Farmers Home Administration); the Minnesota Milk Producers Association\'s challenge to federal milk marketing order provisions; and the pork checkoff case, among others. She has presented hundreds of workshops for farmers and their advocates on agricultural credit, contract-farming, environmental, commodity pricing, and antitrust issues. She has assisted farm organizations in developing proposed regulations and legislation at both the state and federal levels in many of these same issue areas. Lynn received her B.A. in English from Coe College in Cedar Rapids, Iowa, and her J.D. from Columbus School of Law, Catholic University of America, in Washington, D.C. Amanda Heyman joined FLAG as a staff attorney in January 2011. Prior to joining FLAG, she served as a judicial law clerk for U.S. Magistrate Judge Franklin L. Noel and U.S. District Judge Ann D. Montgomery in the District of Minnesota. During her clerkships, Amanda worked on a wide variety of cases, including contract disputes, civil rights litigation, administrative appeals, and First Amendment claims. In addition, Amanda has significant experience in the legal services setting, including advocacy on behalf of Hurricane Katrina survivors on the Mississippi Gulf Coast. Amanda earned her law degree from the University of Michigan Law School in 2008, where she was a Clarence Darrow Merit Scholar, an editor of the University of Michigan Journal of Law Reform, and co-chair of the Environmental Law Society Board. In 2003, Amanda obtained a Bachelor of Science in Journalism and a certificate in Environmental Studies from the University of Wisconsin-Madison. Before embarking on her legal career, Amanda won several awards for her work as a newspaper reporter in Wisconsin and New Mexico. This project\'s work product will be reviewed by this accomplished advisory panel: Jim Riddle, Organic Outreach Coordinator for the University of Minnesota, is the founding chair of the Independent Organic Inspectors Association (IOIA), and chairs the Minnesota Department of Agriculture\'s Organic Advisory Task

Force; Michael Sligh, Sustainable Agriculture Program Director at RAFI-USA, is a farmer, author, and founding chair of the National Organics Standards Board; and Ed Maltby is Executive Director of Northeast Organic Dairy Producers Alliance, one of the nation\'s largest grassroots organization of organic dairy producers. TARGET AUDIENCES: The Target Audience of this project is the growing community of current and transitioning organic farmers whose operations require the interpretation and management of legal contracts with the processors, distributors, and retailers that increasingly dominate their ability to market organic agricultural products successfully. PROJECT MODIFICATIONS: With the approval of NIFA, Lynn A. Hayes replaced Jill E. Krueger as Project Director.

IMPACT

2010/09 TO 2012/08 Change in conditions: FLAG has informed and will continue to alert key audiences about the guide\'s publication. Already, the guide has been posted on the online Organic Agricultural Resource Area of the eOrganic and eXtension websites; the Risk Management Agency\'s Ag Risk Education Library; in press releases to prominent agricultural publications; in a notice to, and a request to be included in, the newsletters and websites of partner organizations, e-mail listservs, website posts, and conference distributions. The precise impact of the guide won\'t be known until the year ahead when FLAG can and will document the numbers of paper copies that are printed and distributed; download traffic on FLAG\'s website; and discussions with individual organic farmers. The ultimate distribution is likely to be significant. In the relatively short time since the guide has been released, it has been downloaded from the FLAG website, in whole or in part, 506 times by people in 46 states and Washington, D.C. In addition, the guide\'s author presented in September on organic contract issues via videoconference for 15 members of the Organic Farmer Agency for Relationship Marketing (OFARM), a producer group that works to sustain organic farming; and has been invited to speak on the guide\'s contents at the Organic Farmers Conference of the Midwest Organic and Sustainable Education Service (MOSES), which ever year is among the nation\'s largest gatherings of the organic farming community. Change in knowledge: Upon review of the final edition of the organic contracts guide, Jim Riddle, Organic Outreach Coordinator for the University of Minnesota, and former chair of the Minnesota Department of Agriculture\'s Organic Advisory Task Force, described it as \"a very useful, readable, and technically sound publication that will stand the test of time!\" **PUBLICATIONS (not previously reported):** 2010/09 TO 2012/08 Heyman, A.N., 2012. Farmers Guide to Organic Contracts, published by Farmers Legal Action Group, Inc., in bound soft cover (available at http://www.lulu.com/spotlight/flagpublications) and in PDF format online in its entirety or by individual chapters (available at http://www.flaginc.org/topics/pubs/organic.php#FGOC).

2010/09/01 TO 2011/08/31 Change in conditions: Based on the expertise acquired in researching and writing this guide, FLAG project staff were invited to present on the legal intricacies of organic contracts at the 2012 Minnesota Organic Conference that will be held on January 13-14, 2012, in St. Cloud, Minnesota, and at the Midwest Organic and Sustainable Education Service (MOSES) conference that will be held on February 23-25, 2012, in LaCrosse, Wisconsin. These conferences will allow for a two-way exchange of information, with FLAG attorneys providing legal information and also obtaining additional feedback on organic contract issues and real-world experiences from organic farmers and other members of the organic industry, all of which will strengthen the guide and increase its usefulness.

PUBLICATIONS

2010/09/01 TO 2011/08/31 Organic Farmers Guide to Contracts is on schedule to be completed and published in 2012.

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Research and Extension Needs Assessment of the Organic Dairy Industry in the Northeast

Accession No.	0222672
Subfile	CRIS
Project No.	NHW-2010-01932
Agency	NIFA NH.W
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21263
Proposal No.	2010-01932
Start Date	01 SEP 2010
Term Date	31 AUG 2012
Grant Amount	$31,372
Grant Year	2010
Investigator(s)	Brito, A.; Townson, D. H.
Performing Institution	Animal & Nutritional Science, UNIVERSITY OF NEW HAMPSHIRE, DURHAM, NEW HAMPSHIRE 03824

NON-TECHNICAL SUMMARY

The University of New Hampshire has a vested interest in establishing research and outreach partnerships with other regional institutions, stakeholders, and state agencies to support the Northeast organic dairy industry. However, a comprehensive needs assessment of organic dairy producers in the region has yet to be conducted. The objective of the current planning proposal is to establish a regional consortium of expertise (Research and Extension Advisory Panel) that can address research and Extension needs of organic dairy producers in the Northeast. We will assemble a team of researchers, Extension personnel, and industry stakeholders to first identify these needs by conducting focus groups to obtain an in-depth understanding of the concerns facing organic dairy producers. Higher priority issues emerging from these groups will be developed into a survey to further refine and prioritize these issues with a broader population of stakeholders. The highest priority issues will lead to follow-up communication with farms interested in serving as pilot sites for future research and outreach education. The Research and Extension Advisory Panel will consist of current proposal participants, additional research/Extension expertise as needed, and industry stakeholders. This panel will develop integrated proposal(s) to submit to the National Institute for Food and Agriculture for the Organic Agriculture Research and Extension Initiative (OREI). Toward this end we have already received pilot funding from the Northeast Agricultural Research and Extension directors to leverage with the current USDA planning proposal.

OBJECTIVES

Project Goal- The goal of this planning proposal is to work closely with stakeholders to obtain a clear and comprehensive understanding of their research and Extension needs, and to enhance their capacity to produce and market high quality, environmentally-friendly organic milk at a sustainable cost. Project Objectives- Objective 1: Develop an in-depth understanding of the research and Extension needs of organic dairy stakeholders from the Northeastern states (i.e., CT, NH, NY, MA, ME, PA, & VT), including the most effective means of communication and outreach, via focus group interviews. Objective 2: Prioritize research and Extension needs identified in the focus groups with a broader population of stakeholders via survey methods. Objective 3: Verify

and validate the priorities with team members and stakeholders, and begin a planning process for conducting integrated research and Extension programs via follow-up workshops. Objective 4: Develop integrated proposals to address the prioritized organic research and Extension needs and organize a network of collaborating stakeholders to help conduct the research (Research and Extension Advisory Panel). Expected outputs-Researchers, Extension educators, and stakeholders will: 1) have an increased knowledge of the research and Extension needs of the organic dairy industry in the Northeast; 2) share information about the needs of the organic dairy industry with others across the country via eXtension and eOrganic; and 3) develop high quality, relevant proposals and programming that responds to the identified needs.

APPROACH

We will assemble a team of researchers, Extension personnel, and industry stakeholders to first identify the research and extension needs by conducting focus groups to obtain an in-depth understanding of the concerns facing organic dairy producers. Higher priority issues emerging from these groups will be developed into a survey to further refine and prioritize these issues with a broader population of stakeholders. The highest priority issues will lead to follow-up communication with farms interested in serving as pilot sites for future research and outreach education. A Research and Extension Advisory Panel consisting of current proposal participants, additional research/Extension expertise as needed, and industry stakeholders will be formed to develop integrated proposal(s) for submission to the National Institute for Food and Agriculture and the Organic Agriculture Research and Extension Initiative (OREI) in the future.

PROGRESS

2010/09 TO 2012/08 OUTPUTS: Activities: Three focus groups interviews conducted with farmers from ME, VT, NY and PA. Two surveys designed based upon the focus group results were submitted to 1,000+ farmers across the Northeast. Participation in the first annual NOFA-NY research symposium. Presentations at the ADSA-AASA join meeting in Phoenix, AZ, to generate stakeholder interest and participation in the project. Training of undergraduate and graduate students with data collection, analysis, and interpretation. Events: A one-day workshop at the University of New Hampshire to foster collaborations among researchers and Extension educators involved in organic agriculture research University of New Hampshire, University of Vermont, University of Maine, Cornell University, and USDA-ARS Pasture Systems and Watershed Management Research Unit). A workshop/webinar about fly control on organic dairy farms hosted at the Essex Inn, Essex, VT. A pasture walk pertaining to pasture dry matter intake, pasture management strategies and direct marketing in Pittsfield, ME. An organic dairy field day about renovating soils and swards of dairy pastures in Dryden, NY. First annual meeting of the Advisory Board for NIFA-OREI grant. Products: A database highlighting the Northeast organic dairy industry needs and research priorities obtained through the survey results. A webinar about fly control on organic dairy farms available through eOrganic. A network of organic dairy farmers and researchers in the Northeast willing to participate/collaborate in future work. An advisory board consisting of university research/extension faculty, organic dairy farmers, and organic dairy industry representatives from ME, VT, NH, NY, PA, MA, and NC. Dissemination: Results presented at the 2011 USDA Organic Farming Systems Research Conference in Washington, DC; the 2012 NOFA-NY Research Symposium in Saratoga Springs, NY; the 2012 NODPA field days in Brattleboro, VT; the 2012 PD workshop for NIFA-OREI-funded projects in Washington, DC. PARTICIPANTS: The project directors (Drs. Brito and Townson) organized and implemented the study in collaboration with colleagues (Drs. Lisa Townson and Paul Tsang) from the University of New Hampshire. Partner organizations included: University of Vermont (Bob Parsons, Heather Darby, Debra Heleba), University of Maine (Rick Kersbergen), Cornell University (Fay Benson), Organic Valley CROPP (Peter Miller). Collaborators included: Doug Donahue (Farmer), Stephen Morrison (Farmer), Rich Smith (UNH Faculty), Kirk Broders (UNH Faculty), Britt Lundgren (Stonyfield Farm), John Amey (Farmer), Kathy Soder (USDA-ARS), Lamar Wadel (Farmer), Jim Cropper (Northeast Pasture Consortium), Brent Beidler (Farmer), Mike Thresher (Dairy Feed Specialist), Steve Getz (Organic Valley CROPP), Mary-Howell Martens (Lakeview Organic), Dave Hardy (Organic Valley CROPP), Ed Maltby (NODPA). TARGET AUDIENCES: The targeted audiences are organic dairy research and Extension personnel, organic dairy producers, organic industry personnel, and veterinarians across the Northeast. Efforts included three focus groups, one survey, three workshops, and one Advisory Board meeting. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Activities: Three focus groups interviews were conducted with a total of 35 farmers from ME, VT, NY and PA. Two surveys designed based on the focus group interviews results were submitted to 1,000+ farmers across the Northeast using the electronic and mailing contact list provided by the

Northeast Organic Dairy Farmers Association. The first attempt to collect information via an electronic survey instrument failed to provide satisfactory responses (only 16 respondents). However, approximately 250 responses were obtained when a hard copy of the survey instrument was mailed to the same audience. The survey results are currently being analyzed by the project directors. Events: A one-day workshop that took place at the University of New Hampshire this past July was conducted to foster collaborations among researchers and Extension educators involved in organic agriculture research from different institutions (University of New Hampshire, University of Vermont, University of Maine, Cornell University, and USDA-ARS Pasture Systems and Watershed Management Research Unit) across the Northeast. The major goal of the workshop was to discuss current and future needs of the organic dairy industry in the Northeast based on the preliminary results of the planning grant, as well as to develop future grant proposals, implement funded projects, and expand the collaboration network to other US regions. Products: A database highlighting the organic dairy industry using the survey results is being constructed. Dissemination: Preliminary results from the planning proposal were presented at the 2011 USDA Organic Farming Systems Research Conference in Washington, DC. PARTICIPANTS: The project directors (Drs. Brito and Townson) organized and implemented three focus group interviews in collaboration with colleagues (Drs. Lisa Townson and Paul Tsang) from the University of New Hampshire. Thirty-five producers from ME, VT, PA, and NY participated at three different sites (Waterville, ME; Binghamton, NY; and Randolph, VT). Each focus group was arranged by a local Extension educator, sometimes with input from Organic Valley or the Northeast Organic Dairy Producers Association). Producers from all three locations cited improved or maintained herd health as one of their greatest successes as a result of transitioning to organic dairying. In particular, implementing grazing systems and forage self-sufficiency were cited as successes. Conversely, producers from all three locations, but particularly in ME and VT, cited extending the grazing season, complying with the new pasture rules, and implementing strategies to facilitate value-added marketing of milk as major challenges to the industry. These high priority issues have formed the basis for a survey that was distributed to a broader population of stakeholders in the Northeast. The resulting highest priority issues will lead to follow-up communication with farmers interested in providing their farms as pilot sites for future research and outreach education. TARGET AUDIENCES: The targeted audiences are organic dairy producers, organic industry personnel, and veterinarians across the Northeast. Three focus groups with organic dairy producers across the Northeast were conducted. The high priority issues raised by this specific target audience have formed the basis for a survey that was distributed to a broader population of stakeholders in the Northeast. Our team is currently planning to host two additional focus group interviews to include local milk processors and veterinarians. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2012/08 Thirty-five producers from ME, VT, PA, and NY, interviewed at three different sites (Waterville, ME; Binghamton, NY; and Randolph, VT) who helped prioritize the research and Extension needs for developing a comprehensive survey. Over one thousand surveys distributed, with 159 responses received, verifying the research and Extension priorities for development of future integrated, multi-state NIFA-OREI grant proposals. Over 120 stakeholders participating in the three workshops offered during a three-month period. Twenty participants from seven Northeastern states serving as consultants/collaborators on future organic dairy research and Extension efforts. Funding of a four year, \$2.9M NIFA-OREI multi-state grant entitled, \"Assisting Organic Dairy Producers to Meet the Demands of New and Emerging Milk Markets.\" **PUBLICATIONS (not previously reported):** 2010/09 TO 2012/08 1. Townson DH, Brito AF, Townson LL, Tsang PCW 2012 Assessing the research and extension needs of the organic dairy industry in the Northeast. Northeast Organic Research Symposium Proceedings. 2. Pereira AB, Brito AF, Townson LL, Townson DH 2013 Assessing the research and extension needs of the organic dairy industry in the Northeast. Journal of Dairy Science (In preparation)

2010/09/01 TO 2011/08/31 This planning proposal has four objectives: -Objective 1: Develop an in-depth understanding of the research and Extension needs of organic dairy stakeholders from the Northeastern states (i.e., CT, NH, NY, MA, ME, PA, & VT), including the most effective means of communication and outreach, via focus group interviews. Results: Thirty-five producers from ME, VT, PA, and NY, interviewed at three different sites (Waterville, ME; Binghamton, NY; and Randolph, VT) indicated that extending the grazing season, complying with the new, federally-mandated pasture rules, and implementing value-added strategies to market milk are among the major challenges of the Northeast organic dairy industry. Our plan is to host additional focus group interviews to include local milk processors and veterinarians. -Objective 2: Prioritize research and Extension needs identified in the focus groups with a broader population of stakeholders via survey methods. Results: Results from approximately 250 survey respondents are being currently analyzed. -Objective 3: Verify and validate the priorities with team members and stakeholders, and begin a planning process for conducting

integrated research and Extension programs via follow-up workshops. Results: The development of the follow-up workshops is pending analyses of the survey results. Objective 4: Develop integrated proposals to address the prioritized organic research and Extension needs and organize a network of collaborating stakeholders to help conduct the research (Research and Extension Advisory Panel). Results: Preliminary results from this planning grant were successfully used by our team members to develop an OREI integrated proposal that was funded this last cycle by NIFA.

PUBLICATIONS

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

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Environmental Sustainability of Organic Farming Systems: On-farm, Experimental, and Watershed Assessments

Accession No.	0222643
Subfile	CRIS
Project No.	OHOW-2010-01929
Agency	NIFA OHOW
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21234
Proposal No.	2010-01929
Start Date	01 SEP 2010
Term Date	31 AUG 2011
Grant Amount	$49,666
Grant Year	2010
Investigator(s)	Shipitalo, M.; Stinner, D.; Bonta, J.
Performing Institution	USDA-ARS-North Appalachian Experimental Watershed, AGRICULTURAL RESEARCH SERVICE, COSHOCTON, OHIO 43812

NON-TECHNICAL SUMMARY

Organic farming practices can reduce the levels of pesticides in the environment while not necessarily being sustainable. Because of frequent reliance on tillage for weed control and the use of animal manure to supplement soil fertility in lieu of herbicides and mineral fertilizers, potential negative effects include excessive loss of soil, nutrients, and animal wastes in surface and ground water and a reduction in soil organic matter levels and soil quality. These concerns have been addressed in a piecemeal fashion using small research plots and on-farm evaluations, but have not been addressed comprehensively. What is needed is a holistic examination of organic production systems in terms of a full suite of water and soil quality parameters (i.e., ecosystem services), including actual measurements of the volume and quality of surface runoff in order to truly assess the environmental sustainability of organic production systems. Therefore, the objective of this planning grant is to design a project to evaluate the effects of innovative organic farming systems using a multi-scale watershed, systems-based, approach. The research will be guided by small farmer needs and adapted to local conditions characteristic of the US Midwest and Northeast. The plan will include a modeling component so that the results can be scaled to larger systems and ungauged watersheds. The full proposal to be developed as a product of this planning grant will benefit producers of organic crops and animals by identifying and developing practical methods of organic production with reduced environmental impact.

OBJECTIVES

The goal of this planning grant is to bring together a multi-disciplinary, multi-state team to develop a full proposal in which the effects of organic crop and animal farming systems on soil and water will be simultaneously investigated using a multi-scale watershed approach. This will be accomplished by assembling a select group of approximately 20 organic producers, cropping systems specialists, environmental scientists, and watershed researchers from Ohio, Wisconsin, West Virginia, New Hampshire, and Pennsylvania for a two-day meeting at the North Appalachian Experimental Watershed near Coshocton, Ohio for a two-day meeting in October 2010. Specific objectives for the project will be developed during this meeting and group leaders will be selected with

the responsibility of formulating and writing each component of the grant proposal. After the initial meeting, the group leaders will visit the proposed research locations in each state in order to assess the specific requirements needed to perform the research. This core group will also visit various organic research institutes in Europe to consult with researchers that have conducted similar research to build on their expertise and avoid duplication of their efforts. A completed draft proposal for internal review will be prepared by mid-January 2011 and a final proposal submitted before the 2011 deadline for submission as specified in the 2011 OREI request for applications.

APPROACH

This planning grant will be used to develop a full proposal to evaluate the environmental sustainability of organic farming practices. This will be accomplished by bringing together a group of organic producers, cropping systems specialists, environmental scientists, and watershed researchers for a two-day planning meeting. Background information on each participant will be collected and circulated before the meeting and a conference facilitator will be used to keep the group focused and on task. The outcome of this meeting will be clearly defined, researchable, objectives and specific investigators assigned to write each component of the proposal. Additional participants may be recruited to join the project if their expertise is required to fulfill the objectives. The investigators charged with writing each component will travel to the proposed research sites to gain additional knowledge of the capabilities at each location and the specific needs to address the objectives. They will develop and circulate their draft components to the other project participants and organic producers in order to refine the proposal in an iterative manner.

PROGRESS

2010/09 TO 2011/08 OUTPUTS: The North Appalachian Experimental Watershed (NAEW) was awarded a planning grant as part of the NIFA Organic Research and Extension Initiative (OREI) for a proposal entitled \"Environmental Sustainability of Organic Farming Systems: On-Farm, Experimental, and Watershed Assessments\". The funds were used to assemble a group of researchers for a planning meeting in which the broad objectives of the project were deliberated and agreed to. The attendees included an interdisciplinary mix of 20+ scientists and representatives of stakeholder groups. The scientists were from The Ohio State University, University of Wisconsin, and University of New Hampshire and the ARS Appalachian Farming Systems Research Center in West Virginia, as well as the NAEW. Disciplines represented included hydrology, hydraulic engineering, dairy science, soil chemistry, biogeochemistry, soil science, entomology, ecology, and rural sociology. Stakeholders were from Organic Valley, Rodale Institute, Discovery Farms, Northeast Pasture Consortium, the Small Farm Institute, and USDA-NRCS. Following the initial, meeting select representatives visited some of the proposed research sites in Wisconsin, New Hampshire, and Pennsylvania. A select group also visited institutes and organizations involved in organic agriculture research in Germany (Institute of Organic Farming in Trenthorst), Finland (Agrifood Research Finland - MTT), Switzerland Research (Institute of Organic Agriculture - FiBL in Frick). In addition, the group met with the Chairman of the International Centre for Research in Organic Food Systems (ICROFS). PARTICIPANTS: Not relevant to this project. TARGET AUDIENCES: Not relevant to this project. PROJECT MODIFICATIONS: Not relevant to this project.

IMPACT

2010/09 TO 2011/08 The collaboration fostered by the planning grant resulted in the identification of a major gap in organic research nationally and internationally. Namely, field-scale evaluation of the environmental impact of tillage in organic systems and development and holistic assessment of conservation systems that reduce the impact of tillage. This gap was addressed in a full proposal entitled \"The Role of Tillage in Sustainability of Organic Farming Systems: On-Farm, Experimental, and Watershed Assessments\" in which the impacts of organic production practices on soil and water quality were to be assessed with on-farm research, complimented with research using the unique field facilities under control of the participating scientists. The contributors to the proposal included 15 PD and Co-PDs and nine key personnel with representatives of the European organic research community included in the later. Although the proposal was not funded, the comments received from the reviewers will aid us in strengthening the proposal for re-submission. **PUBLICATIONS (not previously reported):** 2010/09 TO 2011/08 No publications reported this period

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Sustainable Organic Tribal Bison Production Using an Intra-tribal Supply Chain Management System: a Planning Grant Proposal

Accession No.	0222357
Subfile	CRIS
Project No.	SD00G367-10
Agency	NIFA SD.
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21247
Proposal No.	2010-01916
Start Date	01 AUG 2010
Term Date	31 JUL 2012
Grant Amount	$43,809
Grant Year	2010
Investigator(s)	Fausti, S. W.; Adamson, D. W.; Krishnan, P.; Kattelmann, K.; Lonowski, D.; Wright, C.; Smart, A.; Sexton, P.; Owens, V.; Daily, R.; Henry, L.; Hildreth, M.
Performing Institution	Economics, SOUTH DAKOTA STATE UNIVERSITY, PO BOX 2275A

NON-TECHNICAL SUMMARY

The research team will develop an integrated OREI proposal with the following short-run and long-run stakeholder\'s goals with respect to managing tribal bison herds. The short-run goals include: a) the transition of the tribal bison herd production system to an organic management system, and b) an intra-tribal supply chain marketing system to provide a stable, self-sustaining market though internal Tribal demand for organic bison meat, and an external commercial marketing program for the prime organic bison meat cuts. The long-run goals are: a) an organically based bison production system that is economically self-sustaining, b) provide tribal social organizations with a source of protein that is culturally relevant and provides a healthier diet, and c) develop an extension outreach program that includes eXtension and the eOrganic COP programs.

OBJECTIVES

This planning grant intends to develop a future competitive OREI grant proposal. The goal of the planning grant is to propose the development of a sustainable organic tribal bison production system using an intra-tribal supply chain management mechanism. The planning grant is stakeholder driven. The stakeholders are the Flandreau Santee-Sioux Tribe (FSST) and the Inter-Tribal Bison Council (IBTC).

APPROACH

To obtain the objectives of the planning grant, the planning team will be comprised of a broad based team of agricultural scientists who will develop a plan (with stakeholder input) for the organic transition of FSST forage acreage and their bison herd; and a plan to implement an intra-tribal market supply chain for FSST organic bison meat. Continual interaction between all parties associated with the planning grant will address the complexities of developing a systems based approach to address the stakeholder\'s goals of implementing an organic bison production and marketing system for FSST and ITBC.

PROGRESS

2010/08 TO 2012/07 OUTPUTS: The overall goal of the planning grant proposal was to bring together Native American stakeholders with agricultural and social scientists to develop a systems based grant proposal for implementing organic production practices and an internal community based market for organic production. The planning grant successfully implemented a team based approach that included university scientists and stakeholder representatives to evaluate current: 1) Flandreau Santee Sioux bison, forage, and hay production practices, 2) Flandreau Santee Sioux community organizations (Diabetes and Elderly programs) and the Flandreau Indian School (BIE school) to determine their interest in the development of an intra-tribal bison meat supply chain system, 3) educational and extension objectives of the Intertribal Buffalo Council, the national Native American organization acting as the coordinating agency for national Native American bison development policy, and 4) individuals with expertise in organic production. The outcome of the planning grant resulted in FSST launching its organic transition program in the spring of 2011. FSST is using the Minnesota Crop Improvement Association (MCIA) as their organic certifier. The final objective of the funded planning grant was the submission of a competitive OREI grant application in the spring of 2011 (Proposal Number: 2011-01966. The proposal was ranked medium priority. A one year extension of the planning grant was granted. During the second half of 2011 and winter of 2012 the Bison Planning Grant team and stakeholders worked to address panel comments. OREI Proposal 2012-02202 was submitted in March 2012. The panel review committee again ranked the project medium priority and the project was not funded. PARTICIPANTS: Participants included Flandreau Santee Sioux Tribe, South Dakota State University, Inter-Tribal Buffalo Council, USDA-Agricultural Research Service, Oglala Lakota College, and the Flandreau Indian School. TARGET AUDIENCES: Native American Tribes, bison producers, organic livestock and forage producers PROJECT MODIFICATIONS: Not relevant to this project.

2010/08/01 TO 2011/07/31 OUTPUTS: The goal of the planning grant activity is to bring together Native American stakeholders and agricultural scientists to develop a systems based grant proposal for implementing organic production practices as the foundation for the development of an economic and socially sustainable supply chain mechanism that is consistent with cultural values of FSST members and will enhance the social well-being of the tribal community. The planning grant activity that occurred during 2010-11 strengthened the relationship between stakeholders and the planning team. A stakeholder steering committee has been formed and has been a driving force in the development of the proposed organic production/supply chain system. The planning grant team members made over 25 trips to Flandreau to meet with stakeholders on various aspects of the project during the summer and fall of 2010. The planning team held three one-day conferences at the FSST-owned convention center-hotel complex in Flandreau during 2010. The planning grant allowed the addition of experts to the project to address deficiencies highlighted in the 2009 panel review comments. A competitive grant application was submitted to OREI in the spring of 2011. PARTICIPANTS: Stakeholder: Flandreau Santee-Sioux Tribe 403 W. Broad Avenue Flandreau, SD 57028 Phone: 605-997-3891 CO-PI Leslie Rae Henry Director Cooperative Extension Outreach Education Agriculture & Natural Resource Extension Outreach Education Oglala Lakota College Stakeholder: Jim Stone Executive Director Inter-Tribal Buffalo Council 2497 West Chicago Street Rapid City, SD 57702 Phone: 605-394-9730 23. Stakeholder: Betty Belkham Superintendent Flandreau Indian School 1132 N Crescent St. Flandreau, SD 57028 Phone: 605-997-3773 Fax: 605-997-2601 TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: A one year extension was granted for this planning grant.

IMPACT

2010/08 TO 2012/07 Significant 2011 Activities and Outcomes Related to this Planning Grant Proposal: MCIA organic inspector verified that Flandreau Santee Sioux Tribe (FSST) entered the organic transition period in the Spring of 2011. FSST implemented a major pasture reseeding and restoration project in the Fall of 2011 that complies with organic transition requirements. A herd reduction plan was implemented and the selection of bison for the breeding stocks herd that will be used for organic calf production. South Dakota State University (SDSU) collaborating with Intra Tribal Bison Council (ITBC) launched three pilot projects to gage acceptability of bison into the diets of Native American community members. The focus of these studies is on high risk Native American groups (diabetics, youth, and the elderly). ITBC has entered into an agreement with the Flandreau Indian School (FIS) to supply bison meat on a monthly basis until FSST has its organic production up and running. SDSU and FIS have begun an experimental trial on student preference for beef versus bison. **PUBLICATIONS (not previously reported):** 2010/08 TO 2012/07 No publications reported this period

2010/08/01 TO 2011/07/31 As a result of the planning grant, the planning grant researchers submitted a competitive grant proposal to NIFI-OREI: Program: Organic Agriculture Research & Extension Initiative Proposal Number: 2011-01966 Proposal Title: Intra-Tribal Supply Chain Management System For Organic Bison: A Demonstration Project The grant proposal was not funded. The proposed project was given a medium priority for funding by the grant review panel. Overall, the comments were positive, and after discussing the panel comments with the program leader, the grant team decided to request a one year extension of the grant. The extension was granted. Another application to OREI is planned for March 2012.

PUBLICATIONS

2010/08/01 TO 2011/07/31 No publications reported this period

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Organic Sheep and Goats: Herd Health and Nutrition Planning Proposal for the Northeast Us 2010

Accession No.	0222766
Subfile	CRIS
Project No.	WVA00209
Agency	NIFA WVA
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21360
Proposal No.	2010-01970
Start Date	01 SEP 2010
Term Date	31 AUG 2012
Grant Amount	$31,344
Grant Year	2010
Investigator(s)	Kotcon, J. B.; Peterssen, K.; Stanton, T.; Keilty, M.; Bryan, W. B.
Performing Institution	Plant & Soil Sciences, WEST VIRGINIA UNIVERSITY, PO BOX 6108

NON-TECHNICAL SUMMARY

Intestinal roundworm species infect small ruminants in the Northeast and throughout the world. Haemonchus contortus is generally considered the most important. The nematodes feed by ingesting blood from the lining of the digestive tract. Symptoms of infection are associated with blood loss, and include anemia, pale color of mucous membrane, edema or bottle-jaw, severe loss of condition, diarrhea and poor growth. In severe infections, death may occur within a few days of the appearance of initial symptoms. Young lambs tend to be most susceptible, as adults tend to develop resistance as they mature. Variation in levels of susceptibility are associated with genetic resistance as well as an acquired immune response which varies with breed, age, and diet, as well as dose of the nematodes. Producers can manage parasites through nutritional approaches designed to enhance immunity to the nematode, or through \"safe\" pasture strategies in which animals are rotated among pastures to avoid grazing when infective nematode levels are high. While some success has been achieved at West Virginia University in managing intestinal parasites by intensive rotational grazing with 3-day occupancy periods, the methods are labor intensive and managing pastures optimally for forage quality or production is difficult. Enhanced protein supplementation has been associated with reduced symptom severity, lower egg production and reduced worm burden at slaughter, as well as enhanced weight gain, especially in the more susceptible breeds and similar results have been observed in recent trials at West Virginia University. Sheep fed forages with high tannin content also demonstrated improved resistance to nematodes and decreased fecal egg counts, egg hatch, and larval development have been documented. Condensed tannin containing forages, by themselves, have the potential to provide adequate control of gastrointestinal parasites. Fecal egg counts from dosed lambs were reduced after feeding chicory, sainfoin, and birdsfoot trefoil as fresh forage and similar results have been found for the forage as hay or silage. Sericea lespedeza also suppressed fecal egg counts and worm burden in both sheep and goats. The planning process will propose a project that would build on previous research in organic sheep production at West Virginia University by Kotcon and Bryan, where replicated trials on a fully certified organic research farm have been on-going since 2001. Recent results from IPM-funded research demonstrate great success in limiting losses to gastro-intestinal nematodes in a fully organic, whole-farming systems context. These research results will be expanded and integrated with the new work being proposed on high-tannin forage nutrition, using replicated flocks under controlled, research-farm conditions. Best practices developed at WVU will be melded with nutritional analyses, on-farm research, and

outreach efforts by Petersson, Keilty and Stanton in small ruminants in Rhode Island, Connecticut, Massachusetts, Vermont and New York.

OBJECTIVES

We plan to develop a proposal for coordinated research into the single most important limiting factor in organic sheep and goat production: intestinal parasites. Research objectives that will be considered are to: 1) Evaluate herd health and economic outcomes of pasture mixes with high-tannin lespedezas and protein supplementation for suppression of intestinal parasites; 2) Measure nitrogen utilization and rumen dynamics, ewe milk production, and lamb weight gain; 3) Assess benefits of multi-species stacking and intensive rotational grazing of pastures; 4) Analyze databases of organic certifiers for herd health trends; 5) Determine significance of immune suppression versus avoidance of infection in disease outcomes; and 6) Assess milk and blood proteins to measure immune response to nutritional management practices. Outreach and Extension activities would include: 1) Enroll growers to characterize and track herd profiles and develop herd histories. 2) Include microscopes for growers to do their own fecal egg counts. 3) Develop instant feedback opportunities for growers via on-line databases. 4) Develop risk assessment tools for growers comparing livestock versus cash crop operations. 5) Provide workshops for hands-on training in FAMACHA scores, fecal egg counts, and rotational grazing practices. 6) Field test forages with demonstrated potential to reduce parasite burden in small ruminants. 7) Outreach to farmers via on-farm demonstrations, twilight meetings, and presentations at grower organizations. 8) Use eXtension and eOrganic to develop Communities of Practice with growers, crop advisors, Extension agents, and others. 9) Develop 1-page fact sheets. 10) Develop contacts and publish articles in agriculture and livestock publications of interest to growers. 11) Blog, Twitter, Facebook for grower communication!

APPROACH

A planning process will be initiated in 2010-11 to prepare a detailed proposal to conduct research and outreach activities to improve organic management of intestinal parasites in sheep, using improved nutritional management as the primary approach. Activities will include a series of farm visits to solicit input, hosting up to three producer meetings (preferably in conjunction with other events) to clarify research priorities and identify optimal outreach activities for the proposal, and travel by investigators to planning meetings for proposal preparation. The solicitation of grower participation in this planning proposal will be facilitated by access to existing databases, upcoming producer meetings and workshops, state extension personnel contacts and organic producer organizations such as the Northeast Organic Farming Association (NOFA). Kotcon and Bryan will coordinate a stakeholder meeting at the West Virginia University Organic Research Farm. Stakeholders, including producers, veterinarians, certifiers, and agriculture advisors, from West Virginia, Ohio, western Pennsylvania and western Maryland will be invited to participate. Kotcon will also serve as Principle grant-writer for the 2011 proposal. Peterssen and Keilty will hold one meeting in the central New England Region targeting stakeholders in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. They will also assist with the grant writing for the 2011 proposal. Stanton will coordinate a stakeholder meeting at Cornell University to which stakeholders from New York and eastern Pennsylvania will be invited to participate. She will also assist with the grant writing for the 2011 proposal. After initial contacts and meetings in summer and fall of 2010, a planning workshop will be held in November, 2010, to clarify research plans, identify proposed outreach priorities, and organize grant-writing activities. Stakeholders will form a Grower Advisory Committee. Certification organizations will be solicited to aid in identifying organic growers, and to use certification databases to collect herd health information. We also plan to solicit input and collaborators from veterinarians who would be able to provide information on herd health and identify herd health and nutrition research priorities. We will use on-line databases including Farmers Market lists, localharvest.org, and university and state agriculture specialists to do outreach to producers, extension specialists, and agricultural advisors. Initial grower contacts will be made using outreach via mailings, as well as via one-on-one contacts with identified opinion leaders in the small ruminant production community. A short questionnaire will be used to identify interested growers, as well as to solicit feedback on production problems and research needs. Outreach and extension practices will be discussed to identify those practices that growers are most receptive to. We will use eXtenstion and eOrganic to extend the capacity to provide content for sheep producers throughout the Northeast as well as the rest of the US.

PROGRESS

2010/09 TO 2012/08 OUTPUTS: A planning process was initiated in 2010-11 to prepare a detailed proposal to conduct research and outreach activities to improve organic management of intestinal parasites in sheep, using

improved nutritional management as the primary approach. Activities included a series of farm visits to solicit input, hosting three producer meetings (in conjunction with other events) to clarify research priorities and identify optimal outreach activities for the proposal, and travel by investigators to planning meetings for proposal preparation. Initial contacts and meetings took place fall 2010, through 2011, to clarify research plans, identify proposed outreach priorities, and organize grant-writing activities. Producer information obtained through surveys and as a result of stakeholders meetings and face to face conversations were compiled in a database and the results summarized for the planning process. Meetings and extensive conference calls were undertaken to prepare a full proposal during 2011 and early 2012. The project successfully developed a full proposal for submission to the OREI program that included a multi-component research and outreach program with the following objectives: 1. Evaluate birdsfoot trefoil cultivars to assess agronomic characteristics and tannin contents, identify which condensed tannins are critical for anthelminthic activity and characterize the structure/function relationship of the tannin profiles; 2. Assess the effects of tannin-containing forages on larval and adult nematodes in vitro and in vivo, and measure key immune responses of the host animal; 3. Evaluate herd health and economic outcomes of pasture mixes with tannin-containing birdsfoot trefoil for suppression of intestinal parasites; 4. Conduct on-farm studies to demonstrate deployment of birdsfoot trefoil pastures for parasite suppression on working commercial farms; 5. Promote grower adoption; 6. Develop outreach communications to maximize knowledge dissemination; and 7. Assist growers in realizing profits in organic sheep and goat production. The full proposal was funded in 2012, allowing four years of continued research and development for best practices to deploy high-tannin birdsfoot trefoil pastures for intestinal parasite management. During the project, grower advisory meetings were hosted at Cornell University, West Virginia University, and individual meetings with growers occurred in Maine and Connecticut to solicit grower input for research and outreach priorities and methods. A preliminary cultivar trial was established at the West Virginia University Organic Research Farm in 2012, and the flock of organic sheep there was expanded in preparation for field trials to be conducted in 2013-16 as part of the full proposal. PARTICIPANTS: Dr. James Kotcon served as Principle Investigator and Dr. Scott Bowdridge served as a Co-Project Director. Other co-investigators and collaborating units included Dr. Katherine Petersson and Dr. Rebecca Brown (University of Rhode Island); Tatiana Stanton, Extension Specialist (Cornell university), Dr. Anne Zajac (Virginia Tech); and Dr. Jess Reed, Dr. Christian Krueger and Dr. Dhanansayan Shanmuganayagam (University of Wisconsin). Stakeholders, including producers, as well as veterinarians, certifiers, and agriculture advisors, from West Virginia, Ohio, western Pennsylvania and western Maryland will be invited to participate. TARGET AUDIENCES: The targets for this project are organic producers of small ruminants, as well as Extension specialists, veterinarians, and other herd health advisors. Direct targets will include growers who will participate as advisors, collaborate with on-farm research and demonstration, or serve on grower Advisory Committee for the full proposal. An initial target will be the USDA\'s OREI program to which a full proposal will be submitted. PROJECT MODIFICATIONS: Michael Keilty, University of Connecticut, withdrew from the project in 2011, and Dr. Anne Zajac, Virginia Tech was added. The project was granted a one-year no-cost extension in order to more fully develop a competitive proposal for submission in 2012.

2010/09/01 TO 2011/08/31 OUTPUTS: A planning process was initiated in 2010-11 to prepare a detailed proposal to conduct research and outreach activities to improve organic management of intestinal parasites in sheep, using improved nutritional management as the primary approach. Activities included a series of farm visits to solicit input, hosting three producer meetings (in conjunction with other events) to clarify research priorities and identify optimal outreach activities for the proposal, and travel by investigators to planning meetings for proposal preparation. Initial contacts and meetings took place fall 2010, through 2011, to clarify research plans, identify proposed outreach priorities, and organize grant-writing activities. Producer information obtained through surveys and as a result of stakeholders meetings and face to face conversations were compiled in a database and the results summarized for the planning process. The objective is to develop a full proposal for submission to the OREI program that will include a multi-component research and outreach program that could include the following: 1) Evaluate the efficacy of high-tannin forages such as birdsfoot trefoil for suppression of intestinal nematodes in sheep and goats. 2) Characterize herd health and nutrition in response to grazing management strategies that include high-tannin forages 3) Develop risk assessment tools for growers comparing livestock versus cash crop operations. 4) Workshops for hands-on training in FAMACHA scores, fecal egg counts, and rotational grazing practices. 5) Field testing of forages with demonstrated potential to reduce parasite burden in small ruminants. 6) Outreach to farmers via on-farm demonstrations, twilight meetings, and presentations at grower organizations. 7) Use eXtension and eOrganic to develop Communities of Practice with growers, crop advisors, Extension agents, and others. 8) Develop 1-page fact sheets, and 9) Develop contacts and publish articles in agriculture and livestock publications of interest to growers. The effectiveness of each of these approaches will be assessed by on-farm interviews with growers who will be apportioned to adopter and non-adopter categories. Formal details of an assessment plan will be worked out during the full proposal planning activities. PARTICIPANTS: Dr. James Kotcon will serve as Principle Investigator and Dr. William Bryan will serve

as a Co-Project Director. They will coordinate a stakeholder meeting at the West Virginia University Organic Research Farm. Stakeholders, including producers, as well as veterinarians, certifiers, and agriculture advisors, from West Virginia, Ohio, western Pennsylvania and western Maryland will be invited to participate. Dr. Kotcon will also serve as Principle grant-writer for the 2011 proposal. Dr. Katherine Petersson, C0-PD, University of Rhode Island will hold one meeting in the central New England Region targeting stakeholders in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. She will also assist with the grant writing for the 2011 proposal. Dr. Tatiana Stanton, Cornell University, will coordinate a stakeholder meeting at Cornell University to which stakeholders from New York and eastern Pennsylvania will be invited to participate. She will also assist with the grant writing for the 2011 proposal. Dr. Anne Zajac, Virginia Tech, was added to the project in 2010 and will assist with grant-writing by providing nematode identification and quantification expertise. TARGET AUDIENCES: The targets for this project are organic producers of small ruminants, as well as Extension specialists, veterinarians, and other herd health advisors. Direct targets will include growers who will participate as advisors, collaborate with on-farm research and demonstration, or serve on grower Advisory Committee for the full proposal. An initial target will be the USDA\'s OREI program to which a full proposal will be submitted. PROJECT MODIFICATIONS: Michael Keilty, University of Connecticut, withdrew from the project in 2011, and Dr. Anne Zajac, Virginia Tech was added. The project was granted a one-year no-cost extension in order to more fully develop a competitive proposal for submission in 2012.

IMPACT

2010/09 TO 2012/08 A full proposal submitted to the OREI program by project investigators in FY 2012 was funded. The proposal described a program of research and extension to identify improved management practices for organic sheep and goat producers, and encourage and evaluate the adoption and success of those activities in on-farm use. Priorities included disease management and nutrition, outreach activities for marketing, certified slaughter facilities, labor, training, etc. **PUBLICATIONS (not previously reported):** 2010/09 TO 2012/08 No publications reported this period

2010/09/01 TO 2011/08/31 The expected outcome will be submission of a full proposal to the OREI program in FY 2011. The proposal will describe a program of research and extension that will identify improved management practices for organic sheep and goat producers, and encourage and evaluate the adoption and success of those activities in on-farm use. We will also develop a Grower Advisory Committee through which growers and other cooperators will identify their research and extension needs and priorities for the full proposal, as well as serve as a consulting and review body during the life of the full proposal. Priorities are anticipated to include not only disease management and nutrition, but could add outreach activities for marketing, certified slaughter facilities, labor, training, etc. The Grower Advisory Committee will assist in identifying the current limitations to organic sheep and goat production in the region. We also would use this Committee to identify where the industry can expand and what is keeping it from doing so.

PUBLICATIONS

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

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Economics, Ecology, Education: an Integrated Approach to Ensure the Success of Organic Vegetable Growers

Accession No.	0222372
Subfile	CRIS
Project No.	IND011276G1
Agency	NIFA IND
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21305
Proposal No.	2010-01913
Start Date	15 AUG 2010
Term Date	14 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Gibson, K. D.; Alexander, C.; Beckerman, J.; Hallett, S. G.; Kaplan, I.; Hoagland, L.; Kladivko, E.; Marshall, M.; Sadof, C.
Performing Institution	Botany & Plant Pathology, PURDUE UNIVERSITY, WEST LAFAYETTE, INDIANA 47907

NON-TECHNICAL SUMMARY

The number of organic farms in the Midwest continues to increase. However, many new farmers have little experience operating organic farms and face steep learning curves. Research universities and Extension Educators can increase the success rate of new and existing organic farms by providing research-based recommendations for farm management practices, by helping growers identify markets and develop solid business plans, and by facilitating knowledge transfer from experienced organic growers to growers starting organic farms. The specific objectives of this project are to (1) assess economic opportunities for organic growers in Indiana and identify key barriers to transitioning from conventional to organic agriculture, (2) evaluate the effect of cover crops and intercropping on soil-building and pest management, (3) compare soil-building and pest management in two cropping systems, (4) evaluate the response of tomato cultivars to soil pathogens, (5) develop, test, and implement a program to train Extension Educators to work with organic growers, and (6) develop teaching plots and a student-run organic garden that will serve as living laboratories for agricultural courses at Purdue. Our project will facilitate the development of organic agriculture production, identify tomato cultivars for use in organic breeding programs, evaluate economic benefits to organic producers, and identify marketing constraints on the expansion of organic agriculture. Our project will also develop and implement education training programs and develop programs to address pests and pest-related problems.

OBJECTIVES

Our long-term goal is to increase the number of economically viable organic farms in Indiana and the Midwest and to contribute to the growing body of scientific and economic knowledge regarding organic agriculture. Our short-term goals are to identify economic and marketing constraints to the adoption of organic agriculture in Indiana and develop strategies to address these constraints, evaluate strategies to optimize soil-building and pest management, evaluate tomato cultivars, develop a training program for county Cooperative Extension personnel, and engage university students in organic agricultural practices and research activities. Specifically, we will (1)

assess economic opportunities for organic growers in Indiana and identify key barriers to transitioning from conventional to organic agriculture, (2) evaluate the effect of cover crops and intercropping on soil-building and pest management, (3) compare soil-building and pest management in two cropping systems, (4) conduct on-farm research to evaluate growth of tomato cultivars following cover crops, (5) evaluate interactions between tomato cultivars and soil microbes and identify suitable varieties for organic production, (6) develop, test, and implement a program to train Extension Educators to work with organic growers, and (7) develop teaching plots and a student-run organic garden that will provide students with hands-on opportunities to learn about organic agriculture and serve as living laboratories for existing courses in the College of Agriculture.

APPROACH

We will examine the effect of cover crops, living mulches, and crop rotations on pests and pest management. We are particularly interested in reducing the need for manual cultivation in vegetable crops through the use of living mulch between crop rows and timely mowing. This novel approach has the potential to substantially reduce hours spent on manual cultivation for small-acreage farmers. We will assess the growth of current and heirloom tomato varieties, particularly their interaction with soil microorganisms, as the first step in developing a breeding program for organic production systems. We will develop, test, and implement a program to train Extension Educators to work with organic growers, and develop teaching plots and a student-run organic garden that will provide students with hand-on opportunities to learn about organic agriculture and prepare them for careers as Extension Educators. We will also conduct economic analyses of production costs and benefits and of current and potential markets for organic growers; we will make that information available to Extension personnel and other agricultural professionals who advise organic growers.

PROGRESS

2010/08 TO 2015/08 Target Audience:Information related to our project was disseminated to researchers, farmers, and extension educators through peer-reviewed publications, Extension publications,conferences, field days, and workshops. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Nine graduate students participated in the project and were mentored by faculty. Their professional development included opportunities to present at national and regional conferences.Three theses and two dissertations have been completed. An additional PhD student will graduate in spring 2016. How have the results been disseminated to communities of interest?More than 40 presentations related to the project were given at conferences, field days, and workshops. The presentations were attended by over 1200 stakeholders. The Student Farm hosted more than 150 visitors, supported 21 student interns, and serves as the focal point for a new major, Sustainable Food and Farming Systems, at Purdue.Six papers related to our research have been published in peer-reviewed journals. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2013/08 TO 2014/08 Target Audience: We continued to reach our target audience of farmers, Extension Educators, researchers, and students. Increased effort was placed on reaching Extension Educators. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Three graduate students conducted research related to the project and three undergraduate students asssited with experiments. An undergraduate intern from Colombia assisted with field experiments and will write a report on the sorhum-sudangrass experiment as part of the requirements for his internship. How have the results been disseminated to communities of interest? We continued to disseminate information from our project to our target audience through presentations at conferences and field days. However, we increased our efforts to engage Extension Educators through a day-long workshop at the Indiana Small Farms Conference and by partially supporting a three day visit by Extension Educators and NRCS personnel to the Rodale Institute. What do you plan to do during the next reporting period to accomplish the goals? In the final year of the grant, we will conclude our field experiments and economic survey work and concentrate on preparing manucripts for submssion to peer-reviewed journals, extension publications, and on materials for Extension Educators. We will also host an additional workshop for Educators and farmer at the Indiana Small Farms conference in early winter, 2015.

2012/08/15 TO 2013/08/14 Target Audience: We delivered information related to this project to extension educators, farmers, researchers, and to undergraduate and pre-college students. Our audiences were located primarily in Indiana although we presented our research at regional and national conferences. Changes/Problems: We had hoped to assess tomato cultivars in on-farm trials based on results from our cover

crop experiments and tomato breeding program. In our original plan, we proposed to complete field trials at Purdue\'s research field station before initiating on-farm experiments in order to incorporate the results of our field station work into the on-farm work. However, delays in initiating the fall cover crop experiment and the complete loss of our experiments in 2012 due to drought and a late-season hail storm have prevented us from completing our fall cover crop research at the field station. We will complete the fall cover crop research in 2014 but this will not leave us sufficient time to initiate our planned on-farm research. What opportunities for training and professional development has the project provided? Nine graduate students have worked on this project. Three M.S. students have completed their research and graduated. In addition to mentoring by their major professors, the students have had opportunities to work as part of a large multidisciplinary team, to interact with farmers and extension educators, and to present at conferences, workshops, and field days. How have the results been disseminated to communities of interest? We gave 36 presentations related to our project at conferences, field days, and wokshops. The presentations were attended by over 1000 stakeholders. We also hosted over 20 tours (approximatley 140 visiitors) at our student farm. Activities at the student farm were inlcuded in five courses at Purdue University. What do you plan to do during the next reporting period to accomplish the goals? We will complete our field experiments, develop a series of extension bulletins and videos featuring Indiana organic farmers, complete our economic research, and host a one-day workshop at the Indiana Small Farms Conference. We will disseminate the results of our project by participating in conferneces, workshops, and field days as in the preceeding year. We anticipate the publication of several manuscripts in peer-reviewed journals.

2011/08/15 TO 2012/08/14 OUTPUTS: A web-based survey instrument designed to collect information on production costs, perceived barriers to entry organic production and certification, and management practices was distributed nationally to 4312 growers in the MarketMaker database. A total of 1559 responses from 16 states were collected and analyzed. Five field experiments were conducted in 2012. The \"mow don\'t hoe\" experiment was concluded in 2012 . In this experiment, strips of clover were planted between tomato rows to assess the potential of a living mulch for suppressing weed seed production. The experiment was expanded to assess the effect of clover planted on soil nitrogen availability in subsequent crops. The \"crop rotation\" experiment was repeated in 2012 and will be concluded in spring 2013. A \"fall cover crops\" experiment was initiated in fall 2011. Six treatments were maintained over the winter and the effect of cover crop residue incorporated into the soil or left on the soil surface on pests and crop growth were determined. The fall cover crop experiment will be repeated in 2012. Data were collected for both of these experiments on weed, insects, and plant pathogens as well as on soil fertility and crop yields. Dr. Hoagland continued her research assessing tomato genotypes possessing traits important for organic fresh market tomato production. Genotypes were screened in 2012 for canopy establishment, maturity, vigor, yield, leaf nutrient concentration, disease incidence, hornworn damage (with Dr. Kaplan), brix, titratable acidity and flavor. Seed from segregating genotypes with superior performance were collected. Finally, an experiment was initiated to examine the effects of varying food resources (weed seeds and fly pupae) and structural cover (cover crops) on carabid activity and feeding behavior. Six undergraduate students were employed full-time at the student farm during the summer to raise a variety of vegetable crops and to work on independent research projects. The students developed a business and marketing plan and started selling produce on campus in mid-summer 2012. They continued to improve facilities and develop capacity to grow produce during most of the year. PARTICIPANTS: In addition to the PIs, nine graduate students, one research associate, and a post-doc worked on the grant during the reporting period. RaeLynn Butler, Jose Garcia, and Carolina Zamorano-Montanez are graduate students working with Dr. Gibson on aspects of the project related to weed management. Becca Tucker worked as a research associate in Dr. Gibson\'s lab and assisted with the weed science projects and overall field management. Jessica Garvey is an M.S. student working with Dr. Eileen Kladivko on soil science projects and Carmen Blubaugh is a Ph.D student working with Dr. Ian Kaplan and Dr. Cliff Sadof on weed seed predation and insect control. Brett Lahner works with Dr. Lori Hoagland on aspects of the grant related to soil microbiology. Ariana Torres and Michael Veldstra are M.S. students working with Dr. Corinne Alexander and Dr. Maria Marshall on economic and marketing projects. Dr. Ramandeep Kaurr worked for part of the year as a post-doc in Dr. Janna Beckerman\'s lab. Scott Koenig is an M.S. student working with Dr. Janna Beckerman on plant disease. Two students (Veldstra and Butler) completed their M.S. degrees in 2012. TARGET AUDIENCES: Our primary audience in the second year of the grant was farmers and researchers. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/08/15 TO 2011/08/14 OUTPUTS: A web-based survey instrument was developed to collect information on production costs, perceived barriers to entry organic production and certification, management practices in organically produced tomatoes. The survey is being beta tested and will be distributed nationally in late fall 2011. Tomato producers that use production practices that range from conventional to certified organic were interviewed in the summer and fall 2011 in order to better understand production costs and produce an Indiana tomato production budget. Three field experiments described in the proposal were conducted. The \"mow don\'t

hoe\" experiment was initiated in 2010 and repeated in 2011. In this experiment, strips of clover were planted between tomato rows to assess the potential of a living mulch for suppressing weed seed production. The experiment was expanded in 2010 to assess the effect of clover planted in 2009 on weed densities and soil nitrogen availability in lettuce planted in 2010. The crop rotation experiment was initiated in spring 2011 and will continue until fall 2012. Data were collected for both of these experiments on weed, insects, and plant pathogens as well as on soil fertility and crop yields. Funding was not received in 2010 in time to start the fall cover crop experiment. However, the experiment was initiated in early October, 2011. Dr. Hoagland worked with tomato breeders and organic growers nationwide to collect 22 genotypes possessing traits important for organic fresh market tomato production. In a field experiment, genotypes were screened for canopy establishment, maturity, vigor, yield, leaf nutrient concentration, disease incidence, hornworn damage (with Dr. Kaplan), brix, titratable acidity and flavor. Seed from genotypes with superior performance were collected. Field soil was collected for genotype x microbial interaction greenhouse experiments. The research team met with advisory board members Steve Engleking and Roy Ballard in late fall 2010 to discuss opportunities for developing educational and outreach materials on organic agriculture for extension educators. In spring 2011, the research team met with a larger group of extension educators to discuss their perceptions of organic agriculture and how this project might assist them. The educators noted a lack of readily available information from Purdue University and suggested that the development of a clearinghouse of information on organic agriculture at Purdue University would be helpful. The research team is currently working with Roy Ballard to coordinate a web site that will serve this purpose and provide information related to Purdue\'s Small Farm Team. A five-acre student farm was opened in fall 2010 and approximately two acres planted in vegetable and fruit crops. Five undergraduate students were employed full-time during the summer, under the supervision of Dr. Steve Hallett, to raise a variety of vegetable crops and to work on independent research projects. An undergraduate course on organic agriculture, primarily aimed at students interested in working at the student farm, was offered during spring semester in 2011and will offered annually. PARTICIPANTS: In addition to the PIs, seven graduate students, one research associate, and a post-doc were hired to work on the grant. RaeLynn Butler and Carolina Zamorano-Montane are graduate students working with Dr. Gibson on aspects of the project related to weed management. Becca Tucker is a research associate in Dr. Gibson\'s lab who assists with the weed science projects and overall field management. Jessica Garvey is an M.S. student working with Dr. Eileen Kladivko on soil science projects and Carmen Blubaugh is a Ph.D student working with Dr. Ian Kaplan and Dr. Cliff Sadof on weed seed predation and insect control. Brett Lahner works with Dr. Lori Hoagland on aspects of the grant related to soil microbiology. Ariana Torres and Michael Veldstra is an M.S. students working with Dr. Corinne Alexander and Dr. Maria Marshall on economic and marketing projects. Dr. Ramandeep Kaurr was hired as a post-doc in Dr. Janna Beckerman\'s lab to develop experiments in plant pathology and to monitor plots for plant disease. TARGET AUDIENCES: Extension educators and organic farmers PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/08 TO 2015/08 What was accomplished under these goals? Our research suggests that organic farmers who sell directly to the public are less likely to certify than farmers who sell wholesale, which suggests that certification may be of less importance to customers than buying locally. Farmers who use organic practices but do not certify cited the cost of certification, the certification process, and interactions with certifiers as barriers to certification. Increasing the number of certified organic growers in Indiana may require addressing both perceived challenges with the certification process and providing information to consumers about the organic certification label. Our research on living mulches and sorghum-sudangrass should increase the ability of stakeholders to make informed decisions about the use of summer cover crops to suppress weeds. Our research on seed predation and seed predators reinforces the importance of natural enemies in organic systems and supports the inclusion of relatively undisturbed vegetated areas to maintain seed predator populations. Our student farm will continue to provide students with opportunities to learn about organic agriculture. Finally, our work on disease management in tomatoes has led to a larger project seeking to address pathogen management in organic tomatoes through the use of a participatory breeding program and integrated pest management. Assess economic opportunities for organic growers in Indiana and identify key barriers to transitioning from conventional to organic agriculture. We collected data through an online questionnaire sent to fruit and vegetable growers in 16 states and through a series of in-person interviews with business owners. Our research suggests that the decision to certify is correlated with farm size (larger farms were more likely to certify) and producers who market their produce directly to consumers are less likely to certify. Our analyses also suggest that the likelihood that a farm would be certified increases with the distance from the farm to its markets. Perhaps most importantly, our research suggests that the decision to farm organically is separate from the decision to certify. Farmers who use

organic practices but do not certify cited the cost of certification, the certification process, and interactions with certifiers as barriers to certification. Finally, our results suggest that a direct relationship with consumers may allow a farmer to gather a premium for being local that does not require certification. To some degree, \"local\" appears to have become the new \"organic\". Increasing the number of certified organic farmers in Indiana may require addressing both perceived challenges with the certification process and providing information to consumers about the organic certification label. Evaluate interactions between tomato cultivars and soil microbes and identify suitable varieties for organic production. Tomato varieties (\>20 each year) were screened under organic management conditions for pest resistance, taste, appearance, growth (determinate vs. indeterminate) and yields in a series of experiments from 2011 to 2014. Promising heirloom and hybrid tomato lines and experimental breeding populations that are well suited for organic production in the Midwest were identified. Cover crops and compost supplied enough nitrogen to meet tomato needs. Late blight and septoria leaf spot were identified as the biggest pathogen challenges. An accompanying survey of organic tomato growers suggests that flavor and disease resistance are the key traits that organic growers would like to see emphasized in a breeding program. Dr. Hoagland received a \$1,987,150 grant in 2014 from OREI to develop foliar pathogen control in organic tomato production through participatory breeding and integrated pest management. Evaluate strategies to optimize soil-building and pest management. We conducted a series of experiments to assess the effect of cover crops on pests, primarily insects and weeds and completed a meta-analysis of the literature regarding seed predation in agronomic systems. We examined the effect of disturbance (tillage) on the life cycle of Harpalus pennsylvanicus, the most common carabid seed predator in Midwestern crop systems. Although adults were not affected by disturbance, larvae were almost exclusively found in undisturbed (no tillage) environments with abundant vegetative cover. This supports the importance of cover as a perennial refuge for maintaining stable populations of natural enemies. We examined predator-prey interactions over four trophic levels and discovered that the use of cover by small mammals avoiding nocturnal avian predators substantially reduced the activity (movement) of carabid seed predators. Thus the interaction of carbid seed predators and cover appears to be complex and controlled in part by the behavior of other predators. We simulated seed rain of common lambsquarters and found 38% fewer seedlings in seed-augmented plots with seed predators than in seed-augmented plots where they were excluded. Our meta-analysis supports the importance of vegetation cover (seed predation rates are minimal in environments without cover), and suggests that seed predators have taxa specific seed preferences. We conducted a series of experiments to assess the use of a living mulch (red or crimson clover) planted between tomato rows to suppress late-emerging weeds. The living mulches strongly suppressed weed seed production but we found yield losses for plots containing a living mulch in some years. We also examined the effect of mowing between crop rows on late-emerging weeds in tomato and soybean. Mowing reduced weed biomass and seed pressure in tomatoes but results were not consistent in soybean. We assessed the effect of sorghum-sudangrass planting densities and timing of planting on both weed suppression and sorghum-sudangrass growth. Sorghum-sudangrass reduced weed biomass at least as much as when sown in July as in June in both years. Seed rate did not affect weed biomass, regardless of when the cover crop was sown. Sorghum-sudangrass suppressed weeds and produced substantial biomass, supporting its use a summer cover crop. However, sorghum-sudangrass residues may make it difficult to plant a fall cash crop. Develop, test, and implement a program to train Extension Educators to work with organic growers. We hosted a day-long workshop on organic agriculture for thirty Indiana Extension Educators and NRCS personnel at the Indiana Small Farms Conference (ISFC) in February 2014. Participants learned about the certification process, pros and cons of certifying, and about pest and soil management in organic vegetables. We participated in planning and partially funded a 3-day visit in May 2014 by 18 Educators and NRCS staff to the Rodale Institution for a three-day workshop that included topics such as soil management, no-till organic practices, transitioning from conventional to organic, and a long-term comparison of conventional and organic plots. Develop teaching plots and a student-run organic garden that will provide students with hands-on opportunities to learn about organic agriculture and serve as living laboratories for existing courses in the College of Agriculture. We established the Purdue Student Farm in 2011. The Student Farm is organically managed by paid interns and by a student volunteer organization. New facilities (hoop houses, a large barn) were built or renovated and additional sections of the farm were brought into production. A full-time farm manager was hired in fall 2013. The student farm developed sufficient infrastructure and experience during 2013 to contract with Purdue\'s dining halls to deliver fresh produce for 2014 and routinely sells produce at local farmers markets. **PUBLICATIONS (not previously reported):** 2010/08 TO 2015/08 1. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: CK Blubaugh, I Kaplan. 2015. Invertebrate Seed Predators Reduce Weed Emergence Following Seed Rain. Weed Science, in press 2. Type: Journal Articles Status: Published Year Published: 2015 Citation: CK Blubaugh, I Kaplan. 2015. Tillage compromises weed seed predator activity across developmental stages. Biological Control 81, 76-82 3. Type: Journal Articles Status: Under Review Year Published: 2016 Citation: CK Blubaugh, I Kaplan. In review. Does fear beget fear? Moonlight and refuge mediate intraguild predation and predator avoidance over four trophic levels. Ecology 4. Type: Journal Articles Status: Published Year Published: 2015 Citation: Hoagland, L., Navazio, J., Zystro, J., Kaplan, I., Gomez Vargas, J., Gibson, K., 2015. Identification of key traits and adapted

germplasm for an organic participatory tomato breeding program for the Midwest U.S. HortScience 50(9):1-8. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Hoagland, L., Navazio, J., Kaplan, I., Gibson, K., 2014. Selecting organic fresh-market tomatoes for the Midwest U.S. American Society of Horticultural Science Annual Meeting, Orlando, FL. 6. Type: Journal Articles Status: Published Year Published: 2014 Citation: Veldstra, M. D., C. E. Alexander and M. I. Marshall (2014). \"To certify or not to certify? Separating the organic production and certification decisions.\" Food Policy 49: 429-436. 7. Type: Journal Articles Status: Published Year Published: 2013 Citation: Butler, R. A., S. M. Brouder, W. G. Johnson, and K. D. Gibson. 2013. Response of five summer annual weed species to mowing frequency and height. Weed Technology. 27:798-802 8. Type: Other Status: Published Year Published: 2014 Citation: Blubaugh, C.K. 2014. Putting the weed seed predators to the test. International Organization for Biological Control Nearctic Regional Section Newsletter. 36:1-3 9. Type: Other Status: Published Year Published: 2012 Citation: Blubaugh, C.K. 2012. Research update: Cover crops and weed seed predation services. Purdue Vegetable Crops Hotline. 561:3-4. 10. Type: Other Status: Published Year Published: 2012 Citation: Blubaugh, C.K. 2012. Meet the (beneficial) beetles: Harpalus pensylvanicus, weed seed predator. Purdue Vegetable Crops Hotline. 559:2.

2013/08 TO 2014/08 What was accomplished under these goals? Assess economic opportunities for organic growers in Indiana and identify key barriers to transitioning from conventional to organic agriculture. We published our first paper on the results of our national online survey. Our research suggests that the decision to farm organically is separate from the decision to certify. Our paper suggested that decision to certify was correlated with farm size (larger farms were more likely to certify) and producers who market their produce directly to consumers were less likely to certify. Our more recent analyses suggest geographical considerations may also affect certification; farmers located further from their customers were more likely to certify. Cumulatively, our results suggest that the certification process itself and policies that promote "local foods" may discourage organic certification. Increasing the number of certified organic growers in Indiana may require addressing these factors. We had originally planned on assessing current markets for organic growers in Indiana through a mailed survey. This approach proved problematic and we are currently conducting a series of in-person interviews with business owners to assess their interest in organic products and potential barriers to purchasing locally grown organic produce. Data collection will be completed by late 2014; we anticipate the submission of a research article in 2015. Evaluate the effect of cover crops and intercropping on soil-building and pest management. We conducted four sets of experiments related to this goal. First, we modified our fall cover crop experiment by placing cover crop residue in litterbags and monitoring decomposition throughout the growing season. Our preliminary results suggest very slow decomposition rates for cereal rye, which may contribute to its perceived ability to suppress weeds. We planted cover crops in fall 2013 and repeated the experiment in 2014. Litterbags were destructively sampled from May to early September. We will grind residues from each harvest for analyses of carbon and nitrogen. Data analyses will be completed during winter 2014-15 and we anticipate the submission of a manuscript during summer 2015. Second, we examined the ability of cover crop residues to directly suppress weed populations or indirectly suppress weed populations by providing habitat for seed predators. In the absence of cover crop residues, seed predators substantially reduced weed seedling densities. However, seed predators did not significantly reduce weed seedling densities in treatments containing cover crop residues. This suggests that the primary effect of the cover crop residues on weed seedling densities is through direct interference and not because the residues increase seed predation. Cover crops were planted in fall 2013 and insect monitoring continued in 2014. The experiment will be concluded in fall 2014. An article describing the effect of tillage on larval populations has been submitted for publication and we anticipate the submission of second journal article in 2015. Third, we grew crimson clover or velvetleaf at various distances from a tomato plant under field conditions 2013 and repeated in 2014. We allowed the clover or velvetleaf to emerge with the crop or at the onset of crop flowering. Data analyses will be completed during winter 2014-15 and a manuscript submitted for publication in 2015. Finally, we initiated a new experiment in 2013 to assess the effect of sorghum-sudangrass planting densities and timing of planting on both weed suppression and sorghum-sudangrass growth. We mowed the cover crop at the end of the growing season and left the residue on the soil surface. We planted soybeans into the residues in spring 2014 to determine if crop yields or weed emergence are affected by the residues. We repeated the experiment in 2014 in a different location and will plant soybean into the residues in 2015. Analyses of the 2013 data suggest strong weed suppression even when sorghum sudangrass was planted later in the season. We will conclude this experiment in late summer 2015. Compare soil-building and pest management in two cropping systems. Nothing new to report Conduct on-farm research to evaluate growth of tomato cultivars following cover crops. Nothing new to report. Evaluate interactions between tomato cultivars and soil microbes and identify suitable varieties for organic production. Tomato varieties (\>20 each year) were screened under organic management conditions for pest resistance, taste, appearance, growth (determinate vs. indeterminate) and yields in 2011 and 2012. Promising lines with both high yields and good disease and insect resistance were planted in 2013 and 2014 to identify optimal germplasm. We are developing a paper describing the results of our breeding program for submission to a peer-reviewed journal. Develop, test, and implement a program to train

Extension Educators to work with organic growers. We hosted a day-long workshop on organic agriculture at the Indiana Small Farms Conference (ISFC) in February 2014. Participants learned about the certification process, pros and cons of certifying, and about pest and soil management in organic vegetables. Thirty of the 56 participants were extension educators or worked for USDA NRCS. We will offer a similar workshop on organic vegetable production in 2015 but focus more on pest and soil management. We participated in planning and partially funded a 3-day visit in May 2014 by 18 extension educators and NRCS staff to the Rodale Institution for a three-day workshop that included topics such as soil management, no-till organic practices, transitioning from conventional to organic, and a long-term comparison of conventional and organic plots. The participants established an informal working group after the workshop to share information and strategies to improve communications with stakeholders interested in organic agriculture. Develop teaching plots and a student-run organic garden that will provide students with hands-on opportunities to learn about organic agriculture and serve as living laboratories for existing courses in the College of Agriculture. A full-time farm manager was hired in fall 2013. Since her hire, she has developed a multi-year crop rotation plan, a farm plan and budget to make the farm largely self-sufficient by 2016, and started seedlings for the 2014 field season. The student farm developed sufficient infrastructure and experience during 2013 to contract with Purdue's dining halls to deliver fresh produce for 2014. **PUBLICATIONS (not previously reported):** 2013/08 TO 2014/08 Type: Journal Articles Status: Published Year Published: 2014 Citation: Veldstra, M.D., C.E. Alexander, and M.I. Marshall. 2014. To certify or not to certify? Separating the organic production and certification decisions. Food Policy , http://dx.doi.org/10.1016/j.foodpol.2014.05.010

2012/08/15 TO 2013/08/14 What was accomplished under these goals? We increased our understanding of constraints to the adoption of organic agriculture in Indiana and published research that should increase the ability of stakeholders to make informed decisions about where to focus efforts to increase the number of certified organic farmers. We increased our understanding of the interactions of cover crops, crop rotation, mowing, and seed predation. We continued our program to identify pest-resistant lines for organic tomatoes suitable for Indiana. We further developed the capacity of our student farm to educate both undergraduate students and the general public. Finally, we developed resources for extension educators and the general public that will be made available in 2014. Cumulatively, we disseminated the results of our program through conferences, workshops, and field days to over 1000 stakeholders. 1. Assess economic opportunities for organic growers in Indiana and identify key barriers to transitioning from conventional to organic agriculture. We published our first paper on the results of our national online survey. Our research suggests that the decision to farm organically is separate from the decision to certify. The decision to certify was correlated with farm size (larger farms were more likely to certify) and producers who market their produce directly to consumers were less likely to certify. Our more recent analyses suggest geographical considerations may also affect certification; farmers located further from their customers were more likely to certify. Cumulatively, our results suggest that the certification process itself and policies that promote "local foods" may discourage organic certification. Increasing the number of certified organic growers in Indiana may require addressing these factors. 2. Evaluate the effect of cover crops and intercropping on soil-building and pest management. We conducted three sets of experiments related to this goal. First, we modified our fall cover crop experiment by placing cover crop residue in litterbags and monitoring decomposition throughout the growing season. Our preliminary results suggest very slow decomposition rates for cereal rye, which may contribute to its perceived ability to suppress weeds. Second, we examined the relative contribution of cover residues to directly suppress weed populations or indirectly suppress weed populations by providing habitat for seed predators. In the absence of cover crop residues, seed predators substantially reduced weed seedling densities. However, seed predators did not significantly reduce weed seedling densities in treatments containing cover crop residues. This suggests that the primary effect of the cover crop residues on weed seedling densities is through direct interference and not because the residues increase seed predation. Finally, we initiated a new experiment in 2013 to assess the effect of sorghum-sudangrass planting densities and timing of planting on both weed suppression and sorghum-sudangrass growth. Data analyses are on-going. 3. Compare soil-building and pest management in two cropping systems. We completed the second year of our crop rotation experiment. Data analyses are ongoing but preliminary analyses suggest that mowing between-rows later in the season has the potential to reduce weed seed production. Weed seed production was substantially reduced in both years in tomato and in one year in soybeans. We published research suggesting that several common weed species are able to recover from a single mowing pass in the absence of competition from a crop. To increase the effectiveness of mowing for weed suppression, either multiple passes will be needed or mowing must be combined with crop competition, possibly by seeding a living mulch that can be mowed. 4. Conduct on-farm research to evaluate growth of tomato cultivars following cover crops. Nothing new to report. 5. Evaluate interactions between tomato cultivars and soil microbes and identify suitable varieties for organic production. Tomato varieties (\>20 each year) were screened under organic management conditions for pest resistance, taste, appearance, growth (determinate vs. indeterminate) and yields. Several promising open-pollinated lines have been identified with both high yields and good disease and insect resistance. We are developing a paper

describing the results of our breeding program for submission to a peer-reviewed journal. 6. Develop, test, and implement a program to train Extension Educators to work with organic growers. Eight Indiana organic farmers were interviewed in 2013; video of the interviews and their farms will be developed for online and print extension bulletins. The content of these interviews will be used to increase the knowledge of Indiana Extension Educators regarding organic agriculture and the needs of organic farmers. We completed a survey in 2013 of Indiana Extension Educators to assess their experience with and attitudes towards organic agriculture. The results of this survey will be used to develop tools and training for Extension Educators. Finally, we developed a day-long workshop for Extension Educators that will address the certification process, pest management, and soil health. The workshop, which will be held in February 2014, will also address the challenges/benefits experienced by Extension Educators who work with organic farmers in Indiana. 7. Develop teaching plots and a student-run organic garden that will provide students with hands-on opportunities to learn about organic agriculture and serve as living laboratories for existing courses in the College of Agriculture. Six undergraduate students participated in summer internships at the student farm. New facilities (livestock pens, hoop houses, a large barn) were built or renovated and additional sections of the farm were brought into production. A job search was initiated for a full time farm supervisor (funding provided by Purdue) and additional resources for equipment were made available. The student farm developed sufficient infrastructure and experience during 2013 to contract with Purdue's dining halls to deliver fresh produce for 2014.

2011/08/15 TO 2012/08/14 The team continued to meet regularly during the second year of the grant to coordinate activities, discuss project goals, and provide feedback on the field research, student farm, and economic survey. Our knowledge increased in several key areas. First, results from our national survey increased our understanding of the perceived barriers to organic certification. We learned that the largest impacts on a producer\'s decision to certify was his or her philosophical beliefs and perceived risk of losses to pest. The decision to certify was correlated with farm size (larger farms were more likely to certify) and producers who market their produce directly to consumers were less likely to certify. The process of certification is a clear barrier to certification. Our understanding of the effect of living mulches, crop rotations, and cover crops on pest and soil management increased. Planting clover between tomato rows can reduce late-season weed emergence and reduce weed densities in the following spring. Clover seeded in 2011 provided nitrogen to corn planted in 2012; soil nitrate concentrations were higher throughout the 2012 summer in plots with than without clover residues. However, tomato yields were reduced in both years of the experiment, which raises concerns about this practice and the susceptibility of tomatoes to late-season competition. Data are currently being analyzed for the crop rotation and fall cover crop experiments. However, there is some evidence that weed management practices such as cultivation affect within-season insect activity. More beneficial insects were captured in the crop rotation experiment in plots with fewer cultivation passes. Results from a greenhouse experiment suggest that Verticillium wilt was reduced on tomatoes grown in soils containing cover crop residues from our fall cover crop experiment Knowledge of farm management was increased among students participating in the student farm as evidenced by their increased capacity to reliably provide produce for their clientele. Information related to our project was disseminated to researchers, farmers, and extension educators. Our research team gave 15 presentations related to the project that were attended by approximately 430 participants at conferences, field days, and workshops: economics (3 presentations, approximately 180 participants), entomology (3 presentations, approximately 70 participants), soil microbiology and crop breeding (4 presentations, approximately 80 participants) soil science (2 poster presentations), weed science (3 presentations, approximately 100 participants). Two papers were published by the plant pathology group.

2010/08/15 TO 2011/08/14 The team met approximately every two weeks during the first year of the grant to coordinate activities, discuss project goals, and provide feedback on the field research, student farm, and economic survey. Funds were used to support project activities ranging from seed purchases to reimbursing travel for extension educators. Seven graduate students, a post-doc, and research associate were hired and assumed key roles in data collection and analyses. Data analyses are underway but this report was filed before the end of the growing season in the first year.

PUBLICATIONS

2012/08/15 TO 2013/08/14 1. Type: Journal Articles Status: Published Year Published: 2013 Citation: Butler, R. A., S. M. Brouder, W. G. Johnson, and K. D. Gibson. 2013. Response of five summer annual weed species to mowing frequency and height. Weed Technology. 27:798-802 2. Type: Journal Articles Status: Awaiting

Publication Year Published: 2013 Citation: Veldstra, M., C.E. Alexander, and M.I. Marshall. 2013 (accepted). ?To Certify or Not to Certify? Separating the Production and Certification Decisions.? Food Policy.

2011/08/15 TO 2012/08/14 Kaur, R. and Beckerman, J. 2012. Cover crop amendments for the suppression of Verticillium wilt in organic tomatoes grown in greenhouse, 2011. Plant Disease Management Reports 6:V159 Kaur, R. and Beckerman, J. 2012. Evaluation of fungicide BAS500WU for control of seedling damping-off in tomato, 2011. Plant Disease Management Reports 6:OV160

2010/08/15 TO 2011/08/14 No publications reported this period

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Strengthening Public Corn Breeding to Ensure That Organic Farmers Have Access to Elite Cultivars.

Accession No.	0222310
Subfile	CRIS
Project No.	IOWW-2010-02363
Agency	NIFA IOWW
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21447
Proposal No.	2010-02363
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Scott, P.
Performing Institution	AGRICULTURAL RESEARCH SERVICE, RR #3 BOX 45B, AMES, IOWA 50011

NON-TECHNICAL SUMMARY

Corn is a remarkably productive crop with incredible diversity, making it amenable to industrial manipulation for foods, fuel, and feed. Due to modern focus on grain yield under conventional conditions it has not been developed for low-input and organic agricultural systems. Private corn breeding is dominated by companies who sell transgenic hybrids almost exclusively. The biotechnology and genomics revolution of the past decades has left public corn breeding in a precarious position. Seed industry consolidation and its focus on large seed markets have left market opportunity in organic and non-GMO corn seed. This market opportunity may be short-lived if a steady supply of improved varieties from public breeders does not stay available to these seed companies. Farmers increase their business stability by using their corn to feed livestock, or selling it as food or feed grain. Crop rotations, soil quality, soil and pest management practices, and grain quality needs are different for organic farms as compared to conventional farms. Breeding varieties under organic conditions for organic needs and refining the offerings by testing in organic systems will give organic farmers hybrids that are optimized for their farming system. Essentially all organic corn produced in the USA is used for the production of animal feed or human food. Improving its nutritional quality will result in health benefits to consumers, eliminate expensive supplements in feed, and improve the quality and decrease the cost of organic animal products. This is a clear change in direction from industrial corn breeding where there is a disincentive to improve nutritional quality because industrial corn is used for fuel in cars and starch in animal rations and human food. Public breeders are experts in developing improved varieties but they need to cooperate with seed companies to get them to farmers. A network of public and private breeders, NGO\'s, farmers, small seed companies and organic poultry companies has come together for breeding, testing, doing outreach, and facilitating variety release. This project will provide for the breeding, testing, and outreach programs of public organic breeding programs in Iowa, Wisconsin, Ohio, and New York, enabling them to develop the appropriate varieties. It will provide an organic winter nursery to double the speed at which new varieties become available. They will also test, exchange and catalogue the best breeding populations, and make them publicly available. Special emphasis will be on breeding for disease and pest control and on increasing nutritional value of grain. We will increase the content of protein and the essential amino acids lysine and methionine because they limit the growth, health, and productivity of poultry, hogs, cattle and people. Our project facilitates organic breeding, determines desirable traits for commodities, conducts advanced on-farm experimentation, and develops improved seed varieties for organic agriculture. Seed company

use of public germplasm will return money to the public programs through licensing. Farmer and breeder interaction will help breeders to select better lines and hybrids.

OBJECTIVES

Organic farmers need productive, reliable corn hybrids adapted to their farming systems with better grain quality. Their options and choice are decreasing due to increasing industry consolidation and fewer elite lines available to organic seed companies, while public corn breeding is facing a crisis of survival. A long-term goal of this project is to reinvigorate public corn breeding by forming networks with farmers and seed companies so that an uninterrupted stream of improved high-quality hybrids are available for organic agriculture. This project will help us create a system that provides organic farmers with a wider choice of improved corn hybrids. We have a clear protocol in place for developing and disseminating superior varieties for organic producers. This project will help us develop a funding mechanism to stabilize and support the public sector\'s breeding programs. This mechanism will serve as a model for other groups focused on improved organic seed. The objectives are to assemble a catalog of corn breeding germplasm for organic production in the major U.S. corn-producing areas, to build a sustainable corn breeding effort that can reliably provide varieties to an emerging seed industry dedicated to organic markets, to build a cooperative network including farmers, small seed companies, winter nursery providers, organic grain users, and others that ensures that organic farmers have access to elite corn varieties, to develop cultivars that are targeted for organic needs and adapted for seed production and grain production under organic conditions through on-farm testing, stress nurseries, and grain quality testing, and to disseminate our results through farmer meetings, seminars, booklets, scholarly publications, by working with seed, retail, and end-user companies, and by putting information on the internet. The availability of public cultivars will support the profitability and expansion of organic farming and seed, and meet specific nutritional needs of organic livestock. Organic farmers and their customers deserve the same economic benefits from improved cultivars adapted to their farming systems that have been realized in conventional agricultural systems. This work will support farmers interested in sustainable production strategies, increasing production carried out with environmentally-friendly practices. There will be several expected outputs associated with this work. We will have a published assessment of the germplasm base of improved public breeding populations. We will conduct selection, plot trials, and strip trials that will lead to improved varieties demonstrated to farmers and seed companies at field days. Commercialization and supply channels involving farmer seed production, farmer evaluations, and seed company use of our varieties will be ongoing. In addition, an organic winter nursery site will become functional. These outputs will also benefit others in the public and private sector.

APPROACH

We are implementing a new approach to corn breeding, variety evaluation, and delivery for organic farmers in the Corn Belt with collaborators from public universities, USDA-ARS, non-profit NGOs, or who are independent breeders, in conjunction with small seed companies and farmers. We will work with companies to evaluate elite and experimental hybrids under organic systems and with with farmers to evaluate those with greatest on-farm potential. Through these and other interactions (e.g., field days, meetings) we will offer seed companies parental seed that will provide farmers with choice in purchasing a wide variety of productive, reliable hybrids. We have a clear protocol in place for developing and disseminating superior varieties for organic producers. Our project will strengthen the various components of this team effort, enabling us to develop, test, multiply, and release high quality productive corn cultivars for organic farmers as soon as possible. It will involve accelerated breeding, testing, and multiplication at organic test sites in Iowa, Wisconsin, Ohio, and New York, a special stress testing site in Illinois, and an organic winter site for multiplication and breeding in Puerto Rico. We will continue and expand our outreach program which includes interacting with farmers and industry, field days, information on relevant websites, and literature. We will conduct joint yield trials using locations in each state, using the improved breeding populations that each breeder has developed. By the end of this testing, we will have a database of breeding populations, their adaptation to a wide variety of organic environments, their grain quality, and a measure of their native disease and insect resistance. Because the yield tests will be conducted on farms and in some locations used for field days, farmers and seed companies will be able to observe the populations and their performance. Experimental hybrids from our breeding programs will be tested in small replicated plot trials at cooperating organic farms. These trials will be managed by the breeder. In addition, selected varieties from the plot trials of the four breeding programs will be tested in large strip-trial plots on farms. The most promising hybrids from plot and strip trials will be entered into the USTN trials. The data collected from screening for grain quality, stress, disease, and insect resistance will be used to characterize the entries. Data will be shared at winter meetings and through other venues including scientific meetings and published. We have considerable experience with the breeding and analytical techniques and do not expect any major problems in

interpreting the results to breed new cultivars. Relevant commercial organic check hybrids will assist in the determination of the percentage of entries that are not significantly different from the pertinent benchmarks. This will help seed and end-user companies to look to the USTN and our other trials for new potential products.

PROGRESS

2010/09 TO 2015/08 Target Audience:The target beneficiaries of our activities aimed at improving the infrastructure for public corn breeding were corn breeders at universities and NGOs as well as those working for small seed companies that serve organic producers. For example, the US testing network membership consists of about 14 seed companies, 7 universities, and 4 NGOs. Because we work on traits of interest to all corn breeders such as yield and disease resistance, corn breeders in large companies may benefit from this work as well. Organic producers who are interested in learning about breeding benefit from information we have released. Additional producers of organic corn have grown and benefited from varieties developed by this program, which are better suited to the needs of organic producers. An additional benefit is that organic producers have a greater choice of varieties to plant. Because corn is used in so many different organic products, the impact of improved varieties ripples through several industries. Corn is used directly in production of organic food products such as chips, polenta and tortillas. It is also the main ingredient in many livestock and poultry diets so the meat, dairy and egg industries benefit as well. Scientists working on the targets of our breeding programs such as nutritional quality, nitrogen use efficiency and gametophytic incompatibility benefit from the experimental varieties we have developed and the information we have shared in publications and at talks in meetings. Having a robust public corn breeding effort that releases improved varieties will increase the quality and safety of organic products while reducing the cost of production of these products, benefitting consumers of organic products. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Some of the work on this project was carried out by two graduate students with thesis topics aligned with the objectives of this project. In addition, several undergraduate students participated in the project. These students were provided background information about the project to ensure they understood the importance of what they were doing and were taught the fundamentals of plant breeding. The result was an intense internship experience for them. In addition, some of our products including presentations at field days and a webinar in the eOrganic webinar series provided informal continuing education opportunities to members of the public. How have the results been disseminated to communities of interest?Our results were disseminated through scholarly peer-reviewed and other types of publications, including web-based media with global exposure. Open access publishing was used when possible to ensure the widest possible dissemination of our results. Lectures were presented at scientific meetings attended by researchers interested in organic production practices. Several of these lectures are available on the internet and have reached an international audience. Our project was featured in several popular press internet publicaitons. Project cooperators have hosted or were guest speakers at field days that were open to the public and attended by producers and other individuals interested in organic corn production. Yield trial data from the US Testing Network was shared with organizations participating in the test as agreed upon by the participants. Yield, agronomic data and photos of some of our experimental breeding populations is contained in our \"Corn population catalog\" (http://practicalfarmers.org/corn-population-catalog/). In addition to the information about corn populations, this catalog provides instructions for requesting seeds of the populations described. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2013/09 TO 2014/08 Target Audience: Nothing Reported Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Alyssa Beavers (co-major Professors Manju Reddy and M.P. Scott) received her M.S. Degree in Nutritional Science. (2014) Thesis Title: Recurrent selection to alter seed phytic acid content and iron bioavailability in maize. How have the results been disseminated to communities of interest? Our results have been disseminated through peer-reviewed and other types of publications. A graduate student and several undergraduate students participated in our breeding efforts. In addition professional development opportunities were made available to the public through several outreach activities. Our webinar on A certified Organic Winter Nursery for Corn Breeding is available on YouTube (https://www.youtube.com/watch?v=HUiyXFwGQ0w) and has about 200 views. In addition, lectures presented at scientific meetings attended by researchers interested in organic production practices. Our work has been featured popular press and trade journals, including Seed World (http://seedworld.com/organic-seed-gains-ground/) and Lancaster Farming (http://www.lancasterfarming.com/news/Organic-Corn-Breeding-Goes-South-for-the- Winter#.VMpF7n 7F5Q) Scott, M.P., Invited presentation in the Iowa State University Interdepartmental Plant Biology seminar series, \"Preventing promiscuity in plants: Using gametophytic incompatibility systems to control outcrossing in maize\" March 5, 2014. Scott, M.P. Presentation at American Dairy Science Association Discovery Conference, \"Historic and Current Genetic Variation in Corn Endosperm Types\", (October 7, 2014), Naperville,

ll. Amol Nankar, F. Omar Holguin, Barry Dungan & Richard Pratt (2014) Evaluation of anthocyanin from blue corn borderland landraces, Poster at ASA,CSSA, SSSA International Annual meeting, Long Beach, CA. What do you plan to do during the next reporting period to accomplish the goals? This was the planned last reporting period, however we requested a one year no - cost extension to complete the final products of the project and the final report.

2011/09 TO 2012/08 OUTPUTS: Activities: Hybrids and open pollinated varieties being developed for production in organic systems were tested or observed on one site in Wisconsin, New York, Ohio, Illinois, Virginia, and Colorado, Arizona, and New Mexico, two sites in California and in Oregon, and three sites in Iowa. Material was tested in Uganda as well. These sites represent a cooperative network consisting of the institutions cooperating on this grant as well as individual farmers. Agronomic and grain quality traits were evaluated. In addition, PIs advanced breeding material in nurseries in New York, Wisconsin, Illinois, Iowa and New Mexico. Most sites were certified organic, certifiable or in transition. A cooperative organic winter nursery in Lajas Puerto Rico was used to advance breeding material and produce seed as well. Breeding efforts focused on dent corn, with smaller efforts on specialty varieties including blue corn, pollen-excluding corn designed to preserve the genetic purity of organic varieties and nutritionally improved varieties. In addition to monthly conference calls, the PIs met in Ithaca, NY to exchange breeding technique information, learn about PI Smith\'s breeding program and conduct planning. Events: PI Sarah Carlson of Practical Farmers coordinated three field days. 45 farmers attended a field day at the Tjlemlund farm near McCallsburg, IA. Farmers Shriver and Cornelius hosted 85 farmers on their organic farm near Jefferson, IA. Both of these field days included yield trial plots for hybrids produced by this grant as well as hybrids produced by seed companies. A third field day was held near River Falls, WI and organized by Brownseed Genetics (BSG). 35 attendees included farmers, seed company representatives and end-users including grain buyers. PI Smith held a fourth field day at Cornell University. PI Montgomery conducted a tour of Montgomery Consulting nurseries and pest trials near Maroa, IL. Products: From Cornell\'s organic corn breeding program, one hybrid is being produced and marketed commercially as organic corn seed. We produced data and seed that will be used for selection of inbred lines to be released by this project. In addition, we produced data that will be included in a public catalog of breeding populations which will be a major product of this work. We also planned and produced seed for an experiment examining the combining ability of inbred lines produced by the grant cooperators. Practical Farmers hosts a website containing a list of non-gmo and organic seed companies. Dissemination: Farmer cooperators disseminate information about this work in informal discussions with other farmers and seedsmen. PIs from the project presented results and information at field days. Smith described our organic corn breeding effort at a winter meeting of the Northeast Organic Farming Association of New York and at the winter meeting of the Northern Grain Growers Association in Vermont. Results relating to nutritional value were presented by PI Goldstein in three conferences in India. PI Scott presented data on selection for methionine content at two universities in Thailand and at Cornell University in Ithaca NY. PARTICIPANTS: Change of Project Director from Dr. Craig Abel to Dr. Paul Scott TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Activities: We used four organic breeding nurseries in summer 2011 and a winter nursery (2010-2011) to advance germplasm being developed for high yield, grain methionine content, gametic incompatibility and resistance to biotic and abiotic stresses in a range of maturity zones. We carried out organic variety trials at seven sites. Two farmers conducted on-farm strip trials in Ohio and Iowa. Those corn samples were also tested for quality characteristics on an NIR machine that is calibrated for measuring methionine and lysine values in addition to protein, oil and starch. A report about the results will be authored by February 2012. We provided parent seed for commercial seed production of Cornell D2901 (our double cross hybrid released for commercial sale earlier this year) to an organic grower in Penn Yan, NY (Lakeview Organic Grain, run by Klaas and Mary-Howell Martens). We also produced new parent seed of all four inbred parents and the two single crosses that are parents of D2901. The effects of bacterial endophytes on maize performance were examined. We mentored one graduate student. Events: Our group organized a field day in Ames Iowa on September 13, 2011 which was attended by 52 people who we educated about breeding corn for organic production. Our cooperator, Brownseed Genetics also organized a field day that highlighted the efforts of this project in breeding for high oil and altered fatty acid content. This field day was attended by 70 people. Services: We offered training to users of our NIR instrument. Products: Data regarding yield, lodging, resistance to cold shock, leaf blight and stalk rot, grain content of protein, oil, starch, methionine, lysine and cysteine for maize varieties in our breeding programs were collected. Commercial seed of Cornell D2901 was sold and grown by several growers in New York and in the Midwest. Seed of our Quality Protein Maize lines was shared with the seed company GEI, Johnston, Iowa. Dissemination: Members of our group gave talks about this project at several events: Smith talked about this project at a field day at the Musgrave Farm in Aurora, New York on 14

July 2011 and at another one especially for organic grain growers on 12 September 2011 as well as at the Northeast Organic Farming Association of NY\'s Dairy and Field Crop Conference, on 4 November 2011. Scott presented a talk and discussed this project with researchers in Flakkebjerg, Denmark on November 18, 2011. Montgomery presented information at the Maize Research Institute in Gongzhuling, Jilin, China on October 24, 2011. Iowa Public Radio ran a story about our field day, with more than 200,000 Iowans hearing the story. Practical Farmers of Iowa wrote blog posts about both field days. PARTICIPANTS: Participants: Linda Pollak (Project Director), Craig Abel (Project Director), Susan Duvick, Walter Goldstein, Sarah Carlson, Kevin Montgomery, Rich Pratt, Margaret Smith, Charles Hurburgh, Paul Scott, Jode Edwards, Partner organizations: USDA-ARS, Practical Farmers of Iowa, Montgomery Consulting, Ohio State University, New Mexico State University, Michael Fields Agricultural Institute, The Mandaamin Institute, Iowa State University, Cornell University, Collaborators and contacts: Brownseed Genetics, Genetic Enterprises International, The USDA-ARS Germplasm Enhancement of Maize program, Training or professional development: One graduate student supported by this grant received formal training. Informal training in breeding corn for organic production systems was carried out for attendants of our field days and for about 10 hourly workers, most of whom are undergraduate students. TARGET AUDIENCES: Our target audiences are farmers who produce organic corn and all participants in the seed supply chain of these farmers, including seed companies and breeders. Our work also ultimately impacts consumers of items produced using organic corn such as meat and corn-based food products. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Plant breeding helps meet the increasing global demand for food through development of new crop varieties with higher yields and improved quality. In corn, the majority of the breeding effort is in the private sector where several large seed companies produce the majority of the varieties on the market. Public corn breeding efforts have diminished due to reductions in resources and perceived need. This is problematic because all breeding programs depend on public corn breeding to train their workforce and carry out basic research in breeding approaches. Further, public breeders can address niche markets that are too small or risky to attract private breeding efforts. An example of this is corn for organic producers, which is one of the fastest growing corn markets but is limited by the availability of varieties with high nutritional quality, ability to exclude unwanted pollen, and natural resistance to insects and diseases. We formed a network centered on the grant cooperators that produces new varieties and delivers them to organic producers. Key elements of this network are 1. Cooperative yield tests. 2. Shared Winter Nursery. 3. Advisory group of seed company representatives. 4. Shared stress nurseries. 5. Shared grain quality testing. 6. Shared germplasm. 7. New methods for measuring traits of interest to organic producers. These innovations led to the development of a robust breeding pipeline and facilitated the release of several new varieties with traits desired by organic producers. Many experimental varieties are now in the pipeline, including varieties with improved nutritional quality, ability to grow in low input systems, ability to exclude GMO pollen, natural resistance to insects and diseases and blue corn for production of specialty food products. Taken togther, the infrastructural advances, increased cooperation and focus on corn for organic producers have led to a revitalized public corn breeding effort. Corn grain is at the base of food production systems because it is a main component in animal feed and it provides grain, sweeteners, starch and oil for food production. Our ability to produce new corn varieties for oganic producers impacts the growth of many parts of the organic market. The tools and technology we developed and the people trained on this project will support innovation and economic growth. Products of this work will increase yields while improving quality, reducing the cost of food and increasing the quality and safety of organic products. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 No publications reported this period.

2013/09 TO 2014/08 What was accomplished under these goals? Our project has developed a cooperative network with the goal of producing corn seeds specifically tailored for use by organic producers. Through discussions with stakeholders we identified the following traits as being important: Ability to exclude unwanted pollen, nutritional quality, including grain methionine content and carotenoid pigments. Productivity in organic systems is a goal common to all of our breeding efforts and includes ability to yield in low input (especially N) systems and ability withstand weeds and insects. Ability to germinate in cold, wet conditions and early season vigor is important because organic producers prefer to avoid seed treatment. To accomplish these goals, we developed the following infrastructure. A protocol for an organic winter nursery has been developed, essentially doubling the rate at which our breeding programs advance. To facilitate breeding for pollen excluding varieties, we characterized the region around the Ga1 locus. This allowed us to develop molecular markers that aid breeding for this trait. To facilitate breeding for nutritional quality, we developed an NIR calibration for prediction of several essential amino acids. Measurement of amino acids costs about \$100 / sample, but this calibration

allows us to predict values for less than \$1 per sample. Taken together, these activities provide infrastructure for public maize breeding that has allowed development of new varieties for organic producers. A few of these new varieties have already been grown by producers. Because it takes years to develop and deploy new varieties, the main impact of this work will be realized over the next 5 years. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 1. Type: Journal Articles Status: Published Year Published: 2014 Citation: Jaradat, A.A., and W. Goldstein. 2014. Diversity of maize kernels from a breeding program for protein quality: II. Correlatively expressed functional amino acids. Crop Science, 54:1-24. 2. Type: Journal Articles Status: Published Year Published: 2014 Citation: Mahan A.L., Murray S.C., Crosby K., Scott M.P. (2014) Quality Protein Maize Germplasm Characterized for Amino Acid Profiles and Endosperm Opacity. Crop Sci. 54:863-872. 3. Type: Journal Articles Status: Published Year Published: 2014 Citation: Newell M.A., Vogel K.E., Adams M., Aydin N., Bodnar A.L., Ali M., Lauter A.N.M., Scott M.P. (2014) Genetic and biochemical differences in populations bred for extremes in maize grain methionine concentration. BMC Plant Biology 14:49. 4. Type: Journal Articles Status: Published Year Published: 2015 Citation: Harakotr B., Suriharn B., Tangwongchai R., Scott M.P., Lertrat K. (2014) Anthocyanin, phenolics and antioxidant activity changes in purple waxy corn as affected by traditional cooking. Food chemistry 164:510-517. DOI: http://dx.doi.org/10.1016/j.foodchem.2014.05.069. 5. Type: Journal Articles Status: Published Year Published: 2015 Citation: Harakotr B., Suriharn B., Tangwongchai R., Scott M.P., Lertrat K. (2014) Anthocyanins and antioxidant activity in coloured waxy corn at different maturation stages. Journal of Functional Foods 9:109-118. DOI: http://dx.doi.org/10.1016/j.jff.2014.04.012. 6. Type: Journal Articles Status: Published Year Published: 2015 Citation: Harakotr B., Suriharn B., Scott M., Lertrat K. (2014) Genotypic variability in anthocyanins, total phenolics, and antioxidant activity among diverse waxy corn germplasm. Euphytica:1-12. DOI: 10.1007/s10681-014-1240-z.

2011/09 TO 2012/08 There is growing demand for corn varieties suited to organic production. This demand is driven in part by an increased awareness of the benefits of organic production and in part by a reduction in the effort being put into development of non-GMO corn varieties by large seed companies. As a result of this project, the number of varieties available to organic producers has increased. This gives organic producers a greater choice of varieties to plant, enabling them to select varieties that are best suited to their production systems and markets. This will ultimately result in increased production of organic corn, supporting the demand for organic products and ultimately satisfying the public\'s desire for organic products. Because corn is used in many products including animal feed and many foods, the increased production of organic corn benefits consumers of organic meat and food products as well. Our work on improving methionine content increases the nutritional value of organic animal feed made from corn. It provides an alternative to the practice of adding expensive supplements to animal feed, decreasing the cost organic meat production. In addition, some of these supplements are not considered natural and are therefore not desired by the organic community. Improved diets improve animal welfare as well. Our work on pollen-excluding varieties brings us closer to development of corn that cannot be pollinated by corn from neighboring fields. This will allow farmers to produce organic corn with a high degree of genetic purity. Not only will this reduce the level of GMO contamination in organic corn, it will increase the purity of other market classes of corn as well. Our cooperative testing network and outreach efforts have effectively engaged producers in our breeding program. This increases awareness of our varieties and organic corn in general. It also provides valuable feedback to project PIs on breeding approaches and targets. Most importantly, the public has gained a sense of ownership of the project, creating good will. **PUBLICATIONS (not previously reported):** 2011/09 TO 2012/08 1. Yi, G., Lauter, A.M., Scott, M.P., Becraft, P.W. 2011. The thick aleurone1 Mutant Defines a Negative Regulation of Maize Aleurone Cell Fate That Functions Downstream of defective kernel1. Plant Physiology 156 (4):1826-1836. 2. Scott, M.P., Byrnes, K., Blanco, M. 2012.Dry matter and relative sugar yield from enzymatic hydrolysis of maize whole plants and cobs. Plant Breeding 131 (2):286-292. 3. Carlson, S, 2012. Non-GMO Corn Strip Trial Yield and Quality Practical Farmers of Iowa Research Report. http://www.practicalfarmers.org/pdfs/Non-GMO Corn Strip Trials: Yield and Quality %282012%29.pdf. 4. Goldstein, W.A. 2012. A new holistic approach to crop breeding that meets increased food needs by combining enhanced nutritional quality and productivity under growing conditions with climatic instability and limited access to expensive external inputs. In: Rodriguez, Aruna ed. Can GM crops meet India\'s food security and export markets Tara Foundation, New Delhi. Pp 44-49. 5. Jaradat, A.A. and W. Goldstein. 2012. Diversity of Maize (Zea mays L.) Kernels from a Breeding Program for Protein Quality I. Physical, Biochemical, Nutrients and Color Traits. Accepted for publication by Crop Science. 6. Hoch, J., Moran Lauter, A., Scott, M.P. 2012. Comparison of Tungsten Carbide and Stainless Steel Ball Bearings for Grinding Single Maize Kernels in a Reciprocating Grinder. Maize Genetics Cooperation Newsletter 85:2. 7. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2012. Infection process in resistant and susceptible maize (Zea mays L.) to Cercospora zeae-maydis. Plant Protection Science (In Press). 8. Correa, V.R., D.R. Majerczak, E.-D. Ammar, M. Merighi, R.C. Pratt, S.A. Hogenhout, D.L. Coplin, and M.G. Redinbaugh. 2012. The bacterium Pantoea stewartii uses two different type III secretion systems to colonize its plant host and insect vector. Appl. Environ. Microbiol. 78(17):6327. DOI: 10.1128/AEM.00892-12. 9. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2012. An effective integrated crop

management strategy for enhanced maize production in tropical agroecosystems prone to gray leaf spot. Crop Protection 41:57-63. 10. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2012. Variation in aggressiveness among isolates of Cercospora zeae-maydis in low-, medium- and high-altitude maize agro-ecologies of Tanzania. Archives of Phytopathology and Plant Protection. iFirst article 1-11. 11. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2012. Composted cattle and poultry manure provide excellent fertility and improved management of gray leaf spot in maize. Field Crops Research 126:97-103.

2010/09/01 TO 2011/08/31 At this early stage of the project our outcomes and impacts have largely been internal to our group. Changes in knowledge have resulted from our use of organic production systems in corn breeding experiments. Our results have taught us how to better manage our yield trial and nursery experiments under organic production practices. We have applied this information in a change in actions by improving our methods in subsequent years of the grant.

PUBLICATIONS

2012/09/01 TO 2013/08/31 1. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Goldstein, W.A. 2012. A new holistic approach to crop breeding that meets increased food needs by combining enhanced nutritional quality and productivity under growing conditions with climatic instability and limited access to expensive external inputs. In: Rodriguez, Aruna ed. Can GM crops meet Indias food security and export markets Tara Foundation, New Delhi. Pp 44-49 2. Type: Book Chapters Status: Published Year Published: 2012 Citation: Goldstein,W.A. ,W.Schmidt, H.Burger, M.Messmer, L.M. Pollak, M. E. Smith, M.M. Goodman, F.J. Kutka, and R.C. Pratt. 2012. Maize breeding and field testing for organic farmers. Pp. 175-189. In: Organic Crop Breeding. Pub. Wiley-Blackwell, NY. 3. Type: Journal Articles Status: Published Year Published: 2013 Citation: Jaradat, A.A., and W. Goldstein. 2013. Diversity of maize kernels from a breeding program for protein quality: physical, biochemical, nutrients and color traits. Crop Science, 53 956-976. 4. Type: Journal Articles Status: Published Year Published: 2013 Citation: Ellwood E.C., Scott P., Lipe W.D., Matson R.G., Jones J.G. (2013) Stone-boiling Maize With Limestone: Experimental Results and Implications for Nutrition Among SE Utah Preceramic Groups. Journal of Archaeological Science 40:35-44.

2010/09/01 TO 2011/08/31 1. Goldstein, W.A., W.S., H. Burger, M. Messmer, L.M. Pollak, M.E. Smith, M.M. Goodman, F. J. Kutka, and R.C. Pratt. 2012. Chapter 10. Maize: Breeding and Field Testing for Organic Farmers. In: (E. Lammers van Bueren and J. Myers Eds.) Organic Crop Breeding. Wiley Interscience. (In Press) 2. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2012. Composted cattle and poultry manure provide excellent fertility and improved management of gray leaf spot in maize. Field Crops Research 126:97-103. (published on-line 2011) 3. Brummer, C.E., W.T. Barber, S.M. Collier, T. S. Cox, R. Johnson, S.C. Murray, R.T. Olsen, R.C. Pratt, and A.-M. Thro. 2011. Plant breeding for harmony between agriculture and the environment. Frontiers in Ecology and the Environment (In Press: on-line at http://www.esajournals.org/doi/pdf/10.1890/100225) 4. Lyimo, H.J.F., Pratt, R.C. and R.S.O.W. Mnyuku. 2011. Heritability and gene effect estimates for components of partial resistance to grey leaf spot of maize by generation mean analysis. Plant Breeding 130:633-639. 5. Asea, G., B. Vivek, P.E. Lipps and R.C. Pratt. 2011. Genetic gain and cost efficiency of marker-assisted selection of maize for improved resistance to multiple foliar pathogens. Molecular Breeding (DOI: 10.1007/s11032-011-9568-8) 6. So, Y.S., & Edwards, J. 2011. Predictive Ability Assessment of Linear Mixed Models in Multievenvironment Trials in Corn. Crop Sci. 51:542-552 7. Pollak, L. M., P. Scott and S.A. Duvick. 2011. \"Resistant starch and starch thermal characteristics in exotic corn lines grown in temperate and tropical environments.\" Cereal Chemistry 88(5): 435-440.

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Pasteurization of High Quality Organic Fruit and Vegetable Juices Using Nonthermal Technologies

Accession No.	0222952
Subfile	CRIS
Project No.	TEN02010-01988
Agency	NIFA TEN
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2010-51300-21437
Proposal No.	2010-01988
Start Date	01 SEP 2010
Term Date	31 AUG 2013
Grant Amount	$0
Grant Year	2010
Investigator(s)	Harte, F.; Goodrich, R.; Reyes de Corcuera, J.; Golden, D.; Critzer, F.; Williams, R.
Performing Institution	Food Science & Technology, UNIVERSITY OF TENNESSEE, 2621 MORGAN CIR

NON-TECHNICAL SUMMARY

Organic processors currently rely on high temperature as the sole processing option for the pasteurization / sterilization of juices. However, the thermal processing of fruit juices and fruit concentrates is known to affect nutrient content (e.g., loss of thermo-labile vitamins B1, B2, A), antioxidant capacity, and/or organoleptic properties (e.g., flavor, cloudiness, color) depending on the specific product. The overall goal of this Research and Extension Planning Proposal is to assess the critical needs and potential impact of a systems-based comprehensive proposal on the application of nonthermal technologies for the processing of safe and high quality organic fruit juices. Specific objectives include: (1) Survey of Juice processors and assessment of their knowledge and attitudes towards nonthermal technologies, (2) Design commodity-specific safety and quality experiments and confirm the feasibility for coordinating multi-institution experiments, (3) Integrate a steering committee to determine the specific key elements for success including safety, quality, and cost, (4) Submit a proposal to USDA-NIFA-Organic Agriculture Research and Extension Initiative in 2011. This one year proposal is designed to actively involve organic processors on nonthermal technologies. To achieve these objectives, funds will be used to organize (a) two strategic meetings (06/2010, 11/2010) and (b) a feasibility experiment, where a single source juice will be processed by the various institutions involved in this project. This is a multi-institutional team with expertise on nonthermal technologies including high pressure homogenization, high hydrostatic pressure, UV light, and plasma processing. The team has also extensive expertise on microbiology and sensory evaluation of fruit juices, engineering and processing operations, and outreach and education.

OBJECTIVES

Objective 1: Survey of Juice processors and assessment of their knowledge and attitudes towards nonthermal technologies. Objective 2: Design commodity-specific safety and quality experiments and confirm the feasibility for coordinating multi-institution experiments. Objective 3: Integrate a steering committee Objective 4: Submit a proposal to USDA-NIFA-Organic Agriculture Research and Extension Initiative in 2011

APPROACH

The long term goal supporting this one year planning proposal is to build a comprehensive system-based approach to the subject of nonthermal technologies for the processing of organically grown safe fruits and vegetable juices. We intend to provide organic growers and processors with proven nonthermal processing technologies for the pasteurization / sterilization of high quality organic juices. This planning proposal intends to test a pilot experiment and to engage processors and growers in a steering committee to uncover specific needs, outcomes, and success criteria to be addressed in a subsequent three year comprehensive proposal on the use nonthermal technologies in juice processing.

PROGRESS

2010/09 TO 2013/08 Target Audience: During this planning project we reached out to several small organic juice processors, including Apple Rush (Glenview, IL), Barsotti Juice Company (Camino, CA), Big B's Juice and Cider (Hotchkiss, CO), and Columbia Gorge Organic Juices (Hood River, OR). These companies expressed interest in the full NTJUICE proposal and were part of the Advisory Board of the project. The microbiology, sensory and physicochemical techniques used to prove the viability of the NTJUICE project were shared among the various Stations participating in the original proof of concept project. These techniques will be potentially shared to students within these institutions. A presentation on nonthermal technologies highlighting the NTJUICE project was given in the 2013 IFT Annual meeting Pre-Annual Meeting Short Course \"Advances in Commercialization of Nonthermal Processing\" in Chicago, IL July 12-13. About fifty people from the food industry attended this course and the presentation entitled \"High Pressure Homogenization--Principles and Applications\". Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? The project demonstrated that it is possible to evaluate several nonthermal technologies over the same substrate (juice). This was consider a major accomplishment as the various Co-PIs developed the expertise required for the full project. The NTJUICE proposal was ranked \"high priority\" two times by USDA-NIFA-OREI but did not receive funding How have the results been disseminated to communities of interest? A survey was conducted among juice procesors to determine their \"awarness\" related to nonthermal technologies. This survey was instrumental in our understanding of the lack of general knowledge and strong interest by processors on nonthermal technologies for the processsing of organic juices. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2011/09/01 TO 2012/08/31 OUTPUTS: The Specific objectives of the project were to (1) Survey of Juice processors and assessment of their knowledge and attitudes towards nonthermal technologies, (2) Design commodity-specific safety and quality experiments and confirm the feasibility for coordinating multi-institution experiments, (3) Integrate a steering committee to determine the specific key elements for success including safety, quality, and cost, (4) Submit a proposal to USDA-NIFA-Organic Agriculture Research and Extension Initiative in 2012. All four objectives were achieved; during 2012 several conference call meeting took place among the various participants of the project and a final integrated proposal was submitted to USDA in 2/10/2012. The proposal was ranked \"high priority\" but below the funding cut. PARTICIPANTS: Michael Barsotti,Barsotti Juice Co,Juice industry liaison Jane Burns, U. Tennessee, Sponsored programs Robert Corr, Apple Rush, Juice industry liaison David Golden, U. Tennessee, Microbiology, Plasma Renee Goodrich, U. Florida, Coordinator extension Federico Harte, U. Tennessee, Coordinator research, high pressure homogenization Jose Matos, Blue Lake Citrus, Juice industry liaison Carmen Moraru, Cornell U., Ultra/micro filtration Jose Reyes, U. Florida, Physicochemical properties Seth Schwartz, Two Brothers Organics, Inc Juice industry liaison Charlie Sims, U. Florida, Sensory evaluation Jimmy Stewart, Stewart Brothers, Inc., Juice industry liaison Jeyam Subbiah, U. Nebraska, Ultra-violet light TARGET AUDIENCES: An abstract was submitted to the IFT annual meeting during 2012. The corresponding poster will be presented in July 13-16 2013. The objective is to emphasize the importance of testing several nonthermal technologies over the same organic juice product to be able to draw comprehensive conclusions with regard to the suitability of a given processing operation vs. other available technologies PROJECT MODIFICATIONS: A no cost extension until 08/31/2013 was requested on 8/22/2012 and approved by USDA

2010/09/01 TO 2011/08/31 OUTPUTS: The Specific objectives of the project were to (1) Survey of Juice processors and assessment of their knowledge and attitudes towards nonthermal technologies, (2) Design commodity-specific safety and quality experiments and confirm the feasibility for coordinating multi-institution experiments, (3) Integrate a steering committee to determine the specific key elements for success including

safety, quality, and cost, (4) Submit a proposal to USDA-NIFA-Organic Agriculture Research and Extension Initiative in 2011. All four objectives were achieved; the final integrated proposal was submitted to USDA in 2/10/2011 PARTICIPANTS: Jane Burns U. Tennessee Sponsored programs Robert Corr Apple Rush Juice industry liaison David Golden U. Tennessee Microbiology, Plasma Renee Goodrich U. Florida Coordinator extension Federico Harte U. Tennessee Coordinator research, high pressure homogenization Carmen Moraru Cornell U. Ultra/micro filtration Jose Reyes U. Florida Physicochemical properties Lou Reyes Smucker\'s Juice industry liaison Charlie Sims U. Florida Sensory evaluation Jeyam Subbiah U. Nebraska Ultra-violet light Ray Trejo U. Tennessee Graduate student Rob Williams Virginia Tech. High hydrostatic pressure Jose Matos Blue Lake Citrus Juice industry liaison TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: A no cost extension to 08/31/2012 was requested for this project.

IMPACT

2010/09 TO 2013/08 What was accomplished under these goals? 6/11/2010 Planning proposal 2010-01988 accepted 7/19/2010 meeting took place from 9:30 to 10:45 am in room S105d at McCormick Place during the Institute of Food Technologists Annual meeting, Chicago, IL 12/15 2010 Meeting held in Orlando (FL). (R112015129) 2/10/2011 Proposal "NTJUICE: Nonthermal processing for safe fresh-like organic juices" submitted to USDA on 2/10/2011 (Proposal Number Assigned by NIFA: 2011-01970) 4/14/2011 Conference call, Conference call 6/2/2011 Proposal rejected, Proposal 2011-01970 submitted by Harte, NTJUICE: Nonthermal processing for safe fresh-like organic juices, This proposal was placed in High Priority 7/30/2011 Request for extension to 8/31/2012 10/11/2011 Conference call, Conference call 3/8/2012 Proposal sent to NIFA Title: NTJUICE: Nonthermal processing for safe fresh-like organic juices. Proposal Number Assigned by NIFA: 2012-02199 7/13/2012 Proposal rejected Proposal Number: 2012-02199 rejected, This proposal was placed in: High Priority 7/30/2011 Request for extension to 8/31/2013 **PUBLICATIONS (not previously reported):** 2010/09 TO 2013/08 Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Federico Harte, Carmen I Moraru, Jeyam Subbiah, Renee M Goodrich Schneider, Jose I Reyes-De-Corcuera, Charles Sims, David Golden, Robert Williams. NTJUICE Nonthermal Processing of Orange Juice: Comparing Apples to Apples. Abstract 264-11. 2013 IFT Annual Meeting, July 13 ? 16, 2013, Chicago Illinois

2011/09/01 TO 2012/08/31 The outcomes of this year\'s project are similar to the previous annual report. The project further demonstrated that several nonthermal technologies can be tested in the same organic juice matrix. The main challenge was to prove that a raw juice could be extracted frozen and shipped to various experimental stations, tested, frozen again, and returned to a central station to be tested. This was proven possible and will be used as the basis for the proposal submitted to USDA. Another challenge was to integrate an industry-university steering committee. This was also achieved and will have impact on how the results from the various proposed experiments are rapidly shared with the stakeholders.

2010/09/01 TO 2011/08/31 This one year project intended to demonstrate that several nonthermal technologies can be tested in the same organic juice matrix. The main challenge was to prove that a raw juice could be extracted frozen and shipped to various experimental stations, tested, frozen again, and returned to a central station to be tested. This was proven possible and will be used as the basis for the next proposal to be submitted to USDA. Another challenge was to integrate an industry-university steering committee. This was also achieved and will have impact on how the results from the various proposed experiments are rapidly shared with the stakeholders.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Proposal NTJUICE: Nonthermal processing for safe fresh-like organic juices submitted to USDA on 2/10/2011 (Proposal Number Assigned by NIFA: 2012-02199) 2. Harte, F., et al., 2013. NTJUICE Nonthermal Processing of Orange Juice: Comparing Apples to Apples. Accepted abstract and poster submitted to the Institute of Food Technologists annual meeting. Chicago, IL, July 13-16, 2013. Final ID: 264-11

2010/09/01 TO 2011/08/31 Proposal NTJUICE: Nonthermal processing for safe fresh-like organic juices submitted to USDA on 2/10/2011 (Proposal Number Assigned by NIFA: 2011-01970)

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Development of Cultivars and Ipm Strategies for Organic Cotton Production

Accession No.	0222493
Subfile	CRIS
Project No.	TEX09451
Agency	NIFA TEX
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21268
Proposal No.	2010-01870
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Dever, J. K.; Parajulee, M. N.; Kerns, D. L.; Arnold, M. D.
Performing Institution	Lubbock-TAMU Agr Res Cntr, TEXAS A&M UNIVERSITY, 750 AGRONOMY RD STE 2701

NON-TECHNICAL SUMMARY

More than 90% of the cotton grown in Texas currently comes from varieties with biotechnology traits and commercial seed developers are not releasing new conventional varieties. GMO varieties are both unapproved in organic cotton production and prohibitively expensive for many low-input producers on the Texas High Plains, which produce a majority of the cotton grown in the U. S. A. The Texas High Plains represents the most viable production region for organic cotton, with significant insect pressure coming mainly in the first 40 days of growth. Targeting early-season insects through tolerant conventional varieties and their interaction with approved insect control strategies can have potential economic benefit to producers who use organic methods. Organic cotton fiber is an emerging specialty market, both domestically and internationally. In 2008, approximately 50% of cotton planted in the Texas High Plains was treated with a preventative insecticide and 17% of the acres were treated with at least one foliar remedial insecticide. In conventional cotton, the high front-end cost of all effective preventative thrips management tactics is a limiting factor for producers when considering the adoption of preventative thrips management strategies. Organic cotton growers are currently not afforded the luxury and simplicity of utilizing effective at planting, preventive treatments for thrips; no such options exist. Currently, few Texas organic cotton growers utilize any treatments to manage thrips. A combination of greenhouse screening of ancestral cotton accessions, modified pedigree breeding methods, choice and no-choice field resistance screening and factorial experiments with approved substances for organic cotton production targeting pest resistance will be used to develop cotton cultivars suitable for organic cotton production. It is expected that a thrips resistant cultivar will be developed and made available to organic growers through a partnership with a seed company at the termination of the project, along with best management practice guidelines for growing the new varieties. An ongoing breeding program with lines developed from this project will seek to provide a pipeline of improved non-transgenic cotton cultivars that address the primary constraints of organic cotton production in the major organic cotton growing region in the U. S. Without this potential pipeline, organic cotton producers are at risk of losing available planting seed options. This project focuses on introgression of thrips tolerance into high quality cotton varieties and developing integrated pest management solutions for production of new, conventional varieties. The project most significantly addresses the OREI legislatively-defined goal 8. \"Developing new and improved seed varieties that are particularly suited for organic agriculture\" in its primary objective of creating

thrips-tolerant cotton cultivars. Goal 1, \"Facilitating the development of organic agriculture production, breeding and processing methods\" is also addressed in the objective of combining thrips resistance with drought tolerance and improved fiber quality.

OBJECTIVES

The most significant area for U. S. organic cotton production is in the High Plains of Texas. Availability of planting seed suitable for organic production in this region is a primary concern of organic cotton producers because major seed companies have discontinued non-genetically modified varieties. Major constraints to organic cotton production include early-season insect pressure from thrips complex, as well as drought tolerance and fiber production in cooler environments. Ongoing research at Texas AgriLife Research breeding program includes screening wild cotton collections for thrips tolerance, developing varieties for limited water production and a long history of fiber quality improvement. This project focuses on introgression of thrips tolerance into high quality, sustainable cotton varieties and developing integrated pest management solutions for production of new, conventional varieties. The long term goal of this project is to develop adapted, high quality cotton cultivars resistant/tolerant as seedlings to damage by the Texas High Plains thrips complex. At present, the major cotton industry exclusively uses insecticides for thrips control. Since this type of control is not available to organic cotton growers they are at the mercy of this pest. It is expected that a thrips resistant cultivar will be developed and made available to organic growers through a partnership with All-Tex Seed Inc / Levelland Delinting at the termination of the project, along with best management practice guidelines for growing the new varieties. An ongoing breeding program with lines developed from this project will seek to provide a pipeline of improved non-transgenic cotton cultivars that address the primary constraints of organic cotton production in the major organic cotton growing region in the U. S. Without this potential pipeline, organic cotton producers are at risk of losing available planting seed options. The extension and education components of this project will be developed, disseminated, and evaluated with input from grower clientele and other key stakeholders. The evaluation of the impact of the outreach program will include two major components: 1) measuring delivery of practical information to growers and pest control advisers (short term outcomes) and 2) measuring changes in grower and pest control adviser knowledge, skills, and thrips management practices and linking those changes to specific outreach products (medium-term outcomes). Additionally, economic impacts of changes in thrips management practices as a result of these outreach efforts will be quantified. These assessments will be made at various venues where information delivery has been made (county and regional meetings), and by surveying individual organic cotton growers identified by our advisory panel.

APPROACH

The initial screening method uses greenhouse grown wheat to rear thrips for uniform, medium to excessive thrips pressure. Visual ratings, differential leaf surface area reduction, and a plant washing method to accurately recover thrips are used to calculate indicators of resistance. The method for no-choice screening uses cages to restrict movement of thrips between test plants, eliminating antixenosis as a mechanism of resistance. Accessions that show resistance in the free-choice testing are tested in no-choice screening. Standard methods that plot plant health against insect health indicators are used to identify the mechanism of resistance as tolerance or antibiosis. Existing F2 populations (G. barbadense accession TX110 x breeding program elites) from a thrips tolerant cultivar and 2 adapted breeding lines have been screened in the field and plants identified and selected that show resistance in the early seedling stage to the thrips complex and exhibit day-neutral flowering characteristics. F3 plant selections will be crossed to G. hirsutum backgrounds screened for drought tolerance and fiber quality characteristics and to cold tolerance selections exhibiting improved thrips tolerance. Tolerance of selections will be confirmed by paired-plot studies with and without approved products for thrips avoidance. Multi-location performance testing, including certified organic farms, will begin in the F4-F5 generation. The effectiveness of OMRI approved insecticides for managing western flower thrips infesting conventional and thrips tolerant cotton cultivars will be evaluated using factorial design with 4 replicates. Orthene will be included as a conventional standard for comparison purpose if the test is not conducted on an organically certified field. The compensatory ability of selected thrips tolerant and susceptible cotton cultivars (3 tolerant and 3 susceptible cultivars) to thrips-induced plant growth and maturity delays will be examined. Fruit retention will be monitored using standard COTMAN SQUAREMAN protocols throughout the growing season. The variation in carpel wall thickness among cultivars with varying levels of thrips tolerance will be quantified. Greenhouse screening for thrips tolerance uses a simple randomized block design measuring differences in leaf surface area biomass and is analyzed using SAS. A completely randomized design or randomized block design will be used for field trials depending on irrigation type. These designs will allow for statistical comparison between cultivars no matter the variable. Any cultivar developed that has potential use in organic cotton production will be registered with the

Texas A&M Office of Technology and Commercialization. Breeder seed will be maintained by Texas AgriLife Research. Cultivars will be used for planting seed in organic cotton production. Recommendations on OMRI-approved material for early season insect control will be disseminated to organic cotton growers. Results from compensatory and carpel wall studies will be used in the cotton breeding program to develop a pipeline of potential cotton seed varieties for organic cotton production.

PROGRESS

2010/09 TO 2015/08 Target Audience:Organic cotton farmers, public cotton breeders Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Dylan Wann received his Ph. D. from Texas Tech University in Mary, 2015. Technician Heather Elkins Flippin was promoted to Research Assistant in March, 2013, and is currently an M. S. candidate in the Plant Breeding Distance Degree program at Texas A&M University. How have the results been disseminated to communities of interest?Numerous posters and presentation have been presented at ASA-CSSA-SSSA national meetings, Beltwide Cotton Research Conference regional meetings, and local field days. Results of this research have been presented at the Texas Organic Cotton Marketing Cooperative annual meeting and Field Day every year of the project. Project personnel have participated in the Textile Exchange annual conference Organic Cotton Round table since 2011, including meetings in Barcelona, Hong Kong, Istanbul, Portland, and Mumbai. 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 cotton farmers and members of Texas Organic Cotton Marketing Cooperative attended field days, and invited presentations at their annual meeting. Participants at Textile Exchange Organic Cotton Roundtable heard efforts to improve seed security in organic cotton systems, including underserved farmers in India, Turkey, Africa, and other low-input cotton producing countries. Plant breeding students at Texas Tech University and Texas A&M University heard guest lectures on organic plant breeding.Stakeholders at Seeds and Breeds conference in Washington, DC, March, 2013 heard presentation on cotton germplasm collection characterization efforts.Organic Trade Association annual Policy Conference heard panel discussion on organic agriculture research priorities. Changes/Problems: Apurba Barman replaced David Kerns as Extension Entomologist - Cotton. Extension of funds is requested to compensate for 8-month delay in procuring graduate student Dylan Wann. What opportunities for training and professional development has the project provided? Graduate Research Assistant Dylan Quincy Wann was hired eight months after the initiation of the project and intends to graduate May, 2015. He is dedicated to this project and is shared by PI Dever and Co-PI Parajulee. Mr. Wann participated in Textile Exchange Organic Cotton Round Table in Istanbul, Turkey, November, 2013; Organic Seed Alliance Workshop in Corvallis, OR, January, 2014; Beltwide Cotton Research Conference, New Orleans, LA, January, 2014; and will participate in National Association of Plant Breeders and Student Organic Seed Symposium in August, 2014. Jane Dever serves as PI and served as chairman of the Cotton Improvement Conference at the Beltwide Cotton Research Conferences in January, 2014, and participated in the Seeds and Breeds summit in March, 2014. How have the results been disseminated to communities of interest? Several oral and poster presentations were made during the Beltwide Cotton Production Research conference in January, 2014. A technical bulletin was mailed to organic cotton farmers and posted on the Texas A&M AgriLife Research and Extension Center website. A field day was attended by farmers, textile processors, NGO, and other interested stakeholders. What do you plan to do during the next reporting period to accomplish the goals? Three thrips resistant germplasm lines will be released through Journal of Plant Registrations. One cultivar is planned to be released through Texas A&M Plant Release Comittee and Journal of Plant Registrations. Data necessary to complete second year of IPM study will be collected so publication can be realized.

2012/09/01 TO 2013/08/31 Target Audience: Members and stakeholders of the Texas Organic Cotton Marketing Cooperative; Organic Cotton Roundtable participants at the Textile Exchange annual conference; Seed Matters, an initiative of the Clif Bar Family Foundation; 180 participant of the biennual international Cotton Breeder tour sponsored by Cotton Incorporated; participants of the Cotton Improvement Conference at the Beltwide Cotton Production and Research Meeting. Changes/Problems: No major changes or problems in approach were encountered during the reporting period. Dr. Apurba Barman replaced Dr. David Kerns as the Cotton Extension Entomomlogist in Lubbock and enthusiastically contributed to the project during 2013. What opportunities for training and professional development has the project provided? 16-18 Sept. 2013 - Graduate Research Assistant Dylan Quincy Wann attended a shortcourse at University of California - Davis on \"How to Manage a Breeding Program.\" 16-18 Sept. 2013 - Jane Dever, Mark Arnold and Heather Flippin attended the international Cotton Breeder Tour in Lubbock, Texas, USA. 14 Oct. 2013 - Jane Dever was a panel (GMO: Facts and Fiction) participant at the Rachel\'s Network fall retreat. 4 Nov. 2013 - Jane Dever and new GRA Ryan Gregory attended

a meeting at the Clif Bar Family Foundation headquarters in Emeryville, CA to participate in developing a messaging campaign for the Seed Matters initiative. 11 Nov. 2013 -- Graduate Research Assistant Dylan Quincy Wannwas a panel participant in the Textile Exchange Organic Cotton Roundtable in Istanbul, Turkey. How have the results been disseminated to communities of interest? 29 Oct. 2013 -- Organic Cotton Field Day, Texas Organic Cotton Marketing Cooperative. This year's event was the second consecutive field day to include an official stop at the Texas A&M AgriLife Research and Extension Center near Lubbock to showcase our organic research. ndergraduate technician Heather Flippin and Senior Research Associate Mark Arnold gave presentations on wild cotton germplasm screening to discover native traits for organic breeding. GRA Dylan Quincy Wann showcased plot demonstrations for potential new organic cotton defoliant. PI Jane Dever led a participatory breeding exercise. 29 April 2013 - Jane Dever presented update on National Genetic Resources Advisory Council and discussed 2013 seed options, Texas Organic Cotton Marketing Cooperative board meeting. 5-6 Jan. 2013 -- Three presentations and one poster from the project were presented at the Beltwide Cotton Production and Research Conference in San Antonio, TX. 7 March, 2013 - Wann, D. Q. and J. K. Dever, Evaluation of thrips-tolerant cotton for the Texas High Plains. High Plains Association of Cotton Consultants Annual Meeting, Lubbock, TX, USA 23 Oct. 2012 - Organic Cotton Field Day, Texas Organic Cotton Marketing Cooperative. 3 Oct. 2012 -- Jane Dever introduced via video the Organic Cotton Round Table topic "Seed Security in a Minority Environment" to a diverse group ranging from small to large scale seed projects, brand representatives from organic cotton processors and stakeholders in organic cotton from production to finished product at the Textile Exchange annual meeting in Hong Kong. 4 Jan. 2012 -- Three posters from the project were presented at the Beltwide Cotton Production and Research Conference in Orlando, FL. What do you plan to do during the next reporting period to accomplish the goals? Third year of cotton performance trials under organic production will be processed and analyzed. With three years of data, manuscripts are anticipated to be prepared for the Journal of Cotton Science on the lines combining best performance for organic production and thrips resistance. A second year of genotype X organic insecticide trial will be planted in 2014 (repeat of 2013 trial). Data from mapping trials will be compiled for potential thrips resistance marker development. Lines selected from the 2013 nursery will be planted in multi-location performance trials. During the next reporting period, it is anticipated a new variety will be identified for organic cotton producers in Texas. During the next reporting period, trials will be initiated to support registration of a new organic cotton defoliant.

2011/09/01 TO 2012/08/31 OUTPUTS: Five types of experiments were conducted during the 2011-2012 reporting period toward the objective of developing cultivars and integrated pest management systems for organic cotton production. These included performance evaluation of existing breeding lines, thrips screening on existing breeding lines, population evaluation for molecular marker development on thrips resistance, efficacy and compensation studies for OMRI-approved insecticides, and establishment of breeding nurseries. Data were analyzed from two locations of RCBD, 4-replication performance trials conducted in 2011, one on certified organic land and one at the LREC research station; and 3 new trials were established in 2012, 2 on certified organic land and one at LREC not on certified land, but treated as organic. Each trial had 8 experimental lines and 2 check cultivars commonly used by organic cotton growers. Results from the trial were disseminated at the Texas Organic Cotton Marketing Cooperative annual meeting, and the 2012 LREC performance trial will be highlighted during the TOCMC Fall Field Day. Two of the 2012 locations had sufficient thrips pressure to make comparative damage ratings on all of the lines. A greenhouse trial was also initiated in 2011 to evaluate an F2 population derived from an interspecific cross for potential molecular marker development. Thrips pressure in the greenhouse was too low to adequately phenotype thrips injury, therefore a similar trial was initiated in the field in 2012. Visual thrips damage ratings were conducted on an individual plant level and tissue samples were collected for future QTL analysis. Graduate student Dyaln Quincy Wann won second place at the Texas Tech University graduate student poster competition presenting these results. Eight OMRI-approved insecticides were applied to RCBD 4-replication trials in 2011 and 2012. Adult and larvae thrips numbers, average biomass, average leaf area/plant, leaf chlorophyll and root and shoot length were evaluated among the 8 insecticides and untreated control. Three poster presentations on thrips studies were presented at the Beltwide Cotton Research Meetings in January, 2012. A thrips nursery has also been maintained since 2010 for the development of new varieties with high levels of thrips tolerance. To date, we have planted 13 different crosses in the field and selected 330 individual plants that exhibit high thrips tolerance or excellent yield and fiber quality. Currently, there are F2, F4, and F5 generations planted in the nursery. Ideally, the lines developed in the nursery will be yield-tested at the field level, similar to the aforementioned trials, and high-yielding, thrips-resistant varieties will be identified for commercial release. Research team members have had the opportunity to present research results and perspectives on seed security in a GM environment during international organic cotton round table discussions at Textile Exchange annual meetings in Barcelona, Spain and Hong Kong. In addition to organic cotton farmers, this has reached downstream stakeholders including retail brands involved in organic cotton merchandising. PARTICIPANTS: Jane Dever, PI, Associate Professor and Cotton Breeder; Megha Parajulee,Co-PI, Professor and Research Entomologist; Mark Arnold, Co-PI, Research Associate; David Kerns, Co-PI,

Professor and Extension Entomologist, has accepted a position with Louisiana State University and his duties were performed by County Extension Agent - IPM Monti Vandiver; RB Shrestha, Research Scientist; Dylan Quincy Wann, Graduate Research Assistant, Carol Kelly, Assistant Research Scientist; Heather Flippen, Technician. Dylan Quincy Wann, Jane Dever, Megha Parajulee, Monti Vandiver, RB Shrestha and David Kerns attended Beltwide Cotton Research Conferences. Jane Dever was appointed to the National Genetic Resources Advisory Council. Partner organizations and collaborators involved with the project during the reporting period include Textile Exchange, Plains Cotton Growers, Texas Organic Cotton Marketing Cooperative, the board members of TOCMC that comprise the project advisory board, and All-Tex Seed, Inc. Cliff Bingham, Jeremy Brown and Steve Neff are the organic cotton farmer cooperators on whose land performance trials were planted. Kelly Pepper, manager of Texas Organic Cotton Marketing Cooperative, was approved by the Texas Tech Graduate School as a voting member of Dylan Quincy Wann\'s graduate advisory committee. Other committee members include Eric Hequet (fiber quality expert and graduate student coordinator in Plant and Soil Science department), Jane Dever(PI), Megha Parajulee (Co-PI), Chris Rock (Genetics professor in Biology department), and Robert Wright (Molecular geneticist in PSS). TARGET AUDIENCES: Target audiences include organic cotton farmers, seed companies interested in accessing germplasm for conventional variety development, end-user stakeholders and NGOs interested in establishing and maintaining seed security in a GM environment. PROJECT MODIFICATIONS: The only modification to report is that Co-PI David Kerns left the Texas AgriLife system for an appointment at Louisiana State University. County Extension Agent - IPM Monti Vandiver has assumed his duties temporarily. We hope the new Extension cotton entomology specialist, when hired, will be assuming Dr. Kerns\' part of the project.

2010/09/01 TO 2011/08/31 OUTPUTS: Eighty Texas racestocks, in the 600-700 racestock number range, were screened for thrips resistance in 8 greenhouse, free-choice experiments. Thrips counts, variable leaf surface area reduction and subjective ratings were recorded. Sixteen potential thrips resistant lines are under development, including 4 lines from TX110 X CA2266 and TX110 X CA 3027 (F4), 8 thrips-resistant X drought crosses (F3) and 4 crosses with a day-neutral Pima parent (F1). Two variety trials with 7 potential organic lines and one check in an RCBD with 4 replications were conducted at the Texas AgriLife Research and Extension Center at Lubbock and at an organic farm in Meadow, Texas, in cooperation with organic grower Cliff Bingham. Thrips counts were obtained at the seedling stage and leaf surface area samples were taken from coytledon to fifth true leaf stage. A trial was conducted to evaluate managing thrips using organically approved insecticides. Several OMRI-approved insecticides were investigated for their efficacy towards thrips infesting cotton. In addition, a trial was conducted to study the effects on plant parameters of potential organic pesticides for Western Flower Thrips management in seedling cotton. Project personnel participated in the Texas Organic Marketing Cooperative fall field day and tour, the Beltwide Cotton Conferences and the U. S. Cotton Breeder\'s tour in August. Project leader presented a poster at the Organic Farming Systems Research Conference in Washington, DC on \"Development of cultivars and IPM systems for organic cotton production\"; and participated in an expert panel session at the Textile Exchange annual conference in Barcelona, Spain on \"The future of non-GMO seed supply. The project was also featured in a special issue of the Textile Exchange newsletter \'Exchange\', World Environment Day Theme - Biodiversity, Issue 12, June, 2011. Personal interaction with organic growers on the Texas High Plains remains strong and has garnered potential additional support for the project. PARTICIPANTS: Jane Dever is Associate Professor and Cotton Breeder, Megha Parajulee is Professor and Cotton Research Entomologist, David Kerns is Professor and Cotton Extension Entomologist, Mark Arnold is Research Associate, Valerie Morgan is Research Assistant, Carol Mason Kelly is Post-doctoral Research Associate and Heather Flippen is Technician at Texas AgriLife Research and Extension Center in Lubbock, TX. Dylan Quincy Wann is Ph. D. graduate student at Texas Tech University, doing research and employed at Texas AgriLife Research in Lubbock. Monti Vandiver and Brant Baugh are IPM Agents with Texas AgriLife Extension in Crosby and Lubbock counties, respectively. C. Wayne Smith is Professor and Cotton Breeder at Texas A&M University in College Station and public breeders G. Myers (LSU), P. Chee (UGeorgia) and F. Bourland (UArk) have also collaborated on this project. Lori Hinze and Richard Percy work with the USDA-ARS Germplasm unit in College Station which is critical to supplying racestock seed for screening. Eric Hequet, Professor and Associate Director of the Fiber and Biopolymer Research Institute at Texas Tech University performs fiber testing for variety tests. Our most significant partner organization is the Texas Organic Cotton Marketing Cooperative in Lubbock, TX; but we are also supported by Plains Cotton Improvement Program. Textile Exchange has become an important collaborator as we relate our experience in developing non-GMO varieties to interested parties in emerging GMO markets such as India, Africa and Brazil. TOCMC sponsors a fall field day and tour each year which has allowed for development and education of several participants of the program including Jane Dever, Mark Arnold, Megha Parajulee, Heather Flippen and Dylan Wann. Jane Dever was also able to attend the Organic Farming System Research Conference with project funds as well as sending Mark Arnold to the Beltwide Cotton Research and Production Conference. TARGET AUDIENCES: Besides the board and members of the Texas Organic Cotton Marketing Cooperative, we have expanded our focus to down-stream processors and made contact with Anvil Knitwear, the largest consumer of

US organic cotton; and with the Textile Exchange members. Because of Anvil Knitwear\'s initiative to double the supply of organic cotton from the USA, target audience includes conventional farmers interested in converting some land to certified organic production. Availability of productive, resistant varieties, effective OMRI-approved products and compensatory studies to develop IPM programs are of interest to these farmers. Target audience also includes international group interested in organic cotton and how to preserve non-GMO seed areas in emerging GMO countries such as India and Africa. PROJECT MODIFICATIONS: An effort to map genes in G. barbadense that confer resistance to thrips will be initiated for molecular marker-assisted breeding. A participatory breeding project will include members of Texas Organic Cotton Marketing Cooperative and their primary customers.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? At least two germplasm releases for thrips-tolerant breeding lines appropriate for developing cotton cultivars for organic production will be widely released. Summary of experimental results: A wide variety of endogenous host plant thrips resistance and susceptibility was observed among the genotypes included in these evaluations. There was also a wide range of suitability for organic production. Under heavily-elevated thrips pressure in the greenhouse, 07-7-519CT and FM 958 (an experimental breeding line and the current commercial standard for organic cotton production, respectively) consistently displayed the highest natural resistance to thrips feeding.Thrips populations in the greenhouse were high enough to overcome thrips resistance in even the most resistant G. barbadense germplasm (TX 110), indicating that 100% resistance to thrips pests does not exist in currently-documented characterized germplasm. A novel 1-9 visual thrips injury rating scale was utilized in these evaluations, and exhibited a very strong correlation (rs = -0.884) with directly-quantifiable leaf area reduction data. Leaf surface area varied significantly among genotypes in the thrips-free control blocks, in two of the three greenhouse evaluations. This indicates that measurement of leaf surface area alone, without a corresponding \"clean\" control, is a poor method for phenotyping thrips injury, due to natural variation in cotton leaf area. Simple linear regression analyses also indicates that thrips densities on cotton plants only account for a marginal amount of variation in thrips injury (\< 6%). This, along with no differences in thrips density among genotypes, suggest that antixenosis is likely not a mechanism of resistance to thrips in cotton. Field evaluations also revealed differences in thrips resistance among genotypes. Cold-tolerant lines 07-7-519CT, 07-7-1001CT, 07-7-1020CT, and 07-7-1303CT all exhibited the least injury to thrips pests, along with 11-2-802GD. Additionally, simple linear regression analyses indicate that thrips density accounted for little variation in visual thrips injury at the field level (\< 7%). These support the hypothesis that antixenosis contributes little or nothing to endogenous thrips resistance.Excellent thrips resistance of both 07-7-1001CT and 07-7-1303CT indicatesthese two lines could be suitable parents for introgressing thrips resistance to elite germplasm. Linear regression analyses of all genotypes indicated that leaf pubescence did not affect thrips densities or thrips injury, thereby eliminating pubescence as a possible component of thrips resistance.Based on the results of these evaluations, 07-7-519CT, 07-7-1020CT, and 11-2-802GD have the greatest potential of the evaluated genotypes for utilization in organic production. All three have notable resistance to thrips injury in the absence of insecticide applications. They also had acceptable levels of leaf pubescence and sufficient stand establishment potential. Additionally, 07-7-519CT and 07-7-1020CT had consistently-desirable boll morphologies, as well as sufficient maturity within a normal growing season on the Texas High Plains.Broad sense heritability estimates for thrips resistance ranged 41-67%, depending on the family. H2 in families sharing a common resistant Cobalt parent (57-67%) was higher than those with a common TX 110 parent (41-50%). This was likely the result of the wild, highly-photoperiodic nature of TX 110, which had an extraneous amount of background segregation for other traits and was likely masking some segregation for thrips resistance. Cobalt is a day-neutral, commercial G. barbadense cultivar that likely provided a more stable background for introgression of resistance. The high H2 values for all families also suggested that thrips resistance is simply-inherited, controlled by either one or two genes. Genetic segregation analyses indicated possible resistant/susceptible ratios of 3:1, 13:3, and 11:5, although the evaluated populations tended to fit more closely to the 13:3 and 11:5 ratios. These ratios suggest that thrips resistance is controlled by two genes, acting in either a dominant suppression epistasis relationship (13:3), or an additive duplicate dominance relationship (11:5). The data were insufficient to definitively discriminate between the two possible scenarios. However, they were sufficient to suggest that thrips resistance in cotton is a simply-inherited dominant trait, and is likely controlled by two genes. Actual gain from selection values ranged 2-21% per cycle of selection, depending on the selection intensity (SI). The optimum SI in this case was 5%, which yielded a 21% gain from selection. This value was moderately low, likely as a result of low thrips populations in 2012 and mild damage to the F-2 population, along with the complex dominant nature of the resistance trait. Choosing field locations with consistent thrips pressure and adjusting SI based on initial population estimates would likely result in greater gains from

selection.Combinations of host plant resistant genotypes and weekly spinosad insecticide applications showed clear potential for reducing thrips infestations and subsequent damage to an organic cotton crop. Resistant entries + spinosad reduced thrips injury 60-83% over the non-sprayed susceptible and commercial controls in 2013. Resistant genotypes alone resulted in 26-37% reductions in thrips injury over the susceptible and commercial controls. In addition, spinosad applications alone reduced thrips injury up to 37% and increased lint yield 10%.Lint yields differed significantly among genotype and spray treatments, where 07-7-1020CT produced the greatest yields of the four genotypes and the weekly spray treatment yielded more than the non-sprayed treatment. Lint yields were not significant among genotype or spray treatments in 2014. HVI fiber quality differed somewhat among genotypes and spray treatments in both 2013 and 2014, but all treatments tended to fall in the same organic cotton market pool.The current application cost for the Entrust insecticide product alone is approximately \$62 ha-1, which is cost-prohibitive for large scale use. While there was clear synergism between resistant germplasm and spinosad in 2013, using resistant genotypes alone achieved almost the same reduction in thrips injury as did three weekly spinosad applications. In all, these studies revealed that host plant thrips resistance varies widely in cotton, and can be sufficiently captured and introgressed by plant breeders, and subsequently utilized in commercial-level production. Resistant germplasm is also an effective tool for the integrated management of thrips pests and their damage to an organic crop. While the exact mechanism of resistance remains speculative, it appears that it is caused by some form of physical resistance, direct tolerance, or a combination of both. It can also be easily identified and phenotyped visually, which is valuable for plant breeders who are continually balancing time and financial resources. 100% resistance has yet to be identified; continuing efforts to screen a wide variety of germplasm are essential for identifying potential genotypes with complete resistance. Nevertheless, current host plant resistance in cotton is a cheap and effective means for mitigating thrips damage to a crop, especially in a world of technology fees and limited chemical control options. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Book Chapters Status: Published Year Published: 2014 Citation: Percy, R. G., J. E. Frelichowski, M. D. Arnold, T. B. Campbell, J. K. Dever, D. D. Fang, L. L. Hinze, D. Main, M. A. Sheehan, M. Ulloa, J. Yu, and J. Yu. 2014. ?The National US Cotton Germplasm Collection ? its Contents, Preservation, Characterization and Evaluation,? Chapter 7 (pp. 167-201) in World Cotton Germplasm Resources, edited by Ibrokhim Y. Abdurakhomonov. InTech Publishing. 2. Type: Other Status: Published Year Published: 2015 Citation: Dever, J. K., V. Morgan, C. M. Kelly, T. A. Wheeler, H. Elkins, V. Mendoza, and J. Arce. 2015. Cotton performance tests in the Texas High Plains, 2014. Texas A&M AgriLife Research Technical Report 15-1. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Vandiver, M., *D. Q. Wann, A. K. Barman, J. K. Dever, M. Parajulee, and M. D. Arnold. 2014. Managing thrips organically using host plant resistance and Entrust insecticide. Proceedings of the Beltwide Cotton Conferences. National Cotton Council of America. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Wann, D. Q., J. K. Dever, M. N. Parajulee, and M. D. Arnold. 2015. Breeding value of host plant thrips resistance for new cultivar development. Proceedings of the Beltwide Cotton Research Conference. National Cotton Council of America. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Gregory, R. A., J. K. Dever, G. L. Ritchie, and P. A. Dotray. 2015. Visual screening strategy for purity and seed quality in conventional breeding nurseries. Proceedings of the Beltwide Cotton Research Conference. National Cotton Council of America. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Kothari, N., J. Frelichowski, J. Love, L. Hinze, J. K. Dever, and R. Percy. 2015. Genetic diversity among accessions in the US National Cotton Germplasm Collection. Beltwide Cotton Research Conference. National Cotton Council of America. 7. Type: Theses/Dissertations Status: Published Year Published: 2015 Citation: Wann, D. Q. 2015. Breeding Value and Utilization of Host Plant Resistance for Integrated Thrips (Thysanoptera: Thripidae) Management in Cotton (Gossypium spp.). Dissertation. Texas Tech University

2013/09 TO 2014/08 What was accomplished under these goals? Cotton Improvement Program (CIP), Texas A&M AgriLife Research and Extension Center Lubbock (LREC) began an initiative in 2011 to develop high-quality cultivars tailored to the unique challenges proffered by organic cotton systems. A nursery has been maintained at LREC since 2010, for development of cultivars with high levels of thrips tolerance combined with yield and fiber quality potential. CIP also maintains other nurseries dedicated to developing cultivars with resistance to drought stress, salinity, Verticillium wilt and bacterial blight pathogens, and root-knot nematodes, some of which are good candidates for organic production. In 2013, CIP maintained 11,444 field plots, created 40 new populations, selected 2,302 individual plants, evaluated 5,614 progeny rows, selected 67 new lines for testing, and increased seed of 96 breeding lines. Twelve advanced cotton breeding lines and four cultivars were evaluated in 2012 on both certified-organic dryland location (Lamesa) and an organically-managed irrigated location (Lubbock). In 2013, four advanced lines were added to the evaluation, and trials were conducted in two irrigated locations near Halfway and Meadow. The Halfway location was on conventional land managed without insecticides, whereas the Meadow location was certified organic land. CIP also evaluated a potential organic IPM system for thrips management. In 2011, an on-farm field trial was initiated to evaluate the impact of 13 organically-approved

insecticide treatments on thrips control in an organic cotton system. Insecticide applications were made weekly, beginning at emergence and continuing through the 5th true leaf stage. Collected data included thrips numbers at 3-4 and 7-8 days after each treatment (DAT), visual injury ratings at 5 weeks after planting (WAP), and final lint yield. In 2012, the number of insecticide treatments was reduced to include only the four best treatments, along with non-sprayed control. Insecticide applications were made weekly beginning at 85% emergence and continuing for 5 weeks. In 2013, an on-farm trial was initiated to evaluate the combined effects of resistant genotypes with an organic-approved insecticide for integrated thrips control. The test was conducted certified organic land near Muleshoe, TX, with consistently heavy ambient thrips pressure. Two thrips-tolerant lines, a susceptible check, and commercial standard were planted and subjected to three weekly spray treatments of Entrust, beginning at near 100% emergence. Spray treatments consisted of weekly sprays or no sprays on each entry, in a split plot experimental design, with entry as the main plots and spray treatments as subplots. Collected data included thrips numbers and single leaf areas (at 1-5 weeks after planting \WAP\), and visual injury ratings at 5 WAP. The line evaluations were planted in May, 2014, at Meadow, Lubbock, Halfway and Lamesa; IPM test was planted at Muleshoe and will be repeated in 2014. All nurseries are established. A comprehensive report was mailed to organic cotton farmers in April, 2014 and posted on-line, http://lubbock.tamu.edu/files/2014/03/2014-Organic-Cotton-Research-Report.pdf. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 1. Type: Journal Articles Status: Published Year Published: 2012 Citation: Arnold, M. D., J. K. Dever, M. N. Parajulee, S. C. Carroll, and H. D. Flippin. 2012. A simple and effective method for applying thrips feeding pressure to cotton seedlings in a greenhouse environment. Southwest Entomologist 37(3): 305-313. 2. Type: Other Status: Published Year Published: 2014 Citation: Wann, D. Q, 2014. Field evaluations for organic cotton production, 2012-2013. Texas A&M AgriLife Research Technical Report 14-2. 3. Type: Other Status: Published Year Published: 2014 Citation: Dever, J. K., V. Morgan, M. S. Kelley, T. A. Wheeler, H. Flippin, V. Mendoza, and A. Cranmer. 2014. Cotton performance tests in the High Plains and Trans-Pecos areas of Texas, 2013. Texas A&M AgriLife Research Technical Report 14-3. 4. Type: Conference Papers and Presentations Status: Accepted Year Published: 2014 Citation: Stelly, D. M., D. A. Raska, S. Saha, J. N. Jenkins, J. C. McCarty, J. K. Dever, M. D. Arnold, H. D. Flippin, and D. C. Jones. 2014. Facilitating the use of wild species germplasm for cotton improvement via CS lines. Proceedings of the Beltwide Cotton Conferences. National Cotton Council of America. 5. Type: Conference Papers and Presentations Status: Accepted Year Published: 2014 Citation: Gregory, R. A., and J. K. Dever. 2014. Screening strategy for maintaining purity and seed quality in cotton breeding nurseries. Proceedings of the Beltwide Cotton Conferences. National Cotton Council of America. 6. Type: Conference Papers and Presentations Status: Accepted Year Published: 2014 Citation: Vandiver, M., D. Q. Wann, A. K. Barman, J. K. Dever, M. Parajulee, and M. D. Arnold. 2014. Managing thrips organically using host plant resistance and Entrust insecticide. Proceedings of the Beltwide Cotton Conferences. National Cotton Council of America. 7. Type: Conference Papers and Presentations Status: Accepted Year Published: 2014 Citation: Wann, D. Q., J. K. Dever, M. Parajulee, M. D. Arnold, and H. D. Flippin. 2014. Field performance and heritability of thrips resistance for cotton variety development. Proceedings of the Beltwide Cotton Conferences. National Cotton Council of America.

2012/09/01 TO 2013/08/31 What was accomplished under these goals? Field Performance Trials: Field trials were initiated in 2011 to evaluate non-GM germplasm previously developed by the Texas A&M AgriLife Research Cotton Improvement Program. Eight advanced breeding lines and two cultivars were planted on a cooperator's certified organic land near Meadow, TX. A second yield test was planted on non-certified land at the Texas A&M AgriLife Research and Extension Center near Lubbock, TX and included seven advanced cotton breeding lines and one cultivar. Each genotype was evaluated for a variety of agronomic and fiber quality characteristics. There were no significant yield differences (P \> 0.05) among genotypes at both locations, likely as a result of extreme drought conditions in 2011. All genotypes were statistically equivalent to 'FM 958' (PI 619096), the organic production standard, at both locations. There were a number of differences in various High-Volume Instrument (HVI®) fiber quality characteristics for the evaluated lines at each location (P ≤ 0.05). Most notable were lines 07-20-1304D and TAM 04WB-33s, which both had excellent combinations of fiber length, uniformity, strength, and elongation values. Lines 07-7-1407CT and 07-14-510FS did not display as high of fiber quality values as 07-20-1304D and TAM 04WB-33s, but exceeded most quality parameters compared to FM 958. 2012 yield tests were planted in three locations near Idalou, Lamesa, and Lubbock, TX. Visual thrips injury ratings were conducted on all plots at the Lamesa location on 20 June and the Lubbock location on 14 June, 21 June, and 28 June. Ambient thrips pressure at the Idalou location was insufficient for adequately discriminating among genotypes. Significant differences among genotypes occurred in the 14 June ratings at Lubbock (P ≤ 0.05). Lines 07-7-1001CT and 07-7-1020CT exhibited the highest visual ratings (i.e. the least thrips injury). Both of these lines were originally selected for cold tolerance and have characteristically thicker leaves, which could have also conferred some amount of tolerance to thrips feeding. Visual ratings for leaf pubescence, which could also affect thrips tolerance and/or leaf grade, were conducted on 25 Sept. (Lubbock) and 26 Sept. (Lamesa) to assess differences among lines. Results were consistent among the two locations, with most of the lines exhibiting very minimal

pubescence. However, 07-7-1001CT, 07-7-1303CT, and Tamcot 73 were all significantly pubescent, which would prove problematic for growers at the commercial level. Correlation analyses between pubescence ratings and leaf grade confirm that a significant, positive relationship exists. Based on these results, the three aforementioned lines would not be desirable for organic production. Only visual thrips injury data are available for the 2013 trials at present. Ambient thrips pressure was much greater at the Halfway and Meadow locations than Lubbock; however there were significant differences among genotypes ($P \leq 0.05$) at all three locations. Similar to 2012, the cold-tolerant ("CT") lines displayed the greatest tolerance to thrips feeding injury (07-7-519CT, 07-7-1020CT, 07-7-1303CT, and 07-7-1407CT), along with 07-14-205FS. However, 11-2-802GD, a new addition to the test from the organic breeding effort, consistently exhibited the greatest thrips tolerance among all locations and rating dates. Organic Integrated Pest Management (IPM) Study: In 2013, an on-farm trial was initiated to evaluate the combined effects of resistant genotypes with an approved insecticide for integrated thrips control. The test was conducted on a cooperator's certified organic land near Muleshoe, TX; an area noted for consistently heavy ambient thrips pressure. Two thrips-tolerant lines (07-7-1020CT and 07-7-1407CT), a susceptible check (Atlas), and standard cultivar (FM 958) were planted and subjected to weekly spray treatments of Entrust®, an organic-approved spinosad insecticide with proven efficacy on thrips pests. Fourteen OMRI-approved treatments were tested in 2011 and 2012; Entrust had the best efficacy. Spray treatments consisted of weekly sprays or no sprays on each genotype, in a 4 x 2 factorial arrangement. Collected data includes thrips numbers (at 4 and 5 WAP), and visual injury ratings and single leaf areas from 5 WAP. At 4 WAP, the combination of 07-7-1020CT and FM 958 with Entrust® resulted in the lowest thrips numbers ($P \leq 0.05$). Similarly, 07-7-1020CT, 07-7-1407CT, and FM 958 combined with Entrust® resulted in the least thrips injury ($P \leq 0.05$). Finally, 07-7-1020CT and 07-7-1407CT resulted in the greatest single leaf area, despite significant ambient thrips pressure ($P \leq 0.05$). Given these data, either 07-7-1020CT or 07-7-1407CT, combined with weekly Entrust® applications, would result in the least amount of thrips damage to an organic cotton crop. Genotype had no effect on thrips numbers at 4 WAP or 5 WAP (P \> 0.05); both 07-7-1020CT and 07-7-1407CT displayed less visual thrips injury and subsequently greater single leaf area at 5 WAP ($P \leq 0.05$). Therefore, either of these lines would be good candidates for growers to utilize in an integrated thrips management system. Entrust® applications also resulted in significantly lower thrips numbers than no sprays at 4 WAP and 5 WAP ($P \leq 0.05$). Similarly, Entrust® applications significantly reduced visual thrips feeding injury and increased single leaf area by 5 WAP (($P \leq 0.10$). Mapping Study: A field trial was initiated in 2012 to evaluate the potential for molecular marker development of the thrips resistance trait. A thrips-resistant, Gossypium barbadense, cultivar ('Cobalt') was crossed with upland, G. hirsutum, cotton line (07-7-1407CT). Visual thrips injury ratings were conducted on the parent, F1, and control plots; and on the F-2 individuals at the 4-5th true leaf stage. The F2 values did not display a wide variation, but their distribution indicated the trait is multigenic. Tissue samples were collected from each F2 individual and work will continue in the lab to assess the potential for molecular marker development of the thrips resistance trait. In 2013, 204 F3 progeny rows were planted at the Texas A&M AgriLife research station near Halfway, TX, derived from the F2 07-7-1407CT x Cobalt seed collected in 2012. Each progeny was evaluated on a whole-row basis utilizing the same 1-9 visual thrips damage scale and these data will be corroborated with the F2 data. Composite leaf tissue samples were collected from each F3 row for subsequent molecular analysis. Thrips Nursery: A thrips nursery has also been maintained since 2010 for the development of new varieties with high levels of thrips tolerance. To date, we have planted 13 different crosses in the field and selected 622 individual plants and 12 whole rows since 2010 that exhibited high thrips tolerance or excellent yield and fiber quality. Currently, there are F3, F5, and F6 generations planted in the 2013 nursery. Ideally, the lines developed in the nursery will be yield-tested at the field level, similar to the aforementioned trials; and high-yielding, thrips-resistant varieties appropriate for organic production will be identified for release.

2011/09/01 TO 2012/08/31 Over 95% of cotton grown in the U.S. is genetically-modified (GM), which is prohibited for use in certified organic production systems. Greater diversity and availability of non-GM cotton varieties are needed to preserve the long-term sustainability of organic cotton systems. Performance trials on breeding lines developed for organic cotton production have demonstrated that at least 2 lines have exhibited significantly ($P=0.05$) higher levels of thrips resistance than current cultivars, with equivalent yield and fiber quality and improved storm resistance. Storm resistance is a visual rating of advantageous boll structure that would reduce cotton losses to late-season weather events (important in organic production since harvest must wait until after a killing frost). One OMRI-approved insecticide, Entrust, provides efficacy below economic threshold for adult thrips, thrips larvae and total thrips, and is significantly better ($P=0.05$) than other products tested and the untreated control. Cotton treated with Entrust also had significantly higher biomass and leaf area per plant. There were no significant differences among treatments for leaf chlorophyll content nor root and shoot length. Reducing the number of OMRI-approved insecticide to test will allow design of experiments that includes a higher number of varieties so the combination of organic pest control and resistant varieties can be evaluated for organic cotton production systems. This work has the potential to significantly improve the diversity and availability of productive, non-GM cotton varieties for organic cotton growers on the Texas High Plains. In any production system, it is

important for the long-term sustainability of the system to utilize more than one crop variety. Additionally, thrips-resistant cotton varieties have the potential for greatly improving the integrated management of thrips pests in organic cotton systems, which impacts the long-term sustainability and profitability of the system as a whole. This is especially important on the Texas High Plains, where over 95% of U.S. organic cotton is currently grown. These varieties would have dual applicability, since thrips resistance is also beneficial to conventional cotton growers. Not only would organic cotton production be improved by this research, but it could also aid in reducing pesticide use in conventional cotton systems. Since USDA-AMS has been documenting varieties grown by organic cotton farmers in their market news report Cotton Varieties Planted, the same 2 varieties have been listed; varieties that are no longer commercially available so foundation seed for planting seed production is also not available. Texas Organic Cotton Marketing Cooperative announced they can no longer provide planting seed produced by their members because GM contamination issues are difficult and breeders are not available to maintain genetically pure seed stocks. However, in mp cn 833 USDA-AMS market report, Cotton Varieties Planted 2012 crop, there are 7 varieties listed that can be approved for organic production. Three of them are new varieties from this project\'s seed company partner, All-Tex Seed, Inc.

2010/09/01 TO 2011/08/31 Results of the thrips screening project affirm that G. barbadense as a species is thrips-tolerant and that thrips-resistant characteristics from G. barbadense can be carried to the F4 generation in a G. hirsutum background following interspecific hybridization and 2 cycles of dual selection at the seedling stage and pre-harvest stage. Success with photoperiodic wild G. barbadense introgression prompted additional hybridization with day-neutral, cultivated G. barbadense varieties to improve probability of combining thrips tolerance and day-neutral flowering habit in a G. hirsutum background. Two F4 lines from the original TX110 populations were selected for multi-location performance testing in 2012. Outcomes of 2011 experiments indicate a moderate probability of success for a molecular marker development program which will be initiated in the next annual period. Of several OMRI-approved products tested, 4 were examined further for plant compensatory effects; Surround (Kaolin clay), PyGanic (Pyrethrum), Saf-T-Side (petroleum oil) and Entrust (Spinosad). Entrust, this first year, appeared to most effective at controlling thrips, while Surround-treated plots produced the highest seedling root-shoot biomass. Both the efficacy trials and compensatory trials will be reported at the 2012 Beltwide Cotton Conference and the screening project and variety trial results will be presented in a poster at the same conference.

PUBLICATIONS

2012/09/01 TO 2013/08/31 1. Type: Journal Articles Status: Published Year Published: 2013 Citation: Martini, X., J. Gustafson, N. Kincy, K. Vaugn, J. K. Dever, and C. Nansen. 2013. Positive association between thrips and spider mites in seedling cotton. Agriculture and Forest Entomology online: doi:10.1111/afe.12004. 2. Type: Journal Articles Status: Published Year Published: 2013 Citation: Eng, E. H., K. Jernigan, W. Smith, E. Hequet, J. K. Dever, S. Hague, and A. Ibrahim. 2013. Stability analysis of upland cotton in Texas. Crop Science online: doi: 10.2135/cropsci2012.10.0590. 3. Type: Other Status: Published Year Published: 2013 Citation: Dever, J. K., T. A. Wheeler, M. S. Kelley, C. Hardin, L. Schoenhals, and V. Morgan. 2013. Cotton performance tests in the High Plains and Trans-Pecos areas of Texas, 2012. Texas AgriLife Research Technical Report 13-2. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Hague, S., C. W. Smith, J. K. Dever, and K. Rathore. 2013. Enhancing cotton seed qualities through plant breeding. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: 55. Wann, D. Q., J. K. Dever, M. N. Parajulee, M. D. Arnold, and H. D. Flippen. 2013. Thrips resistance and field performance of advanced cotton breeding lines and cultivars under organic management. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Sheehan, M. N., J. K. Dever, M. D. Arnold, M. N. Castillo, J. L. Mabry, L. W. Wells, H. D. Flippin, and D. Q. Wann. 2013. Progress in screening the U.S. germplasm collection for diversity. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Flippin, H. D., J. K. Dever, M. D. Arnold, and D. Q. Wann. 2013. Greenhouse thrips screening to support development of cultivars for organic cotton production. 2013. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 8. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Vandiver, M. R., R. B. Shrestha, J. K. Dever, M. D. Arnold, and M. N. Parajulee. 2013. Managing thrips using organically approved insecticides. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 9. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Parajulee, M. N., R. B.

Shrestha, M. R. Vandiver, D. Q. Wann, J. K. Dever, and M. D. Arnold. 2013. Evaluation of organic pesticides for western flower thrips management in seedling cotton: effect of plant parameters. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America.

2011/09/01 TO 2012/08/31 1. Hinze, L. L., J. K. Dever and R. G. Percy. 2012. Genetic Variation Among and Within Improved Cultivars in the U. S. Germplasm Collection. Crop Science. 52(1): 222-230. 2. Dever, J. K., T. A. Wheeler, M. S. Kelley, D. Kerns, M. E. Riley, A. Cranmer, L. Schoenhals and V. Morgan. 2012. Cotton Performance Tests in the Texas High Plains and Trans-Pecos Areas of Texas, 2011. Texas AgriLife Research Technical Report No. 12-2 3. Vandiver, M., D. L. Kerns, B. Baugh, M. N. Parajulee, J. K. Dever and M. D. Arnold. 2012. Managing Thrips Using Organically Approved Insecticides. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 4. Wann, D. Q., J. K. Dever, M. D. Arnold and H. D. Flippen. 2012. Field Evaluation of Advanced Breeding Lines for Organic Cotton Production. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 5. Shrestha, R. B., W. O. McSpadden, J. K. Dever, M. D. Arnold, D. L. Kerns and M. N. Parajulee. 2012. Potential of Organic Pesticides for Western Flower Thrips Management in Seedling Cotton: Effect of Plant Parameters. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America.

2010/09/01 TO 2011/08/31 1. Dever, J.K., 2011. \"World Environment Day Theme - Biodiversity. In Engage, Special Edition, Issue 12, Textile Exchange. 2. Myers, G.O., F. Bourland, P.W. Chee, J.K. Dever, S. Hague, C.W. Smith, J. Zhang, E.F. Hequet and D.C. Jones. 2011. Advances in high quality conventional cottons. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 3. Dever, J. K. and M. A. Sheehan. 2011. Update of Cotton Race-Stock Screening and Phenotypic Characterization. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 4. Hinze, L., J.K. Dever and R. Percy. 2011. Genetic Diversity and Agronomic Potential of Cultivars Within the U. S. Cotton Collection. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America. 5. Morgan, V. M., C. M. Kelly and J. K. Dever. 2011. Maintaining Purity in a Conventional Breeding Program. Proceedings of the Beltwide Cotton Production and Research Conferences. National Cotton Council of America.

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Improved Organic Milk Production Through the Use of the Condensed Tannin-containing Forage Legume Birdsfoot Trefoil

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Investigator(s)	MacAdam, J. W.; Brummer, J.; Eun, J. S.; Gray, C. W.; Heleba, D.; Islam\`, A.; Reeve, J.; Shewmaker, G.; Young, A.; McMahon, D.
Performing Institution	Plants, Soils & Climate, UTAH STATE UNIVERSITY, LOGAN, UTAH 84322

NON-TECHNICAL SUMMARY

We will partner with established organic dairy producers in the Mountain West to determine the impact of replacing grass pasture with birdsfoot trefoil (BFT) on milk production and milk quality. This will be done through advanced on-farm research on working organic farms. Long-term environmental impacts on organic dairy systems will be estimated from short-term changes in nutrient utilization by organic cows, nutrient release and organic matter retention in soil, which will increase conservation and environmental outcomes relating to organically produced agricultural products. We will determine desirable traits for organically produced milk by comparing the quality of cheese made from BFT-, grass- and total mixed ration-fed cows. Milk production of BFT-fed cows is significantly higher than grass-fed cows, but per-acre herbage dry matter production of BFT is lower than for grass. Therefore, we will conduct an economic analysis to determine potential costs and benefits of the use of BFT. eOrganic Dairy will be a key tool for communication as well as data collection and dissemination during this project. Outreach strategies will be developed jointly by the project staff and cooperating producers with input from advisory panel members. We will use eOrganic, fact sheets, newsletters, pasture walks and field days to reach producers, and feature articles in local newspapers to communicate results to the public. This project has the potential to increase milk production and milk and cheese omega-3 fatty acid concentrations, and decrease nutrient release into groundwater and the atmosphere compared with current organic farming systems.

OBJECTIVES

Goals: Organic dairies are most often small, grazing-based operations. Grazing reduces mechanical harvesting, and time on pasture contributes to the health of dairy cows. However, the cool-season grasses that constitute most well-managed, rotationally stocked, irrigated dairy pastures in the West contain excessive crude protein - often as much as 20% of DM - resulting in high N concentrations in blood, milk and urine. Urine spots in pastures release ammonia to the atmosphere and leach nitrate to groundwater (Stout et al., 2000). High N levels in ruminant blood represent lost milk production and can be detrimental to reproduction (Canfield et al., 1990). The long-term goal of this project is to capture this lost nutrition and in the process, improve the profitability and

environmental sustainability of organic dairies in the Mountain West. Research carried out in New Zealand over the past 25 years has demonstrated that feeding tannin-containing forages can significantly improve ruminant livestock production, and that the forage with the best type and concentration of tannins for this purpose is birdsfoot trefoil (BFT). We will partner with regional certified organic dairy producers to compare grass-based and BFT-based pastures for forage production, milk production, and milk quality. We will also use milk from certified organic cows to document the underlying differences in ruminant nutrition, the potential impacts on soil nutrient cycling and organic matter retention, and the quality of cheeses made from grass-, BFT- and conventionally fed cows. We will also evaluate the economic costs and benefits of a BFT-based system of dairy production. Objectives: 1. Determine the potential value for organic dairies of BFT pastures compared with grass pastures for forage dry matter production, intake, milk production, and milk quality, 2. Compare the fate of the feed nutrients from organic BFT and grass by studying intake, partitioning, and excretion by organic dairy cows (total collection study), 3. Compare the rate of mineralization of fecal nutrients from organic cows fed BFT or grass and determine the potential effect of these forages on soil organic matter content, 4. Compare the cheese-making characteristics and quality of organic cheese made with milk from cows fed BFT or grass, 5. Determine the economic risks and benefits for organic dairies of converting grass pastures to BFT pastures. Outputs: Training in BFT pasture establishment and tannin effects will be organized by the PD and state co-PDs for outreach professionals in each state in the summer of 2013, and study results will be reported at these events. Information posted on eOrganic Dairy will also be distilled into a semi-annual newsletter sent to local organic and non-organic dairy producers, state outreach professionals, organic certification personnel, private crop and livestock nutrition consultants, lenders, and local, state and regional policymakers. Results of the project will be published as Extension bulletins and refereed journal articles.

APPROACH

For Objective 1, dairy producers will manage pastures and cows, and state PDs will assist in planning and collection of pasture and dairy samples. Pasture samples will be assayed for tannin and fatty acid composition, and milk samples will be assayed for composition and fatty acids. For Objective 2, a total metabolism trial will be carried out using four grass-fed and four BFT-fed organic cows. For Objective 3, feces from grass- and BFT-fed organic cows will be incubated with soil to determine rates of organic matter decomposition and nutrient release. For Objective 4, cheese will be made from drylot-, grass-, and BFT-fed cows. Taste panels will evaluate these cheeses, and their fatty acid composition will be determined. For Objective 5, economic analyses will determine the costs and benefits associated with the use of BFT compared with grass pasture for cooperating producers.

PROGRESS

2010/09 TO 2015/08 Target Audience:Target Audience Organic dairy producers, conventional dairy producers, hay producers, dairy and natural resource outreach professionals, organic certification personnel, private crop and livestock nutrition consultants, agricultural lenders, local, state, and national policy makers, local and regional consumers, and the general public. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Opportunities Two graduate research assistantships were funded by this grant: Hunt, S.R. 2014. Stem development, seeding rate, and establishment of birdsfoot trefoil (Lotus corniculatus) for organic, grazing-based dairies. Master\'s Thesis, Utah State Univ., Logan, UT. Christensen, R. G. 2015. Improvement of nutrient utilization efficiency, ruminal fermentation, and lactational performance of dairy cows by feeding birdsfoot trefoil. Doctoral Thesis, Utah State Univ., Logan, UT. In addition to these graduate students, technicians, hourly professional research assistants and undergraduate students were trained in field data collection, sample processing and laboratory analyses by MacAdam, Brummer, Eun, Islam, Reeve, Shewmaker and Ward to carry out collection of field and laboratory data. How have the results been disseminated to communities of interest?Dissemination Training workshops in pasture and grazing management, also funded by WSARE EW11-019, utilized data, publications and recommendations from this project and were targeted to outreach professionals to increase their understanding of the value of tannin-containing forages, particularly for organic producers, Cooperative Extension, forage seed industry and NRCS outreach personnel. Brummer and Shewmaker held workshops in Fort Collins, CO from 20-22 August 2013; Dallas, OR from 22-24 October 2013; and Logan, UT 27-29 May 2015. There were 80 students from: universities and extension (43), NRCS/CD (27), and industry and state agency (10). Instructors for the seminar/workshop used 12 extension employees from University of Idaho, Washington State University, Oregon State University, Colorado State University, Montana State University, Utah State University, and University of Wyoming; 1 USDA-ARS; and 1 industry instructor. Research and outreach publications not listed elsewhere: Brummer, J., G. Shewmaker, and C. Engel. 2011. Challenges and benefits of interseeding legumes into grass-dominated stands, p. 72-78. In: Proceedings, 2011 Western Alfalfa & Forage Conference, Las Vegas, NV, 11-13 December, 2011.

UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA. Brummer, J.E., G.E. Shewmaker, and C.L. Engel. 2012. Challenges and benefits of interseeding legumes into grass-dominated stands. In: Proceedings of the 5th National Conference on Grazing Lands, December 9-12, 2012, Orlando, FL. Brummer, J. and L. Villalobos. 2013. Nitrogen fertility of grass forages versus interseeded legumes. Western Alfalfa & Forage Conference, December 11-13, 2013, Reno, NV Clemensen, A.K., J.R. Reeve, and J.J. Villalba. 2014. Understanding plant secondary compounds in grazing systems; above and below ground. Society for Range Management, February 8-13, 2014, Orlando, FL. Islam, M.A. 2012. Birdsfoot trefoil: A bloat-free forage legume. Wyoming Livestock Roundup, the Weekly News Source for Wyoming\'s Ranchers, Farmers, and Agribusiness Community, Vol. 24, No. 27, November 10, 2012. Shewmaker, G.E. and L. Hooper. 2013. Interseeding legumes into grass-dominated pastures, Abstract #25 Society for Range Management, 2-8 February, 2013 Oklahoma City, OK What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Organic dairy producers, conventional dairy producers, hay producers, dairy and natural resource outreach professionals, organic certification personnel, private crop and livestock nutrition consultants, agricultural lenders, local, state, and national policy makers, local and regional consumers, and the general public. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? The PI presented data from this project at the International Grassland Congress, and data from this project were also presented at the Crop, Animal and Dairy Science meetings. Students have gained skills from collecting data for these projects, writing manuscripts and making presentations based on the results. Technical skills were also gained from designing and building pasture enclosures. How have the results been disseminated to communities of interest? The PI published a paper in the refereed proceedings of the International Grassland Congress and abstracts of presentations at the Crop, Animal and Dairy Science meetings were published as abstracts. A number of Extension publications and journal articles related to this project have been published or are accepted for publication. What do you plan to do during the next reporting period to accomplish the goals? The field work related to Obj. 1 has been completed, but field samples are being processed (freeze drying, tannin assays, forage quality assays) and data are being statistically analyzed. Obj. 2 will be carried out in the late spring and early summer of 2014. Some assays related to Obj. 3 are still in process. Milk was collected and cheese made for Obj. 4 in in 2013; those sensory data and analyses will be carried out in 2014. Economic data for Obj. 5 are still being collected and analyzed.

2011/09/01 TO 2012/08/31 OUTPUTS: \"1. The ruminal fermentation characteristics and lactational performance of dairy cows fed a hay-based diet birdsfoot trefoil were evaluated. 2. The feed intake, milk production, ruminal fermentation, and milk fatty acid profiles of dairy cows grazing birdsfoot trefoil or grass pastures effects were evaluated in the first year of a two-year study. 3. The forage production and intake of dairy cows grazing birdsfoot trefoil and grass pastures was evaluated. 4. Samples were taken for assay of tannin content and forage nutritive value of grass and birdsfoot trefoil pastures to support milk production and milk quality data. 5. Economic data was collected from all of the dairy producers participating in this grant. 6. Milk from organically fed cows grazing grass pastures and birdsfoot pastures was collected on two dates, along with milk from cows fed a total mixed ration, and parmesan cheese was made. 7. The PD attended a NIFA Organic PD conference in October of 2012, and presented intake and milk production results at the American Society of Agronomy annual meeting in October of 2012. 8. A presentation on fiber development in birdsfoot trefoil was made at the Crop Science Society of America meeting, and a related manuscript was submitted for review to Annals of Botany PLANTS. 9. A presentation on the establishment of birdsfoot trefoil on five organic dairy farms was made at the CSSA meetings\" PARTICIPANTS: The PD is Jennifer MacAdam. Co-PDs on this grant are Jong-Su Eun and Allen Young (ADVS), Don McMahon and Robert Ward (NDFS), Jennifer Reeve (PSC), and five others from Idaho, Wyoming, Colorado, and Vermont. Two USU graduate students are supported by this proposal, along with numerous USU undergraduate students. TARGET AUDIENCES: \"Dairy and beef producers Extension specialists Industry personnel Scientific communities\" PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Soil samples were taken in mid-summer of 2010 from the land assigned to grass and birdsfoot trefoil (BFT) pasture treatments on all cooperator farms, analyzed, and amendment recommendations were made based on results. Initial economic data were also collected in mid-summer of 2010 and completed by spring of 2011. Pastures in which BFT was to be established, which were in long-established sod, were ploughed in autumn 2010. Through discussions with producers, and to address concerns that further cultivation would result in better establishment of a new perennial pasture, the decision was made to delay planting of birdsfoot trefoil until late summer/early autumn of 2011, and to plant oats in the spring of 2010. The additional cultivation would improve the seedbed and an oat crop would minimize weed establishment while

providing feed. Spring of 2011 was cold and wet across the study area, so this was a good decision in retrospect. The graduate student supervised by MacAdam, Sara Hunt, spent a week on each cooperator\'s farm in the summer of 2011, contributing her work, getting to know the producers and becoming familiar with their operations. OMRI-certified seed coating was carried out just before seed was shipped, and BFT pastures were planted on all cooperator farms between late July and early September. To facilitate the on-farm research that is planned for 2012, grazing cells were designed for each cooperator farm, and initial fencing and watering infrastructure was installed. A seeding rate study begun in June of 2010, after announcement of the award but before funding was awarded, was harvested twice in 2011. An establishment study was carried out on the Idaho and Utah producers\' BFT pastures following planting in autumn of 2011. During spring of 2011, BFT tannins were purified and preliminary assays on BFT and grass herbage, root and soil samples were carried out. Dissemination: Three articles were disseminated to producers on this project as well as to other Organic Valley dairy producers, and to the members of the Advisory Panel. Their titles are How Does Birdsfoot Trefoil Increase Ruminant Productivity, What is the Best Seeding Rate for Birdsfoot Trefoil, and Establishment of Birdsfoot Trefoil. These articles are also available through the project\'s web space on eOrganic Dairy. PARTICIPANTS: Cooperators: The project originally included seven cooperators; one of these was Aurora Organic Dairy (AOD). Their participation became circumscribed to the extent that we felt the data collected from their pasture would not contribute to the project, so we essentially replaced them with a seventh Organic Valley producer. Our only AOD expenditure was for seed. A birdsfoot trefoil pasture was established at AOD and should allow them to make some worthwhile observations. Having this pasture on the AOD farm will also give co-PI Brummer (Colorado) the opportunity to continue to interact with AOD on this and other projects, and to deliver information on BFT, its benefits and use. Individuals: In this initial year of the project, the participants were the project director, Jennifer MacAdam, co-investigators Wilson Gray, Jennifer Reeve, Anowar Islam, Joe Brummer, and Glenn Shewmaker, graduate research assistant Sara Hunt, and technician Lance Pitcher. MacAdam worked with producers to determine the best strategy for establishment, acquired seed and seed coating, and made arrangements to deliver seed to co-PIs or producers. Gray worked with producers to acquire economic data, and Reeve sampled or supervised soil sampling and analyses, and made amendment recommendations. Islam, Brummer and Shewmaker advised producers and facilitated economic and soil data collection. MacAdam worked with producers on initial grazing cell designs, and Pitcher and Hunt continued this interaction with producers in acquiring materials and carrying out initial fencing infrastructure installations. MacAdam and Reeve designed the seeding rate study, and MacAdam, Pitcher and Hunt seeded the study and harvested it in 2011. Hunt designed the establishment study and carried it out in autumn of 2011. MacAdam and Hunt developed a protocol for tannin purification and assay, and Hunt carried out initial tannin assays. MacAdam wrote the first draft of the three articles that were disseminated to organic dairy producers, and solicited input from Islam, Brummer and Shewmaker to develop these articles into Extension publications. TARGET AUDIENCES: MacAdam participated in three focus groups comprised of beef producers. Information from work done on this organic dairy proposal, such as the seeding rate study, was disseminated informally to these individuals. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Accomplishments This grant had three major goals: 1. Conduct advanced on-farm research on working organic dairy farms by comparing the daily milk production of cows grazing commonly used perennial grass pastures with the daily milk production of cows grazing pastures composed primarily of the tannin-containing, non-bloating perennial legume birdsfoot trefoil (BFT). Although we encountered some challenges with BFT establishment, we accomplished this goal by demonstrating that milk production on well-established BFT pastures averaged 18.5% greater than on well-established mixed grass pastures. This outcome directly addresses the production deficit incurred when organic milk producers are required by the \"pasture rule\" to use seasonal grazing to provide at least 30% of dry matter intake. 2. Examine optimal conservation and environmental outcomes relating to organically produced agricultural products by quantifying the nitrogen use efficiency and methane gas emissions of cows fed the non-bloating, tannin-containing perennial legume BFT compared with cows fed alfalfa, a non-tannin-containing perennial legume or perennial grass pastures. We found that nitrogen use efficiency was improved, even on low-tannin BFT pastures compared with grass pastures. When a higher-tannin BFT hay was fed, rumen ammonia, milk urea nitrogen and the nitrogen concentration of urine were all reduced in comparison with alfalfa hay. In an in vitro study of rumen digestion, methane emissions were reduced regardless of supplementation when diets were based on BFT compared with orchardgrass. 3. Determine desirable traits for organic commodities by comparing the quality of cheese made from the milk of cows on organic dairy farms grazing BFT pastures or grass pastures with cheese made from the milk of cows on a conventional dairy fed a total mixed ration (TMR). Cheddar cheeses

made from the milk of cows grazing BFT or grass pastures were compared with cheddar made from the milk of cows fed a TMR in confinement. While an expert sensory panel detected some less-desirable taste characteristics, particularly in the grass-based cheese, both the grass- and BFT-based cheeses had significantly higher concentrations of anti-carcinogenic conjugated linoleic acid. Both pasture-based cheeses, but particularly the BFT-based cheese, had much more favorable ratios of omega-6 to omega-3 fatty acids. Our research and extension efforts were organized around five objectives: Obj. 1. Determine the potential value for organic dairies of BFT pastures compared with grass pastures for forage dry matter production, intake, milk production, and milk quality. On seven cooperating organic dairy farms, 10 acres of existing grass pasture was replaced with BFT pasture. Existing pastures were plowed in the fall of 2010 and oats were planted in spring of 2011. In early fall of 2011, oats were cultivated and BFT was broadcast seeded. The two WY farms ceased milk production before data could be collected, although excellent stands were established on one and on a 6-acre pasture at Aurora Organic Dairy in Platteville, CO, and remained productive through 2015. Two of the remaining five farms carried out milk yield and quality studies in 2012, but one of these stands was so severely overgrazed that the BFT did not recover in 2013. The BFT stands on the remaining three organic dairy farms were compromised by weeds or poor irrigation. Therefore, our analysis of forage and milk production has focused on the dairy farm where a good stand of BFT was achieved in the year after planting, and maintained by good grazing management. Successful establishment was due to a well-established system of crop rotation that minimized the weed bank; a lateral-roll sprinkler rather than flood irrigation; and the ability to greenchop weedy spring growth in 2012, which allowed optimal development of seedling BFT plants. On well-established BFT, intake and milk production were significantly greater in both 2012 and 2013 than on grass pastures. Obj. 2. Compare the fate of the feed nutrients from organic BFT and grass by studying intake, partitioning, and excretion by organic dairy cows (total collection study). Nitrogen use efficiency of pasture-fed cows was improved on BFT pastures due not only to the presence of tannins, but also to lower fiber and higher non-fibrous carbohydrate concentrations in BFT compared with mixed-grass pastures. Cows were fed either BFT or alfalfa hay as part of a TMR (40:20:40 hay:corn silage:concentrate) in a crossover design. This BFT cultivar had a tannin concentration approximately twice that of the cultivar used in the grazing study. Both the milk urea nitrogen concentration and the ratio of urinary-to-fecal nitrogen concentration were lower for cows fed BFT hay. Ruminal ammonia concentration was approximately half as great for cows fed BFT as for cows fed alfalfa hay. In a further study, cows were fed TMRs differing in the source of hay; treatments were BFT hay, alfalfa hay, or an equal mixture of both. The cows fed BFT hay or mixed alfalfa and BFT hay tended to have higher milk production, which was attributed to improved fiber digestion in these two treatments. In an vitro study, diets were based on either BFT or orchardgrass that was unsupplemented, supplemented with ground barley, or used as part of a TMR. These supplements did not change the results, which were that rumen ammonia nitrogen concentrations and enteric methane emissions were lower for BFT- compared with orchardgrass-based diets. Obj. 3. Compare the rate of mineralization of fecal nutrients from organic cows fed BFT or grass and determine the potential effect of these forages on soil organic matter content. In a study of the nitrogen mineralization of feces collected from cows grazing BFT or mixed grass pastures, no significant difference was found. However, in a separate experiment, the nitrogen mineralization of the feces of steers fed the higher-tannin legume sanfoin plus tall fescue grass was reduced compared with feces of steers fed the non-tannin legume alfalfa plus tall fescue grass. These findings indicate that tannins do have the potential to slow the nitrogen mineralization of feces in the soil. Obj. 4. Compare the cheese-making characteristics and quality of organic cheese made with milk from cows fed BFT or grass. Cheddar cheese was made with milk collected on two dates from the milk of cows on a conventional TMR diet and from cows grazing either BFT or mixed grass pasture and supplemented daily with 10 lbs. of barley grain and minerals. The BFT- and grass-based cheeses differed from the TMR-based cheese by having 16 and 22% less fat, respectively. After aging, the three cheeses were compared by a trained descriptive sensory panel. For most flavor descriptors (e.g., sulfur, brothy, nutty, sour, salty, sweet), there were no differences. However, mothball and grassy descriptors were detected for both pasture-based cheeses, and were more pronounced for the grass-based cheese; barny was used to describe the grass-based but not the BFT-based cheese. When the fatty acid composition was assayed, the grass- and BFT-based cheeses had 54 and 56% greater conjugated linoleic acid (CLA), respectively, than the TMR-based cheese; CLA has anti-carcinogenic activity. Low omega-6 to omega-3 fatty acid ratio is a highly desirable trait, and the grass- and BFT-based cheeses were 55 and 66% lower than the TMR-based cheese. Obj. 5. Determine the economic risks and benefits for organic dairies of converting grass pastures to BFT pastures. The statistical analysis of milk production and milk components has just been completed (November 2015), so the economic analysis has not been finalized. However, BFT was established with minimal feed loss from the 10 acres of land used in this study, and where a good stand of BFT was established, milk production was 21% (P \< 0.01) and 16% (P = 0.01) greater in the first and second years following planting. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2015 Citation: Conference Proceedings MacAdam, J. W., Hunt, S. R., Griggs, T. C., Christensen, R., Eun, J.- S., Ward, R. E., McMahon, D. J. (2015). Enhanced forage intake and milk production on birdsfoot trefoil pastures in the western US. Proceedings of the 2015 Organic

Agriculture Research Symposium, 25-26 Feb 2015, La Crosse, WI. 2. Type: Other Status: Published Year Published: 2015 Citation: Refereed Journal Articles Hunt, S. R., MacAdam, J. W., Reeve, J. (2015). Establishment of birdsfoot trefoil (Lotus corniculatus) pastures on organic dairy farms in the Mountain West USA. Organic Agriculture, 5, 63-77 3. Type: Other Status: Other Year Published: 2015 Citation: Other MacAdam, J. W., Hunt, S. R. (2015). Using a rising plate meter to determine paddock size for rotational grazing. AG/Forages/2015?01pr. Utah State University Cooperative Extension Service, Logan http://extension.usu.edu/htm/publications/publication=15793&custom=1

2012/09 TO 2013/08 What was accomplished under these goals? Obj. 1. Milk production of cows grazing either BFT or grass pasture was investigated for six weeks on three commercial organic dairy farms. Ten to 18 multiparous cows in mid-lactation were paired by previous milk production, parity, and days in milk, and randomly assigned to the grazing treatments. Production from BFT-fed cows was significantly higher than from grass-fed cows. This result could increase milk production on pastures sufficiently to overcome the production gap with large industrial organic dairies that feed a primarily grain- or TMR-based diet year-round. Obj. 2. Fencing was completed on two dairies on which data had not been collected in 2012, and data for forage production and intake as well as forage nutritive value and tannin content were collected on the three organic dairy farms from which milk production data were collected. Forage production and intake was higher on BFT pastures than on grass pastures. Tannin and forage quality data have not yet been determined. The superior growth and quality of the deep-rooted perennial legume birdsfoot trefoil is advantageous compared with grass pastures in mid-summer. Obj. 3. Feces from grass-fed and birdsfoot trefoil-fed cows was freeze dried and incubated in soil to determine rate of nitrogen mineralization. This study is ongoing. Obj. 4. Milk of TMR-, BFT- and grass-fed milk cows was collected on two occasions and used to make cheddar cheese. Cheese from 2012 was tested for fatty acid content, and the omega-3 fatty acid content of cheese from BFT-fed cows was significantly higher than that of cheese from grass-fed cows, which was higher than the omega-3 fatty acid content of cheese from TMR-fed cows. Consumers are interested in the superior quality and potential health benefits of organic dairy products, and these results suggest a further added value from cows fed birdsfoot trefoil. Obj. 5. Relevant economic data was collected from all producers involved in the organic dairy project in 2012. Data have not yet been summarized. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: MacAdam, J. W., Hunt, S. R., Martini, S., Christensen, R. G., Eun, J.-S. (2013). In P. Nichols et al. (Ed.), Meat and milk production on irrigated birdsfoot trefoil pastures in the Mountain West USA (pp. 501-502). Proceedings, 22nd International Grasslands Congress, 15-19 September 2013, Sydney, Australia 2. Type: Journal Articles Status: Published Year Published: 2013 Citation: Hafla, A. N., MacAdam, J. W., Soder, K. J. (2013). Sustainability of US Organic Beef and Dairy Production Systems: Soil, Plant and Cattle Interactions. Sustainability, 5, 3009-3034. 3. Type: Other Status: Published Year Published: 2013 Citation: Christensen, R.G., Eun, J.-S., Young, A., MacAdam, J. W. (2013). Lactational performance and ruminal fermentation profiles of dairy cows fed diets containing birdsfoot trefoil hay. ((Suppl. 1) ed., vol. 96, pp. 514). J. Dairy Sci. 4. Type: Other Status: Published Year Published: 2013 Citation: Christensen, R.G., Eun, J.-S., Young, A., MacAdam, J. W. (2013). Milk production and ruminal fermentation characteristics of dairy cows grazing birdsfoot trefoil pasture on a commercial organic dairy farm. ((Suppl. 1) ed., vol. 96, pp. 511). J. Dairy Sci. 5. Type: Other Status: Other Year Published: 2013 Citation: MacAdam, J. W., Griggs, T. C. (2013). Irrigated Birdsfoot Trefoil Variety Trial: Forage Nutritive Value. AG/Forages/2013?02pr. Utah Cooperative Extension Service, Logan.Utah Cooperative Extension, Logan, Utah. 6. Type: Other Status: Other Year Published: 2013 Citation: MacAdam, J. W., Griggs, T. C. (2013). Irrigated Birdsfoot Trefoil Variety Trial: Forage Yield. AG/Forages/2013?01pr. Utah Cooperative Extension, Logan, Utah. 7. Type: Other Status: Other Year Published: 2013 Citation: MacAdam, J. W., Brummer, J., Islam, A., Shewmaker, G. (2013). The benefits of tannin-containing forages. AG/Forages/2013?03pr. Utah Cooperative Extension Service, Logan.

2011/09/01 TO 2012/08/31 \"The new applied knowledge that was generated by this project: Preliminary data suggest that production and intake of birdsfoot trefoil pasture is much greater than production and intake of grass pasture, especially during the hottest part of the summer. This, along with differences in forage quality, resulted in significantly higher milk production by organic dairy cows on birdsfoot trefoil pastures than on grass pastures. These data are of most value to organic dairy producers. but will be of increasing interest to dairy producers where ammonia emissions are regulated, such as in California. Other studies have determined that ammonia emissions are significantly reduced and production is increased in cows fed birdsfoot trefoil as compared with alfalfa as part of a total mixed ration, increasing the interest in our results.\"

2010/09/01 TO 2011/08/31 Organic Seeding Rate Study: The generally recommended seeding rate for birdsfoot trefoil is 6.7 kg/ha (6 lbs./acre) pure live seed (PLS). Planting a companion crop is not recommended for conventional establishment, and autumn planting of birdsfoot trefoil and other perennial legumes is

recommended because annual weed competition is less than in spring. The organic seeding rate study was designed to test spring and autumn planting, with and without an oat companion crop, and to test seeding rates of 3.4, 6.7, 20.2, and 33.6 kg/ha (3, 6, 18 and 30 lbs./acre) PLS. Initial results from the organic seeding rate study indicate that yield in the year following establishment is higher when BFT is seeded without a companion crop, regardless of whether seed is planted in spring or autumn. A seeding rate of 20.2 kg/ha (18 lbs./acre) results in higher yield and (by observation) fewer weeds than lower seeding rates, and no benefit accrues to a higher seeding rate. A second year of data will be collected before the results of this study are published. Establishment Study: Preliminary data indicate that irrigation has a significant impact on germination of fall seedings, with sprinkler irrigation showing the greatest success. Additional data will be collected in spring of 2012 to assess winter kill and germination of hard seed.

PUBLICATIONS

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

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

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Development of Tech. Training and Support for Ag. Service Providers & Farmers in Certified Organic Dairy Production Systems Through Eorganic

Accession No.	0222469
Subfile	CRIS
Project No.	VT-0063CG
Agency	NIFA VT.
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21361
Proposal No.	2010-01944
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Darby, H.; Daley, C.
Performing Institution	Extension Administration, UNIVERSITY OF VERMONT, BURLINGTON, VERMONT 05405

NON-TECHNICAL SUMMARY

Over the past ten years, organic dairy production has been the fastest growing sector of the organic market (McBride and Greene, 2009). However, research-based information on organic dairy farming techniques is lagging and many agriculture service providers have had little training or experience in offering technical advice and analysis of organic dairy operations (Jones, 2007). Federal and state funding for organic research and financial support for technical services has failed to keep pace with this growth (Wheeler, 2008). Today\'s economic crisis has accelerated the maturation of the organic dairy industry and the realization that planning for a continued annual 20% increase in demand is likely unrealistic. Early organic dairy adopters were established farmers who realized the demands that transition would place on their production practices and had good support by the few existing field staff. The change in NOP regulations attracted farmers who had little organic production experience and few support services. Steep increases in recent feed and fuel costs have added financial strain to all organic dairy farms. The U.S. economic crisis has lead to a stagnant and, in some cases, even declining market which has resulted in lower pay prices for organic dairy producers. Unfortunately, there have been very few support services to assist farmers in adapting production processes to cut costs. The crises in organic dairy has highlighted that assistance for the more than 2,030 U.S. organic dairy farms remains underserved. To sustain organic dairy farms, agricultural service providers need training in organic dairy production systems and the USDA NOP. Dramatic changes in demand for organic dairy products have necessitated balancing of supply by lowering farmer pay price and restricting production. Today, organic dairy farmers will need to develop production practices that are based on fluctuating pay price, low cost production and full utilization of their own forages (NODPA, 2010). This project develops an innovative educational strategy to increase the number of knowledgeable service providers and profitable dairy farmers. The first step will be through the development of high quality curricula. Materials will be developed by extensive collaboration among top organic dairy leadership in the U.S. We also recognize that internet usage on dairy farms lags behind other agricultural producers and know that not all farmers and service providers enjoy learning in isolation. Farmers already spend many long days alone and enjoy the social interaction that meetings provide. To overcome these barriers we have

developed an innovative learning strategy that will give our stakeholders access to high quality content while providing a regional social networking among producers and those that serve them. Part of ensuring knowledgeable future service providers is providing them with good foundation. This eXtension project will develop and demonstrate educational tools for county Cooperative Extension personnel and other agricultural professionals who advise producers on organic dairy practices.

OBJECTIVES

The objectives for this project are as follows: 1. To develop organic dairy production systems training materials (articles, webinars, videos, powerpoint presentations, and two online courses) through eOrganic for U.S. Extension educators, USDA NRCS personnel and other service providers, and the farmers with whom they work. Continuing Education Credit may be earned by professionals who successfully complete the courses, thereby creating a \"Train-the-Trainer Certificate Program\" ideally approved by the NOP. In addition, curricula will be available for universities and colleges to adopt or integrate into their programs for students interested in organic agriculture. 2. To deliver the organic dairy training materials to no fewer than 500 service providers and farmers across the country, and evaluate the effectiveness of the content and online delivery approaches. 3. To develop and/or strengthen service provider-to-farmer networks to enhance support systems for the organic dairy farming community as well as build capacity for service providers so they may work more effectively with the farmers they serve. The training materials will be shared on a national level through live and recorded webinars, videos, powerpoint presentations, and written material. All content developed will go through a peer-review process. Material will also be presented at regional hubs around the country where producers and professionals can participate in an online learning group setting. Content developed will be used to create two online courses from which service providers can earn Continuing Education Credit.

APPROACH

This project will conduct activities to meet the following objectives: Objective 1. eOrganic training materials (articles, videos, webinars, and two on-line courses) will be developed to provide education to U.S. Extension educators, USDA NRCS personnel and other service providers, and the farmers with whom they work, on certified organic dairy production systems. Continuing Education Credit can be earned by professionals and curricula for undergraduates will be available for universities and colleges to adopt or integrate into their programs. To that end, the courses will constitute a \"Train-the-Trainer Certificate Program.\" Online Courses. The culmination of all materials developed for this project will be the creation on two online, asynchronous courses: 1) An Introduction to Organic Dairy Production Systems, and 2) Advanced Organic Dairy Production. The on-line organic dairy production courses will be developed as content modules that are posted to the eXtension\'s online course site designed for the general public at http://campus.extension.org. eXtension uses Moodle for its online course development. Objective 2: Delivery of training materials to U.S. service providers and farmers Training materials will be delivered to no fewer than 500 service providers and farmers across the U.S. Upon completion of content development, press announcements will be created and distributed through multiple communication channels announcing their availability. Articles, narrated powerpoints, and FAQs will be published on eXtension.org and we will monitor their use through Google Analytics, a web statistics service. Videos will be made available on both eOrganic\'s YouTube channel as well as eXtension.org with accompanying audio text. Objective 3: Facilitation of service provider-farmer networks The long-term success of the organic dairy farming community depends upon strong, trustworthy support systems. This project will build service provider-to-farmer as well as provider-to-provider networks for the benefit of farmer support and increased research and education collaboration. To that end, we propose to develop four regional learning hubs (one each in the Northeast, South, Mid-west, and West). These hubs will serve several purposes: 1) provide a gathering place for farmers and service providers to view the webinars together as co-learners; 2) provide access for farmers who do not have high-speed Internet to access this information; 3) act as focus groups where service providers and farmers will provide feedback on the webinars; and 4) provide local support groups (based on the farmer-discussion group model). Regional hubs will also be able to develop educational information pertinent to the geographical area and climate. Each region will have a hub coordinator that organizes the groups and provides follow-up assistance (i.e. directing participants to appropriate resources and/or planning follow-up field-based events). Progress 09/01/10 to 08/31/15 Outputs Target Audience:The target audience for this reporting period included farmers (certified organic dairy farmers and those considering a transition to certified organic production) as well as professionals that currently work and/or aspire to work with organic dairy farmers. These professionals include Extension personnel, researchers, certified crop advisers, veterinarians, non-profit staff, USDA NRCS employees, and other agricultural service providers. During this reporting period, the project reached more than 50,900 with its videos, peer-reviewed articles, webinars and webinar recordings, and online courses. Changes/Problems: Nothing

Reported What opportunities for training and professional development has the project provided?This project was an eXtension project type and therefore focused on developing training materials and providing professional development to agricultural service providers, farmers, and students. Aspreviously described, webinars, articles, videos, conference broadcasts, and online courses were developed as tools to provide service providers, farmers, and others with professional development around certified organic dairy production systems. This eXtension project filled a critically needed niche of developing high quality, peer-reviewed certified organic dairy training materials, and distributing these materials across the U.S. to farmers, Extension educators, and others who advise producers on organic dairy practices. As a result of the project, these professionals increased their knowledge of and access to science-based, peer-reviewed curricula for use in training current, transitioning, and aspiring organic dairy farmers; in addition, they increased their knowledge of certified organic dairy production systems. From follow-up surveys of webinar participants, we know that farmers and service providers changed their behaviors as a result of what they\'ve learned from our content, including calculated dry matter intake from pastures, changed pasture management based on animal behavior, and increased the amount and quality of pasture fed to organic dairy cattle. Further, we increased eOrganic dairy team members (the Extension educators, farmers, researchers, USDA and non-profit staff, certification specialists, veterinarians, and other professionals who write, film, edit, and review our training materials) around the country from 55 at the start of this project to 95, resulting in increased communication and new research and education partnerships among those who are interested in supporting the organic dairy industry in the U.S. How have the results been disseminated to communities of interest?All project materials developed have been posted on the organic agriculture resource section of eXtension at: http://www.extension.org/organic_production. In addition, video and webinare recordings are also available on eOrganic\'s YouTube channel at: http://www.youtube.com/eorganic to extend the reach of our content to communities of interest. A variety of outreach tools were used to inform the project\'s target audiences about available materials including: 1) eXtension.org (calendar tool and news features, as well as direct listing of content); 2) social media channels including Facebook, Twitter, YouTube; 3) emails, both through direct contacts, e-newsletters, and agricultural listservs; and 4) farm conference exhibits. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported Impacts What was accomplished under these goals? Over the course of the project, the following content was developed and published to meet objective 1. The project exceeded its goal of delivering the content to service providers and farmers, described in objective 2, as follows. 136 articles were developed on a full range of topics on certified organic dairy production systems\--from certification standards and animal health and nutrition to grazing management, season extension, and soil fertility. All articles received a blind peer review to ensure high quality, relevant information; they also were reviewed by a certification specialist to make sure that all content met USDA organic standards. Analysis of viewer metrics revealed that the articles receive more than 230,770 unique views. 30 webinars were conducted on a range of organic topics including mastitis management, management intensive grazing, economics, and alternative livestock feeds. The live webinar broadcasts were attended by 2,226 (660 farmers, 1,566 Extension and university personnel, USDA employees, and other agricultural professionals). The webinar recordings received an additional 39,320 views on eOrganic\'s YouTube channel. Quick polls conducted at the close of the webinars revealed that, on average, 81% of respondents said they gained a better understanding of the topics covered as a result of the webinars; 72% said they would make a change on their farm or how they advise farmers based on what they learned. Seven instructional videos were also developed on herd health, pasture management, and dairy farm innovations. Storyboards and scripts were developed and peer-reviewed in advance of video production; edited videos were published onto eOrganic\'s YouTube Channel. The videos received more than 109,625 views. Two online, asynchronous organic dairy courses were developed. \"An Introduction to Organic Dairy Production\" and \"On the Ground: A Closer Look at Organic Dairy Pasture, Forages, and Soils,\" were offered through eXtension\'s online campus. The Introductory course was composed on ten modules on key organic dairy topics. Each module combined required readings, narrated lessons, recommended resources, and end-of-module quizzes. The advanced course was composed of five modules focused on improving livestock feeds and pasture soils. Each module had required readings, a narrated powerpoint presentation from an expert on the topic, and recommended additional resources. Both courses offered continuing education units for Certified Crop Advisors. Fifteen students (7 organic certifiers, 6 farmers, 1 Extension educator, and 1 graduate student) participated in the Introductory course online. The course was also piloted with a group of 57 undergraduate students at the California State University-Chico. Students took the course either entirely online, or online with supplemental in-person instruction. An end-of-course survey revealed that all students gained knowledge on all topics covered through the course. All but one indicated they would use the information learned in the future, mostly as they prepare for their careers in agriculture. Service provider-to-farmer networks, objective 3, were strengthened; ninety-five Extension educators, researchers, USDA and non-profit personnel, farmers, and certification specialists became members of the eOrganic dairy team with the purpose to develop and review content on certified organic dairy production systems. Publications Type: Websites Status: Published Year Published: 2015 Citation: eOrganic Community of Practice. Organic Agriculture \Online\. eXtension. eXtension Foundation. Available at: http://www.extension.org/organic_production (verified 30

Nov 2015). Progress 09/01/13 to 08/31/14 Outputs Target Audience: Target audience for this quarter was professionals that work directly with organic dairy farmers. These professionals include certified crop advisers, extension personnel, veterinarians, and other stakeholders associated with organic dairy. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? This project, \"Development of Technical Training and Support for Agricultural Service Providers and Farmers in Certified Organic Dairy Production Systems through eOrganic\" is an eXtension project type and is therefore focused on developing training materials and providing professional development to agricultural service providers, farmers, and students. As previously described in the progress report, webinars, articles, videos, conference broadcasts, and an online course have been developed to meet the project\'s goals. How have the results been disseminated to communities of interest? All published materials are posted on the organic agriculture resource section of eXtension at: http://www.extension.org/organic_production. In addition, video and webinare recordings are posted on eOrganic\'s YouTube channel at: http://www.youtube.com/eorganic. A variety of outreach tools were used to inform the project\'s target audiences about available materials including: 1) eXtension.org (calendar tool and news features, as well as direct listing of content); 2) social media channels including Facebook, Twitter, YouTube; 3) emails, both through direct contacts, e-newsletters, and agricultural listservs; and 4) farm conference exhibits. What do you plan to do during the next reporting period to accomplish the goals? Plans are underway to complete one additional online course to be peer-reviewed and published to eXtension.org. We plan to offer our current online introductory course to undergraduate students at no fewer than one university/college. During the next reporting period, we also plan to conduct 6 webinars. We will plan to conduct project evaluations during this period, including follow-up evaluations of our webinars to determine participant behavior change as a result of what they learned from the content presented. Impacts What was accomplished under these goals? This eXtension project is developing educational tools for county Cooperative Extension personnel and other agricultural professionals who advise producers on organic dairy practices. As a result of the project, we expect that service providers increase their knowledge of and access to science-based, peer-reviewed curricula for use in training current, transition, and aspiring organic dairy farmers; increase their knowledge of certified organic dairy production systems; increase their awareness of whole farms system approach on organic dairy farms; and increase their confidence in providing information and support to farmers with whom they work. Accomplishments were achieved under all three project objectives during the reporting period, as follows. Objective 1. Development of training materials. During the reporting period, 8 webinars were conducted on mastitis management, management intensive grazing and animal behavior, economics, and alternative livestock feeds. The live broadcasts were attended by 646 people (200 farmers, 446 Extension and university personnel, USDA employees, and other agricultural professionals). An additional 3,803 viewed the recordings of the webinars on eOrganic\'s YouTube channel. Quick polls conducted at the close of the webinars revealed that, on average, 87% of respondents said they gained a better understanding of the topics covered as a result of the webinars; 71% said they would make a change on their farm or how they advise farmers based on what they learned. The project team began the development of an advanced online, asynchronous organic dairy course called, \" On the Ground: A Closer Look at Organic Dairy Pasture, Forages, and Soils,\" offered through eXtension\'s Moodle campus. The course is being composed of five modules focused on improved livestock feeds and pasture soils. Each module has required readings, a narrated powerpoint presentation from an expert on the topic, and recommended additional resources. Objective 2. Delivery of training materials. During the reporting period, the project\'s 37 videos and webinar recordings were viewed 6,826 times, bringing the cumulative views of these resources to 34,474. Eight students (4 organic certifiers, 3 farmers, and 1 graduate student) participated in the Introduction to Organic Dairy Production online course during the reporting period, bringing the total online participants of the course to 14 since it was launched on the eXtension campus site. The 128 peer-reviewed articles that have been developed for the public and published on the eXtension.org site were viewed 18,555 times during the reporting period. Objective 3. Strengthen service provider and farm networks. Our eOrganic dairy membership is composed of 95 farmers, Extension educators, researchers, non-profit and USDA personnel, and industry representatives; these professionals aid in the creation and review of materials. In addition, ongoing communication of these professionals is strengthening this network of folks interesting in supporting the organic dairy community. Since the start of the project, eOrganic dairy membership has increased 73% to 95 members. The membership has helped improved the quality of materials developed for the project (through peer- and NOP-compliance reviews) as well as given an opportunity to coordinate eOrganic outreach efforts with other USDA NIFA OREI funded projects. Publications Type: Websites Status: Published Year Published: 2014 Citation: http://www.extension.org/organic_production

PROGRESS

2012/09 TO 2013/08 Target Audience: During the reporting period, we offered 6 webinars which were attended by 550 people, including: 214 farmers, 124 Extension and other university personnel, 67 USDA employees, and 145 other agricultural professionals. An additional 2,370 viewed the recordings of the webinars on eOrganic's

YouTube channel. Our 7 peer-reviewed videos on organic dairy production topics posted to YouTube received 25,531 views during the reporting period, mostly (73%) by males between 45 and 64 years of age. We conducted one conference broadcast; this was an effort of our regional learning hubs. Here, a panel of farmers at the Vermont Organic Dairy Conference was broadcast to the the NOFA-NY Organic Dairy and Field Crops Conference. It reached a combined audience of 134 farmers and others. A group of 57 undergraduate students at the California State University\--Chico piloted "An Introduction to Organic Dairy Production," an online course developed by the project. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? This project, \"Development of Technical Training and Support for Agricultural Service Providers and Farmers in Certified Organic Dairy Production Systems through eOrganic\" is an eXtension project type and is therefore focused on developing training materials and providing professional development to agricultural service providers, farmers, and students. As previously described in the progress report, webinars, articles, videos, conference broadcasts, and an online course have been developed to meet the project\'s goals. How have the results been disseminated to communities of interest? All published materials are posted on the organic agriculture resource section of eXtension at: http://www.extension.org/organic production. In addition, video and webinare recordings are posted on eOrganic\'s YouTube channel at: http://www.youtube.com/eorganic. A variety of outreach tools were used to inform the project\'s target audiences about available materials including: 1) eXtension.org (calendar tool and news features, as well as direct listing of content); 2) social media channels including Facebook, Twitter, YouTube; 3) emails, both through direct contacts, e-newsletters, and agricultural listservs; and 4) farm conference exhibits. What do you plan to do during the next reporting period to accomplish the goals? Plans are underway to complete at least one additional online course to be peer-reviewed and published to eXtension.org. During the next reporting period, we also plan to publish 3 instructional video clips, 6 farmer case studies, 7 narrated powerpoint presentations; in addition, we plan to conduct 10 webinars. We will plan to conduct project evaluations during this period, including follow-up evaluations of our webinars to determine participant behavior change as a result of what they learned from the content presented.

2011/09/01 TO 2012/08/31 OUTPUTS: Certified organic dairy agriculture has been the fastest growing sector of the organic market, yet little related research currently exists and there is an information gap among educators and agriculture service producers on this organic production system. To provide farmer support needed throughout the country, this project, funded by the USDA Organic Agriculture Research and Extension Initiative (OREI), is developing research-based content (articles, videos, webinars, and two online courses) to build a network of agricultural service providers knowledgeable and confident about organic dairy production systems who are better able to provide direct assistance to current and/or aspiring organic dairy farmers. The content is being developed by the eOrganic dairy team (see eorganic.info), a group of more than 60 researchers, educators, farmers, certifiers, veterinarians, and other service providers across the country who have certified organic dairy farming experience. It is published on eXtension.org, an Internet-based collaboration among land grant universities across the U.S. to exchange and provide objective, research-based knowledge to the public. During the reporting period, we launched a pilot of an Introduction to Organic Dairy Production Systems online course. The course is being taken and evaluated by 56 undergraduate students at the California State University at Chico, half of which are participating in an asynchronous offering, and half taking the course with real-time instruction by Dr. Cindy Daley, co-director of this project and manager of the university organic dairy farm. We also conducted six webinars and conference session broadcasts on timely organic dairy topics, including soil and weed management in pastures, herd health, and breeding and genetic considerations. The live webinars and conference broadcasts reached 613 farmers and ag service providers, and an additional 1,352 people who viewed the session recordings on the eXtension.org website or on YouTube during FY12. Webinar participants came from 42 U.S. states, 6 Canadian provinces, and 9 other countries around the globe. One third of the participants were farmers; the rest were Extension educators and university personnel, NRCS and other USDA staff, certifiers, industry personnel, and other interested citizens. In addition, during the FY12 reporting period, we developed and updated ten peer-reviewed articles and developed and published five peer-reviewed instructional videos. Topics addressed included certification requirements, pest management, herd health practices, and pasture improvement strategies. Over the reporting period, the articles were viewed by 1,873 visitors and the videos were viewed by 3,754. All published content can be accessed at: eXtension.org/organic production. The eOrganic dairy team will continue to develop content, including advanced online coursework, within the next two years. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: During the reporting period, we developed and published four peer-reviewed articles and seven peer-reviewed instructional videos. We conducted seven webinars conducted on

timely topics. We piloted a regional learning hub at the January 13, 2011 Vermont Organic Dairy Producer Conference where a guest speaker provided her keynote presentation virtually to a live audience of approximately 94 dairy producers and others. Events: Seven webinars were conducted during the reporting period as follows. Cumulatively, 548 (115 farmers and 452 ag service providers) participated in the live broadcasts of the webinars, and an additional 3,557 people viewed the webinar recordings on the eXtension.org website or on YouTube. Maximizing Dry Matter Intake on your Organic Dairy Pastures, with speaker Karen Hoffman, USDA NRCS, 9/16/2010. 92 participated in the live session; 146 views of the archived recording. Setting up a Grazing System on Your Organic Dairy Farm, with speakers Sarah Flack, Sarah Flack Consulting, and Cindy Daley, California State University, Chico, 10/1/2010. 80 participated in the live session; 156 views of the archived recording. Transitioning Organic Dairy Cows Off and On Pasture, with speaker Rick Kersbergen, University of Maine, 11/23/2010. 67 participated in the live session; 77 views of the archived recording. Shades of Green Dairy Farm Calculator, with speaker Charles Benbrook, The Organic Center, 2/1/2011. 73 participated in the live session; 157 views of the archived recording, and 185 views of recording. Using Small Grains as Forages on Your Organic Dairy, with speaker Heather Darby, University of Vermont Extension, 4/14/2011. 62 participated in the live session; 481 views of the archived recording. Fly Management in the Organic Dairy Pasture, with speakers Donald Rutz and J. Keith Waldron, NYS IPM Program, Cornell Cooperative Extension. 92 participated in the live session; 548 views of the archived recording. Stockpiling Forages to Extend the Grazing Season on Your Organic Dairy, with Laura Paine, Wisconsin Department of Agriculture, Trade and Consumer. 82 participated in the live session; 337 views of the archived recording. Products: 4 peer-reviewed articles were published onto eXtension.org during the reporting period. Access to Pasture Rule New and Revised Definitions (69 views) An Overview of the Access to Pasture Rule on Organic Dairy Farms (80 views) Finding a Pasture Stick in Your Area for Your Organic Dairy Farm (215 views) How to Comply with the Pasture Rule on Your Organic Dairy Farm: A 10 Step Summary (179 views) 7 instructional videos were created and published to the YouTube channel. Calculating Paddock Size on Organic Dairy Pastures (909 views) Calculating Dry Matter Intake in Organic Pastures Using a Pasture Stick (1,254 views) Creating a Grazing Map in Accordance with the New Access to Pasture Rule (259 views) Innovations on an Organic Dairy: Successful Calf Rearing (5 views) Innovations on an Organic Dairy: \"The Fly Barrel\" (15 views) Innovations on an Organic Dairy: California Mastitis Test (8 views) Healthy Cow: How to Perform a Physical Exam (8 views) PARTICIPANTS: Individuals: Heather Darby, University of Vermont, PI, oversees project and provides project leadership Cindy Daley, Chico State University, Co-PI, provides project leadership, leads online course development, regional learning hub coordinator Debra Heleba, University of Vermont, project staff, assists PI and co-PI with project leadership, manages project content development, regional learning hub coordinator Amanda Gervais, University of Vermont, project staff, develops instructional videos Harriet Behar, MOSES, regional learning hub coordinator, developed instructional videos Marti Day, North Carolina State University, regional learning hub coordinator, Sarah Flack, grazing specialist, content and video development Partner Organizations: Northeast Organic Dairy Producers Alliance, Ed Maltby, Executive Director Oregon State University, Alex Stone, Lead for eOrganic.org eXtension Foundation TARGET AUDIENCES: Please read attached sections from the Outputs and outcomes sections of this report PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2012/09 TO 2013/08 What was accomplished under these goals? Over the past ten years, organic dairy production has been the fastest growing sector of the organic market. However, research-based information on organic dairy farming techniques is lagging and many agriculture service providers have had little training or experience in offering technical advice and analysis of organic dairy operations. To maintain a strong organic dairy industry, agricultural service providers need training in organic dairy production systems and the USDA National Organic Program. Therefore, this eXtension project is developing educational tools for county Cooperative Extension personnel and other agricultural professionals who advise producers on organic dairy practices. As a result of the project, we expect that service providers increase their knowledge of and access to science-based, peer-reviewed curricula for use in training current, transition, and aspiring organic dairy farmers; increase their knowledge of certified organic dairy production systems; increase their awareness of whole farms system approach on organic dairy farms; and increase their confidence in providing information and support to farmers with whom they work. Accomplishments were achieved under all three project objectives during the reporting period, as follows. Objective 1. Development of training materials. During the reporting period, 6 webinars were conducted on organic masitits management, forage production, soil health, bovine milk fats, and alternative livestock feeds. The live broadcasts were attended by 550 people (214 farmers, 124 Extension and other university personnel, 67 USDA employees, and 145 other agricultural professionals). An additional 2,370 viewed the recordings of the webinars on eOrganic's YouTube channel. Quick polls conducted at the close of the

webinars revealed that 85% of respondents said they gained a better understanding of the topics covered as a result of the webinars; 72% said they would make a change on their farm or how they advise farmers based on what they learned. Twenty-nine articles and one video were published to the organic production Community of Practice of eXtension.org. All content underwent a blind peer review to assure quality and relevance. The project team completed an online, asynchronous course called, "An Introduction to Organic Dairy Production," offered through eXtension's Moodle campus. The course is composed of ten modules addressing a range of topics related to certified organic dairy production, including certification, soil health, pasture and forages, herd health and nutrition, milk quality, and calf management. Each module has required readings, a narrated powerpoint presentation from an expert on the topic, and recommended additional resources. During the 2012 fall semester, the course was piloted among a group of 57 undergraduate students at the California State University\--Chico. Students took the course either entirely online, or online with supplemental, in-person instruction. An end-of-course survey revealed that all students gained knowledge on all topics covered through the course. All but one indicated they would use the information learned in the future, mostly as they prepare for their careers in agriculture. One student said, \"One of the best online classes I have taken.\" Another said, \"The information is solid. Being that I am headed back to my dairy, I will certainly use the knowledge I gained from this course.\" Still another said, \"Having this knowledge will really give me a \"one-up\" on a lot of other people in the industry, as the organic side of things is becoming more prevalent in farming. Whatever direction I may go in, I can always use this information to try to better operations and educate other farmers.\" Objective 2. Delivery of training materials. During the reporting period, 743 people participated in our course, webinars, and conference activities. Articles, videos, and webinar recordings developey by the project received 62,686 views between September 1, 2012 and August 31, 2013. Objective 3. Strengthen service provider and farm networks. Our eOrganic dairy membership is composed of farmers, Extension educators, researchers, non-profit and USDA personnel, and industry representatives; these professionals aid in the creation and review of materials. In addition, ongoing communication of these professionals is strengthening this network of folks interesting in supporting the organic dairy community. Since the start of the project, eOrganic dairy membership has increased 40% to 91 members. During the reporting period, we conducted one conference broadcast; this was an effort of our regional learning hubs to share farmer-to-farmer information. Here, a panel of farmers at the Vermont Organic Dairy Conference was broadcast to the the NOFA-NY Organic Dairy and Field Crops Conference. It reached a combined audience of 134 farmers and others. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Other Status: Accepted Year Published: 2013 Citation: Daley, C., H. Darby, S. Flack, A. Denney and D. Heleba. 2013. Development of technical training and support for agricultural service providers and farmers in certified organic dairy production systems through eOrganic. Poster presented at American Society of Horticultural Science Annual Conference, Palm Desert, CA. 22-25 Jul. 2013.
http://ashs.confex.com/ashs/2013/webprogram/Paper15797.html (accessed 23 Jan. 2014). 2. Type: Other Status: Accepted Year Published: 2012 Citation: Darby, H.M., D. Heleba, S. Flack, and C. Daley. 2012. Developing on-line training and national support networks on certified organic dairy production systems through eOrganic. Poster presented at: Visions for a Sustainable Planet ASA, CSSA, and SSSA International Annual Meetings, Cincinnati, OH. 21-24 Oct. 2012.

2011/09/01 TO 2012/08/31 During the reporting period, eOrganic dairy webinar participants were asked to complete a series of end-of-presentation quick poll questions as well as end-of-session online evaluations. Data from these evaluation instruments revealed that about 26% of respondents were farmers, 32% were agriculture professionals, 19% were Extension or university personnel, and 23% were other individuals. On average, 80% of respondents said they better understand the topic addressed as a result of the webinar, and 73% said the webinar significantly or moderately improved their understanding of the topic. 82% said the information presented was just right in terms of technical sophistication and 81% said they would recommend the webinar to others. Based on what they learned during the webinars, 70% of respondents said they will make changes to their farm practices or how they advise farmers based on what they learned; 31% indicated a high intention to apply knowledge gained to their work. Evaluation results included positive feedback from participants including one participant who said, What a wonderful educational opportunity. I would love to have you cover talks from technical conferences so we can all benefit from hearing more great speakers like those at this conference. A service provider remarked, I felt that this was an important webinar for our dairy farmers therefore in advance I sent a bulk email informing them of this opportunity to participate. What you are offering with your webinars is important information. Thank you. Another participant said, The webinar with Dr. Karreman was an excellent example of the valuable service that eOrganic provides. It is no exaggeration to describe Dr. Karremans work as state of the art; he is as knowledgeable about organic ruminant care as any practitioner in the country. Thanks to eOrganic, this knowledge is now available to anyone with a computer. This is the state of organic science: we didn\'t have this knowledge ten years ago, nor the technology to disseminate it, anyway. Now we have both and this is encouraging.

2010/09/01 TO 2011/08/31 During the reporting period, end-of-session evaluations were administered to our webinar participants. As a result of the webinars, on average, 80% of respondents said they had a better understanding of the topic addressed based on what they learned during the webinars, and 65% said they will make changes to their farm practices or how they advise farmers based on what they learned. In specific, 78% of respondents said they better understand the inter-relationships between pasture management, feeding, and animal behavior as a result of the webinar; 88% learned how to avoid problems in their grazing system during the webinar; 44% will change the way they feed concentrates to their cows during the non-grazing season; and 85% said they will add grains into their livestock operation or change how they advise farmers based on what they learned at the webinar. Evaluation results included positive feedback from participants including one farmer who said, \"I just wanted to say that I really love your webinars. They are the perfect way to learn- I don\'t have to take time off the farm to travel, if the information is not applicable, I can leave, and the topics are pertinent. Today was perfect \-- a cold, rainy day here \-- and I got to come in for an hour and a half, have a cup of coffee, and watch the webinar. Right after the webinar on pastures, I was inspired to head back out and make some changes to my grazing system. Thanks for inspiring and informing me!\" Another farmer said, \"The kind of research reported in the webinar provides very practical answers that are pertinent to dairy farmers with small and mid-size operations. I see that some of these findings might also apply to beef cattle, sheep, and goat producers. It is what researchers in Land Grant Universities should be doing and should be rewarded for doing.\" Another farmer stated, \"Thank you very much for providing this great service. As a busy farmer, I find it very difficult to attend on farm trainings. Webinars are great because it the experts are able to come to me.\" Industry personnel also provided feedback on our webinars, including milk processor Nancy Hirshberg, Stonyfield Farm, who said, \"I just want to thank you for the FABULOUS webinars! What an amazing resource. I hate to miss any of them. I guess I date myself by saying this, but I think back to not too long ago when farmers would ask us technical questions and there was no one to turn to for help. In fact, Extension would roll their eyes and make derogatory comments about organic. To have this great resource created by Extension is phenomenal. The webinar technology is working GREAT, and the research and information is invaluable. THANK YOU!\"

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Darby, H. 2012. Frost Seeding: A Cheap Alternative to Improve Hay and Pasture Land \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/64559 (verified 17 Oct 2012). 2. Flack, S. and L. McCrory. 2012. Transition to Certified Organic Milk Production \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18552 (verified 17 Oct 2012). 3. Flack, S. and A. Gervais. 2012. Video: Creating a Grazing Map in Accordance with the Access to Pasture Rule \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/62061 (verified 17 Oct 2012). 4. Gamroth, M. 2012. Increasing Pasture Dry Matter Intake for the Organic Dairy Herd \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/20123 (verified 17 Oct 2012). 5. Jahnke, K., H. Behar, and A. Gervais. 2012. eOrganic Video: Innovations on an Organic Dairy\--Successful Calf Rearing on Pasture and Mob Feeder \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/63674 (verified 17 Oct 2012). Jahnke, K., H. Behar, and A. Gervais. 2012. Video: Innovations on an Organic Dairy \-- California Mastitis Test \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/63691 (verified 17 Oct 2012). 6. Jahnke, K., H. Behar, and A. Gervais. 2012. Video: Innovations on an Organic Dairy: The Fly Barrel \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/62007 (verified 17 Oct 2012). 7. Karreman, H. and A. Gervais. 2012. Video: Healthy Cow Check-Up\--How to Perform a Physical Exam \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/64752 (verified 17 Oct 2012). 8. Riddle, J. 2012. Approved Health Care and Medication Regulations for Organic Dairy and Livestock in the United States \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18562 (verified 17 Oct 2012). Riddle, J. 2012. Feed, Feed Supplement, and Feed Additive Regulations for Organic Dairy and Livestock in the United States \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18563 (verified 17 Oct 2012). 9. Riddle, J. 2012. Living Condition Regulations for Organic Dairy and Livestock in the United States \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18559 (verified 17 Oct 2012). Riddle, J. 2012. Organic Dairy Certification: Why, How, and What \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18336 (verified 17 Oct 2012). 10. Riddle, J. 2012. Parasiticide Regulations for Organic Dairy and Livestock in the United States \Online\. eXtension Foundation, eOrganic

Community of Practice. Available at: http://www.extension.org/pages/18556 (verified 17 Oct 2012). 11. Riddle, J. 2012. Synthetic Substances Allowed for use in Organic Livestock Production in the United States \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/18553 (verified 17 Oct 2012).

2010/09/01 TO 2011/08/31 1. Behar, H. 2010. An Overview of the Access to Pasture Rule on Organic Dairy Farms \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/28875 (verified 28 Nov 2011). 2. Behar, H. Daley, C. Darby, H. Flack, S. Maltby, E. McCrory, L. 2010. How to Comply with the Pasture Rule on Your Organic Dairy Farm: A 10 Step Summary \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/30340 (verified 28 Nov 2011). 3. Flack, S. Gervais, A. 2010. Video: Calculating Dry Matter Intake in Organic Pastures Using a Pasture Stick \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/28874 (verified 28 Nov 2011). 4. Flack, S. Gervais, A. 2011. Video: Calculating Paddock Size on Organic Dairy Pastures \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/60289 (verified 28 Nov 2011). 5. Heleba, D.M. 2010. Access to Pasture Rule New and Revised Definitions \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/29158 (verified 28 Nov 2011). 6. Heleba, D.M. 2010. Finding a Pasture Stick in Your Area for Your Organic Dairy Farm \Online\. eXtension Foundation, eOrganic Community of Practice. Available at: http://www.extension.org/pages/28873 (verified 28 Nov 2011).

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Carbon Sequestration, Nutrient Bioavailability, and Environmental Services from Organic Agriculture

Accession No.	0223304
Subfile	CRIS
Project No.	WNP04685
Agency	NIFA WN.P
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21620
Proposal No.	2010-01965
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Carpenter-Boggs, L.; Smith, J.; Huggins, D.; Stockle, C.; Granatstein, D. M.; Higgins, S.; Zaher, U. E.; Verhey, S.
Performing Institution	Ctr for Sustaining Agric & Natural Resources (CSANR), WASHINGTON STATE UNIVERSITY, 240 FRENCH ADMINISTRATION BLDG

NON-TECHNICAL SUMMARY

This project addresses needs of 3 stakeholder groups: organic producers, organic certifying agents and agencies, and purchasers/traders of carbon credits. These groups need a scientifically sound yet simple estimation of the carbon sequestration and net greenhouse gas (GHG) balance likely in a given organic cropping system scenario. Producers will benefit from the additional information of nutrient availability and timing. A user-friendly Life Cycle Assessment tool adapted for use with organic farms will be developed and introduced to organic producers and certifying agents through in-person training sessions, a webinar on eOrganic, and eOrganic publications on using the integrated ?OFFoot? tool and the process of Life Cycle Assessment. Presentations and hands-on workshops will be made at regional and national meetings of agricultural producers and certifiers. Undergraduate majors in Organic Agricultural Systems will be targeted for summer internships to take part in both research and outreach activities. Both producers and carbon credit traders will benefit economically by access to a validated model for carbon sequestration in organic systems that will allow sale and trade of carbon credits for organic production. Environmental benefits will accrue from the sequestration of carbon, minimizing of greenhouse gas emissions, and efficiency of nutrient utilization that will all be improved by using the outputs of this project as farm management planning tools. Organic producers, organic certifying agents and agencies, and purchasers/traders of carbon credits are calling for the studies and tools proposed here. Stakeholders are involved both in developing the proposed research and models (particularly to ensure usability of resulting models), and after the models are developed (in conducting carbon, greenhouse gas, and nutrient bioavailability assessments of the ?focus farms?). Both organic producers and organic certifying agents will be trained to use the user-friendly integrated model for Life Cycle Assessment, carbon sequestration, and GHG emissions, also allowing an evaluation of the resulting output.

OBJECTIVES

Goals: Goal 1. Determine the carbon sequestration, greenhouse gas balance, and nutrient availability effects of common inputs, crops, and practices used in organic farming. Conduct laboratory and field experiments to parameterize and evaluate predictive models. Goal 2. Elaborate on the current CropSyst model to enable quantitative prediction of the carbon-, nutrient-, and greenhouse gas-related ecosystem services of operations common to organic farming. Goal 3. Develop a simplified model with LCA capabilities (OFFoot 1.0) to allow the evaluation by farmers, agencies, extension personnel, and organic certifiers of greenhouse gas (GHG) emissions, carbon sequestration, and nutrient balance under user-specified organic farms conditions. Goal 4. Conduct educational outreach and trials. Train organic producers and organic certifiers to use the LCA tool for soil C management. Goal 5. Utilize the LCA tool for a minimum of 5 commercial certified organic farms and 2 certified organic research fields. Assess the relative importance of C sequestration, N2O efflux, transportation, and input choices on a total farm carbon footprint. Outreach objectives: Introduce organic producers and certifiers to tools for assessing the soil carbon, nutrient cycling, and greenhouse gas impacts of organic farming practices and systems. Enable producers to use the tools to evaluate alternative farm management options that would improve soil and water quality and reduce greenhouse gas emissions. Milestones/dates: Stakeholder meetings to guide LCA development: Twice annual, Feb & Oct Stakeholder meeting for C, GHG, nutrient research input: As above, plus Jan 2011 and 2012 C & GHG research - model parametrization: Sept 2010 - Aug 2012 Nutrient availability research for model parameterization: Sept 2010 - Aug 2013 LCA development: Sept 2010 - Jan 2013 CropSyst enhancement: Jan 2011 - Mar 2014 Nutrient availability model: Sept 2012 - Mar 2014 Soil C, GHG, nutrient research - model validation: May 2012 - Dec 2013 LCA & CropSyst model training workshops (4): Nov 2013 - March 2014 LCA model posted to web, linked to eOrganic article: Oct 2013 LCA use on focus farms: Feb 2013 - July 2013 LCA model training webinar: Feb 2014 Final reporting April: 2014 - Aug 2014 Expected Outcomes One of the project end-products is the OFFoot 1.0 model with LCA capabilities that will contribute to the long-term profitability and sustainability of organic agriculture. This tool evaluates the GWP from organic farming and the carbon footprint of organic products. Therefore, the LCA contributes to organic farming profitability by 1) evaluating the carbon credit achieved from carbon sequestration and reduced emissions and 2) meeting the international market requirements for climate friendly products. In addition to evaluating climate change impact, the integrated tool also evaluates organic carbon and nutrient sequestration which is the main mechanism to increase soil fertility in organic farming. Assessment of emissions and soil fertility contributes to the long-term sustainability of organic agriculture.

APPROACH

We will determine the carbon sequestration, greenhouse gas balance, and nutrient availability effects of common inputs, crops, and practices used in organic farming by conducting laboratory and field experiments to parameterize and evaluate predictive models. Decomposition kinetics of these materials will be determined from lab incubations. Characterizations will be accomplished by tracking C and N pools in lab-incubated and field-applied samples We will assess the availability of macro- and micro-nutrients using short-term lab incubations with ion exchange membranes. We will develop a model, OFFoot, which will simulate carbon dynamics, account for GHG emissions and nutrient dynamics under organic management. OFFoot will be complemented by Life-Cycle Analysis (LCA) to evaluate ecosystem services of organic farming. OFFoot will be developed by farmer-collaborators and modelers/researchers. LCA will quantify carbon, nutrients and energy on organic farms in addition to off-farm manufacturing, transportation, disposal, and recycling. The modeling tools will allow optimization of organic farming subsystems and generate a Life Cycle Inventory (LCI) for each subsystem. Other ecosystem processes will be configured to expand the LCA system boundary, automate the LCA computations and evaluate the farm carbon footprint. The model-LCA tool will be applied to 5 organic focus farm case studies to assess their carbon balance. Results will support the certification process of the organic farms and determine compliance of their products to National and International market requirements. Project participants will meet twice a year with the these growers to review progress on the modeling and lab studies, and solicit suggestions for adapting the LCA to grower needs. Once the modeling tools are completed and results from the case study farms have been generated the model-LCA will be delivered to target audiences via eOrganic publications, a webinar, a workshop for certifiers, and presentations at organic conferences. The carbon, nutrient, and LCA tools will be put on line at WSU with links from eOrganic. County extension faculty will be invited to host an in-person training with the tools. The International Organic Inspectors Association and Accredited Certifiers Association will be contacted to arrange for training of their members at one of their scheduled events. Presentations will be made to growers at venues such as the Washington Tilth Producers annual conference, and at other major conferences. The impact will be measured by tracking the end-users of the LCA tool. A record will be kept of the workshops\' participants. On-line registration will be required before downloading the tool, its manuals and training webinars. The ability of the case study growers to use the models will be measured as work progresses. They will complete an evaluation regarding the learning that occurred and resultant changes in management. A pre-test/post-test evaluation will be used for the webinar and for training meetings to measure learning. Organic

certifiers will be queried about how the tools will be used to improve their evaluation of compliance with organic standards.

PROGRESS

2010/09 TO 2015/08 Target Audience:The primary target audience has beenorganic producers, both certified and non-certified. Secondary targets have beenWashington State Department of Agricultureorganic certification program; undergraduate students, and thegeneral public. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Two graduate students have completed their M.S. theses as part of this project, and two others have contributed to the project. Each of the students have gained training and professional development related to this project. In addition, four technical staff have contributed to the project who have also gained new trainings.These trainings include: M.S. in Environmental Science: 1 student M.S. in Soil Science: 1 student Life Cycle Assessment 1-day workshop: 1 student, 1 staff Open LCA training: 1 student, 2 staff Data management and R Statistical package 3-day workshop: 3 students Coursera course in Life Cycle Assessment: 1 student Mentorship in decomposition dynamics research: 2 students, 2 staff Participation in conferences: 3 students, 3 staff How have the results been disseminated to communities of interest?The team initiated public outreach for producers, professionals, and communities of interest in November 2010 with a webinar on \"Greenhouse Gases in Agriculture: Where Does Organic Farming Fit?\" Our group of farmer stakeholders and researchers held twice-annual meetings to guide the research, conduct farm tours and inspections, and to work with the Ofoot model. The primary end-product of the projectis the OFoot tool, which cancontribute to the long-term profitability and sustainability of organic agriculture. The Ofoot tool beta version was posted to the web in September 2013, and updated versions approximately each 6 months, leading to the standing version posted July 2015.This tool evaluates the global warming potential (in CO2-equivalents)from organic farming and the carbon footprint of organic products. Therefore, the LCA contributes to organic farming profitability by 1) evaluating the carbon credit achieved from carbon sequestration and reduced emissions and 2) meeting the international market requirements for climate friendly products. In addition to evaluating climate change impact, the integrated tool also evaluates organic carbon sequestration and nitrogen cyclingwhich is the main mechanism to increase soil fertility in organic farming. The tool enables evaluation ofalternative farm management options that mayimprove soil and water quality and/or reduce greenhouse gas emissions.Assessment of emissions and soil fertility contributes to the long-term sustainability of organic agriculture and allows producers to estimate the effects of management choices. We have madefivepublic presentations about this project and use of the Ofoot tool at the Tilth Producers of Washington annual conferences (2010, 2013, 2014, 2015)and the California Climate Action Network (2015), and engaged undergraduate students at Washington State University. Undergraduate students used the Ofoot tool as a course assignment and provided feedback about the usability of the current product.These events haveintroducedproducers, inspectors, students, and other ag professionalsto the method of use and content of the Ofoot toolfor assessing the soil carbon, nutrient cycling, and greenhouse gas impacts of organic farming practices and systems. Professional peers were informed aboutthe project and Ofoot tool at a seminar in the Washington State University Department of Crop and Soil Sciences, and atthe Agronomy Society of America annual conference. The team has also had conversations with the Washington State Department of Agriculture Organic Program leadership and inspectors. WSDA is highly interested to cooperate in further developments of Ofoot to make the tool dovetail with organic certification requirements. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Organic and sustainable producers Agricultural and Environmental researchers Agricultural, Energy, and Natural Resource Agencies Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Two graduate students completed their MS programs in this project in 2013. Four people are learning OpenLCA for Life Cycle Assessment. Approximately 15 organic growers used the first public trial of the OFoot tool to estimate their farms\' carbon footprint. How have the results been disseminated to communities of interest? Three seminars were given at Washington State University, each to approximately 40 researchers, technicians, and students: Carbon Footprint of a Small Diversified Organic Farm; Nutrient and Gas Fluxes of Organically Amended Soils; Nutrient Bioavailability Estimates by Chemical and Ion Exchange Methods. A poster and display were presented to approximately 400 growers and students of organic and sustainable agriculture at the Tilth Producers of Washington Annual Conference, Yakima WA, Nov 8-10, 2013. What do you plan to do during the next reporting period to accomplish the goals? The OFoot tool will be released to the public for estimation of organic farm carbon footprint. A webinar will be presented through eOrganic to describe the OFoot tool. A brief tutorial will also be posted to the WSU CSANR website. Summary statistics of field and laboratory trials will allow initial validation of the OFoot tool and CropSyst expansion.

2011/09/01 TO 2012/08/31 OUTPUTS: Activities: Field plots were managed in 2012 in Puyallup, WA and Royal City, WA. Organic fertilizers were applied to organically managed plots of spring wheat or bare plots. Gas fluxes were measured intensively during 5 36-hr periods at critical plant growth stages. Soils were sampled and analyzed from multiple fields at all 5 of the OFoot Focus Farms across Washington State. Events: Two full team meetings were held with a large majority of PIs and Focus Farmers during November 1-2, 2011 and May 19-20, 2011. Initial data from field activities were shared. Development of the Life Cycle Analysis tool was discussed. Output Products: The online webinar \"Greenhouse Gases and Agriculture: Where Does Organic Farming Fit\" by co-PI\'s Lynne Carpenter-Boggs, David Granatstein, and Dave Huggins is available both through YouTube and eOrganic. At YouTube the video has been viewed over 200 times. An informational poster and mini-presentation were made for a June 26, 2012 event: \"Climate, Land Use, and Agricultural and Natural Resources: Activities in Interdisciplinary Research, Education and Outreach.\" The event was held at Washington State University and organized by the Biosphere-relevant Earth system modeling (BioEarth) team with the Center for Environmental Research, Education, and Outreach (CEREO); the Center for Sustaining Agriculture and Natural Resource (CSANR); and the State of Washington Water Research Center (SWWRC). PARTICIPANTS: PIs: Lynne Carpenter-Boggs provides overall project management. Stewart Higgins manages field and lab research. Claudio Stockle incorporates new data into CropSyst. Usama Zaher is building databases for life cycle analysis. David Granatstein provides outreach and extension. Dave Huggins and Jeff Smith are USDA-ARS and provide guidance in lab analyses. Cooperators: Five organic farms in Washington managed by April Thatcher, Maurice Robinette, Henning Sehmsdorf, Brad Bailie, and Jim Baird. Other Washington State University employees: Susan Wang, Bryan Carlson, Rachelle Greenwood, Eric Davidson, Nick Stansbury, Bertie Weddell, Roger Nelson, Marina Heppenstall, and Cornelius Adewale have all contributed to field and/or lab projects in 2012. Marina Heppenstall and Cornelius Adewale are MS students who have taken coursework and have been mentored in research and statistical skills. TARGET AUDIENCES: This project is primarily targeted at organic farmers and commercial outlets for organic farm products. Other producers and businesses involved in certifying carbon credits or sustainability measures will also use the outputs. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Group presentation at 2010 Tilth Producers of Washington Conference, \"Measuring the Footprint of Organic Farming: a New WSU Project.\" Approximately 75 people in attendance, primarily organic farmers and students. eOrganic webinar presented November 15, 2010 by David Granatstein, Lynne Carpenter-Boggs, and Dave Huggins. \"Greenhouse Gases and Agriculture: Where Does Organic Farming Fit?\" 135 people attended the live webinar and it remains available online: http://www.extension.org/pages/30835/greenhouse-gases-and-agriculture :-where-does-organic-farming-fit-webinar. Measuring the organic footprint. Good Fruit Grower May 1, 2011. P. 20-21. How big is the orchard footprint? Good Fruit Grower May 1, 2011. P. 18. PARTICIPANTS: PIs: Lynne Carpenter-Boggs provides overall project management. Stewart Higgins manages field and lab research. Claudio Stockle incorporates new data into CropSyst. Usama Zaher is building databases for life cycle analysis. David Granatstein provides outreach and extension. Dave Huggins and Jeff Smith are USDA-ARS PI\'s who provide guidance in lab analyses. Cooperators: 5 organic farms in Washington managed by April Jones, Maurice Robinette, Henning Sehmsdorf, Brad Bailie, and Jim Baird. other WSU employees: Austin Lesure, Susan Wang, Bryan Carlson, Rachelle Greenwood, Eric Davidson, Nick Stansbury, Bertie Weddell, Roger Nelson, Andy Bary have all contributed to field and/or lab projects in 2011. TARGET AUDIENCES: This project is primarily targeted at organic farmers. Other producers and businesses involved in certifying carbon credits or sustainability measures will also use the outputs. PROJECT MODIFICATIONS: none

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Goal 1. Laboratory and field experiments were conducted in Pullman, Royal City, and Puyallup WAto determine the carbon sequestration, greenhouse gas balance, and nutrient availability effects of green manures, livestock manures, composts, commercial organic fertilizers, and crop residues. Nutrient availability was studied using both traditional chemical extractants and ion exchange resins to assess this alternative technology.Thesedata, in addition to prior published research, havebeen used toparameterize and evaluate predictive models. Goal 2. The CropSyst model for crop and soil carbon and nitrogen dynamics has been significantly enhancedto enable quantitative prediction of the carbon-, nutrient-, and greenhouse gas-related ecosystem services of operations common to organic farming. Twenty-eight new crops were added to the program to better represent the high diversity of many organic farming

enterprises. The capacity to use short-term and long-term cover crops and green manures was added. A crop phenology adjuster was added to fit crop growth dynamics across the U.S. Pacific Northwest. Decomposition and nutrient release dynamics of a range of organic crop residues, composts, manures, and mined fertilizers were added. Goal 3. A simplified model with LCA capabilities (OFoot) was developed and made available online to allow the evaluation by farmers, agencies, extension personnel, and organic certifiers of greenhouse gas (GHG) emissions, carbon sequestration, and nitrogen leachingunder user-specified farmconditions.This tool is now available at ofoot.wsu.edu . The tool indicates the overall farm carbon footprint as well as the major and individual sources of this footprint. Farm carbon footprint information is graphically and numerically described, andlinked to U.S.E.P.A. website to further compare a farm footprint to other sources and activities such as automotive and household carbon footprints. Goal 4. Educational outreach has been conducted at multiple events. Organic producers, inspectors, students, and other ag professionals have been trainedto use the Ofoot tool. See further details below in dissemination. Goal 5. The tool has been used to thoroughly assessthe 5 commercial certified organic farms and 2 certified organic research fields that have collaborated throughout this project. In addition approximately 30 other farms have used the tool so far. One of the producers has so far used the outputs from this tool as documentation of environmental stewardship to gain a high value contract for his farm products. The tool indicates not only overall farm carbon footprint but indicates the sources of carbon footprint.The producers have frequently been surprised at the results, and subsequently consider or makechanges in farm management. Most people are unaware of the embedded (or embodied) energy and carbon footprint in equipment and infrastructure. Several have also been surprised at the carbon footprint comparison of electricity and fuel from various sources. For instance, because biodiesel carries a very low carbon footprint it has gained interest among our stakeholders. Most find the outputs to be interesting and thought-provoking in numerous ways.
PUBLICATIONS (not previously reported): 2010/09 TO 2015/08 1. Type: Journal Articles Status: Published Year Published: 2014 Citation: Carpenter-Boggs, L., et al. 2014. \"Decomposition of Dairy Manure Assessed in the Field by Monitoring Natural Abundance of C.\" Soil Science Society of America Journal 78.6 (2014): 1949-1952. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Adewale, C., L. Carpenter-Boggs, D. Huggins. 2015. Analysis of Organically Farmed Soils Using Ion Exchange Membranes and Chemical Extractions. American Society of Agronomy Annual Meeting, poster 1329. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Adewale, C., L. Carpenter-Boggs, S. Higgins, U. Zaher. 2015. Identifying Hotspots in the Carbon Footprint of a Small Scale Organic Vegetable Farm. American Society of Agronomy Annual Meeting presentation 177-9. 4. Type: Journal Articles Status: Under Review Year Published: 2016 Citation: Adewale, C., L. Carpenter-Boggs, U. Zaher, S. Higgins, D. Granatstein, A. Thatcher, and C. St?ckle. Identifying Hotspots in the Carbon Footprint of a Small Scale Organic Vegetable Farm. International Journal of Life Cycle Assessment. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Carpenter-Boggs, L., C. Adewale, and S. Higgins. 2015. Carbon Sequestration, Nutrient Bioavailability, and Environmental Services from Organic Agriculture. California Climate Network, Davis, CA, March 25, 2015. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Carpenter-Boggs, L., D. Granatstein, and C. Adewale. 2015. The Environmental Footprint of Organic Farming. Tilth Producers of Washington Annual Conference, Spokane, WA.

2012/09 TO 2013/08 What was accomplished under these goals? Final soil, plant, and gas samples from field and laboratory trials were analyzed. Interpretation of analyses have produced decomposition kinetics descriptions of 7 fertilizers and crop residues. Inventories were created of the inputs, equipment, infrastructure, crops, and activities of each of the 5 organic Focus Farms. One of these farms has been assessed under a Life Cycle Assessment (LCA) thus far. Potential nutrient bioavailability in organically managed soils were analyzed using traditional chemical and new ion-exchange methods. Fertilizer recommendations based on these analyses indicate large differences, with significant implications for crop production, waste potential, and grower profit.
PUBLICATIONS (not previously reported): 2012/09 TO 2013/08 1. Type: Theses/Dissertations Status: Accepted Year Published: 2013 Citation: Adewale, Cornelius. 2013. CARBON FOOTPRINT AND NUTRIENT BIO-AVAILABILITY ASSESSMENT OF ORGANIC SYSTEMS. M.S. Thesis. Washington State University. Heppenstall, Marina. 2013. CARBON AND NUTRIENT FLUXES IN ORGANICALLY AMENDED SOILS. M.S. Thesis. Washington State University. 2. Type: Websites Status: Accepted Year Published: 2013 Citation: Center for Sustaining Agriculture and Natural Resources. Organic Farming Footprints (OFoot). http://csanr.wsu.edu/pages/Organic Farming Footprints/. 3. Type: Theses/Dissertations Status: Accepted Year Published: 2013 Citation: Heppenstall, Marina. 2013. CARBON AND NUTRIENT FLUXES IN ORGANICALLY AMENDED SOILS. M.S. Thesis. Washington State University. 4. Type: Conference Papers and Presentations Status: Accepted Year Published: 2013 Citation: Carpenter-Boggs, L., C. Adewale, M. Heppenstall., S. Higgins, D. Huggins, J. Smith, C. Stockle, A. Thatcher, U. Zaher. 2013. Organic Farming Footprints: A new tool for organic farm management. Poster and 3-day display. Tilth Producers of Washington Annual Conference, Nov 8-10, 2013, Yakima, WA.

2011/09/01 TO 2012/08/31 Students have increased knowledge of farm operations and styles, and research protocols. All PIs and producers have increased knowledge of the diversity of organic farm operations. Producer cooperators have increased knowledge of research methods and the logic used.

2010/09/01 TO 2011/08/31 This project is 1 year old and does not yet have outcomes and impacts to report.

PUBLICATIONS

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

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

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Crop Plant Nutrition and Insect Response in Organic Field Crop Production: Linking Farmer Observation to University Research and Extension

Accession No.	0222288
Subfile	CRIS
Project No.	WIS01533
Agency	NIFA WIS
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21282
Proposal No.	2010-01998
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	CULLEN, E. M.; Barak, P.; Whitaker, P.; Shelley, K.
Performing Institution	Entomology, UNIV OF WISCONSIN, 21 N PARK ST STE 6401

NON-TECHNICAL SUMMARY

This project addresses a lack of research on soil test calibration data and plant tissue analyses specifically comparing different organic fertility management approaches with each other, and for potentially corresponding crop plant-mediated pest and beneficial insect population response. The two organic fertility systems chosen by farmer stakeholders for consideration in this project test the general hypothesis that insect pest populations are less variable and stabilize at lower densities under organic fertility systems affording crop plant tissue a regulated and balanced nutrient supply. Conceptually, our project combines 1) on-farm observation and data collection; 2) a controlled long-term experiment systems trial and 3) greenhouse/laboratory reductionist approaches. These components reinforce each other to deliver practical research based information on the role of organic crop plant nutrition in insect IPM. The intent of this project is not to convince farmers to use one fertility approach over the other, but rather to involve farmers in shaping the research direction so they can use the results in whole farm planning and Land-grant University research/extension personnel can offer improved systems based programs to address insect pest suppression in organic crops. Only by understanding both the ecological complexity and reductionist mechanisms behind organic grower observations of plant-insect interactions can researchers help apply this knowledge in new situations. Knowledge gained from this project will improve organic farmer ability to document soil and crop nutrient management as an IPM strategy when developing an organic system plan (OSP), and working with technical service providers under the USDA NRCS Environmental Quality Incentives Program (EQIP). Under National Organic Program Standard 205.206, soil and crop nutrient management are required to prevent crop pest insects, weeds and diseases. Our project will identify pest and natural enemy insect response indicators that can be used to document changes in effectiveness of organic fertility systems as an underlying IPM strategy in organic agriculture. Expected OUTCOMES/IMPACTS: Organic grain and forage crop producers will gain awareness of soil test analytical method nuances and impacts on interpreting results, improved attitude toward land-grant university approach to organic fertility systems research, and increased knowledge of principles of crop plant mineral nutrition and insect response for key field and forage crop pest complexes (short term). Organic producers will improve insect IPM success through alignment of their existing organic fertility approaches with pest management goals, and applying new IPM research knowledge base to

organic fertility input cost decision -making. (medium term). Organic grain and forage crop farm net revenue and profitability will improve because of increased farmer capacity to make decisions about allocating scarce resources (soil fertility amendments) in the most effective ways, and utilizing soil-plant-insect interactions for crop protection will enhance environmental sustainability of organic agriculture (long term).

OBJECTIVES

This project is designed to develop and disseminate practical research-based information on how soil fertility and resulting crop plant nutrition contribute to insect pest suppression and the integrated pest management (IPM) paradigm and its application in organic agriculture. Our long-term GOALS are to: 1) More clearly define the role of soil fertility, crop plant nutrition and insect response in organic agriculture systems, resulting in practical insect IPM recommendations in Wisconsin and across the U.S.; 2) Improve organic grain and forage crop farm net revenue and profitability because of increased farmer capacity to make decisions about allocating scarce off-farm resources (i.e., soil fertility amendments) in the most effective ways; 3) Utilize soil-plant-insect interactions for crop protection to enhance environmental sustainability of organic agriculture. Project OBJECTIVES are to: 1) Evaluate two different organic fertility systems in a certified organic grain/forage crop long-term experiment by comparing soil and crop plant nutrient status with pest and beneficial insect response; 2) Conduct simple experiments on working organic farms to test hypotheses from the long-term experiment and grower observations on their farms that integrate organic fertility practices with other National Organic Program-compliant insect pest suppression tactics; 3) Develop a multi-institutional partnership between Wisconsin organic farmers, UW Madison, Cooperative Extension, and two-year campuses of the UW Colleges system to achieve full integration of research, extension, and education project goals. EXPECTED OUTPUTS from the project include: Controlled Long-Term Experiment (LTE) research comparing organic fertility systems for effects on soil chemistry of plant nutrients and insect response; Conduct greenhouse studies using modified LTE field soil (precise Ca, Mg cation calibration) and elucidate crop plant and insect response mechanisms; Perform on-farm research on factors most important to practical crop nutrient and insect IPM application; Develop extension resources and decision support tools that enhance IPM paradigm for organic agriculture.

APPROACH

This integrated research/extension/education project investigates two organic fertility practices in a four-year grain crop/forage legume rotation. Under the Standard Organic Fertility system, nitrogen and other crop nutrients are supplied by livestock manure and 2 years of alfalfa hay in the rotation. The Soil Balance system incorporates a more intensive off-farm input approach with annual \"cation-balancing\" application of gypsum as a calcium soil amendment. A 30-acre certified organic long-term experiment systems trial, and on-farm research with cooperating growers in southern and north central Wisconsin achieve the OREI high priority goal to conduct advanced on-farm research and development that emphasizes observation of, experimentation with, and innovation for working organic farms. Project outcomes will more clearly define how organic crop plant nutrition and insect response mechanisms contribute to pest suppression through plant mediated effects and beneficial insect functional response. Extension deliverables will offer IPM recommendations for crop-pest associations of economic concern to organic field crop growers regionally and nationally. These include soybean: soybean aphid, corn: Lepidoptera ear and stalk boring caterpillar pests, and alfalfa: potato leafhopper. This integrated project focuses on plant-insect interactions (soil chemistry and plant nutrition), through field studies conducted within the context of a large scale, long-term systems trial. Processes in soil and plants that are potentially relevant to pest and beneficial insect response mechanisms are not likely to occur within a short time frame of 2-3 years. Because systems research field trials often yield significant results in later project stages, our methods include shorter-term, controlled greenhouse and laboratory experiments targeting processes relevant to our overall hypotheses. A greenhouse trial involving the creation of \"artificial\" base saturation ratios represents one such test of the same hypotheses from the long-term field experiment under more tightly controlled conditions. Project PD consults regularly with the University of Wisconsin Madison CALS statistical consulting service on all aspect of project analysis, particularly multivariate methods which are a useful approach to dealing with overall complexity of long-term systems trials. Principle component analysis will be used to reveal the internal structure of data from the long-term experiment and on-farm research location replicates, in a way which best explains the variance and identifies explanatory patterns in data of high dimension (e.g., ecological complexity). Additionally, this project is building a multi-institutional integrated education/research partnership providing organic agriculture classroom curriculum credits and mentored on-farm research internships to undergraduates at small sized freshman/sophomore campuses of the UW Colleges system who are seldom offered integrated education/research opportunities in organic agriculture due to a smaller student body (less than or equal to 1,000) and distance (greater than 100 miles) from the UW Madison campus. **PROGRESS: 2010/09 TO 2015/08**

Target Audience:Wisconsin, Upper Midwest, and U.S. organic and transitional grain and forage crop farmers, land-grant university Extension educators and county agents, undergraduate students at the freshman/sophomore campus of University of Wisconsin-Marathon County, UW Fox Valley, and agriculture industry professionals that serve organic grain crop farmers. Target audience also included research science peers in Agronomy, Soil Science, Crop Science, and Entomology fields. 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?Outreach methodology included summer growing season field days, winter grower meetings, Upper Midwest Organic Farming Conference workshops, meetings with farmer advisors to project, eOrganic webinar (live and archived), and regional and national scientific meeting presentations (submitted papers, poster, and invited symposia): Ecological Society of America Annual Meeting, Minneapolis, MN (2013); North Central Branch Entomological Society of America Annual Meeting, Des Moines, IA (2014); ASA-CCSA-SSA and Entomological Society of America Joint Annual Meeting, Minneapolis, MN (2015). What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported **IMPACT: 2010/09 TO 2015/08** What was accomplished under these goals? IMPACTS: This project developed and delivered systems based programs to address insect pest related management problems for organic grain and forage crops. A university researcher (Dr. Eileen Cullen, UW-Madison), farmer (Christine Mason, Standard Process Farm, Palmyra, WI) and a graduate student (Robin Mittenthal, UW-Madison) co-taught an eOrganic Webinar titled \'Integrated Pest Management for Organic Field Crops\' delivering organic field and laboratory research results and pest management content tailored to organic crops to 127 farmers, extension agents and agricultural professionals from all regions of the U.S., and attendees from Canada, Greece and Chile. 63 percent participant survey respondents (post-program) improved their understanding of insect mangement strategies for organic farming, and 69 percent intend to use this knowledge on their own farms or advising organic farmers. The eOrganic webinar has been viewed as on online resource over 1,200 times since the March 29, 2011 live presentation. The workshop was approved for Certified Crop Advisor (CCA) Continuing Education Credit and is available at eExtension\'s Campus website. CCAs take the course online, complete a 10-question exam, and earn credit for pest management content fitting to an organic production system. In the undergraduate education and on-farm research internship portion of this project, we developed a freshman/sophomore course curriculum titled \'Social and Scientific Aspects of Organic Agriculture\'. This interdisciplinary three-credit semester course was cross-listed as Botany and Sociology. It was taught for five year by Dr. Paul Whitaker and lecturer Kat Becker at UW-Marathon Co. campus and offered live via distance education technology to students throughout the UW Colleges system. Approximately 200 students enrolled in the course, and 184 completed it. The course has since been adapted by Dr. Eileen Cullen, now at California State Polytechnic University, Pomona and offered as an upper division PLT 499 course \'Introduction to Organic Agriculture\', since spring 2015. Finally, the project engaged north central Wisconsin freshman/sophomore students in paid internship faculty and farmer mentored research. Students addressed research questions developed in consultation with local organic farmers in north central WI. 2- 4 students participated each summer for 3 years, on field and lab research, and presented their findings at an organic farmer conference research symposium. RESULTS: Objective 1) Evaluate two different organic fertility systems in a certified organic grain/forage crop long-term experiment by comparing soil and crop plant nutrient status with pest and beneficial insect response; Study 1.1 \Environ. Entomol. 43(5): 1264-1274\ This study examined: 1) The European corn borer, Ostrinia nubilalis (Hubner), larval response on corn (Zea mays L.) grown in field soils with different soil management histories; and 2) resilience of these plants to O. nubilalis herbivory. Treatments included: 1) standard organic - organically managed soil fertilized with dairy manure and 2 yr of alfalfa (Medicago sativa L.) in the rotation; 2) basic cation saturation ratio - organically managed soil fertilized with dairy manure and alfalfa nitrogen credits, plus addition of gypsum (CaSO42H2O) according to the soil balance hypothesis; and 3) conventional - conventionally managed soil fertilized with synthetic fertilizers. Results demonstrate that different fertilization regimens can significantly affect insect performance within the context of organic systems, but the effects in this study were relatively minor compared with effects of intraspecific competition. Study 1.2 \Ecosphere, 6(6): doi:10.1890/ES14-00501.1\ We obtained soils from agricultural fields managed under 3 different soil fertilization practices for 5 continuous years: Synthetic fertilizers only with a 2-year corn-soybean rotation (conventional farming, or CONV), dairy manure with a 4-year alfalfa/oat-alfalfa-corn-soybean rotation (standard organic farming, or STDO), and dairy manure with a 4-year alfalfa/oat-alfalfa-corn-soybean rotation with biannual gypsum applications (organic basic cation saturation ratio farming, or BCSR). We reared field corn plants in these soils in a greenhouse, then used them to conduct oviposition choice assays with the corn insect pest Ostrinia nubilalis (European corn borer, or ECB). Our results indicate that both fertilization practices and mycorrhizal associations can interact to modify oviposition in pest insects, which may have significant implications for the utilization of fertilization practices for pest insect suppression. Study 1.3 \ASA-CSSA-SSA 2015 Annual Meeting with Entomological Society of America, Symposium Proceedings\ Mineral supplementation can benefit nutrient deficient crops, but the plant mineral composition can also affect the insect pests that feed upon them. Gypsum (Ca2SO4) is a fertilizer used to improve soil aggregation and increase calcium and sulfur concentrations. It is unknown how regular gypsum

additions may affect plant-insect interactions. We conducted a field study in 2013 using 8 randomized corn plots in Wisconsin, organically farmed in a corn-soybean-alfalfa-alfalfa rotation since 2008. Plots had been fertilized with manure only (standard organic, or STDO) or manure+gypsum (mineral balanced plots, or BAL). Plants were infested with European corn borer (ECB) egg masses; our results suggest that mineral supplementation may benefit early season insect pests, but may negatively impact late season pests and impart some protection to maturing corn. Objective 2) Conduct simple experiments on working organic farms to test hypotheses from the long-term experiment and grower observations on their farms that integrate organic fertility practices with other National Organic Program-compliant insect pest suppression tactics; Study 2.1 \Agroecology and Sustainable Food Systems, 37:550-577\. This study presents a conversation among researcher, agroecology student, and farmers about the association between cover crops and seedcorn maggot in organic grain crops. Survey data showed that Wisconsin organic farmers would use cover crop management, insect degree day forecasting, and planting date cultural controls, given appropriate knowledge context and extension information provision. We developed electronic and print resources and engaged with farmers and educators nationally through the eOrganic Community of Practice. Project outcomes exemplify student and farmer ability to effect change in land grant university extension recommendations through integrated pest management content and delivery aligned with a cropping systems perspective. Objective 3) Develop a multi-institutional partnership between Wisconsin organic farmers, UW Madison, Cooperative Extension, and two-year campuses of the UW Colleges system to achieve full integration of research, extension, and education project goals. A 3 credit semester course, Scientific & Social Aspects of Organic Agriculture was developed and taught at UW Marathon County for 5 years. The curriculum begins with an introduction to organic agriculture - its origins, philosophical and biological science assumptions, and current practice under regulation by the USDA\'s National Organic Program. The course content is organized around \"issues\" in organic agriculture including social and scientific challenges to the principles of organic agriculture that have arisen as consumer awareness and market share have increased. Positions on both sides of these issues (pro- and anti- or unaware about organic production) are often aired publicly, but are not always well supported by research data. This course explores some of these issues in order to understand social and scientific foundation of organic agriculture production methods and systems-based thinking. PUBLICATIONS (not previously reported): 2010/09 TO 2015/08 1\. Type: Journal Articles Status: Published Year Published: 2015 Citation: Murrell, E.G., Hanson, C.R., Cullen, E.M. (2015). European corn borer (Ostrinia nubilalis) oviposition response to soil fertilization practices and arbuscular mycorrhizal colonization of corn. Ecosphere 6(6). doi:10.1890/ES14-00501.1 2\. Type: Journal Articles Status: Published Year Published: 2014 Citation: Murrell, E.G., Cullen, E.M. (2014). Conventional and organic farming practices affect corn nutrition and Ostrinia nubilalis (Lepidoptera: Crambidae) larval performance. Environmental Entomology, 43(5): 1264-1274. 3\. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Murrell, E.G., Cullen, E.M. (2015). Is Mineral Balance Beneficial Gypsum Fertilization Affects European Corn Borer Development and Insect Damage to Corn. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America Annual Meeting, November 2015, Minneapolis, MN. In Symposium - Insect Ecology in Organic Crop Management Systems. 4\. Type: Journal Articles Status: Published Year Published: 2013 Citation: Cullen, E.M., Holm, K.M. (2013). Aligning insect IPM programs with a cropping systems perspective: Cover crops and cultural pest control in Wisconsin organic corn and soybean. Agroecology and Sustainable Food Systems 37: 550-577. 5\. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Cullen, E.M. (2012). Crop plant nutrition and insect response in organic field crop production: Linking farmer observation to university research and extension. In Institute of Food Production and Sustainability Organic Programs Project Directors Meeting Proceedings, pp. 55-59. October, 2012. USDA NIFA, Washington, DC. 6\. Type: Websites Status: Published Year Published: 2011 Citation: Cullen, E.M., Mason, C., Mittenthal, R. (2011). Integrated Pest Management in Organic Crops Webinar. eOrganic. https://articles.extension.org/pages/33362/integrated-pest-management-in-organi c-field-crops-webinar Accessed: 02/11/2016. 7\. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Whitaker,P., Cyr, K., Lange, A., Murphy, N. (2014). Evaluating neem oil as a systemic soil drench to protect Brassica transplants from cucumber beetle feeding. Submitted poster presentation at the Organic Research Symposium in La Crosse, WI, February 28 - March 1, 2014. 8\. Type: Theses/Dissertations Status: Published Year Published: 2010 Citation: Cyr, K. 2014. Effects of foliar and soil applications of cold-pressed neem oil solutions on vigor and leaf phytotoxicity in cucurbits. University of Wisconsin Colleges Student Research Journal 1: 1-18.

PROGRESS

2012/09 TO 2013/08 Target Audience: Target audiences include Wisconsin, Upper Midwest, and U.S. organic and transitional grain and forage crop farmers, land-grant university Extension educators and county agents, IPM researchers at land-grant universities and colleges, undergraduate students at the freshman/sophomore campuses of the UW Colleges system, and educators and agricultural professionals who serve or interact with a

diversity of organic farmers and farmers or educators interested in learning more about insect pest management in organic systems. Efforts to reach target audiences included extension and outreach field day presentations, research presentation and proceedings publications at organic farming conference research symposia, roundtable meetings with organic farmer advisory board to project, and eOrganic webinar presentation by project PI, graduate student, and organic farmer advisor to national audience. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Postdoctoral Associate, Dr. Ebony Murrell entered her second year with the project completing two studies, submitting one manuscript, a second manuscript is in final preparation, and presented at two national meetings (Ecological Society of America, and Entomological Society of America). Undergraduate Student, Christine Walrath, UW-Madison Biology 152 student completed a fall 2013 semester mentored research project quantifying, analyzing and presenting results at a campus poster symposium. Ms. Walrath\'s project examined beneficial root fungi (arbuscular mycorrhizal colonization) in corn plants grown in the two organic field soil treatments collected form the long-term experimental field plots. How have the results been disseminated to communities of interest? Co-PIs E. Cullen and K. Shelley and postdoctoral associate E. Murrell presented a field day extension talk titled Impact of Mineral Balance Fertility Strategies on Crop Performance featuring OREI research plots and project results at the 08/13/13 UW-Madison CALS Organic Agriculture Field Day at Arlington Agricultural Research Station. The event was attended by 67 organic farmers, county extension agents, university researchers and students and NRCS technical service providers. What do you plan to do during the next reporting period to accomplish the goals? In the next reporting period, we are revising and submitting two publications (listed below). A no-cost extension is being filed for the project because the postdoctoral associate started in year 2 of the project and salary budget remains to support completion of work under Objective 1) Evaluate two different organic fertility systems in a certified organic grain/forage crop long-term experiment by comparing soil and crop plant nutrient status with pest and beneficial insect response. Work planned for the 2014-15 reporting cycle includes documentation of the effects of organic soil fertility treatments on a range of properties that are pivotal to the functioning and productivity of organic pest management systems including soil chemistry and crop root association with beneficial fungal communities in the soil (mycorrhizal colonization of crop roots under different soil fertility systems, and resulting crop nutrient uptake, plant tissue profiles and foliage feeding insect response. Study locations include the long-term experiment Arlington research station trial and up to 20 on-farm study sites with organic farmer advisors to the project. To date, this project has tested the hypothesis that soil amendments of gypsum in Wisconsin cornfields alter crop plant nutrition and, correspondingly, insect response. We have found this to be the case (see publications below), however the primary change to plants appears to be increase in uptake of additional sulfur, and not the additional calcium, provided by gypsum. Our data suggest that soil balance organic fertility practices in organic crops can alter pest insect response and possibly reduce crop damage, although not necessarily due to the nutritional mechanisms hypothesized (e.g., relative proportion of cation exchange capacity occupied by Ca:Mg:K). Our results indicate that the relationship between soil fertility type and mycorrhizal associations interact to influence crop plant nutrition and insect response when comparing organic and conventional, but that the different organic fertility systems tested in our study are not significantly different from each other. To measure this we will collect soil from organic and conventional farm fields with known history (grain and forage crop rotation, years in organic production, soil type). Soybean will be grown in the greenhouse in each of these soil treatments and root analysis conducted to assess vesicular arbuscular mycorrhiza associations, crop plant nutrient profiles, and insect response for both a chewing (beet armyworm) and piercing-sucking (soybean aphid) insect. Publications in next reporting period: Murrell, E.G., and E.M. Cullen. Accepted pending revision. Conventional and organic farming practices affect corn nutrition and Ostrinia nubilalis (Lepidoptera: Crambidae) larval performance. Environmental Entomology. Murrell, E.G., C.R. Hanson, and E.M. Cullen. In prep. European corn borer (Ostrinia nubilalis) oviposition response to soil fertilization practices and arbuscular mycorrhizal colonization of corn. Ecological Applications.

2011/09/01 TO 2012/08/31 OUTPUTS: LARVAL EXPERIMENT: A greenhouse experiment of soil type effects on European corn borer (ECB) larval performance and yield was conducted at UW-Madison. Soil was collected from 2012 corn plots at the long-term experimental site, Arlington, WI for Standard Organic (STD), Soil Balance Organic (BAL), and Conventional (CONV). One hundred thirty-five pots were lined with plastic to prevent nutrient loss and filled with one of the three soil types (total: 40 CONV, 45 STD, and 50 BAL pots). A single untreated corn seed was planted in each pot, raised to maturity and hand-pollinated. At 10-12 days post-pollination, the primary ear on each corn plant was infested with 0, 10, 20, 30, or 40 first-instar ECB larvae. All ears were bagged to prevent migration of ECB larvae among plants. After 17 days post-infestation, each plant was collected, frozen, and later dissected to determine the yield loss (proportion kernels damaged) as a function of both ECB density and soil type, and also to determine ECB performance (proportion survival, mean mass, and mean developmental stage) as a function of end-point infestation rates and soil type. Both lethal and nonlethal effects of intraspecific larval competition were present. There was an additional significant effect of soil type on developmental stage of ECB ($p=0.0021$), in that ECB larvae on BAL plants were significantly more developed

than larvae on the STD plants, with CONV falling between the two organic soil types. Overall, there is some evidence that STD (standard organic soil treatment) could suppress ECB larval development in relation to CONV or BAL soil types. Ongoing work includes analysis of corn plant tissue collected from each of the plants in this experiment prior to infestation. These data will be used to determine (a) if plant tissue profiles differ among soil types, and (b) if ECB larval performance and/or yield loss is correlated with plant tissue profiles. ADULT OVIPOSITION EXPERIMENT: This was an mentored undergraduate student project. Soil was collected from the same corn plots at the long-term experiment as described above for a total of 44 pots (14 CONV, 15 STD, 15 BAL). A single corn plant was raised to the V5 stage per pot. For each replicate, one plant reared in each soil type was randomly selected and placed in a cage. Five cohort adult Z-strain ECB females and 2 males were released into the cage and allowed to oviposit on the 3 plants for two days. Eggs were counted on each plant and removed. Female ECBs showed a significant oviposition preference (p\<0.0001), laying fewest eggs on CONV plants and greatest on BAL plants. Ongoing work includes analysis of plant tissue nutrient profiles and soil micronutrients, and assessment of arbuscular mycorrhizal (AM) colonization in the roots of plants used in this experiment. Results will determine if AM colonization differs among the soil types, which could explain differences in plant tissue nutrient profiles and ECB oviposition behavior we observed. PARTICIPANTS: INDIVIDUALS: EILEEN CULLEN, Associate Professor/Extension Specialist, University of Wisconsin-Madison Entomology Department. Roles: Project coordination and responsibility, experimental research design and oversight, graduate student advising, generate, analyze, publish and disseminate results through research/Extension field crops IPM program. PHILLIP BARAK, Professor, University of Wisconsin-Madison Soil Science Department. Roles: soil science project expertise to improve understanding of soil mineral composition and interpretation of crop plant nutrient analyses. KEVIN SHELLEY, University of Wisconsin-Madison Nutrient and Pest Management Program Outreach Coordinator, Project Co-director. Roles: Organic crop management at the 30-acre Arlington Agricultural Research Station long-term experiment (LTE) site and organic grower advisory board communications/educational outreach coordination. PAUL WHITAKER, Professor, Biological Sciences. Roles: Responsible for development and teaching of UW Colleges Bot/Soc 291 three credit fall semester course titled Social and Scientific Aspects of Organic Agriculture. Directs UW Marathon County summer intern students in on-farm research entomology and plant biology summer program in collaboration with local organic farmers. COLLABORATORS: KAT BECKER, Associate Lecturer of Sociology, University of Wisconsin-Marathon County. Roles: Responsible for co-development, coordination and teaching of a UW Colleges Bot/Soc 291 titled Scientific and Sociological Aspects of Organic Agriculture with Whitaker. KAT BECKER and TONY SCHULTZ, Stoney Acres Farm, Athens, WI. Roles: Farmer mentors to UW Marathon County summer intern students. Co-design and supervise student research intern experiments on insect IPM issues relevant to Stoney Acres Farm needs. TRAINING OR PROFESSIONAL DEVELOPMENT: EBONY MURRELL, PhD Postdoctoral Research Associate. Role: Conduct entomology and soil science field and laboratory experiments, data analyses and manuscript preparation. PARTNER ORGANIZATIONS: UW Arlington Agricultural Research Station, Arlington, WI. Roles: Assist, advise and provide logistical farming support for organic production and annual organic certification inspection at LTE study site. Wisconsin Organic Farmer Advisory Board to the project includes: DAN and DARLENE COEHOORN, Viewpoint Farm, Rosendale, WI; CHRISTINE MASON/DARREN PAULSON, Standard Process Farms, Palmyra, WI; TOM AND JIM MILLER, R & G Miller and Sons, Columbus, WI; STEVE SLINGER, Randolph, WI; TIM ZANDER, Columbus, WI; TOM WEAVER, Weaver Feeding and Management, Cuba City, WI; GARY WEDIG, Platteville, WI. Roles: Input on determining and pursuing project objectives to meet the needs of organic grain/forage crop producers. Guide researchers on best management practices for organic field crop production systems. TARGET AUDIENCES: Target audiences include Wisconsin, Upper Midwest, and U.S. organic and transitional grain and forage crop farmers, land-grant university Extension educators and county agents, IPM researchers at land-grant universities and colleges, undergraduate students at the freshman/sophomore campuses of the UW Colleges system, and educators and agricultural professionals who serve or interact with a diversity of organic farmers and farmers or educators interested in learning more about insect pest management in organic systems. Efforts to reach target audiences included extension and outreach field day presentations, research presentation and proceedings publications at organic farming conference research symposia, roundtable meetings with organic farmer advisory board to project, and eOrganic webinar presentation by project PI, graduate student, and organic farmer advisor to national audience. PROJECT MODIFICATIONS: Not relevant to this project.

2010/09/01 TO 2011/08/31 OUTPUTS: During a previous grant (USDA NIFA IOP/OREI, CRIS Accession No. 0207138), ending via no-cost extension 08/31/2011, project PIs completed the first four years of data collection and analyses at the certified organic long-term experiment site Arlington, WI, USA. This includes soil fertility system whole plot treatment (soil balance, standard organic) x crop rotation (oat/alfalfa/grass - alfalfa/grass - corn - soybean) with analyses of mineral composition and organic matter soil chemistry properties, crop plant nutrient profiles, and pest and beneficial insect population response variables. Standard organic and soil balance plots had Ca:Mg ratios of 1.8 and 1.7, respectively, at the beginning of the experiment in 2006 prior to CaSO4.H20

amendment of soil balance whole plots. Current ratios are 1.9 for the standard organic system plots, and 2.5 for the soil balance system plots, a statistically significant increase (p\<0.0001, independent sample t-test). Crop yields (corn, soybean, alfalfa) were not significantly different between soil balance and standard organic treatments. Lepidoptera larvae on corn and potato leafhopper in alfalfa were not significantly different. Soybean aphid densities on soybean were significantly different by fertility system with avg. aphids/plant lower in both organic systems (soil balance, standard organic) than conventional check (p\<0.05) and no difference between organic systems. Caged soybean plant experiments (natural enemy exclusion) to isolate soybean plant nutrient mediated effects on soybean aphid showed similar results. Although the soil balance treatment had numerically lower aphid peak, it was not significantly different from the standard organic treatment. In the laboratory, we successfully modified organic field soils to establish a range of target cation ratios for Ca:Mg, low (2.05), medium (2.95) and high (4.65). We also characterized calcium oxalate (CaOX) crystal distribution in soybean plant tissue and positively correlated soil test Ca levels with soybean plant tissue CaOX levels. Insect feeding and development assays were conducted on soybean plants grown in the three Ca:Mg ratio treatments above using soybean aphid and beet armyworm larvae, respectively, to represent sucking and chewing insect feeding types. Data analysis and manuscript preparation from this greenhouse study are underway. Significant product outputs include March 2011 eOrganic webinar presented to national audience by project researcher, graduate student, and organic farmer to disseminate project information and results. Our webinar was selected by eOrganic as an audio/video product at the eXtension.org campus website for Certified Crop Advisor continuing education units, http://www.extension.org/pages/60988. Additionally, our UW Colleges curriculum and 3-credit fall semester course Bot/Soc 291 Social and Scientific Aspects of Organic Agriculture entered its second year at UW Marathon and UW Fox Valley campuses, as did the UW Marathon County summer internship for organic IPM research mentored by organic farmers and offered for credit under project objectives 2 and 3. PARTICIPANTS: INDIVIDUALS: EILEEN CULLEN, Associate Professor/Extension Specialist, University of Wisconsin-Madison Entomology Department. Roles: Project coordination and responsibility, experimental research design and oversight, graduate student advising, generate, analyze, publish and disseminate results through research/Extension field crops IPM program. PHILLIP BARAK, Professor, University of Wisconsin-Madison Soil Science Department. Roles: soil science project expertise to improve understanding of soil mineral composition and interpretation of crop plant nutrient analyses. KEVIN SHELLEY, University of Wisconsin-Madison Nutrient and Pest Management Program Outreach Coordinator, Project Co-director. Roles: Organic crop management at the 30-acre Arlington Agricultural Research Station long-term experiment (LTE) site and organic grower advisory board communications/educational outreach coordination. PAUL WHITAKER, Professor, Biological Sciences. Roles: Responsible for development and teaching of UW Colleges Bot/Soc 291 three credit fall semester course titled Social and Scientific Aspects of Organic Agriculture. Directs UW Marathon County summer intern students in on-farm research entomology and plant biology summer program in collaboration with local organic farmers. COLLABORATORS: KAT BECKER, Associate Lecturer of Sociology, University of Wisconsin-Marathon County. Roles: Responsible for co-development, coordination and teaching of a UW Colleges Bot/Soc 291 titled Scientific and Sociological Aspects of Organic Agriculture with Whitaker. KAT BECKER and TONY SCHULTZ, Stoney Acres Farm, Athens, WI. Roles: Farmer mentors to UW Marathon County summer intern students. Co-design and supervise student research intern experiments on insect IPM issues relevant to Stoney Acres Farm needs. TRAINING OR PROFESSIONAL DEVELOPMENT: ROBIN MITTENTHAL, PhD Graduate Research Assistant, University of Wisconsin-Madison Entomology Dept. Role: Conduct entomology and soil science field and laboratory experiments, data analyses, assistance with organic farming duties at LTE site, coordination of organic record-keeping for certification purposes at LTE study location. PARTNER ORGANIZATIONS: UW Arlington Agricultural Research Station, Arlington, WI. Roles: Assist, advise and provide logistical/technical farming support for all aspects of organic production and certification transition at LTE study site. Additionally, a Wisconsin Organic Farmer Advisory Board meets formally once per year with project individuals in a winter/spring project meeting and a second time each summer at a field day or other Extension venues. Members: DAN and DARLENE COEHOORN, Viewpoint Farm, Rosendale, WI; CHRISTINE MASON/DARREN PAULSON, Standard Process Farms, Palmyra, WI; TOM AND JIM MILLER, R & G Miller and Sons, Columbus, WI; STEVE SLINGER, Randolph, WI; TIM ZANDER, Columbus, WI; TOM WEAVER, Weaver Feeding and Management, Cuba City, WI; GARY WEDIG, Platteville, WI. Roles: Input on determining and pursuing project objectives to meet the needs of organic grain/forage crop producers. Guide researchers on best management practices for organic field crop production systems. TARGET AUDIENCES: Target audiences include Wisconsin, Upper Midwest, and U.S. organic and transitional grain and forage crop farmers, land-grant university Extension educators and county agents, IPM researchers at land-grant universities and colleges, undergraduate students at the freshman/sophomore campuses of the UW Colleges system, and educators and agricultural professionals who serve or interact with a diversity of organic farmers and farmers or educators interested in learning more about insect pest management in organic systems. Efforts to reach target audiences included extension and outreach field day presentations, research presentation and proceedings publications at organic farming conference research symposia, roundtable meetings with organic farmer advisory board to project, and March 2011 eOrganic

webinar presentation by project PI, graduate student, and organic farmer advisor to national audience. PROJECT MODIFICATIONS: Not relevant to this project.

IMPACT

2012/09 TO 2013/08 What was accomplished under these goals? Through this project, land-grant university entomology research and extension in Wisconsin offered improved systems-based programs to address insect pest related problems for organic crops. This project focused on integrated pest management in organic grain and forage crops studying soil fertility management practices, crop plant nutrition and pest and beneficial insect response. The project team has on-going communication and meetings with an 8-member organic farmer advisory board to incorporate farmer knowledge into the research and experimental results discussion and application. Results from this project are leading to change in knowledge for organic and transitional farmers, extension educators, and technical service providers that allows them to better integrate soil and crop nutrient managagement under the National Organic Program pest management standard 205.206. Objective 1: Evaluate two different organic fertility systems in a certified organic grain/forage crop long-term experiment by comparing soil and crop plant nutrient status with pest and beneficial insect response. Murrell EG, Cullen EM. (2014). Conventional and organic soil fertility management practices affect corn plant nutrition and Ostrinia nubilalis (Lepidoptera: Crambidae) larval performance. Submitted: Environmental Entomology. Few studies compare how different soil fertilization practices affect plant mineral content and insect performance in organic systems. This study examined: (1) European corn borer, Ostrinia nubilalis (Hübner), larval response on corn (Zea mays L.) grown in field soils with different soil management histories, and (2) resilience of these plants to O. nubilalis herbivory. Treatments included: (1) standard organic (STDO) -- organically managed soil fertilized with dairy manure and two years of alfalfa (Medicago sativa L.) in the rotation, (2) basic cation saturation ratio (BCSR) -- organically managed soil fertilized with dairy manure and alfalfa nitrogen credits, plus addition of gypsum (CaSO4.2H2O) according to the soil balance hypothesis, and (3) conventional (CONV) -- conventionally managed soil fertilized with synthetic fertilizers. Corn plants were reared to maturity in a greenhouse, then infested with 0-40 O. nubilalis larvae for 17 days. O. nubilalis exhibited lethal and nonlethal competitive response to increasing larval densities. Mean development time was significantly faster for larvae consuming BCSR plants than those on STDO plants, with CONV plants showing intermediate larval development time. Neither total yield (number of kernels), nor proportion kernels damaged, differed among soil fertility treatments. Soil nutrients differed significantly in K, Mg, and S, as well as Ca:Mg and Ca:K ratios, but plant tissue samples taken prior to O. nubilalis infestation differed among soil fertility treatments only in S. Results demonstrate that different fertilization regimens can significantly affect plant nutrition and insect performance within the context of organic systems. Application: While plant maturation was significantly faster in both organic treatments compared to CONV, the addition of gypsum in BCSR served only to increase O. nubilalis performance without any significant benefit to development or yield of the plants over STDO. Manure applications only provided the best compromise for suppressing insect development and improving plant nutrition. Murrell, E.G., C.R. Hanson and E.M. Cullen. (2014). European corn borer (Ostrinia nubilalis) oviposition response to soil fertilization practices and arbuscular mycorrhizal colonization of corn. In Preparation: Ecological Applications. Conventional and organic farming both rely on soil fertilization to optimize yields, crop nutrition. These practices can also affect the colonization and efficacy of arbuscular mycorrhizae (AM), which in turn may improve crop resilience to drought and soil nutrient deficiencies. Both soil mineral fertilization and AM colonization have been shown to affect herbivorous insect oviposition response and performance. However, the below-ground interaction of common fertilization practices and AM colonization on plant nutrition and insect oviposition response has been largely unexplored. To test this, we obtained soils from fields in Arlington, WI that have employed 3 fertilization practices for at least 5 years: Synthetic fertilizers only (conventional farming, or CONV), manure only (standard organic farming, or STDO), and manure + biannual gypsum applications (organic basic cation saturation ratio farming, or BCSR). We reared field corn plants in these soils in a greenhouse, then used them to conduct oviposition choice assays with the common corn pest Ostrinia nubilalis (European corn borer, or ECB). Soil nutrients varied among soil treatments in their Ca:Mg:K ratios and also in S content. Colonization of AM on plant roots did not significantly differ among soil treatments. Plant tissue nutrients (primarily S, Fe, and Cu) varied significantly among soil treatments but were not affected by AM colonization. However, the number of ECB eggs laid per plant per trial varied significantly by both plant tissue nutrient composition and AM colonization, with a significant interaction effect between AM colonization and some plant nutrients. Our results indicate that both fertilization practices and mycorrhizal associations should be taken into account when managing crops for optimal nutrition and pest insect suppression. Application: Ostrinia nubilalis moths showed a strong positive response to S-fertilized plants when mycorrhizae abundance was low, but this response dissipated when mycorrhizae were present. Addition of mycorrhizae to fields has the potential to mediate pest attraction to well-fertilized fields. Objective 3. Develop a

multi-institutional partnership between Wisconsin organic farmers, UW-Madison, Cooperative Extension, and two-year campuses of the UW Colleges system to achieve full integration of research, extension, and education project goals. Work under Project Objective 3 resulted in Social and Scientific Aspects of Organic Agriculture, the first organic/community agriculture course offering in the UW Colleges system. The 3-credit fall semester course was offered over the last five years at UW-Marathon County and UW-Fox Valley, meeting UW Colleges' interdisciplinary (biology and sociology) and writing emphasis curriculum requirements. Both campuses, located in northern Wisconsin, serve many first-generation college students, returning students, and those for whom a four-year university is not economically accessible. This USDA OREI project also provides stipends for UW Colleges students to conduct research projects with UW faculty and farmer mentors at Stoney Acres, a Community Supported Agriculture farm in Athens, WI near the UW-Marathon County campus. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Murrell, E. and E.M. Cullen. 2013. Bottom-up effects of conventional and organic soil fertility management on Ostrinia nubilalis development and resistance of corn plants to herbivory. Abstract and Paper Presentation, Ecological Society of America Annual Meeting, Minneapolis, MN. August 4-9, 2013. 2. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Murrell, E.G., C. Hanson and E.M. Cullen. 2013. ottom-up effects of conventional and organic soil fertility management on Ostrinia nubilalis oviposition response and larval development, and resistance of corn plants to herbivory. Abstract and Paper Presentation, Entomological Society of America Annual Meeting, Austin, TX. November 9-14, 2013. 3. Type: Journal Articles Status: Under Review Year Published: 2014 Citation: Murrell E.G. and E.M. Cullen. (2014). Conventional and organic soil fertility management practices affect corn plant nutrition and Ostrinia nubilalis (Lepidoptera: Crambidae) larval performance. In Review: Environmental Entomology. 4. Type: Conference Papers and Presentations Status: Other Year Published: 2013 Citation: Hanson, C.R., E. Murrell and E.M. Cullen. 2013. Soil fertility practices, plant nutrient profiles, and mycorrhizal colonization affect oviposition response of Ostrinia nubilalis to corn plants. Absract and Poster Presentation, Ecological Society of America Annual Meeting, Minneapolis, MN. August 4-9, 2013.

2011/09/01 TO 2012/08/31 Intended Outcome (medium-term) from Project Logic Model: Land-grant university research/extension and technical service providers will offer improved systems based-programs to address insect pest-related management problems for organic field crops. Project Impacts: (1) A university researcher (Eileen Cullen), organic farmer (Christine Mason), and graduate student (Robin Mittenthal) taught an eOrganic webinar \'Integrated Pest Management for Organic Field Crops\' delivering research results and IPM content tailored to organic grain crops to 127 farmers, extension agents and agricultural professionals from all regions of the U.S., plus Canada. Sixty-three percent of participants improved their understanding of insect management strategies for organic farming, and 69% intend to use this knowledge on their farms or in educational and service provider programs. (2) The eOrganic webinar \'Integrated Pest Management for Organic Field Crops\' has been viewed online 733 times to date since the March 2011 live presentation. The webinar was also approved for Certified Crop Advisor (CCA) Continuing Education Credit (1 credit) and is now available online at eXtension\'s Campus website. CCAs can take the course online, complete a 10-question exam and earn credit for IPM content aligned with an organic cropping systems perspective. (3) Insect sampling data from this project\'s long-term experiment site at Arlington, WI were used to develop an online seedcorn maggot degree-day thermal model to help WI and MN farmers predict seedcorn maggot peak flights and plan spring cover crop incorporation and corn and soybean planting dates outside peak pest activity (cultural pest control). (4) Results from a mail survey of WI organic farmers (n=252; 60% response rate from 55 counties) were used to launch a new publication series specific to organic IPM through UW Extension Cooperative Extension Publications. (5) A 3-credit course and curriculum developed by Paul Whitaker and Kat Becker for this project (BOT/SOC 291 \'Social & Scientific Aspects of Organic Agriculture) is offered fall semester at UW-Marathon County in Wausau, WI and simultaneously via distance education technology to UW-Fox Valley students in Menasha, WI. To date, 134 students have successfully completed this course. The course meets UW Colleges interdisciplinary requirement. In 2012, the course was expanded to fulfill UW Colleges\' Writing Emphasis option requirement.

2010/09/01 TO 2011/08/31 With overlap between 08/31/11 end of previous USDA NIFA IOP/OREI grant (CRIS Accession No. 0207138) and year one of the current USDA NIFA OREI grant in this report, Outcomes/Impacts text is the same between the two reports for 09/01/10 to 08/31/11 CHANGE IN KNOWLEDGE: 127 individuals participated in the March 29th, 2011 eOrganic webinar presented by our researcher/farmer team titled Integrated Pest Management in Organic Field Crops. Content included information from this USDA project and IPM concepts and practices/recommendations for organic systems. eOrganic organizers administered a survey to participants with the following results. Of 127 respondents invited, 86 completed the survey for a response rate of 67.72%. The majority of survey respondents were farmers (22%) or Extension personnel (13%) with the remainder University researcher/educator or non-profit organization staff. Respondents were from all regions of

the U.S. as well as Canada, Greece and Chile. Two-thirds of respondents significantly (23%) to moderately (40%) improved their understanding of organic field crop IPM and soil and crop nutrient management as part of a pest management approach. One-third (33%) improved their understanding a little, and only 5% indicated no improvement at all. 70% of respondents intend to apply the knowledge they gained in this webinar to their work with the remainder opting to apply a little (24%) or none (6%) of the information. 84% felt the information presented was just right, not too technical and not too basic. 72% would definitely recommend this webinar to others and 27% may recommend it to others. Examples of comments from respondents include: I liked having the farmer talk practicality and the research backing up the topic. I would like more from the farmer, discussing the impact of the research; I think it was very helpful to have research-based speakers as well as speakers who are using methods on their farms. I liked the mix of practical and academic. In addition to the eOrganic webinar at the end of this project term, face-to-face contacts were made with target audience at 11 field days and workshops over four years. These contacts allowed over 520 individuals (Upper Midwestern and U.S. farmers, educators, researchers and agriculture professionals) to gain knowledge and expand their concept of applying the IPM paradigm to organic field and forage crops. CHANGE IN ACTIONS: eOrganic and eXtension created an audio/video product of our webinar and project PI Cullen wrote CCA study questions to accompany this distance education product. CCAs now have the option to utilize this product as a resource specific to organic agriculture pest management, earn CCA continuing education units and apply this knowledge in pest management decision-making on farm or in the field. CHANGE IN CONDITIONS: Our UW Colleges interdisciplinary Bot/Soc 291 curriculum and 3-credit fall semester course titled Social and Scientific Aspects of Organic Agriculture is the first interdisciplinary course offering on organic agriculture through UW Colleges. Entering its third year fall 2011, it is an established offering of the UW Colleges institution.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Cullen, E.M. and K.M. Holm. 2013. Aligning insect IPM programs with a cropping systems perspective: Cover crops and cultural pest control in Wisconsin organic corn and soybean. Agroecology and Sustainable Food Systems. In Press. 2. Holm, K. and E. Cullen. 2012. Insect IPM in Organic Field Crops: Seedcorn Maggot. Publication A3972-01. University of Wisconsin-Extension Cooperative Extension Publishing, Madison, WI. 6pp.

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

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Improving the Safety and Quality of Organic Leafy Greens: Assessment of Good Production Practices Along the Farm to Fork Continuum

Accession No.	0222350
Subfile	CRIS
Project No.	ARZT-3278200-G02-534
Agency	NIFA ARZT
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21760
Proposal No.	2010-01945
Start Date	01 SEP 2010
Term Date	31 AUG 2014
Grant Amount	$1,072,766
Grant Year	2010
Investigator(s)	Ravishankar, S.; Jaroni, D.; Bright, K.; Patel, J.; Gerba, C.; Friedman, M.; Nolte, K.

NON-TECHNICAL SUMMARY

Consumers today are aware of the health benefits of consuming fresh produce. Many consumers prefer organic fresh produce over conventional due to the risks associated with the presence of pesticides or other chemical residues on conventionally grown fresh produce. Also, due to the foodborne illness outbreaks associated with fresh produce in recent years, safety of fresh produce has also become a cause for concern. In the proposed integrated project, scientists from the academia and the US Department of Agriculture, in conjunction with extension specialists, growers and processors will work collaboratively to assess the role of organic production practices in safety and quality of organic leafy greens. The mechanisms of attachment and possible internalization of microorganisms on organic leafy greens, and attachment on harvesting equipment will be investigated. Environmental factors and agricultural practices that can affect organic leafy greens safety and quality will be determined. Irrigation canal water and sediments will be tested for foodborne bacteria and viruses in summer and winter including rainy and non-rainy days. The effects of organic certified fertilizers such as compost teas on plant growth and on the microbiological safety of leafy green crops will be assessed. Post-harvest interventions (organic plant derived antimicrobials, organic sanitizers and plant antimicrobial incorporated fruit or vegetable based edible films) that can prevent spoilage and pathogenic microbial (bacteria and viruses) growth in organic leafy greens will be evaluated. Natural plant based antimicrobials and organic sanitizers will be applied as rinses, and antimicrobial edible films will be included in packaged leafy greens. The effects of recycling of antimicrobials and organic sanitizers on their efficacy will be studied. The most effective interventions will be validated on a semi commercial scale. Sensory analysis will be carried out on uninoculated antimicrobial treated leafy greens. An aggressive and extensive outreach program and a follow-up evaluation program for different sectors of the society including agricultural professionals, industry personnel and consumers will be developed and implemented. This program will be shared with other states throughout the nation.

OBJECTIVES

Goals and Objectives: The increased number of foodborne outbreaks associated with fresh produce in recent years has undermined consumer confidence in food supply. Additionally, the role of organic farming practices in

the safety and quality of fresh produce is not clearly understood. The long term goal of this project is to improve the profitability of organic leafy green farms by developing and implementing commercially feasible technology and operational production/handling programs to assure the safety and quality of organic leafy greens. The specific objectives of this project are: 1) To elucidate mechanisms by which foodborne pathogens such as Escherichia coli O157:H7 and Salmonella enterica, a) may attach to and internalize organic leafy greens; and b) attach to equipment surfaces commonly used for harvesting. 2) To understand environmental factors and agricultural practices that may affect organic leafy green safety and quality. 3) To evaluate the efficacy of alternative pre- and post-harvest interventions that can improve shelf-life and control pathogenic microbial growth and survival on organic leafy greens. 4) To conduct an aggressive outreach/education program for stakeholders, including agricultural professionals, industry personnel, and consumers on production practices that can improve the safety and quality of organic leafy greens. Target Dates: Objective 1 will be completed within the first 2 years. Objectives 2 and 3 will start in year 1 and be completed by year 3. Objective 4 will be done in years 3 and 4. Expected Outputs: Successful accomplishment of the goals of the project will benefit the organic leafy greens industry by helping them improve their production and processing practices which are environmentally more friendly, improving the safety and quality of their product and thereby increasing their profitability. It will also benefit the consumers of organic fresh produce by providing them with safer organic products that have enhanced quality and shelf life.

APPROACH

Attachment and Internalization: The attachment and biofilm forming properties of Escherichia coli O157:H7 and Salmonella enterica on leafy greens will be determined. Bacteria labeled with green fluorescent protein genes will be evaluated for internalization in leafy greens. Surface charge and hydrophobicity measurements will be done and attachment will be viewed under confocal scanning laser microscope (CSLM). Field studies will be conducted using nonpathogenic surrogates, and attachment assessed on coring tool and lettuce. Attachment strength will be calculated. Environmental Factors and Agricultural Practices: Irrigation canal water and sediments will be tested for the presence of foodborne bacteria and viruses using standard procedures during both summer and winter months. If problems exist in the concentration of pathogens from water due to sediment clogging of the 0.45 micron membrane, micro fiber glass filters or immunomagnetic separation will be employed. Rainy days and non-rainy days will be included. Quantitative microbial risk assessment will be used to model microbial risks from contaminated irrigation water used for leafy greens production. The microbial quality of commercial compost teas will be determined. Crops will be subject to common production and handling practices and effects of compost teas on microbiological safety of leafy green crops will be assessed. Leafy greens will be grown with different input of organic fertilizers to determine any benefits to plant growth. Pre- and Post-harvest Interventions: The efficacy of various plant antimicrobials and organic sanitizers against bacteria (both spoilage and pathogenic) and viruses will be tested on coring equipment and on organic leafy greens (14 day storage). The re-usability of plant antimicrobials and organic sanitizers for washing leafy greens will be evaluated. Effectiveness of antimicrobial edible films in packaged organic leafy greens (10 day storage) against spoilage and pathogenic bacteria will be tested. The most effective treatments will be validated on a semi commercial scale. Sensory analysis will be done on uninoculated treated samples. Outreach/Education Activities: The results of research will be used to educate the organic agricultural professionals and industry personnel via training workshops, in service training, traditional contact, and consumers via mass media, on practices that improve the safety and quality of organic leafy greens. An Organic Leafy Greens Awareness Website will be created Data Analysis: Data will be analyzed using ANOVA or other appropriate statistical methods such as LSD or Tukeys (SAS software). Evaluation of Outputs: Evaluation of goals 1, 2 will be based on results obtained from laboratory and field studies. Evaluation of goal 3 will be based on finding effective alternative interventions for organic leafy greens. The findings from all 3 goals will be used in developing the outreach/education program. The evaluation of goal 4 will be based on successful implementation of safe alternative practices by the organic leafy greens growers and industry. The presentations and publications resulting from the project will be enumerated.

PROGRESS

2010/09 TO 2015/08 Target Audience:The target audiences for this project include: growers, producers, and processors of organic leafy greens; manufacturers of natural antimicrobials and organic sanitizers; and consumers of organic leafy greens. Leafy green producers, manufacturers of natural antimicrobials, organic sanitizers have been involved in this project by providing in-kind support. Duncan Family farms, Buckeye, AZ and JV Farms, Yuma, AZ provided lab equipment and organic leafy greens. CreAgri Inc., Hayward, CA and Apple Poly, LLC., Morrill, NE provided antimicrobial plant extracts and Spectral Imaging, Tucson, AZ provided imaging equipment. The following companies provided organic sanitizers: GTX Technologies, Amarillo, TX; E3 Organics,

Inc., CA; Summerdale, Inc., Verona, WI; ASC Agrecom, Inc., Tucson, AZ; Arch Chemicals, Inc., Charleston, TN; and BioSafe Systems, East Hartford, CT. They have been informed periodically on the project results through various forums such as seminars, reports, talks and demonstrations. For growers, information about the project results was shared at meetings, conferences, seminars and via demonstrations. Meetings such as the Arizona Produce Research Priorities meeting organized by the Center for Produce Safety, Food Safety Summit (2011-2015), Southwest Agricultural Summit (2011-2015), and Lettuce days (2011-2015) provided Drs. Sadhana Ravishankar, Kelly Bright, Charles Gerba, Kurt Nolte, Jorge Fonseca and Divya Jaroni an opportunity to present their research findings and develop a deeper insight about food safety challenges faced by the growers. Dr. Ravishankar and Gerba have served as panel members in food safety panels at the Southwest Agricultural Summits in Yuma, AZ. Dr. Ravishankar serves in the Food Safety Advisory Board for Duncan Family Farms. Visits to farms and meetings with growers nurtured an efficient channel of communication between stakeholders and researchers. Visits to farms such as JV Farms, Dole Fresh Produce, Pasquinelli Produce Company, Fresh Express, Taylor Farms, Duncan Family Farms and Foxy Fresh Produce by research team helped understand current issues associated with safety of organic leafy greens. Farms were also advised on water sampling techniques and frequency based on results obtained about water quality and pathogen surveillance conducted during the project. The research team often exceeded the scope of the project to improve food safety knowledge and awareness by testing the role of dust in pathogen transfer, an issue of concern for AZ leafy green growers, and testing biofilm formation by E. coli on leafy green wash water contact surface. The initiative to test different viruses as reliable indicators of fecal contamination was also done to help growers develop robust biomarkers for environmental contamination. Research data was presented at international conferences, academic meetings, professional associations and for students. These included the Annual Meetings of the following: American Society for Horticultural Sciences (2012-2014), International Association for Food Protection (2011-2015), Institute of Food Technologists (IFT; 2011-2015), University of Arizona Food Safety Consortium (2012-2015), Yuma Fresh Vegetable Association (2012), Arizona Iceberg Lettuce Research Council (2012-2015) and Yuma Safe Produce Council (2015). Demonstrations on use of plant antimicrobials for produce washing and safe handling of produce was conducted at the Youth Biotechnology Career Expo in Tucson, AZ (2013); Science City, Tucson Festival of Books (2012-2015); Cactus IFT meeting, Phoenix & Tucson (2014 & 2015); Career Day at Summit View Elementary School, Tucson (2015); and the Clean and Green Produce Safety Workshop, Tucson, AZ (2015). A total of 27 presentations/demonstrations were conducted by Dr. Ravishankar and her team during the grant duration. The audiences at these conference and meetings included food safety professionals, produce growers, produce industry professionals and students. Research was also presented to elementary, middle, and high school, undergraduate and graduate students to develop awareness about organic agriculture, food safety, produce handling, and sanitizers. The initiative to develop an interest in research and analytical thinking was catered to by developing activities and demonstrations that involved active learning. Biophotonic imaging was used to develop awareness of cross contamination and sanitizer efficacy. Glitter contaminated cutting boards were used to demonstrate cross contamination to younger children. These activities were well received by the audience. Three workshops with hands on demonstrations were conducted for University of AZ and AZ Western College, Yuma, AZ students (27 participants) on organic leafy green safety. Dissemination of information to the public occurred through radio shows, news coverage and USDA blogs. Dr. Ravishankar was interviewed by Phoenix Public Radio KJZZ 91.5 FM, \"Agronomically Speaking\" Radio 710 KURV, Texas, and Arizona Public Media (Tucson section NPR). News coverage also included print media- Fresh Cut Magazine, California Farmer Magazine \"Compendium\" by the UA College of Agriculture and Life Sciences. Interviews with the Daily Wildcat, Packer magazine and UA News were also published. These were well received by both industry and consumers who contacted Dr. Ravishankar via emails for more information or to foster collaborations. Two national level webinars hosted by E3 Organics and eOrganics were also presented by Dr. Ravishankar. The webinars were attended by students, produce industry personnel and state regulatory agencies. Dr. Ravishankar presented the results via seminars at the Western Regional Research Center, Albany, CA; Texas A&M University, College Park, TX; Arizona Senior Academy, Tucson, AZ; Microbiology Club, Tucson, AZ; and the Annual Registered Sanitarians Conference, Phoenix, AZ. The extension team at Yuma developed effective and innovative methods to disseminate information to growers that continue to be a source of applicable data for stakeholders. Dr. Nolte and his team developed a website, created and uploaded YouTube videos, developed training DVDs and has made information accessible over Facebook, Pinterest and Twitter. Apart from improving the accessibility to latest research in food safety and good agricultural practices, he has also conducted seminars and training series in different parts of Arizona addressing pressing issues in food safety. A unique feature of his efforts has been the bilingual mode of instruction in order to reach a larger target audience and non-English speaking minorities. Dr. Jaroni spoke at 2 workshops in Opelousas, LA and 2 field-days in Baton Rouge, LA. These were designed to increase knowledge of growers in food safety, agricultural practices and nutritional properties of crops grown in LA. The workshops and field days were attended by at least 50 & 100 farmers, respectively. Dr. Jaroni also presented results at 3 Plant Biosecurity symposiums held at Southern University attended by about 200 fresh produce industry and academia professionals and consumers. Dr. Brandenberger and Dr. McGlynn carried out a

total of 24 presentations to several groups of fresh produce growers and processors in Oklahoma related to fresh produce safety. These are generally small-scale producers who sell their products at the local grocery stores or farmer\'s markets. The PIs from Oklahoma State University have also finalized and made public a website related to fresh produce safety, which is intended to provide Oklahoma growers, processors, and interested consumers with single-source access to relevant research results. A total of 20 abstracts were submitted by Dr. Jaroni\'s group and accepted for oral and poster presentations at various meetings. Dr. Jitu Patel of USDA-ARS shared results on internalization and natural antimicrobials with the largest organic growers in the mid-Atlantic region. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?All postdoctoral fellows, technicians and students hired to work on this project have received training in good laboratory practices, including pathogen safety precautions, media preparation, product sampling, field sampling and other laboratory activities related to the project. Dr. Sadhana Ravishankar\'s lab had 23 undergraduate students, 8 graduate students, 1 research specialist and 2 postdoctoral research associates involved with organic leafy greens research. All students have been trained in bacterial inoculation & enumeration, environmental isolation of pathogens, soil, organic composts and compost teas evaluation and have been involved with conducting experiments under the guidance of Drs. Ravishankar and Dev Kumar. Students have been trained to analyze and present data and have presented research posters at Food Safety Conferences in University of Arizona and at the Cactus Institute of Food Technologists regional meeting. Dr. Dev Kumar was trained in confocal microscopy at the USDA, Beltsville facility in Maryland by Dr. Patel. Dr. Ralph Meer and research specialist Libin Zhu were trained in confocal microscopy and a graduate student Arlette Schneider in fluorescent microscopy (for investigating mechanism of action of clove bud oil) at the University of Arizona. Three graduate students were trained to design primers, develop master mixes for polymerase chain reaction (PCR) and perform PCR for the identification of foodborne pathogens. These students were also trained in antibiotic resistance testing for bacteria. Dr. Ravishankar\'s team offered hands on organic leafy greens safety training workshop covering various topics to undergraduate and graduate students from Tucson and Yuma and industry in August 2015. Dr. Ravishankar also trains local elementary, middle and high school students in microbiological techniques and allows them to work on produce safety projects using non-pathogenic bacterial strains. Four high school students, two middle school students and two elementary school students conducted their research projects in Dr Ravishankar\'s lab for science fairs. Three high school students won awards at the school and regional levels (Southern Arizona Science and Engineering Fair) and got the opportunity to participate at the Intel International Science and Engineering Fair, where two high school students won special awards. Two elementary school and one middle school students won awards at the school and regional levels. Produce safety demonstrations were conducted by Dr. Ravishankar\'s research team during lab tours for local school students Dr. Ravishankar\'s students and postdoctoral research associate (Dr. Dev Kumar) had the opportunity to present research results at various occasions. Dr. Dev Kumar presented a seminar on biofilms on leafy green wash water equipment surfaces at the Fall seminar series of the School of Animal and Comparative Biomedical Sciences, University of Arizona. He also presented the research results in the form of oral presentations at the quarterly meetings of the Arizona Iceberg Lettuce Research Council in November 2013, July 2014 and 2015. These meetings were attended by leafy green growers and industry professionals from Yuma, AZ and California. Dr. Dev Kumar also had the opportunity to present the research results as a technical oral presentation at the Annual Meeting of the International Association for Food Protection in Indianapolis and the Yuma Fresh Produce Council meeting. Dr. Ravishankar\'s students and postdoctoral research associate presented their research results in the form of posters at the Annual Food Safety Conference hosted by the University of Arizona Food Safety Consortium in 2012, 2013, 2014 and 2015. Dr. Ravishankar\'s graduate student Xeeroy Rada and Arlette Schneider won the third place and first place respectively in the student poster competition at this conference. Dr. Ravishankar\'s students and postdoctoral research associate had the opportunity to participate in food safety demonstrations about natural antimicrobial/organic sanitizers for washing produce, safe produce handling and cross contamination at the following events: for the local high school students at the at the Youth Biotechnology Career Expo in October 2013, Tucson, AZ; for the local high school students at the Southwest Ag Summit in February 2014, and 2015 at Yuma, AZ; for the local community at the Tucson Festival of Books in March 2012, 2013, 2014, and 2015 at Tucson, AZ; for the local community at the Lettuce Days in February 2014 and 2015, Yuma, AZ. In the Yuma Agricultural Center, 5 research technicians and 1 undergraduate student were trained in laboratory work for analyzing the safety and quality aspects of organic leafy greens; organic composts and compost teas production; investigating the survival of non-pathogenic E.coli and background microflora in compost teas; cross-contamination potential of original and modified design coring tools; field work involving organic leafy greens production, application of compost teas with and without E.coli; harvesting leafy greens and analyzing them for quality and market attributes. One media specialist assisted Dr. Kurt Nolte in the production of audiovisual material, YouTube videos and other social media networking. She interviewed few project members and produced YouTube videos on specific topics concerning organic leafy greens production. Dr. Nolte also trained one undergraduate student in outreach material production. In Dr. Patel\'s lab, two postdoctoral fellows, 1 graduate, and 2 undergraduate students were trained in food microbiology under the research project to

determine attachment and internalization of E. coli O157:H7 on organic leafy greens. In Dr. Jaroni\'s lab 3 postdoctoral fellows, 8 graduate and 16 undergraduate students were trained as food microbiologists to evaluate the efficacies of various approved organic sanitizers/antimicrobials against E.coli O157:H7 on organic leafy greens. The students and postdocs also had opportunities to present their research (oral and poster) at several venues for their professional development; at the Annual meeting of International Association for Food Protection (IAFP), the Oklahoma State University (OSU) Research Week, the annual FAPC Research Symposium, the Dept. of Animal Science (ANSI) Seminar series, and the FAPC Seminar series. 12 graduate and 11 undergraduate students were also trained during the FDSC 4253/5120 Preharvest Food Safety course offered in Spring Semesters through the ANSI Food Science Program at OSU. Dr. Kelly Bright trained Sheri Carlino, research specialist and two graduate students to perform environmental field sampling for bacterial pathogens and the culture and isolation of bacterial foodborne pathogens from irrigation waters. Also, Dusty Tyree, part-time research technician was trained to perform environmental field sampling for bacterial and viral pathogens, the concentration of viruses from water, and quantitative PCR for the detection of viruses in water. The use of mass media for the propagation of food safety information to stakeholders has given students and other researchers in the Ravishankar lab and the Yuma Agricultural Center an opportunity to participate in interviews about their research for Youtube videos. The new forum helps students and researchers present their findings in a succinct and easily accessible format. Drs. Ravishankar, Jaroni, Gerba, Bright, Patel and Nolte\'s students and team members have had the opportunity to present their research findings at international and state level conferences such as the Annual Meetings of the International Association for Food Protection, the Institute of Food Technologists and the American Society for Horticultural Sciences, as well as the food safety summits in Yuma, AZ, Annual Food Safety Conference and PI meetings in Tucson, AZ, through poster and oral presentations. How have the results been disseminated to communities of interest?The extension teams at the Yuma Agricultural Center, Oklahoma State University, Dr. Nolte and Dr. Ravishankar\'s team have been involved in dissemination of information to communities of interest. Seminars, training sessions, conferences, demonstrations, videos, internet based communications and print media have all been used. Overall Extension/ Outreach Summary- Dr. Nolte, University of Arizona- 06/2012-05/2015: 1. Arizona Organic Food Safety Workshops, Target Trainings and Demonstrations: Since initiating Organic Fresh Produce USDA GHP/GAP targeted trainings, tours, workshops in 2012, the total number of Organic Safety training participants was 3,474. During this period, the number of Arizona specific, USDA GHP/GAP certified growers has increased 3-fold. Initiated the first Arizona Group USDA GHP/GAP effort and submitted a Quality Management System to USDA-AMS for external review and approval. With USDA approval, Arizona Group GAP effort will be the first University/State Department of Agriculture/Local Grower Network fresh produce collaboration in the US. 2. Internet Video Outreach Developed and published a collection of 31 (19 in English, 12 in Spanish) Extension and targeted training videos which provides research outcomes to users. Total viewership includes 10,470 individual views from among 12 countries. Video modules can be viewed on the Fresh Produce Safety Channel (http://www.youtube.com/user/FreshProduceSafety/featured). A portion of this video series is also available in a DVD format for use when an internet connection is not available. 3. Social Media Interfacing Extension also included programming that utilized a dedicated web interface, Facebook, Twitter, and Pinterest. Since the live release in early 2013, the sites have generated over 11,170 global interactions and fresh produce safety communication continues to grow daily. Workshops have been conducted throughout the state to provide content detailed training involving the safe production of organically grown leafy greens. In 2015, the following workshops were conducted: Tucson (March, 2015): A GHP/GAP training workshop was provided to 125 attendees during the Greenhouse Crop Production and Engineering Design Short Course Phoenix (March, 2015) 23 participants Phoenix (Spring, 2015): Initiated an Arizona Group USDA GHP/GAP effort to be organized in Central Arizona (Phoenix), and being facilitated by Stewart Jacobson (Arizona Department of Agriculture) and Kurt Nolte (University of Arizona). The Central Arizona Group USDA GHP/GAP, Quality Management System was submitted to the USDA-AMS for review. With USDA approval, the Arizona Group GAP effort will be the first University/State Department of Agriculture/Local Grower Network fresh produce collaboration in the US. Specific regulatory and grower related training was provided to educate clientele or third party auditors about research outcomes to gain greater insight on industry needs. Fresh Produce Safety Tour Series in Yuma (Jan. - Mar., 2015) included 880 participants. Extension Videos covering the following topics were developed: edible films; microbial internalization; organic sanitizers, compost teas; reducing contamination in irrigation water; safe management practices for composted manures. Also a 4-part, video series of field worker training modules (English and Spanish) covering hand washing, field sanitization, bodily fluid discharge and field etiquette were developed for field workers. Growers found these very useful. Dr. Ravishankar and her team attended the Annual Food Safety Conferences in Tucson, AZ where project results were shared with stakeholders and posters were presented. Dr. Ravishankar\'s graduate student presented a poster on the efficacy of plant antimicrobial combinations at the University of Arizona Student Poster Competition to inform the university community about the efforts associated with making produce safer. Dr. Ravishankar\'s team conducted food safety demonstrations on natural antimicrobial/organic sanitizers for washing produce, safe produce handling and cross contamination

for local high school students at the Youth Biotechnology Career Expo (2013) in Tucson, AZ and Southwest Ag Summit (2014, 2015) in Yuma, AZ; for local community at Science City, Tucson Festival of Books (2012-2015) and Lettuce Days (2014, 2015) at Yuma, AZ; for food professionals at Cactus IFT meeting, Phoenix and Tucson (2014, 2015); for students Career Day at Summit View Elementary School (2015); and for college students and industry at the Clean and Green Produce Safety Workshop, Tucson, AZ (2015). Dr. Dev Kumar presented the work on biofilm based attachment of E. coli to washing equipment surfaces at the University of Arizona (2013) and the Arizona Iceberg Lettuce Research Council Quarterly meeting (2013, 2014) in Yuma, AZ. Dr. Ravishankar and her graduate student attended the Food Systems Network meetings during January-March 2014 at Tucson, Arizona to discuss produce safety issues. Dr. Ravishankar presented the results of her research at 2 National Webinars conducted by E3 Organics and the eOrganic in 2013 and 2014. The project team attended the Southwest Agricultural Summit (2012-2015) at Yuma, Arizona to provide information to stakeholders on produce safety issues. Dr. Ravishankar discussed research on produce safety and novel interventions at the Food Systems Network conference in April, 2014. She participated in the Foodborne Task Force Meeting in August 2014, organized by the Arizona Department of Health Services where some findings from the project were shared. A total of 27 presentations/demonstrations were conducted by Dr. Ravishankar and her team. Dr. Dev Kumar presented research on Salmonella internalization in spinach at the IAFP annual conference and the Yuma Safe Produce Council Executive Breakfast in 2015. Dr. Ravishankar presented the results via seminars at the Western Regional Research Center, Albany, CA; Texas A&M University, College Park, TX; Arizona Senior Academy, Tucson, AZ; Microbiology Club, Tucson, AZ; and the Annual Registered Sanitarians Conference, Phoenix, AZ. Dr. Ravishankar was interviewed by Phoenix Public Radio KJZZ 91.5 FM, \"Agronomically Speaking\" Radio 710 KURV, Texas, and Arizona Public Media (Tucson section NPR). News coverage also included print media- Fresh Cut Magazine, Packer magazine, California Farmer Magazine, Daily Wildcat and \"Compendium\" by the UA College of Agriculture and Life Sciences. Oklahoma state University team also participated in various talks, presentations and website development for information dissemination. Drs. Brandenberger and McGlynn carried out a total of 24 presentations to several groups of fresh produce growers and processors in Oklahoma related to fresh produce safety. These are generally small-scale producers who sell their products at the local grocery stores or farmer\'s markets. The PIs from Oklahoma State University have also finalized and made public a website related to fresh produce safety titled: Fresh Produce Safety (www.freshproducesafety.okstate.edu). This website is intended to provide Oklahoma growers, processors, and interested consumers with single-source access to relevant research results, Extension outreach materials, and a calendar of upcoming events related to fresh produce food safety. A total of 20 abstracts were submitted by Dr.Jaroni\'s group and accepted for Oral and Poster presentations between 2012 and 2015 for the following: IAFP Annual Conferences; OSU Research Week, FAPC Research Symposia; Plant Biosecurity Symposia at Southern University. Dr. Jitu Patel of the USDA-ARS shared the results of his research on internalization and natural antimicrobials with the largest organic growers in the mid-Atlantic region. A video on \'pathogen internalization in leafy greens\' was prepared by Dr. Patel\'s group in collaboration with University of Arizona Extension for dissemination of science to growers. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Target Audiences The target audiences for this project include: growers, producers, and processors of organic leafy greens; manufacturers of natural antimicrobials and organic sanitizers; and consumers of organic leafy greens. Leafy green producers and manufacturers of natural antimicrobials and organic sanitizers have been involved in this project by providing in-kind support to the project. They have been informed periodically on the results of this project through various forums such as seminars, talks and demonstrations. Dr. Ravishankar visited fresh produce growers and industry personnel in Goodyear, AZ and Yuma, AZ in May 2012 and December 2012, respectively, to discuss research needs. She was invited as the featured speaker at the Yuma Fresh Vegetable Association Annual Meeting in December 2012 in which she provided an overview of the organic leafy greens project and an update on the project progress to the attendees that included fresh produce professionals. Dr. Ravishankar attended the Food Safety Research Update Meeting with the Yuma Fresh Produce Growers in September 2013 and gave the most recent update on the results from this project. Information about the results from the project was also shared with stakeholders at the Food Safety Consortium at the University of Arizona in October 2013, where posters on efficacy of plant antimicrobial combinations, biofilm formation by E. coli on produce wash water contact surfaces and attachment and cross transfer of Salmonella from soil to produce surfaces were presented. The audience in these meeting included produce growers, students and other faculty involved in food safety research. Dr. Ravishankar also presented the research results generated from this project at the Annual Meetings of the International Association for Food Protection (IAFP; Charlotte, NC) and Institute of Food Technologists (IFT; Chicago, IL) in 2013 in the form of posters. The audiences at these conference included food safety professionals, produce growers, produce industry executives and students. Dr. Ravishankar's research team conducted food safety demonstrations about natural antimicrobial/organic sanitizers for washing produce, safe produce handling and cross contamination for

the local Tucson community at the Science City, Tucson Festival of Books in March 2013 and for the local school students at the Youth Biotechnology Career Expo in October 2013, hosted by the BIO5 Institute, University of Arizona. Dr. Ravishankar's postdoc, Dr. Dev Kumar presented the work on biofilm based attachment of E. coli to washing equipment surfaces in seminar presentations at the University of Arizona (October 2013) and the Arizona Iceberg Lettuce Research Council (AILRC) Quarterly meeting attended by produce growers (November 2013) in Yuma, AZ. Dr. Ravishankar's graduate student presented a poster on the efficacy of plant antimicrobial combinations at the University of Arizona Student Poster Competition in November 2013 to inform the university community about the efforts associated with making produce safer and the novel strategies implemented to achieve this goal. Dr. Nolte of the Yuma Agricultural Center has used multiple communication strategies towards knowledge dissemination. His team has developed a website, uploaded YouTube videos, developed training DVDs and has made information accessible over facebook.com, Pintrest and Twitter. Apart from improving the accessibility to the latest research in food safety and good agricultural practices he has also conducted seminars and training series in different parts of Arizona addressing pressing issues in food safety. A unique feature of his efforts has been the bilingual mode of instruction in order to reach a larger target audience. Dr. Nolte's team presented posters related to this project at the 2013 Annual Meeting of the American Society for Horticultural Sciences in Palm Desert, CA. At the University of Oklahoma, Dr. Brandenberger has given four talks to several fresh produce farmers in Oklahoma, related to fresh produce safety. Dr. William McGlynn has incorporated the results of the studies carried out in Dr. Jaroni's lab in five workshops. He also attended the Center for Produce Safety Produce Research Symposium in June 25 and 26 in Rochester, NY where he participated in discussions and planning sessions related to implementing Good Agricultural Practice (GAP) programs designed to allow smaller-scale, local fresh produce growers and processors to safely supply produce to local and regional retail outlets. He also gathered information about emerging microbial threats and potential mitigation strategies. The Principal Investigators from Oklahoma State University have also established a website related to fresh produce safety. Dr. Jaroni and her graduate students presented the research results generated from this project at the 2013 Annual Meeting of the International Association for Food Protection (IAFP) in Charlotte, NC in the form of posters. Dr. Friedman of the USDA and Dr. Ravishankar participated with Marcia Wood (ARS) in drafting an article for April 2013 issue of Agricultural Research. The article and press release resulted in numerous exchanges of information with reporters of health magazines. Dr. Friedman is also a member of the W3122 Multistate Research Project entitled \"Beneficial and Adverse Effects of Natural Chemicals on Human Health and Food Safety\" for which he exchanged ideas with members (university professors and ARS scientists) to facilitate progress associated with food safety and human health. Dr. Jitu Patel of the USDA-ARS shared the results of his research on internalization and natural antimicrobials with the largest organic growers in the mid-Atlantic region. All post-doctoral fellows, technicians and students hired to work on this project have received training on good laboratory practices, including pathogen safety precautions, media preparation, product sampling, field sampling and other laboratory activities related to the project. Dr. Dev Kumar received training in PCR and use of confocal scanning laser microscopy to study the attachment/internalization of bacteria on/in organic leafy greens from the Palanivelu lab, School of Plant Sciences, University of Arizona, Tucson. Over the past year numerous media outlets have provided coverage/stories on the organic leafy greens research project (see publication list) to reach a wide variety of audience. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? All post-doctoral fellows, technicians and students hired to work on this project have received training on good laboratory practices, including pathogen safety precautions, media preparation, product sampling, field sampling and other laboratory activities related to the project. Dr. Sadhana Ravishankar's lab currently has 6 undergraduate students, 3 graduate students and a postdoctoral research associate involved with organic leafy greens research. Undergraduate and graduate students have been trained in bacterial inoculation & enumeration, environmental isolation of pathogens, soil evaluation and have been involved with conducting experiments under the guidance of Drs. Ravishankar and Dev Kumar. Undergraduate and graduate students have been trained to analyze and present data and have presented research posters at the Food Safety Conference in the University of Arizona. Dr. Sadhana Ravishankar also trains high school students in microbiological techniques and allows them to work on produce safety projects using non-pathogenic bacterial strains. She currently has 2 high school students conducting their science fair projects in her lab. The use of mass media for the propagation of food safety information to stakeholders has given students and other researchers in the Ravishankar lab and at the Yuma Agricultural Center an opportunity to participate in interviews about their research for youtube videos. The new forum helps students and researchers present their findings in a succinct and easily accessible format. Dr. Dev Kumar received training in PCR and use of confocal scanning laser microscopy to study the attachment/internalization of bacteria on/into organic leafy greens from the Palanivelu lab, School of Plant Sciences, University of Arizona, Tucson. Dr. Dev Kumar presented the work on biofilm based attachment of E. coli to washing equipment surfaces in seminar presentations at the University of Arizona (October 2013) and the Arizona Iceberg Lettuce Research Council (AILRC) Quarterly meeting attended by produce growers (November 2013) in Yuma, AZ. Dr. Ravishankar's graduate student presented a poster on the efficacy of plant antimicrobial combinations at the University of

Arizona Student Poster Competition in November 2013 to inform the university community about the efforts associated with making produce safer and the novel strategies implemented to achieve this goal. Drs. Ravishankar, Jaroni, Gerba, Bright, Patel and Nolte's students have had the opportunity to present their research findings at international and state level conferences such as the Annual Meetings of the International Association for Food Protection (IAFP), the Institute of Food Technologists (IFT) and the American Society for Horticultural Sciences (ASHS), as well as the Annual Food Safety Conference in Tucson, AZ, through posters. How have the results been disseminated to communities of interest? The extension teams at the Yuma Agricultural Center, Oklahoma State University and Dr. Ravishankar's laboratory groups have been involved with the dissemination of information to communities of interest. Seminars, training sessions, conferences, demonstrations, videos, internet based communication and print media have all been used. Workshops have been conducted throughout the state to provide content detailed training involving the safe production of organically grown leafy greens in Flagstaff (December, 2012), 35 participants; Phoenix (January, 2013), 18 participants; Maricopa (February, 2013), 22 participants; Flagstaff (March, 2013), 28 participants; Snowflake (April, 2013), 22 participants; Yuma (May, 2013), 7 participants; and Nogales (October, 2013), 18 participants. Extension Videos were developed covering the following topics: Edible Films, Microbial Internalization & Surface Adhesion in Leafy Greens, Organic Sanitizers, Compost Teas, Reducing Contamination in Irrigation Water, Safe Management Practices for Using Composted Manures. A 4-part, video series of field worker training modules (English and Spanish) was developed. Bilingual production of training modules has provided an additional avenue of outreach that includes a clientele base that could not necessarily be otherwise reached. While total viewership has reached 2,100 views (February 2012) since the release of the Fresh Produce Safety Channel in April, 2013, user testimonials have been extremely positive. These training segments cover topical areas that include: Hand Washing, Field Sanitation, Bodily Fluid Discharge, and Field Etiquette. Extension also includes programming that uses a dedicated web interface, Facebook, Twitter, and Pinterest. Since their release the sites have generated over 3,300 client interactions (February 2012) which continue to grow daily. Details Fresh Produce Safety Website (2,700 views). A Safe Organic Training website has been created for producers, and progress is being made to integrate this into eXtension. The site contains key information about the USDA Good Handling and Agricultural Practices (GAP/GHP) program, as well as the online, bilingual version of the training materials (http://cals.arizona.edu/fps/). Facebook (102 fans). The Fresh Produce Safety Facebook page provides networked follower's tips, trends and key information about the practices involving fresh produce safety (https://www.facebook.com/FoodSafety101). Twitter (377 followers). Followers receive instant updates related to fresh produce safety production practices, research developments, workshops, and demonstrations. Allows a seamless way to keep updated (https://twitter.com/FreshFoodSafety). Pinterest (56 subscribers). Allows fresh produce safety materials to be shared with others, a leader in creating referral traffic (http://www.pinterest.com/producesafety). Our team from the Oklahoma state University also participated in various talks, presentations and has developed a website for information dissemination. Dr. Brandenberger has carried out four talks to several fresh produce farmers in Oklahoma, related to fresh produce safety. Dr. William McGlynn has incorporated the results of the studies carried out in Dr. Jaroni's lab in five workshops. Presentations McGlynn, W.G. & Brandenberger, L. 2013. Food Safety 101, presentation given on March 12 at: Oklahoma Market Gardening School. Oklahoma Cooperative Extension Offices, Tulsa, OK. McGlynn, W.G. 2013. Good Agricultural Practices (GAPs): an Introduction. Oral presentation, handouts, given on March 13 to the Otoe-Missouria tribes / Ponca as part of a Plasticulture Market Garden demonstration project. McGlynn, W.G. 2013. Good Agricultural Practices (GAPs): an Introduction. Oral presentation, handouts, given on April 9 to the Otoe-Missouria tribes / Ponca as part of a Plasticulture Market Garden demonstration project. Brandenberger, L.; McGlynn, W.G. 2013. Basic Good Agricultural Practices for Fresh Produce. Oral presentation, handouts, and hands-on demonstration given on May 8 to the Hmong people as part of a Plasticulture Market Garden demonstration project. Brandenberger, L. 2013. Safe Use of Pesticides for Produce Production. Oral presentation, handouts, and hands-on demonstration given on July 2 to the Hmong people as part of a Plasticulture Market Garden demonstration project. Brandenberger, L.; McGlynn, W.G. 2013. Basic Good Agricultural Practices for Fresh Produce. Oral presentation, handouts, and hands-on demonstration given on July 24 to the Otoe-Missouria / Ponca tribes as part of a Plasticulture Market Garden demonstration project. The PIs from Oklahoma State University have also established a website related to fresh produce safety titled: Fresh Produce Safety (www.freshproducesafety.okstate.edu). Dr. Jaroni and her graduate students presented the research results generated from this project at the 2013 Annual Meeting of the International Association for Food Protection (IAFP) in Charlotte, NC in the form of posters. Dr. Jitu Patel of the USDA-ARS shared the results of his research on internalization and natural antimicrobials with the largest organic growers in the mid-Atlantic region. Dr. Sadhana Ravishankar has also been involved with multiple demonstration based activities to educate the public about plant antimicrobials, safe produce handling and the risk of cross contamination in the kitchen. She and her team conducted Food Safety Demonstrations on these topics for the local Tucson community at the Science City, Tucson Festival of Books; for the local school students at the Youth Biotechnology Career Expo, hosted by the BIO5 Institute, University of Arizona. Models were created to demonstrate cross contamination from cutting board to produce surfaces. Biophotonic images of pathogens on

produce surfaces before and after antimicrobial treatments were also used to demonstrate the effectiveness of plant based antimicrobials. Dr. Ravishankar was invited as the featured speaker at the Yuma Fresh Vegetable Association Annual Meeting in December 2012 in which she provided an overview of the organic leafy greens project and an update on the project progress to the attendees that included fresh produce professionals. She attended the Food Safety Research Update Meeting with the Yuma Fresh Produce Growers in September 2013 and gave the most recent update on the results from this project. Information about the results from the project was also shared with stakeholders at the Food Safety Consortium at the University of Arizona in October 2013, where posters on efficacy of plant antimicrobial combinations, biofilm formation by E. coli on produce wash water contact surfaces and attachment and cross transfer of Salmonella from soil to produce surfaces were presented. The audience in these meetings included produce growers, students and other faculty involved in food safety research. Dr. Ravishankar also presented the research results generated from this project at the Annual Meetings of the International Association for Food Protection (IAFP; Charlotte, NC) and Institute of Food Technologists (IFT; Chicago, IL) in 2013 in the form of posters. The audiences at these conference included food safety professionals, produce growers, produce industry executives and students. Dr. Dev Kumar presented the work on biofilm based attachment of E. coli to washing equipment surfaces in seminar presentations at the University of Arizona (October 2013) and the Arizona Iceberg Lettuce Research Council (AILRC) Quarterly meeting attended by produce growers (November 2013) in Yuma, AZ. Dr. Ravishankar's graduate student presented a poster on the efficacy of plant antimicrobial combinations at the University of Arizona Student Poster Competition in November 2013 to inform the university community about the efforts associated with making produce safer and the novel strategies implemented to achieve this goal. What do you plan to do during the next reporting period to accomplish the goals? Objective 1 To study the fate of Salmonella on organic leafy greens we plan to grow spinach sprouts that have been challenged with the pathogen through Salmonella contaminated seed or contaminated water in organic soil. Once the plant reaches the 4 leaf stage, the leaves, stem and roots will be sampled for the presence of surface attached and internalized Salmonella to understand distribution of pathogen after contamination event during germination. To understand the effect of soil contamination by Salmonella on organic leafy greens, we plan to grow spinach in soil contaminated by the pathogen. We will also study fate of pathogen on organic leafy greens when irrigation water is contaminated. The effect of these conditions when root damage occurs will be studied. Both surface contamination and possible internalization by the pathogen will be accounted for. Objective 2 Studies to understand the impact of compost teas on the survival of non-pathogenic Escherichia coli on plants and the benefits of the application of compost teas on plant yield will continue. Survival times and safest methods of compost tea application will be evaluated. Studies on the survival of E. coli in composts will continue to determine raw materials most suitable and safe for composting. Dr. Bright will continue her survey of Arizona irrigation water and sediments for norovirus and hepatitis A virus. A microbial risk assessment of irrigation water will be done. Objective 3 Efficacy of combinations of plant based antimicrobials will be evaluated against Salmonella on organic leafy greens to gauge antimicrobial activity of the combinations at the lowest concentrations. The effectiveness of edible film based antimicrobial delivery in salad packaging in reducing pathogen survival and growth will be evaluated against E. coli O157:H7. The use of plant based antimicrobials to enhance the safe reuse of produce wash water will further be pursued to develop a viable alternative to chlorination for the fresh cut produce industry. Efficacy of antimicrobials and their combinations as determined from our data will be tested in a pilot scale. Our team at the University of Arizona will conduct a sensory evaluation to determine acceptance of organic leafy greens sanitized by plant antimicrobials. Continuation of the antiviral efficacy of plant based antimicrobials will occur to determine most effective concentrations and understand mechanisms of antiviral activity. Our team at Oklahoma state University will complete their evaluation of plant based antimicrobials and commercial sanitizers against spoilage lactic acid bacteria and E. coli O157:H7. Objective 4 Our outreach team will continue their efforts towards education of growers on safe produce handling practices and good agricultural practices. We plan to disseminate the information we have gathered to our stakeholders through conference presentations, meetings, farm visits and consultations. Our efforts to make information more accessible will continue through the development of bilingual training DVD's, youtube videos and classes. Information access through social networking websites has been extremely popular and we will continue to add content to our facebook page, twitter accounts and pinterest. The University of Oklahoma will continue their outreach and extension efforts to inform growers about safe organic leafy green handling and on farm strategies. The team will make information more accessible through the development of their website and conducting training modules and classes for our stakeholders. Dr. Ravishankar and other investigators will be continuing their efforts to provide growers with information and guidance regarding produce safety through seminars, webinars, farm visits and guest lectures. The courses taught by Dr. Ravishankar at the University of Arizona focus on produce safety and information about her research extensively, and are a primer for students interested in food safety and food microbiology. She will also continue conducting her demonstrations on natural interventions, safe produce handling and cross contamination risks at the Science City- Tucson Festival of Books and other educational fairs. All investigators will be presenting their research and findings at various international conferences such as the Annual Meetings of the International Association for

Food Protection (IAFP), Institute of Food Technologists (IFT), the American Society for Horticultural Sciences (ASHS) and others.

2011/09/01 TO 2012/08/31 OUTPUTS: The potential for internalization and consequential phylloplane transfer of shiga-toxigenic Escherichia coli through the root system of hydroponically grown organic spinach (cultivars Waitiki and Space) was studied. Hydrophobicity and curli production ability of Salmonella Newport were tested along with the proclivity of organic leafy greens wash water in aiding S. enterica biofilm formation. Hydrophobicity of organic leafy green microflora isolated from wash water was measured. Survival of S. Newport and E. coli O157:H7 in 8 different commercial organic composts and that of S. Newport in 7 compost teas was determined. Iceberg and romaine lettuces were irrigated with compost teas with and without E. coli K12 to understand risks associated with compost tea application on organic leafy greens in organic plots at the Yuma Agricultural Center. Effect of 3 coring tool designs was evaluated for risk of contamination during coring of lettuce. Comparison was made with a current tool used commercially in reducing the risk of lettuce contamination in the field. Organic leafy green wash waters were analyzed for changes in pH, turbidity and microbial counts with reuse. Irrigation water and sediments were sampled from Maricopa and Yuma agricultural systems during and after growing season and from Yuma region after rainfall events. These samples were analyzed for Salmonella, and E. coli. These are also being processed for hepatitis A, noroviruses and other viruses that could serve as indicators of fecal contamination of water. Hydrogen peroxide, olive, grapeseed and apple extracts were tested against E. coli O157:H7 on organic romaine and iceberg lettuces and mature and baby spinaches and Pediococcus damnosus on baby spinach. Hibiscus tea, hydrogen peroxide, carvacrol (CAR), citral, and essential oils of oregano, cinnamon, and lemongrass were evaluated against E. coli O157:H7 on organic leafy greens. Antimicrobial properties of oregano, cinnamon and lemongrass essential oils, CAR, cinnamaldehyde (CIN), hibiscus tea, green tea and grapeseed extract were explored against S. Newport on organic leafy greens. Hibiscus concentrate, olive and apple extracts, oregano, cinnamon and lemongrass oils were tested against Pseudomonas fluorescens on organic iceberg lettuce. Dietary supplements, mushroom extracts and rice hull liquid smoke were tested against S. enterica. Antimicrobial activities of apple skin polyphenols against L. monocytogenes, E. coli O157:H7, and S. enterica and bactericidal activities of 10 nutraceuticals against E. coli O157:H7, S. enterica, L. monocytogenes, and Staphylococcus aureus were tested. Oregano oil, CAR, cinnamon oil, CIN, lemongrass oil, citral, allspice oil and olive extract were tested in vitro against murine norovirus. Three commercial organic sanitizers and calcium hypochlorite were tested on organic leafy greens inoculated with S. Newport. Antibacterial activities of apple-based edible films containing apple polyphenols were evaluated. Apple, carrot, and hibiscus-based edible films with CIN and CAR were tested for physico-chemical properties and ability to inactivate S. Newport and P. fluoresens in organic leafy green salad bags. PARTICIPANTS: Project Director: Sadhana Ravishankar, Ph.D. Dept. of Veterinary Science & Microbiology, University of Arizona (UA), Tucson, AZ. Staff in Dr. Ravishankar\'s group: a post-doctoral fellow, research technician, graduate and 5 undergraduate students. She oversees all microbiological work related to attachment and internalization of Salmonella enterica on/in leafy greens, and pre- and post-harvest interventions against S.enterica and Pseudomonas spp. on leafy greens. She is involved in education and outreach. The postdoctoral fellow in Dr. Ravishankar\'s lab received training in sample preparation and use of confocal scanning laser microscopy to study the attachment/internalization of bacteria on/in organic leafy greens from the USDA, ARS, BARC research facility in Beltsville, MD. Dr. Ravishankar has been involved with organic leafy green safety knowledge dispersion in classrooms, conferences, book fairs and symposiums. Co-Project Directors: Charles Gerba, Ph.D. & Kelly Bright, Ph.D. Dept. of Soil, Water & Environmental Sciences, UA. Staff in their group: 3 grad. students and one research technician. Dr. Gerba assists with data analysis and performs quantitative microbial risk assessment for test pathogens. Dr. Bright conducts field sampling and laboratory testing of irrigation water samples for bacterial and viral pathogens and evaluates post-harvest interventions against viruses. Jorge Fonseca, Ph.D. Vegetable & Post-harvest Specialist, Yuma Agricultural Center, UA-Yuma, AZ. Dr. Fonseca has 2 research technicians and plans to hire a post-doctoral fellow. Dr. Fonseca investigates attachment of non-pathogenic E.coli on harvesting equipment, and conducts assessment of compost teas/biostimulants and their effects on nonpathogenic E.coli in organic leafy green fields. He is involved in outreach. Kurt Nolte, Ph.D. Director, Yuma County Coop. Extension, Yuma, AZ. Dr. Nolte has a student worker to assist with extension and outreach. He is responsible for all extension activities of this project. Divya Jaroni, Ph.D. Department of Animal Science, Oklahoma State University. Dr. Jaroni has 1 graduate student and one postdoctoral fellow. Dr. Jaroni oversees all microbiological work related to interventions for E.coli O157:H7 and Lactococcus spp. She is involved in education and outreach along with Drs. McGlynn and Brandenberger. Dr. Jitendra Patel, Ph.D. Lead Scientist, Environmental Microbiology & Food Safety Laboratory, USDA-ARS, Beltsville, MD. Dr. Patel has a post-doctoral fellow and 1 research technician. Dr. Patel investigates attachment and internalization of E.coli O157:H7 on/in organic leafy greens. Mendel Friedman, Ph.D. USDA-ARS WRRC, Produce Safety & Microbiology Research, Albany, CA. Dr. Friedman is a consultant, providing expertise on plant antimicrobials. JV Farms, Yuma, AZ provided organic leafy greens. CreAgri Inc., Hayward, CA and Apple Poly, LLC., Morrill, NE provided antimicrobial plant extracts. The following companies provided organic sanitizers: GTX

Technologies, Amarillo, TX; E3 Organics, Inc., CA; Summerdale, Inc., Verona, WI; ASC Agrecom, Inc., Tucson, AZ; Arch Chemicals, Inc., Charleston, TN; and BioSafe Systems, East Hartford, CT. TARGET AUDIENCES: Target audiences for these projects include: growers, producers, and processors of organic leafy greens; manufacturers of natural antimicrobials and organic sanitizers; and consumers of organic leafy greens. Leafy green producers and manufacturers of natural antimicrobials and organic sanitizers have been involved in this project by providing in-kind support to the project (see participants). They have been informed periodically on the results of this project and Drs Nolte and Ravishankar have been involved with creating online and mobile application versions of Fresh Organic Produce safety training, aimed towards meeting needs of commercial producers and direct marketers. Drs. Bright, Gerba and Ravishankar have had multiple interactions with growers and producers in the Yuma, AZ region. Discussion with growers and food safety managers (JV Farms, Dole Fresh Produce, Pasquinelli Produce Company, Fresh Express, Taylor Farms, Duncan Family Farms and Foxy Fresh Produce) were conducted to understand current issues associated with safety of organic leafy greens. Drs. Bright, Ravishankar and Gerba attended the Food Safety Summit at the Yuma Agricultural Center (attended by 65 industry personnel, researchers from University of Arizona, UA Cooperative Extension). Dr. Bright traveled to Yuma, AZ to meet growers and discuss current irrigation water sampling methods and Drs. Bright, Gerba and Ravishankar attended the Yuma Ag Summit that included a panel discussion entitled, \"Quality Standards and Sampling of Irrigation Water for Food Safety\". Drs. Bright, Gerba, Meer and Ravishankar attended a meeting with Dr. Michelle Russell from U.C. Davis and the President and Food Safety Managers of JV Farms in Yuma, AZ to discuss research needs and possible research collaborations with UC Davis scientists. Drs. Bright, Dev Kumar, Ravishankar and Nolte toured and visited Duncan Family Farms in Goodyear, AZ to discuss food safety concerns and best management practices. Drs. Bright, Ravishankar, Nolte and Gerba currently have ongoing research projects in the Yuma, AZ region. Many of these involve cooperation with stakeholders. Dr. Nolte was involved in conducting Arizona outreach food safety workshops with a goal to increase the applied knowledge in specific areas within the production of safe organically grown leafy greens. Dr. Ravishankar and Dr. Dev Kumar conducted a seminar for local high school students about approaches for antimicrobial applications on leafy greens and laboratory techniques involved. Demonstration of safe produce handling practices was performed at the University of Arizona book fair by Drs. Ravishankar and Dev Kumar. Dr. Ravishankar gave a seminar on natural antimicrobials and organic leafy greens to undergraduate microbiology majors. Drs. Ravishankar and Nolte conducted a seminar for students in the University of Arizona on organic leafy green contamination, issues for farmers and steps taken towards contamination mitigation. Dr. Jaroni spoke at workshops held in Opelousas, LA and focus groups in Baton Rouge, LA for fresh produce farmers. These activities were designed to increase food safety knowledge of organic fresh produce farmers in LA. PROJECT MODIFICATIONS: Dr. Divya Jaroni transferred from the Southern University Agricultural Research & Extension Center (SUAREC), Baton Rouge, Louisiana, to Oklahoma State University, Stillwater, Oklahoma. She is currently an Assistant professor in the Department of Animal Sciences at the Oklahoma State University, Stillwater, Oklahoma. She has included Dr. William McGlynn, Horticultural Products Processing Specialist, and Dr. Lynn Brandenberger, Professor, Department of Horticulture & Landscape Architecture at the Oklahoma State University to conduct the extension and outreach activities of this project. Project funds have been transferred to the Oklahoma State University for Dr. Jaroni\'s work in the project. No significant project modifications with regard to the goals of the project have been made.

2010/09/01 TO 2011/08/31 OUTPUTS: Attachment of Escherichia coli O157:H7 isolates to organic romaine and iceberg lettuce and green cabbage was studied. Curli expression, hydrophobicity, and biofilm formation by these strains were evaluated as potential virulence factors. Persistence of wild type and curli and celluose mutant E.coli O157:H7 strains on 4 organic spinach cultivars (Lazio, Waitiki, Emilia, and Space) for 14 days was studied. Effect of natural hormones (growth regulators) on the ability of E.coli to form biofilms and have better survival opportunities in field conditions was investigated. Irrigation water sampling from Yuma, AZ; 15 samples/month are collected and analyzed for indicator organisms, quality parameters, and E.coli O157:H7, Salmonella, hepatitis A virus, and norovirus surveillance. Presumptive positives are analyzed for confirmation. Romaine and iceberg lettuce were planted in semi-commercial fields in Yuma, AZ. One field was planted in October and harvested in January, the other in December and harvested in March, respectively. Both fields are part of the Organic Parcel of the Yuma Agricultural Center managed by Dr.Fonseca, and are used for quality and microbial risk tests of foliar application of organic biostimulants and compost teas. Parallel to first phase of these trials, the survival of E.coli in different compost teas and biostimulants was studied in the lab and in the field being incorporated through foliar application using different spray systems (providing different solution drop sizes). Studies were conducted to determine the risk impact of using a contaminated tool to core iceberg lettuce destined to the fresh-cut industry. Efficacy of low levels of chlorine washes to prevent cross-contamination from field-contaminated lettuce to non-contaminated lettuce was evaluated. Plant compounds (green tea and olive extracts, cinnamaldehyde, citral, and oils of allspice, clove. lemongrass, cinnamon) were tested in vitro against E.coli. Cinnamaldehyde, carvacrol and grapeseed extracts were tested for their activity in vitro against S.typhimurium and E.coli O157:H7.

Effects of hibiscus concentrate and tea, olive extract, carvacrol, cinnamldehyde, citral and oils of cinnamon, clovebud, allspice and lemongrass were evaluated on MS-2 bacteriophage. The bactericidal effects of aqueous extracts of roselle calyces and leaves against E.coli O157:H7, Salmonella enterica and Listeria monocytogenes were evaluated. Roselle calyx concentrate and tea were also tested against E.coli O157:H7 on romaine lettuce and Salmonella on sprouts. The antimicrobial effects of plant extracts (olive, apple, 1-5%; hibiscus, 10-30%) and five organic sanitizers (fulvic acid-based, 1-3%; citric acid-based, 0.05%) against S.Newport on organic romaine and iceberg lettuce, and adult and baby spinach stored at 4C for 3 days were investigated. Plant extracts were also tested against background flora of all 4 organic leafy greens. Effects of carvacrol and cinnmaldehyde (1.5 and 3%) containing edible apple, carrot and hibiscus films against S.Newport in bagged iceberg lettuce, baby spinach and spring mix, and against E.coli O157:H7 in bagged spinach stored at 4C for 7 days were evaluated. PARTICIPANTS: Project Director: Sadhana Ravishankar, Ph.D. Dept. of Veterinary Science & Microbiology, University of Arizona, Tucson, AZ. Staff in Dr. Ravishankar\'s group involved in this project include: 1 post-doctoral fellow, 1 technician, 1 grad. Student and 2 undergrad. students. She oversees all microbiological work related to attachment and internalization of Salmonella enterica on/in leafy greens, and pre- and post-harvest interventions against S.enterica and Pseudomonas spp. on leafy greens. She is involved in education and outreach. Co-Project Directors: Charles Gerba, Ph.D. & Kelly Bright, Ph.D. Dept. of Soil, Water & Environmental Sciences, University of Arizona, Tucson, AZ. Staff in their group involved in this project include: 3 grad. students and one research technician. Dr. Gerba assists with data analysis and performs quantitative microbial risk assessment for test pathogens. Dr. Bright conducts field sampling and laboratory testing of irrigation water samples for bacterial and viral pathogens, and evaluates post-harvest interventions against hepatitis A and murine norovirus. Jorge Fonseca, Ph.D. Vegetable & Post-harvest Specialist. Yuma Agricultural Center, University of Arizona-Yuma, AZ. Dr. Fonseca has 2 research technicians involved in this project and plans to hire a post-doctoral fellow. Dr. Fonseca investigates the attachment of non-pathogenic Escherichia coli on harvesting equipment, and conducts assessment of compost teas/biostimulants and their effects on non pathogenic E.coli in organic leafy green fields. He is involved in outreach activities. Kurt Nolte, Ph.D. Director, Yuma County Coop. Extension, Yuma, AZ. Dr. Nolte expects to hire a grad. student this summer to assist with extension and outreach. He is responsible for all extension activities of this project. Divya Jaroni, Ph.D. Southern University Agricultural Research & Extension Center (SUAREC), Baton Rouge, LA. Dr. Jaroni has 1 grad. student involved in the project and plans to hire a post- doctoral fellow. Dr. Jaroni oversees all microbiological work related to interventions for E.coli O157:H7 and Lactococcus spp. She is involved in education and outreach. Jitendra Patel, Ph.D. Lead Scientist, Environmental Microbiology & Food Safety Laboratory, USDA-ARS, Beltsville, MD. Dr. Patel has a post-doctoral fellow and 1 research technician involved in the project. Dr. Patel investigates the attachment and internalization of E.coli O157:H7 on/in organic leafy greens. Mendel Friedman, Ph.D. USDA-ARS Western Regional Research Center, Produce Safety & Microbiology Research, Albany, CA. Dr. Friedman is a consultant, providing expertise on plant antimicrobials and is involved in education and outreach. JV Farms, Yuma, AZ provides in-kind support in the form of organic leafy greens. CreAgri Inc., Hayward, CA and Apple Poly, LLC., Morrill, NE provide in-kind support in the form of antimicrobial plant extracts. The following companies provide in-kind support in the form of organic sanitizers. GTX Technologies, Amarillo, TX.; E3 Organics, Inc., CA; Summerdale, Inc., Verona, WI.; ASC Agrecom, Inc., Tucson, AZ; Arch Chemicals, Inc., Charleston, TN; and BioSafe Systems, East Hartford, CT. TARGET AUDIENCES: The target audiences for this project include: growers, producers, and processors of organic leafy greens; manufacturers of natural antimicrobials and organic sanitizers; and consumers of organic leafy greens. Leafy green producers and manufacturers of natural antimicrobials and organic sanitizers have been involved in this project by providing in-kind support to the project (see participants). They have been informed periodically on the results of this project. Drs. Ravishankar, Gerba and Bright attended the Arizona Produce Research Priorities meeting organized by the Center for Produce Safety, September 2010 to discuss our fresh produce/leafy greens research. They also visited Yuma in December 2010 to meet leafy greens producers, discuss their research needs and provide an introduction to the organic leafy greens grant. Dr. Ravishankar presented an overview of the grant and some results at the Food Safety Summit in Yuma, January 2011, attended by 65 fresh produce industry professionals. In March 2011, Drs. Ravishankar, Bright, and Jaroni traveled to Yuma, Arizona to attend the Southwest Agricultural Summit. They along with Drs. Nolte and Fonseca discussed this project with agricultural professionals attending the meeting. In April 2011, Drs. Ravishankar, Bright, Gerba, and Meer traveled to Yuma to meet with growers and University of California, Davis researchers, to discuss the research needs of the producers and to develop future plans, including additional collaborations between the growers and researchers at the University of Arizona, Tucson, AZ, and the University of California, Davis, CA. In microbiology classes, at the University of Arizona, for undergraduate and graduate students Dr. Ravishankar has incorporated laboratory exercises to isolate the background microflora, spoilage and pathogenic microorganisms from organic leafy greens. In collaboration with the Joint Institute of Food Safety and Applied Nutrition, Dr. Fonseca offered 2 courses on Good Agricultural Practices at Costa Rica and Mexico for produce exported to the U.S. He plans to offer an on-line course this summer on post-harvest physiology, technology and produce safety for undergrad./grad. students and industry

professionals at the University of Arizona. Dr. Ravishankar will offer a course on food microbiology and biotechnology in spring 2012 which will cover organic leafy greens safety and quality aspects. Information generated from this project was/will be used in all these courses. All post-doctoral fellows, technicians and students hired to work on this project have received training on good laboratory practices, including pathogen safety precautions, media preparation, product sampling, field sampling and other laboratory activities related to the project. Dr. Meer received training in sample preparation and use of confocal scanning laser microscopy to study the attachment/internalization of bacteria on/in organic leafy greens from the USDA, ARS, BARC research facility in Beltsville, MD. Over the past year numerous media outlets have provided coverage/stories on the organic leafy greens research project (see publication list) to reach a wide variety of audience. PROJECT MODIFICATIONS: We have not made any significant project modifications with regard to the goals of the project. However, we intend to request a no-cost extension for the first year of this project since there was a significant delay in the transfer of funds to the subcontracts, and the process of hiring technical assistance (e.g., graduate and undergraduate students, postdoctoral fellows, research technicians, etc.) took longer than anticipated.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Objective 1: Factors causing attachment and internalization of E.coli O157:H7 and Salmonella in organic leafy greens were explored. Strains that expressed curli and were more hydrophobic attached at higher numbers compared to weak/non-expressing strains. E.coli O157:H7 internalized into hydroponically grown intact spinach plants through root. Internalization was dependent on bacterial population, not curli production. Internalized pathogen reached the phylloplane. Cellulose-deficient and wild E.coli O157:H7 strains persisted for 14 days on young spinach plant shoots when sprayed with droplets of phosphate buffered saline, irrespective of cultivar. Rapid attachment of all E.coli O157:H7 (\~3.5-4 logs) was observed on intact and cut leafy green surfaces within 5 min. Internalization of Salmonella was observed in spinach plants developing from contaminated seed and spinach sprouts germinated using contaminated water. Salmonella was isolated from leaves, shoots and roots of spinach plants when grown from contaminated seed or with contaminated water during seed germination. Soil and water runoff were positive for Salmonella. Coring tool design was modified and evaluated for ability to reduce cross contamination to lettuce. Removal of welding from original tool resulted in the highest reduction of E.coli transfer, 44% positives lettuce heads compared to the original tool with 91% positives. Organic matter and iceberg lettuce debris in sanitizing dips promoted attachment of Salmonella to coring tool surface. The ability of E.coli to form biofilms on wash water contact surface and synergistically with leafy green native microbiota was studied. Biofilms formed on unfiltered baby spinach wash water contact surface after one wash (light reuse) by E.coli O157:H7, curli-deficient E.coli O157:H7 and E.coli K12 resulted in OD600 of 0.49, 0.57 and 0.31, respectively, while on stomached (extensive reuse) unfiltered spinach wash water contact surface, OD600 of 1.38, 2.59 and 2.08 resulted. Wash water reuse, curli production by E.coli and synergy with leafy green native microbiota contributed towards biofilm formation. Objective 2: A study on survival of E.coli K12 in homemade compost teas revealed that compost tea made with vegetables allowed E.coli to survive over 4 weeks with 0.5 log reduction. Horse and sheep compost tea with and without E. coli showed longer survival on all crops. E. coli O157:H7 populations fell below levels of detection within 3 days in steer manure compost. For Salmonella, compost tea using Alpaca manure and steer manure based composts with an alkaline pH resulted in highest reduction. Background microflora did not affect pathogen survival in composts. Field studies showed that foliar application of sheep compost tea on iceberg and romaine lettuce resulted in highest recovery of E.coli while cow compost tea showed the fastest reduction. Side dress application was determined as the safer application route. Compost teas with fertilizer application in field improved leafy green crop yield and quality attributes. Analysis of irrigation water samples from Yuma and Maricopa revealed that E.coli was isolated from 9.3% water and 8.1% sediment samples. Salmonella was isolated from 14% water and 22.6% sediment samples. Both E.coli and Salmonella were isolated from 3% water and 0.9% sediment samples from both irrigation systems. All confirmed E.coli isolates were non-pathogenic. A subset of 25% samples from Yuma and 33.3% samples from Maricopa were assayed for the Salmonella invA and himA genes and tested positive. Pepper Mild Mottle virus was isolated from 22% and 80% irrigation water samples from Yuma and Maricopa, respectively. No (0/231) samples were positive for human norovirus, hepatitis A, or Aichi virus. The physico-chemical characteristics and microbial quality of irrigation waters from Yuma and Maricopa did not differ significantly. Quantitative Microbial Risk Assessment could not be done because no E.coli O157:H7 was detected and data collected for Salmonella was qualitative. Objective 3: Plant extracts (olive, apple, grapeseed), essential oils (oregano, clove bud, lemon grass, cinnamon), their active components (carvacrol, eugenol, citral, cinnamldehyde), and combinations were tested against Salmonella, E.coli O157:H7, E.coli K12, murine norovirus and spoilage organisms (Pseudomonas, Lactobacillus) as alternatives to oxidizing sanitizers. Plant based sanitizers were effective in reducing pathogens and spoilage organisms on leafy greens when added to wash

water. Antimicrobial effect was concentration and storage time dependent. Plant antimicrobials had residual activity during storage at 4 and 8°C for 3 days. All essential oils at 0.5% were effective showing no recovery of pathogens immediately upon exposure or by day 1. Olive extract was the most effective among plant extracts with a maximum 5.3 log reductions. Plant extracts were also tested for their activity against background microflora of organic leafy greens and reductions ranged from 0-2.8 logs; effectiveness of olive extract was comparable to that of hydrogen peroxide, while the activity of all plant antimicrobials was better than that of hydrogen peroxide for pathogens. Some combination treatments showed synergistic activity with \>4 logs reduction. Plant antimicrobials and their combinations were tested against starved Salmonella and were effective. Starvation stress rendered Salmonella more susceptible to antimicrobials compared to non-starved cells. Efficacy of plant antimicrobials was evaluated during recycling of wash water for five batches of organic leafy greens both in the laboratory and large scale. Plant antimicrobials maintained their effectiveness during 5 times recycling of wash water and were better at inactivating Salmonella and E.coli K12 than hydrogen peroxide and 50 ppm chlorine. No survivors were detected from any of the treatment wash waters. Apple, carrot and hibiscus films containing antimicrobials were tested against Salmonella, E.coli O157:H7 and Pseudomonas on organic leafy greens in sealed plastic bags during 7 day storage at 4°C. On all produce, 3% carvacrol films were most effective. The films showed a concentration and storage time dependent activity. The efficacy of organic sanitizers (fulvic acid, citric acid, and peracetic acid based, C8C10, CG100, CDG3000, calcium hypochlorite) was also evaluated against pathogens. Chico Wash, C8C10 and CG100 reduced E.coli O157:H7 on organic leafy greens by upto 3.4 logs. For Salmonella Chicowash was the most effective with upto 2.87 log reductions. Carvacrol, cinnamon oil, cinnamaldehyde and olive extract were effective against murine norovirus within six hrs of exposure. Chicowash yielded \>4.56 log reductions within 30 min of exposure. Scanning electron microscopy was used to understand the antiviral mechanism of action. Oregano oil and carvacrol caused viral capsid to expand in size and lose structural integrity. Allspice and clove bud oils appear to break down the virus capsid. Lemongrass oil and citral appear to coat virus capsid and prevent the virus adsorbing to host cell. Organoleptic quality of leafy greens after wash treatments was evaluated by sensory analysis and ranged from acceptable to detection of strong aftertastes. Objective 4: Extension activities in AZ included statewide organic food safety workshops, training seminars, video training series, development of online content (website, social media) and bilingual videos for effective dissemination of research results useful for stakeholders. In Oklahoma, results on fresh produce safety were disseminated to growers and processors. Drs. Ravishankar, Jaroni, Bright, Gerba, Fonseca and Nolte conducted presentations, demonstrations and seminars to growers, students and general public. PIs have also presented results at international professional meetings and published manuscripts in scientific journals to reach both academia and industry. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Dusty Winchester, Rachael Zinn, Jonathan Sexton, Jason Torrey, Kelly Bright. ?Occurrence of Pathogenic (Disease-Causing) Foodborne Viruses In Irrigation Waters in the Southwest?. University of Arizona Student Showcase. November 2012. Friedman, M. Plant Food Constituents that Inactivate Pathogens and Reduce Formation of Heterocyclic Amines. Northern California Chapter, Genetic and Environmental Toxicology Association Symposium Food Safety and Health in a Global Setting: The Good, the Bad, and the Ugly, Oakland, California. June 7, 2012. Jason Torrey, Jonathan Sexton, Rachael Zinn, Dusty Winchester, Jerry Lopez, Kelly Bright. ?Prevalence of Pathogenic Organisms in Irrigation Waters of the Southwest. University of Arizona Annual Food Safety Conference. October 2012. Macarisin, D., Darlington, K., Chauhan, P., Patel, J. 2012. 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Efficacy of Roselle (Hibiscus sabdariffa) Calyx Formulations against Escherichia coli O157:H7 on Bagged Organic Leafy Greens Stored at 4?C. Quality Assurance and Safety of Crops & Foods. Submitted Jordan J. Denton, Mendel Friedman, Sadhana Ravishankar, and Divya Jaroni. Antimicrobial Efficacy of Plant-Derived Compounds against Escherichia coli O157:H7 on Organic Leafy Greens under Refrigeration Temperatures. J. of Food Science and Preservation. Submitted Jordan J. Denton, Buddhini, P. K. Jaysundera, Sadhana Ravishankar, and Divya Jaroni. Evaluation of Antibacterial Effects of Plant-Derived Essential Oils against Escherichia coli O157:H7 o 6. Type: Websites Status: Other Year Published: 2012 Citation: Social Media Networking: Extension at the University of Arizona includes programming that uses a dedicated web interface, Facebook, Twitter, and Pinterest. Since their release the sites have generated over 8,650 client interactions which and continues to grow daily. o Fresh Produce Safety Website (8,850 views): A safe organic training website has been created for producers. The site contains key information about the USDA Good Handling and Agricultural Practices program, as well as the online, bilingual version of the training materials (http://cals.arizona.edu/fps/). o Facebook (1,247 fans): Built to accomplish a social mission ? to make the world more open and connected, the Fresh Produce Safety Facebook page provides networked follower?s tips, tends and key information about the practices involving fresh produce safety (https://www.facebook.com/FoodSafety101). o Twitter (961 followers): Followers receive instant updates related 7. Type: Journal Articles Status: Published Year Published: 2014 Citation: Zhu, L., Olsen, C., McHugh, T., Friedman, M., Jaroni, D. and Ravishankar, S. 2014. 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2012/09 TO 2013/08 What was accomplished under these goals? The influence of organic leafy greens wash water reuse on biofilm formation by curli producing Escherichia coli O157:H7, curli deficient E. coli O157:H7 and non-pathogenic E. coli K12 on baby spinach, mature spinach, romaine lettuce and iceberg lettuce wash water contact surfaces was evaluated. Increased reuse of wash water resulted in increased generation of biofilm. Organic leafy green native microbiota along with E. coli increased biofilm formation indicating a possible synergistic activity. The use of S. Newport contaminated water (8 log CFU/ml) and S. Newport contaminated seed (8 log CFU/g) resulted in presence of the pathogen 6 days after germination on sprouts. Microbiological analysis of surface sterilized tissue indicated presence of internalized S. Newport (3 log CFU/ml) in all 4 spinach cultivars tested. Transfer of S. Newport from soil to leaf surface could depend on multiple factors such as the type of soil and humidity of the environment. The amount of transfer of Salmonella from soil to leaf surface was the highest in compost amended soil, followed by soil from an organic farm. Study of homemade compost tea native microbiota revealed that horse manure compost tea had 5.5 Log CFU/ml of microbiota. By week 2 homemade horse manure tea showed a 3 Log CFU/ml reduction of E. coli. Horse and vegetable tea showed a 2 Log CFU/ml reduction at week 2. Vegetable tea increased by 1 Log from week 1 to 2. Study of E. coli survival on organic leafy

greens after foliar and side dress application of compost teas indicated that romaine lettuce that had commercial compost teas applied foliarly showed E. coli counts up to day 23 whereas iceberg lettuce showed reduction after day 13. Sheep compost tea had the highest recovery and cow compost tea had the lowest recovery of E. coli foliarly on both iceberg and romaine lettuce. Side dress applications of compost tea showed a reduction in E. coli counts much faster than foliar applications. Analysis of yields and quality parameters of organic leafy greens after compost tea application indicated that the yields of Iceberg lettuce with compost tea had more weight (g) and diameter (cm) compared to the control. In spinach, the addition of fertilizers fulvic and humic acids along with compost teas resulted in better crop yield than in the controls that did not contain the fertilizers. Environmental evaluation of waters from the Yuma and Maricopa regions revealed that the two regions were fairly comparable; the only major difference was in water turbidity of water from Yuma. Both E. coli and Salmonella were isolated from 7 of the 236 (3.0%) water and 2 of the 235 (0.9%) sediment samples in total from both irrigation systems. None of the E. coli isolates possessed stx1 and stx2 and eae genes. All of these isolates were confirmed as Salmonella species. No human norovirus (either GI or GII serotypes), hepatitis A virus, or Aichi virus were detected in any of the 231 large volume irrigation water samples from Yuma or Maricopa. Nineteen of 66 samples (28.8%) that were positive for pepper mild mottle virus (PMMV) also had Salmonella spp. in either the water (12 samples) or the sediment (7 samples) samples. Evaluation of Fulvic acid as a sanitizer for coring tools indicated that Fulvic Acid #2 performed the best in reducing E. coli counts on both tool types; Fulvic Acid #3 also performed well at reducing E. coli. Re-designed tool treated with Fulvic Acid #2 showed a 2 log reduction of E. coli. Hibiscus concentrates (10-30%) reduced the Pseudomonas population on leafy greens by 0.7-4.2 log CFU/g, and 1-5% olive extract showed 0.6-4.1 log CFU/g reductions. For essential oils, 0.1-0.5% oregano oil reduced the bacterial population by 0.3-2.5 log CFU/g, and 0.1-0.5% lemongrass oil decreased 0.4-3.1 log CFU/g Pseudomonas. Cinnamon oil was the most effective essential oil tested. At day 3, 0.3% cinnamon oil reduced the bacterial population by 4.3-4.4 log CFU/g. There were 2-3 log reductions at day 0 for 0.5% cinnamon oil treatment, and no survivors were detected at day 3. Evaluation of the effectiveness of plant based sanitizers in increasing the recyclability of wash waters indicated that the 5-time reuse of 3% olive and apple extracts didn't reduce their antimicrobial effects. At day 3 oregano oil reduced the Salmonella population to below detection limit on romaine lettuce after 1st and 2nd washes. Salmonella cells couldn't survive in 3% olive extract, 0.3% oregano and cinnamon oil wash liquids, while there were 0.5-2.1 log CFU/ml surviving cells in 3% apple extract wash liquids. The use of plant based antimicrobial combinations resulted in baby spinach showing 3.5 logs and 4.0 logs CFU/g reductions for S. Newport on day 3 for the cinnamon oil and olive extract, and oregano oil and olive extract combination treatments, respectively. Mature spinach resulted in a 3.0 log CFU/g reduction for both combination treatments. For romaine lettuce, there was a 3.0 log CFU/g S. Newport reduction for the cinnamon oil and olive extract combination, and a 4.0 log CFU/g reduction for the oregano oil and olive extract combination. For E. coli O157:H7 on organic leafy greens, carvacrol at 0.3 and 0.5%, and cinnamaldehyde at 0.5% concentrations inhibited growth to non-detectable levels, while citral at 0.5% decreased E. coli O157:H7 population by 3.8-4.9 log CFU/g. Of the three compounds, carvacrol provided the most effective reduction in pathogen populations among all four leafy greens. Assay of the antimicrobial efficacy of commercial sanitizer CHICO wash indicated that both wash times displayed distinct reduction of the E. coli O157:H7 population. The two minute wash had a remaining population log value of 0.6 logs lower than that of the one minute. Fulvic acid washes resulted in reductions in E. coli O157:H7 population in adult spinach. Fulvic acid \# 2 and 3 at 3% were the two most effective treatments showing approximately 3 logs reduction on Day 0. In baby spinach, 3% Fulvic acid #1 reduced E. coli O157:H7 growth by 2.3 logs by day 3. Carvacrol, cinnamon oil, cinnamaldehyde and olive extract were highly effective against murine norovirus within six hours of exposure. CHICO Wash was quite effective, yielding \>4.56--log reductions within 30 minutes of exposure. Oregano oil and carvacrol caused the viral capsid to expand in size and lose structural integrity. Allspice oil and clove bud oil appear to break down the virus capsid. Lemongrass oil and citral appear to coat the virus capsid and prevent the virus adsorbing to its host cell. Evaluation of novel antimicrobial agents revealed that at pH 7.0, red wine plus oregano oil and red wine plus Hidrox-12 and oregano oil exhibited the highest inhibition of E. coli O157:H7, S. enterica, Listeria monocytogenes, and Staphylococcus aureus. Also, a new polysaccharide was identified as a potential antimicrobial as it protected mice against Salmonella induced sepsis. Extension activities included statewide safety workshops in Arizona and Oklahoma, training seminars, development of online content (social media) and videos for effective dissemination of research results useful for stakeholders. Bilingual training videos were developed by the University of Arizona, covering the following topics; Hand Washing, Field Sanitation, Bodily Fluid Discharge and Field Etiquette. The Oklahoma extension team conducted training programs where the audience belonged to the Otoe-Missouria / Ponca tribes, Hmong people and the Otoe-Missouria tribes. They have established a website on fresh produce safety. Drs. Ravishankar, Jaroni, Bright and Nolte have also conducted presentations, demonstrations and seminars to growers, students and the general public. The PIs have also presented research results generated from this project at the Annual Meetings of the International Association for Food Protection and Institute of Food Technologists in 2013 in the form of posters to both academia and industry. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Journal Articles Status: Accepted Year Published: 2013 Citation:

Macarisin, D., Patel, J., Bauchan, G., Giron, J. A. and Ravishankar, S. (2013). Effect of spinach cultivar and bacterial adherence factors on survival of Escherichia coli O157:H7 on spinach leaves. Journal of Food Protection. 76:1829-1837 Todd, J. L., Friedman, M., Patel, J., Jaroni, D. and Ravishankar, S. (2013). The antimicrobial effects of cinnamon leaf oil against multi-drug resistant Salmonella Newport on organic leafy greens. International Journal of Food Microbiology. 166:193-199. Moore-Niebel, K., Gerber, C., Patel, J., Friedman, M., Jaroni, D. and Ravishankar, S. (2013). Antimicrobial activity of oregano oil against antibiotic-resistant Salmonella enterica on organic leafy greens at varying exposure times and storage temperatures. Food Microbiology. 34:123-129 2. Type: Journal Articles Status: Accepted Year Published: 2012 Citation: Jaroni, D. and Ravishankar, S. (2012). Bactericidal effects of roselle (Hibiscus sabdariffa) against foodborne pathogens in vitro and on romaine lettuce and alfalfa sprouts. Quality Assurance and Safety of Crops & Foods. 4:33-40. 3. Type: Conference Papers and Presentations Status: Accepted Year Published: 2013 Citation: Dev Kumar, G., Patel, J. and Ravishankar, S. 2013. Comparative evaluation of factors affecting Escherichia coli biofilms on organic leafy green wash water equipment surfaces. Poster presented at the 2013 Food Safety Conference, University of Arizona Food Safety Consortium, Tucson, AZ. Tollerson, R., Dev Kumar, G. and Ravishankar, S. 2013. Role of environmental factors in the transfer of Salmonella enterica to iceberg lettuce leaves and biophotonic imaging of transfer sites. Poster presented at the 2013 Food Safety Conference, University of Arizona Food Safety Consortium, Tucson, AZ. Rada, X., Todd, J. L., Friedman, M., Patel, J., Jaroni, D. and Ravishankar, S. 2013. Synergistic effects of combination treatments of essential oils and a plant extract against multi-drug resistant Salmonella enterica on organic leafy greens. Poster presented at the 2013 Food Safety Conference, University of Arizona Food Safety Con 4. Type: Conference Papers and Presentations Status: Accepted Year Published: 2012 Citation: Reyna-Granados, J., Joens, L., Friedman, M. and Ravishankar, S. 2012. Concentration and time-dependent inactivation of Escherichia coli O157:H7 by plant extracts. Poster presented at the International Association for Food Protection Annual Meeting 2012, Providence, RI. Zhu, L. and Ravishankar, S. 2012. Efficacy of sanitizers approved for organic use against Salmonella enterica on organic leafy greens. Poster presented at the International Association for Food Protection Annual Meeting 2012, Providence, RI. Moore-Neibel, K.?, Patel., J., Friedman, M. and Ravishankar, S. 2012. Antimicrobial activity of oregano oil against Salmonella enterica on organic leafy greens at varying exposure times and storage temperatures. Poster presented at the International Association for Food Protection Annual Meeting 2012, Providence, RI. Todd, J. L. and Ravishankar, S. 2012. Survival of Escherichia coli O157:H7 and Salmonella N 5. Type: Journal Articles Status: Awaiting Publication Year Published: 2013 Citation: Zhu, L., Olsen, C., McHugh, T., Friedman, M., Jaroni, D. and Ravishankar, S. (2013). Apple, carrot, and hibiscus edible films containing the plant antimicrobials carvacrol and cinnamaldehyde inactivate Salmonella Newport on organic leafy greens in sealed plastic bags. Journal of Food Science. In press. 6. Type: Conference Papers and Presentations Status: Accepted Year Published: 2013 Citation: Nolte, K.D. 2013. The Track and Scat Fresh Produce Safety Handbook for Southwest, Arizona. Abstract published in the proceedings at the 2013 American Society for Horticultural Science Annual Meeting, Palm Desert, CA. URL: http://ashs.org/abstracts/2013/abstracts13/abstract id 15926.html 7. Type: Journal Articles Status: Accepted Year Published: 2013 Citation: Yossa, N., Patel, J., Millner P., Ravishankar S. and Lo, Y. M. (2013). Antimicrobial activity of plant essential oils against Escherichia coli O157:H7 and Salmonella on lettuce. Foodborne Pathogens and Disease. 10:87-96. Friedman, M. (2013). Rice brans, rice bran oils, and rice hulls: compositions, food and industrial uses, and bioactivities in humans, animals, and cells. Journal of Agriculture and Food Chemistry. DOI: 10.1021/jf403635v. (Review). Includes antibiotic effects. Friedman, M., Henika, P. R. and Levin, C. E. (2013). Bactericidal activities of health-promoting, food-derived powders against the foodborne pathogens Escherichia coli, Listeria monocytogenes, Salmonella enterica, and Staphylococcus aureus. Journal of Food Science. 78: M270-M275. Friedman, M. and Rasooly, R. (2013). Review of the inhibition of biological activities of food-related selected toxins by natural compounds. Toxins. 5: 743-775. Covers fungal,

2011/09/01 TO 2012/08/31 E. coli O157:H7 internalized into hydroponically grown intact spinach plants through root. Internalization was dependent on bacterial population, not curli production. Internalized pathogen reached the phylloplane. S. Newport strains had varying hydrophobicities and were curli positive. S. Newport produced biofilms in produce wash waters. Natural microbiota in wash water had varying hydrophobicities depending on produce. Composts 4 and 5 had reduced populations of both S. Newport and E. coli O157:H7 with no recovery of E. coli after day 3 in composts 1,2,3,4,5 and S. Newport after day 3 in compost 5. S. Newport reduction varied in the compost teas. Compost teas enhanced E. coli K12 attachment to lettuce leaves and increased their survival. Coring tool design significantly affected contamination risk of lettuce, with modified design reducing the risk significantly. Tool with angled core end resulted in 56% of E.coli positive lettuces, compared to 100% from original design. Reused wash waters had increased turbidity and decreased pH. Salmonella and E. coli were detected in 8.7% and 8% water samples and 16.8% and 13.6% of sediment samples, respectively, from Yuma. From Maricopa, Salmonella and E. coli were detected in 18.8% and 25% water samples and 37.5% and 6.3% sediment samples, respectively. Carvacrol (CAR) 0.3%, 0.5%, oregano 0.5%, cinnamon 0.5%, and lemongrass

0.5% oils reduced E. coli O157:H7 on organic baby spinach. On organic iceberg lettuce, 0.1, 0.3 % and 0.5% CAR, 0.3 and 0.5% citral, oregano, lemongrass and cinnamon essential oils reduced pathogen counts significantly at day 0. Hibiscus tea reduced E. coli O157:H7 by 2-4 logs on leafy greens. On day 0, 3% and 5% olive extracts reduced E. coli O157:H7 populations by 2 logs in adult spinach and 3% and 5% olive extracts reduced P. damnosus by upto 4 logs in baby spinach. Salmonella reduction by lemongrass oil directly correlated with exposure time and concentration. Oregano oil proved effective against S. Newport at all levels. Concentration dependent reductions (0.7-2.3 log CFU/g, 0.4-2.0 log CFU/g, and 0.2-1.6 log CFU/g, respectively) were observed in S. Newport on organic leafy greens by hibiscus tea, grapeseed and green tea extracts. CAR at 0.5% showed no survivors of Salmonella by day 1 on organic leafy greens. Cinnamon oil reduced P. fluorescens below detection levels and lemongrass oil by 1 log at day 1 on iceberg. Olive pomace, olive powder and oregano leaves were active against E. coli O157:H7, S. enterica, L. monocytogenes, and S. aureus. Rice hull liquid smoke had antibacterial activity in vitro. Mushroom extracts and rice hull liquid smoke improved recovery in mice from Salmonella infection. CAR, cinnamon oil, cinnamaldehyde, olive extract were effective against murine norovirus showing upto 4 log reductions within 6 h. CHICO wash caused up to 2.5 log Salmonella reduction in 3 days in lettuces. Polyphenol containing apple edible films were highly effective against L. monocytogenes. Edible films with carvacrol reduced Salmonella by 5 logs at day 0 and were also effective against P. fluorescens on organic leafy greens. The pH, color and thickness of the edible films varied.

2010/09/01 TO 2011/08/31 Rapid attachment of E.coli O157:H7 (3.5-4 logs) was seen on intact and cut leafy green surfaces within 5 min. Attachment to intact and cut cabbage increased with time. Cut surfaces had greater attachment than intact surfaces. Strains that expressed curli and were more hydrophobic, attached at higher numbers compared to weakly or non-expressing strains. Attachment strength may be associated with production of surface appendages and subsequent binding to produce. Attachment strength of E.coli O157:H7 was higher on romaine lettuce than cabbage surfaces. Wild type and cellulose deficient strains persisted better than curli deficient and curli and cellulose deficient mutants on spinach cultivars, with Waitiki cultivar supporting higher bacterial levels. In vitro studies showed that growth regulators may interfere with bacterial biofilm formation. Presumptive positives for E.coli O157:H7 were identified in 6 analyzed irrigation water samples from Yuma and will be confirmed. Salmonella was detected in 2 sediment samples. Generic E.coli (\<1-27.2 MPN/100ml) and coliforms (131.4-\>2419.6 MPN/100 ml) were identified. The pH, conductivity, total dissolved solids in irrigation water were 7.2-8.5, 1.0-1.2 mS/cm, 0.5-0.6 g/L, respectively. Most of the biostimulants and compost teas tested had pH levels too low for bacterial survival, one product with a higher pH, showed bacterial survival of 1 week. No difference in leafy green quality due to foliar application of organic products was seen. Different spray applicators showed that big drops held higher bacterial numbers up to 24 h; however, no organisms were detected after day 10. We found that a contaminated tool may contaminate as many as 75 lettuce heads. Most contamination was in the welding area. Chlorine (1.3 ppm free chlorine) washes prevented cross-contamination from field-contaminated lettuce. In vitro studies with plant antimicrobials showed no survivors for E.coli and S.Typhimurium with 0.2% cinnamaldehyde (CIN) at 1 min and 0.05% carvacrol (CAR) at 3 min. Reductions observed for E.coli in vitro tests; \>5.7 logs with 0.2% CIN at 30 min, 6.1 logs with 1% allspice oil at 10 min, 5.2 logs with 1% clove oil at 25 min, \>6 logs with 1.5% cinnamon oil at 30 min, 5 logs with 0.05% citral at 15 min, 4.7 logs with 2.5% olive extract at 30 min. Reductions for MS2 bacteriophage were \>4 logs with olive extract, CIN, cinnamon oil; \>3 logs with hibiscus tea, CAR; about 2 logs with citral, clove oil at 24h. No survivors of E.coli O157:H7 or Salmonella were detected in 24h in vitro and on lettuce and sprouts, and L.monocytogenes in 48h with hibiscus extracts. Olive, apple, hibiscus extracts and hydrogen peroxide showed 1-3 log reductions of S.Newport/background on organic leafy greens. The fulvic and citric acid based sanitizers showed 2-3 log reductions of S.Newport on leafy greens by day 3. Apple, carrot, hibiscus films (3% CAR) were very effective with immediate reductions (at least 5 log) of S.Newport on iceberg lettuce. Reductions of 3.5-4 logs were seen on spring mix and baby spinach with 3% CAR apple, hibiscus films. Apple films (3% CAR) showed about 3 logs reduction of E.coli O157:H7 in bagged baby spinach.

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Holistic Integration of Organic Strategies and High Tunnels for Midwest/great Lakes Fruit Production

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Performing Institution	Horticulture, MICHIGAN STATE UNIV, EAST LANSING, MICHIGAN 48824

NON-TECHNICAL SUMMARY

Growers who want to produce organic fruits in non-arid cool climates like the Great Lakes/Midwest need expanded strategies for soil, plant, pest (insect, disease, weed) and environmental management to enhance crop diversity, productivity and profitability. The goal of this project is to develop and disseminate knowledge for integrating organic production systems with environment-modifying techniques, such as high tunnels, to discover synergistic strategies for crop protection, soil building, season extension, and the expansion of organic production potential for perennial fruit crops like apples, brambles and cherries. Practices to be studied include composts, cover crops, pest exclusion and biodiversification, ecological weed management, nursery tree production, and crop canopy management. Growers and agriculture professionals need educational resources, including small plot and on-farm research workshops as well as on-line course content, that integrate the multitude of environmental, economic and human factors that influence sustainable organic farm management.

OBJECTIVES

The goal of this project is to integrate organic production systems with environment-modifying techniques, such as high tunnels, to develop synergistic strategies for crop protection, soil building, season extension, and the expansion of organic production potential for perennial fruit crops like apples, brambles and cherries suitable for this climate. Management practices to be studied include composts, cover crops, pest exclusion and biodiversification, ecological weed management, and environmental modification. Production Research Objectives: 1. Determine critical organic propagation media components, environmental modifications, and nursery tree production practices for on-farm propagation, grafting and development of organic apple nursery trees. 2. Determine critical soil, orchard floor, and planting system practices and management to optimize organic high tunnel production of raspberries and sweet cherries. 3. Determine key insect and disease management components and practices to optimize organic high tunnel production of raspberries and sweet cherries. Economic Research Objectives: 1. To identify and compare the costs of the various modified environment production system components under study in this project, and their impacts on potential market returns, for

organic fruit producers in the northern cool climate Great Lakes/Midwest region. Outreach Program Objectives: 1. Provide field days, organize visits to on-farm demonstration plots, and workshops to educate extension and agriculture professionals, growers, consumers, legislators (due to our close proximity to the State Capitol), and the public about management methods and economic potential for organic high tunnel fruit production in the northern temperate climate of the Great Lakes/Midwest states. 2. Provide on-line courses to educate extension and agriculture professionals, growers, and the public about basic organic farming principles and practices, including management methods and economic potential for organic high tunnel fruit production in the Great Lakes/Midwest states. The long-term goal is to contribute to the economic, environmental, social and personal health and well-being of the organic farming community and consumers in the Midwest/Great Lakes region and beyond. Long-term impacts will be measured by the number of Michigan and Midwest farms adopting organic high tunnel culture of fruits or other sustainable fruit production components derived from the research results that are developed at the HTRC fruit research high tunnels.

APPROACH

The main experiments will be imposed in the 3-season organic fruit high tunnels constructed at the MSU Horticultural Teaching and Research Center (HTRC) on the MSU campus in association with the Student Organic Farm (SOF). Replicated plots of sweet cherries on dwarfing rootstocks and raspberries will be planted in 6 of the 9 tunnels, three each to cherries and to raspberries. The remaining 3 tunnels will serve as guard tunnels (i.e., tunnels #1, 5, and 9) to eliminate \"edge effects\". These will be interplanted to small groupings of both cherries and raspberries (a raspberry row along each side of the tunnel, and an offset double row of cherries in the center); a portion of each tunnel will also be used for apple nursery tree production. These tunnels will be utilized for demonstration plots to test additional varieties and selections from breeding programs, as well as research plots with banker plants for diversified plant protection strategies. We anticipate that powdery mildew, gray mold, and brown rot will be troublesome diseases, and may require efficacy trials with organic fungicides such as potassium bicarbonate, Serenade (Bacillus subtillis) and Sonata (B. pumilis). Organic pest management strategies will be studied and developed not only at the HTRC high tunnel plots, but also in the collaborative commercial organic fruit production plots of our cooperating advisory group stakeholders. The following hypotheses will be tested by appropriate experiments too lengthy to describe here: 1) The combination of high tunnels and organic propagation media, such as custom blends of milled bark enriched with specific composts, can produce organic apple nursery trees comparable to or better than commercially-available nursery trees. 2) Externally-applied organic sources of nitrogen (N), such as compost and pelleted alfalfa or soybean meal, have different effects on perennial fruit crop growth, disease pressure, and soil health. 3) The use of seasonally-applied weed barriers and cover cropping strips have differential effects on weed competition, perennial fruit crop growth and yields, and long-term soil-building. 4) Insect control strategies for organic high tunnel culture of perennial fruits will be dictated by insect ecology, microclimatic modifications, physical barriers, seasonal cover cropping strategies, mono- vs. poly-culture, and/or changes in plant and soil health. 5) The use of modified environment technologies (high tunnels) and associated production strategies adds significant value for organic fruit producers in the Great Lakes/Midwest region. Project outreach will include small-plot and on-farm research trials that are complemented by on-farm workshops as well as on-line course content, with objectives that focus on knowledge dissemination to beginner and advanced growers, extension educators, and agriculture professionals who need educational resources to integrate the multitude of environmental, economic and human factors that influence the viability of sustainable organic farm management.

PROGRESS

2010/09 TO 2014/08 Target Audience: Our target audience includes organic farmers, agriculture professionals and consultants, and university researchers, educators, and students for whom research-based production strategies that focus on positive ecosystem services, innovative technologies, diversified production potential, and sustainable profits are critical for success. This project particularly targets growers who want to produce organic fruits in non-arid cold climates like the Great Lakes/Midwest and who need expanded strategies for soil, plant, pest (insect, disease,weed) and environmental management to enhance crop diversity, productivity, productin consistency, and profitability, especially those that utilize or with to establish protective high tunnel production structures. Midwest fruit consumers also will benefit from increased availability of, and extended seasons for, locally-produced fresh fruits that provide desirable flavors and dietary/health benefits. Changes/Problems: The multi-generation, broadly-invasive spotted wing drosophila (SWD) fruit fly is a \"game changer\" for organic fruit production in the Great Lakes region, and will require significant and on-going research to address expansion of, and prevention of resistance to, suitable control measures, as well as secondary impacts such as flaring mite populations or increased incidence of saprophytic diseases. SWD was reasonably

controlled by the end of this project with excellent sanitation (removal of non-harvested berries), judicious use of organically-certifeid pesticides, and possibly the use of insect exclusion netting, but the ever-changing dynamics of SWD populations and emergence timing suggests that this will be an area of significant future research needs for organic growers. The successive, though variable, winter-spring climatic problems that damaged cherry fruit buds, flowers, or small fruitlets from 2012 to 2014 precluded much of the organic pest management trials related to fruit protection. However, pest management studies related to general tree health were still able to be carried out. What opportunities for training and professional development has the project provided? Three graduate students have been trained during the course of this project, one in organic production of small fruits, one in organic cover cropping and weed management strategies for sweet cherries, and one in organic insect management for raspberries and sweet cherries. Additional graduate and undergraduate students have been involved in assisting with the research and management of the organic production components of the project. Members of the Student Organic Farm have been involved in the project\'s annual raspberry production, harvest, storage, and marketing tasks. How have the results been disseminated to communities of interest? The annual (2011-2014) field days held over the course of the project have provided opportunities for training of more than 120 participating growers and consultants in organic strategies for raspberry and cherry production under tunnels in Midwestern climates. Seven workshops were also held in conjunction with the MSU Student Organic Farm. A comprehensive two-hour workshop was held at the 2012 MOSES conference for about 125 participants. Two professionally-produced YouTube videos about the project and organic raspberry production management have been posted for internet access, with nearly 2,400 total views to date. Several presentations to update project progress were also made over the course of the project at the Great Lakes Fruit, Vegetable, and Farm Market Expo, with total attendance estimated at more than 200 people. Invited research presentations were made at the 2011 ISHS High Tunnels Symposium in Pennsylvania and the 2012 ISHS Organic Fruit Production Symposium in Washington state, both of which were posted on the internet (www.hrt.msu.edu/greg-lang) and published as peer-reviewed papers in the conference proceedings . Multiple farm visits have been made by project personnel to hoop house and organic growers in Michigan over the duration of the project. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: Organic farmers, agriculture professionals, and university researchers and educators for whom research-based production strategies that focus on positive ecosystem services, innovative technologies, diversified production potential, and sustainable profits are critical for success. This project particularly targets growers who want to produce organic fruits in non-arid coold climates like the Great Lakes/Midwest and who need expanded strategies for soil, plant, pest (insect, disease, weed) and environmental management to enhance crop diversity, productivity and profitability. Midwest fruit consumers also will benefit from increased availability of, and extended seasons for, locally-produced fresh fruits that provide desirable flavor and dietary/health benefits. Changes/Problems: The multi-generation, broadly-invasive spotted wing drosophila (SWD) fruit fly is a "game changer" for organic fruit production in the Great Lakes region, and will require significant and on-going research to address expansion of, and prevention of resistance to, suitable control measures, as well as secondary impacts such as flaring mite populations or increased incidence of saprophytic diseases. Effective organic strategies for cherry fruiting challenges, such as black cherry aphids, plum curculio, and brown rot, remain to be addressed adequately due to the lack of fruit in the first three years of the project orchard. Strategies to manage high summer temperatures in multi-bay tunnels also remain to be optimized. What opportunities for training and professional development has the project provided? Three graduate students have been trained during the course of this project, one in organic productino of small fruits, one in organic cover cropping and weed management strategies for sweet cherries, and one in organic insect management for raspberries and sweet cherries. Additionally, the annual field days have provided opportunities for training of participating growers in organic strategies for fruit production under tunnels in Midwestern climates. How have the results been disseminated to communities of interest? Annual project field days were held at the organic high tunnels in 2011 and 2012, along with two workshops in 2011 and four workshops in 2012 in conjunction with the MSU Student Organic Farm. A workshop was held at the 2012 MOSES conference, and project presentations were made at the 2011 and 2012 annual Great Lakes Fruit, Vegetable, & Farm Market Expo. Invited research presentations were made at the 2011 ISHS High Tunnels Symposium in Pennsylvania and the 2012 ISHS Organic Fruit Production Symposium in Washington state. Multiple farm visits have been made by project personnel to hoop house and organic growers in Michigan over the duration of the project. What do you plan to do during the next reporting period to accomplish the goals? Project videos are currently in production to address high tunnel cherry production, raspberry production, pest management, disease management, and weed management. Organic pest management strategies for black cherry aphid and plum curculio will be tested in 2014.

2011/09/01 TO 2012/08/31 OUTPUTS: This OREI project utilizes nine 26 x 200 ft (8 x 61.5 m) multi-bay 3-season high tunnels at the MSU Horticultural Teaching and Research Center (HTRC) on the MSU campus. 2012 was the second year of the three-year USDA-NIFA-OREI project, a period of significant fruit production for the raspberries and a period of cherry tree canopy training and imposition of the seasonal cover cropping organic research treatments. RASPBERRIES: Fruit production has been impressive, with the horticultural conclusions to date including: 1) weed control is quite easy with periodic mechanical hoeing, since the extremely dry conditions under the tunnel covers favors little weed growth in between the irrigated fruit rows; 2) maintaining adequate soil nutrition throughout the growing season is a significant challenge, without rain to carry top-dressed composts and organic fertilizers into the root zone; injection of organic nutrients into the drip system will be studied more in 2013. Regarding organic pest management, potato leafhopper has been a minor pest, but spotted wing drosophila, only discovered in Michigan in 2011, has become the greatest challenge to organic berry production. Organic control with spinosad and Pyganic has been successful, but season-long limits on spinosad, concern about potential resistance development, and the tendency of Pyganic to cause mite population to explode (due to predator mortality) brings sustainable organic control in the future into question. SWEET CHERRIES: Root competition with weeds or cover crops during the growing season significantly reduced not only cherry tree growth but also nutrient acquisition; seasonal elimination of root competition appears promising. Black cherry aphid populations exploded rapidly in the spring, but were mirrored by a rapid increase in lady bird beetle larvae which quickly brought aphid populations under control. Trees subsequently outgrew the momentary aphid damage to leaves and new shoots in most cases. Varieties with genetic resistance to powdery mildew continue to exhibit no infections even when surrounded by substantial colonies on susceptible varieties. APPLE NURSERY TREES: In the outer guard tunnels, research plots for organic apple nursery production in raised beds was continued. Grafting success was much higher than in 2011, with excellent initial growth, but nutrients became limiting by mid-season in the organic propagation mulch (similar to the raspberry situation, injection of nutrients into the drip lines will be explored in 2013). A companion organic apple nursery research plot at a commercial organic apple orchard operation, in cooperation with a member of the project stakeholder advisory panel, had problems with Phythophthora root rot infections in 2012. DISSEMINATION OF OUTPUTS: Two Powerpoint presentations and two research posters were presented at the International Organic Fruit Crops Symposium in Leavenworth, Washington, and a 90-minute organic high tunnel fruit production workshop was presented at the MOSES conference in Wisconsin. A public twilight tour of the project for interested growers was conducted in mid-summer. PARTICIPANTS: Project Directors/Principal Investigators: Gregory A. Lang, Professor, and Eric J. Hanson, Professor, Dept. of Horticulture, Michigan State University. Drs. Hanson and Lang lead the fruit production research and overall tunnel management activities, particularly soil fertility/plant nutrient management research. Project Co-Principal Investigators: John A. Biernbaum, Professor and Daniel C. Brainard, Assistant Professor, Dept. of Horticulture, Michigan State University; Matthew Grieshop, Assistant Professor, and Rufus Isaacs, Professor, Dept. of Entomology, Michigan State University; Annemiek Schilder, Associate Professor, Dept. of Plant Pathology, Michigan State University; David S. Conner, Assistant Professor, Dept. of Community Development and Applied Economics, University of Vermont. Dr. Biernbaum leads efforts related to organic soil building strategies and developing outreach workshop formats. Dr. Brainard leads efforts related to cover cropping and compost research on weed dynamics and soil fertility/plant nutrient management. Drs. Grieshop leads efforts related to ecosystem services and biologically-based organic insect pest management research and extension in high tunnel perennial fruit crop culture. Dr. Isaacs leads efforts related to multiple organic insect pest management strategies and pollinator services in high tunnel perennial fruit crop culture. Dr. Schilder leads efforts related to organic disease management research in high tunnel perennial fruit crop culture. Dr. Conner leads efforts related to economic analyses of the project\'s organic fruit production system strategies. Key Project Personnel: Adam D. Montri, Outreach Specialist, Dept. of Horticulture, and Vicki L. Morrone, Outreach Specialist, Dept. of Community/Ag/Recreation/Resource Studies, Michigan State University. Mr. Montri serves as the organic high tunnel workshop instructor and high tunnel website webmaster. Ms. Morrone is the extension coordinator for field days, workshops, and farm visits, including preparation, evaluation administration, and impact analysis. Support Professionals: Keith Mason (Research Technician) provides technical support for raspberry and sweet cherry high tunnel entomological studies; Tammy Wilkinson (Research Technical Aide) provides technical support for sweet cherry and raspberry high tunnel horticultural studies; Roger Sysak (Research Technician) provides technical support for compost field studies; Anne Neilsen (Postdoctoral Researcher) provides technical support for ecosystem services research and organic insect pest management practices. Advisory Stakeholders/Cooperators Panel: Jim Koan, Al-Mar Orchards (certified organic apple growers), Flushing, MI; Cheryl and Allen Kobernik, North Star Organics (certified organic cherry growers), Frankfort, MI; Jeremy Moghtader, Outreach Specialist, Student Organic Farm, MSU Dept. of Horticulture, East Lansing, MI; Brad Morgan, Morgan Composting (custom organic compost provider), Sears, MI; Mari and Chris Reijmerink, Kismet Fruit Farm (certified organic raspberry growers), Fennville, MI. Training opportunities are also provided for three graduate students in sustainable horticulture. TARGET AUDIENCES: Organic farmers, agriculture professionals, and university researchers and educators will benefit from this project\'s studies to provide research-based

production strategies that are focused on positive ecosystem services, innovative technologies, diversified production potential, and sustainable profits. This project particularly targets those growers who want to produce organic fruits in non-arid cool climates like the Great Lakes/Midwest and who need expanded strategies for soil, plant, pest (insect, disease, weed) and environmental management to enhance crop diversity, productivity and profitability. Midwest fruit consumers also will benefit from increased availability of, and extended seasons for, locally-produced fresh fruit that provide desirable flavor and dietary/health benefits. PROJECT MODIFICATIONS: The sweet cherry soil fertility experiments were scaled back, with a concomitant expansion of the cover cropping/weed control components of the project. Half of the training systems trial was replanted in 2012 due to excessive tree mortality of one group of nursery trees planted in 2011, which apparently were cold-damaged in the commercial nursery prior to shipping to Michigan for planting.

2010/09/01 TO 2011/08/31 OUTPUTS: This OREI project utilizes nine 26 x 200 ft (8 x 61.5 m) multi-bay 3-season high tunnels at the MSU Horticultural Teaching and Research Center (HTRC) on the MSU campus. Site drainage within the tunnels was modified during fall 2010 by installing subsurface tile lines and minor surface contouring to minimize rainwater movement (run-off shed from the plastic covers) within each plot. Replicated raspberry plots (Autumn Britten and Heritage) were established in spring 2010 in three contiguous tunnels. Replicated sweet cherry varieties on Gisela (Gi) 3 or Gi 5 dwarfing rootstocks were planted in spring 2011 in three other contiguous tunnels (main varieties: Burgundy Pearl, Ebony Pearl, Radiance Pearl, Rainier, and Skeena, along with two experimental selections having genetic resistance to powdery mildew). The two outer tunnels, plus the middle tunnel separating the raspberry and cherry tunnel groups, serve as guard tunnels to the main groups; these are planted as polycultures that include both raspberry and cherry variety test plots. In the outer guard tunnels, research plots for organic apple nursery production in raised beds also was established. A companion organic apple nursery research plot was established at a commercial organic apple orchard operation in cooperation with a member of the project stakeholder advisory panel. Drip irrigation lines were installed for each row of plants in the HTRC tunnels, and soil moisture monitoring tubes were installed in representative tunnel plots. Organic certification was completed in early summer 2011. The initial cover crops and soil-building treatments (e.g., compost applications) were planted or applied in 2010-2011, and initial nutrient and soil quality/health samples were analyzed/assessed to determine site baseline values. Insect populations (pests and natural enemies) were monitored weekly in each tunnel during the growing season. Cider vinegar traps for Spotted Wing Drosophila (SWD) were installed in the raspberry tunnels to monitor for this new pest, which was first reported (at a site nearby) in Michigan in fall 2010. Initial pests of significance have included two-spotted mites, tent caterpillars, and potato leafhopper (the latter of which was most prevalent on the raspberry cultivar Polka). The initial control strategies for these have been release of predatory mites, hand removal, and an OMRI-approved spray trial comparing Pyganic, Mycotrol, and Mycotrol+Pyganic, respectively. The record rainfall during April and May promoted high incidences of cherry leaf spot and bacterial leaf spot in unprotected orchards, but these were negligible in the organic tunnels. A research poster was presented at the USDA Organic Farming Systems Research Conference and USDA-NIFA-OREI Project Directors meeting in Washington DC (March 16-18). A video demonstrating the construction of the 3-season high tunnels for this project was created and posted on the internet at http://www.youtube.com/watchv=xWnI6iIZeVQ. A tour of the HTRC organic fruit high tunnel production plots members of the industry and general public was organized in conjunction with MSU Ag Week activities in July 2011. PARTICIPANTS: Project Directors/Principal Investigators: Gregory A. Lang, Professor, and Eric J. Hanson, Professor, Dept. of Horticulture, Michigan State University. Drs. Hanson and Lang lead the fruit production research and overall tunnel management activities, particularly soil fertility/plant nutrient management research. Project Co-Principal Investigators: John A. Biernbaum, Professor and Daniel C. Brainard, Assistant Professor, Dept. of Horticulture, Michigan State University; Matthew Grieshop, Assistant Professor, and Rufus Isaacs, Professor, Dept. of Entomology, Michigan State University; Annemiek Schilder, Associate Professor, Dept. of Plant Pathology, Michigan State University; David S. Conner, Assistant Professor, Dept. of Community Development and Applied Economics, University of Vermont. Dr. Biernbaum leads efforts related to organic soil building strategies and developing outreach workshop formats. Dr. Brainard leads efforts related to cover cropping and compost research on weed dynamics and soil fertility/plant nutrient management. Drs. Grieshop leads efforts related to ecosystem services and biologically-based organic insect pest management research and extension in high tunnel perennial fruit crop culture. Dr. Isaacs leads efforts related to multiple organic insect pest management strategies and pollinator services in high tunnel perennial fruit crop culture. Dr. Schilder leads efforts related to organic disease management research in high tunnel perennial fruit crop culture. Dr. Conner leads efforts related to economic analyses of the project\'s organic fruit production system strategies. Key Project Personnel: Adam D. Montri, Outreach Specialist, Dept. of Horticulture, and Vicki L. Morrone, Outreach Specialist, Dept. of Community/Ag/Recreation/Resource Studies, Michigan State University. Mr. Montri serves as the organic high tunnel workshop instructor and high tunnel website webmaster. Ms. Morrone is the extension coordinator for field days, workshops, and farm visits, including preparation, evaluation administration, and impact analysis. Support Professionals: Keith Mason (Research Technician) provides technical support for

raspberry and sweet cherry high tunnel entomological studies; Tammy Wilkinson (Research Technical Aide) provides technical support for sweet cherry and raspberry high tunnel horticultural studies; Roger Sysak (Research Technician) provides technical support for compost field studies; Anne Neilsen (Postdoctoral Researcher) provides technical support for ecosystem services research and organic insect pest management practices. Advisory Stakeholders/Cooperators Panel: Jim Koan, Al-Mar Orchards (certified organic apple growers), Flushing, MI; Cheryl and Allen Kobernik, North Star Organics (certified organic cherry growers), Frankfort, MI; Jeremy Moghtader, Outreach Specialist, Student Organic Farm, MSU Dept. of Horticulture, East Lansing, MI; Brad Morgan, Morgan Composting (custom organic compost provider), Sears, MI; Mari and Chris Reijmerink, Kismet Fruit Farm (certified organic raspberry growers), Fennville, MI. Training opportunities are also provided for three graduate students in sustainable horticulture. TARGET AUDIENCES: Organic farmers, agriculture professionals, and university researchers and educators will benefit from this project\'s studies to provide research-based production strategies that are focused on positive ecosystem services, innovative technologies, diversified production potential, and sustainable profits. This project particularly targets those growers who want to produce organic fruits in non-arid cool climates like the Great Lakes/Midwest and who need expanded strategies for soil, plant, pest (insect, disease, weed) and environmental management to enhance crop diversity, productivity and profitability. Midwest fruit consumers also will benefit from increased availability of, and extended seasons for, locally-produced fresh fruit that provide desirable flavor and dietary/health benefits. On-line efforts to reach these target audiences include the New Ag Network (www.new-ag.msu.edu), the Michigan Organic Farming Exchange (www.michiganorganic.msu.edu), and the Midwest Organic Tree Fruit Growers Network (MOTFGN, www.mosesorganic.org/treefruit/intro.htm). PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2014/08 What was accomplished under these goals? ORGANIC APPLE NURSERY TREES: The project demonstrated that organic production of custom variety apple nursery trees can be accomplished by small-scale organic apple growers in high tunnels. The use of raised beds filled with milled bark compost provided a suitable organic growing medium that could be renewed on an annual or bi-annual basis for nursery production, then used for mulching and soil amendment in the organic fruit production operations. Neither plant spacing or bed depth was an overriding factor for achieving adequate nursery tree growth, but the interaction of the two factors was important: closer spacing required deeper beds, or more shallow beds required wider nursery tree spacing, with an overall rooting volume of 31L resulting the best tree growth. Drip irrigation was insufficient for the coarse compost medium used, so microsprinkler irrigation was installed to achieve better tree growth in the raised beds. Nutrients, particularly nitrogen, became limiting by mid-summer, so supplemental fertilization as by injected fish emulsion, pelleted alfalfa, or soybean meal-based nitrogen sources are important for raised bed compost nursery production. The fungal-dominated compost resulted in 30% better growth than the bacteria-dominated compost. Growing nursery trees in the high tunnels facilitated fall digging and planting immediately into the orchard, resulting in better establishment and subsequent season growth than digging and cold-storage the trees for spring planting. ORGANICRASPBERRY PRODUCTION:High tunnels to protect raspberries from rain solved the main fruit rot disease challenges (Botrytis cinera and Cladosporium spp.) and extended the harvest season. Fall berry yields ranged from about 7,000 to 13,000 lb/acre, or double-cropping with both summer and fall harvests had the potential of up to 8,000 lb per acre for each cropping period. Fruit size was generally 20 to 30% larger than typical fruit size from unprotected canes, with longer shelf-life. Overall, these yields were lower than our conventional tunnel production trials (20,000+ lb/acre). Nutrient deficiencies, insect pests and high temperatures likely contributed to the reduced yields. Weeds: Since tunnels excluded rain, weeds grew weakly in the row middles due to lack of moisture; these were managed easily by shallow cultivation and mowing. Within-row weeds emerged primarily near the irrigation lines and were removed by hand twice per year. Since raspberries have a high nutrient demand from May through September, maintaining adequate fertility organically (primarily nitrogen and potassium) has been challenging in the dry tunnel environment. Surface-applied organic nutrient additions were supplemented with a liquid fish product applied through the trickle irrigation to achieve adequate plant growth and leaf health. Key insect pests and secondary diseases: Mite levels varied by year, being low to moderate during the cooler seasons, but reaching epidemic levels in hot, dry summer seasons. The most serious insect pest has been spotted winged drosophila (SWD), an invasive species that did not even exist in Michigan at the beginning of this project. SWD has progressively emerged earlier and reduced marketable yields each year, and SWD-infested fruit provide entries for diseases like yeasts and saprophytic fungi (e.g., Penicillium, Rhizopus stolonifer). Organic pesticides suppressed populations, but did not control them. Use of pyrethrum (Pyganic) insecticide (alternated with spinosad, Entrust) to suppress SWD promoted higher spider mite populations, apparently by damaging predators. This now ubiquitous pest, which has a wide range of

alternative host plants in the Great Lakes environment, represents the primary limitation to organic production of raspberries; preliminary research on utilization of insect-exclusion netting in 2014, in conjunction with high tunnels, looks promising as at least a partial solution. Other notable insect pests included green aphids, raspberry sawfly, potato leafhopper, and Japanese beetles, but these were controllable within economic levels. A trial that examined groundcover (native grasses and broadleaf plants vs. bare ground), with and without predatory mite releases, found no effects on predatory mite numbers, but spider mite numbers were reduced with the native groundcover plus predatory mite releases. Analysis of organic raspberry production costs in tunnels was published as one of the porject outcomes. ORGANICSWEET CHERRY PRODUCTION: Tree growth: Root competition with weeds or cover crops during the growing season significantly reduced not only growth, but also nutrient acquisition; seasonal elimination of root competition with woven plastic weed barrier fabrics enhanced growth. This appeared to be primarily an effect of ground management treatment impacts on root zone water availability, which was best under the season-long weed barrier or spring weed barrier plus a summer (post-harvest, post-shoot elongation) cover crop of sorghum-sudangrass. Other treatments (mowed weeds, winter rye + hairy vetch, perennial grass + white clover) reduced soil moisture in spring by about 20% and growth by about 15 to 27%. The greatest biomass accumulation was with the summer cover crop treatment. The greatest weed suppression was with weed barrier fabric, followed by the winter rye-vetch cover crop. The Upright Fruiting Offshoots (UFO) training system has been the easiest tree architecture to maintain, both for minimal canopy spread (maintained by postharvest hedging) and moderate tree height. The Super Slender Axe (SSA) system has been easy to maintain for canopy spread with post-harvest hedging, but tree vigor creates potentially excessive growth in the tops of trees compared to the UFO. The Tall Spindle Axe (TSA), system tends to be excessively vigorous for the space allotted at three rows per tunnel, both for canopy spread and canopy height. Given the generally increased labor requirements associated with organic production, labor efficiency in canopy development, maintenance, and fruit harvest could be a significant benefit in organic cherry production. Fruiting: Multiple spring freezes in 2012, a late spring frost in 2013, and severe low winter temperatures in 2014 greatly reduced anticipated yields on the organic sweet cherry trees. However, the incidence of bacterial canker, which is common following freeze and frost damage, was minimal compared to many other comparably-aged cherry plots across MSU research centers, though direct statistical comparisons were impossible. It is thought that since high tunnels provide protection from both rain and wind, the potential dissemination and infection by the causal agent of canker, Pseudomonas syringae pv. syringae, may have been significantly reduced compared to orchards fully exposed to spring weather conditions. Black cherry aphid populations can build rapidly in high tunnel sweet cherries, and natural predators (primarily ladybird beetle larvae and lacewings) only provide adequate control in some years. In 2014, dormant oil applications were applied, with resulting aphid populations very manageable, but it is impossible at this point to determine whether that was due to the dormant oil treatment or the severe mid-winter low temperatures. Japanese beetle damage has been more significant in the organic tunnels than in tunnel cherries at other MSU research centers, presumably due to much higher inherent neighboring populations. No effective controls for plum curculio have yet been documented; insect exclusion netting and high density perimeter trapping are being considered for future work. Varieties with genetic resistance to powdery mildew have consistently exhibited no infections even when surrounded by substantial colonies on susceptible varieties. Fruiting has been too sporadic to conduct reasonable tests of organic products for potential brown rot control. **PUBLICATIONS (not previously reported):** 2010/09 TO 2014/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Lang. G.A. 2014. Growing sweet cherries under plastic covers and tunnels: physiological aspects and practical considerations. Acta Horticulturae 1020:303-312. 2. Type: Other Status: Published Year Published: 2014 Citation: Hanson, E., V. Morrone, and R. Isaacs. 2014. Organic raspberry production in three-season high tunnels. MSU Extension Bulletin E3235. 3. Type: Other Status: Published Year Published: 2013 Citation: Lang, G. 2013. Consistent production with covered systems. American/Western Fruit Grower 133(9):26-27. 4. Type: Other Status: Published Year Published: 2014 Citation: Lang, G. 2014. Considerations for high tunnel sweet cherries. American/Western Fruit Grower 134(9/10):48-49. 5. Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Gluck, B. 2013. Organic management of soil and nutrients for primocane fruiting raspberries in high tunnels. M.S. Thesis, Michigan State University.

2012/09 TO 2013/08 What was accomplished under these goals? The concept of growing apple nursery trees in raised beds of organic compost (which could then be used during orchard planting) and renewal of the nursery beds annually was tested in the project tunnels and at Al-Mar Orchards, an organic apple orchard near Flushing, Michigan. Compost type compost type was more important for nursery tree growth than bed depth or plant spacing; closer spacing required deeper beds for adequate growth. Raspberry Culture/Production:The use of high tunnels to protect raspberries from rain solved the main fruit rot disease challenges (Botrytis cinera and Cladosporium spp.), so research primarily has emphasized management of weeds, nutrients, and some key insect pests and secondary diseases. Berry yields have ranged from about 7,000 to 13,000 lb per acre (2013 harvest is still in progress). The highest yields were from ' 'Himbo Top' in 2012. This is lower than our

conventional tunnel production trials, which have exceded 20,000 lb per acre. Nutrient deficiencies, insect pests and high temperatures likely contributed to the reduced yields (see below).Soil fertility: Raspberries have a high nutrient demand from May through September; organically maintaining adequate fertility (primarily nitrogen, N, and potassium, K) has been challenging in the dry tunnel environment. Since raspberries are perennial plants, subsequent annual nutrient incorporation is not possible after establishment. When organic nutrient sources were surface applied during the growing season, the soil become deficient in N and K by late 2012, as confirmed by leaf analysis. In 2013, surface-applied organic nutrient additions were supplemented with a liquid fish product applied through the trickle irrigation. Plant growth and nutrient levels improved to adequate levels as a result. However, currently liquid fish suitable for drip irrigation injection is an expensive fertility source.Key insect pests and secondary diseases: Mite levels have varied by year, being low to moderate during the cooler 2013 season, but reaching epidemic levels in the hot, dry summer of 2012. The most serious insect pest has been spotted winged drosophila (SWD), an invasive species that did not even exist in Michigan at the beginning of this project. SWD has progressively emerged earlier and reduced marketable yields each year, and SWD-infested fruit provide entries for diseases like yeasts and saprophytic fungi (e.g., Penicillium, Rhizopus stolonifer). Organic pesticides suppressed populations, but did not control them. Use of pyrethrum (Pyganic) insecticide (alternated with spinosad, Entrust) to suppress SWD promoted spider mite populations, apparently by damaging predators. Other notable insect pests included green aphids, raspberry sawfly, potato leafhopper, and Japanese beetles, but these were controllable within economic levels. A trial that examined groundcover (native grasses and broadleaf plants vs. bare ground), with and without predatory mite releases, found no effects in 2012 on predatory mite numbers but reduced spider mite numbers with the native groundcover plus predatory mite releases; data from 2013 are still being processed. Incidence of raspberry powdery mildew has been low and readily controlled thus far by early removal of infected shoots before they elongate significantly. Research with organic fungicides, including Serenade Max (Bacillus subtilis), Regalia (giant knotweed extract), Milstop (potassium bicarbonate), JMS Stylet Oil (paraffinic oil), Oxidate (hydrogen peroxide), Nu-Film P (spreader-sticker), compost tea (plant-based, aerated compost tea), compost tea + Serenade Max, and various combinations, is on-going during the 2013 season. Sweet Cherry Culture/Production:Cherries begin primary bearing on two-year-old spurs; unfortunately, multiple spring freezes in 2012 killed spurs such that 2012 fruiting was eliminated and 2013 yields were greatly reduced.Canopy space utilization: Three high density canopy training systems were imposed on the 'RadiancePearl' trees planted in the center row of each tunnel: Tall Spindle Axe (TSA), Super Slender Axe (SSA), and Upright Fruiting Offshoots (UFO). The greatest growth thus far is in the UFO system, followed by the SSA and TSA, which are not significantly different.Groundcover management: Organic soil and weed management in high tunnel production of perennial tree fruits is a challenge for maintaining fertility while minimizing root competition with the dwarfing rootstocks necessary to contain tree growth within the confines of the tunnel structure. Six groundcover management treatments were compared in 2012 and 2013: 1) a weedy control (mowed), 2) a water-permeable black polypropylene weed barrier fabric, 3) partial season weed barrier plus an annual summer cover crop (sorghum-sudangrass, "sudex"), 4) an annual winter cover crop (winter rye + hairy vetch), 5) partial season weed barrier plus annual winter cover crop, and 6) a perennial cover crop mix of grass and white clover. The weedy and perennial cover crop treatments were mowed 2 to 3 times per year. The greatest cover crop biomass accumulation (\>5 ton/acre) was in the sudex treatment; purlane was the dominant weed species, which produced substantial seeds prior to winter kill. Weeds were effectively suppressed in the rye-vetch treatment (5 of 6 plots; perennial quackgrass was problematic in one plot). Soil moisture content was highest and similar for the weed barrier and weed barrier plus sudex treatments in spring (10 May) and summer (30 July). The other treatments were similar, about 20% lower, in spring; by summer, the perennial cover crop was lowest, followed by the weedy treatment. Tree growth reflected soil water contents: the weedy plots had 27% less growth compared to the most vigorous treatments, followed by the perennial cover crop plots (-15%). The other treatments were similar, suggesting that the winter rye-vetch treatment may be as advantageous to growth, water relations, and weed suppression as the partial or full-time weed barrier treatments, with the added advantage of annual additions of organic matter to the soil which would otherwise become progressively depleted with weed barrier fabric alone.Key insect pests and diseases: Black cherry aphid populations increased quickly in spring; in 2012, predator populations began providing control after brief stunting of new growth, but in 2013, damage was severe and continuing on new growth as well as impacting the small initial fruit yields on the trees. Japanese beetle damage was more significant on cherry than on raspberry, and control measures may be needed beyond the daily scouting and manual removal that worked when the trees were small. The best control of cherry powdery mildew to date has been by the use of genetically resistant cherry varieties; tests of organic control products (JMS stylet oil, Milstop, and Oxidate) have not been very effective to date. Once fruiting begins, brown rot is likely to become a key focus for control. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Lang, G.A. 2013. Tree fruit production in high tunnels: current status and case study of sweet cherries. Acta Hort. 987:73-81. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Lang, G., E. Hanson, J. Biernbaum, D. Brainard, M. Grieshop, R. Isaacs, A. Montri, V. Morrone, and A. Schilder,

D. Conner, and J. Koan. 2013. Holistic integration of organic strategies and high tunnels for Midwest/Great Lakes fruit production. Acta Hort. 1001:47-55. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Hanson, E.J., B.I. Gluck, and A. Schilder. 2013. High tunnels for organic raspberry production in the Midwestern US. Acta Horticulturae 1001:73-77. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Gluck, B.I. and E.J. Hanson. 2013. Effect of drip irrigation and winter precipitation on distribution of soil salts in three season high tunnels. Acta Horticulturae 987:99-104. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Demchak, K. and E.J. Hanson. 2013. Small fruit production in high tunnels in the U.S. Acta Horticulturae 987:41-44.

2011/09/01 TO 2012/08/31 Since this is the second year of the three-year project, most results thus far must be repeated and organic management strategies that have been explored to date must be refined before they will make a significant impact. Several new organic and/or high tunnel fruit growers have visited the project during field days, to explore the possibility of establishing or expanding their own production operations based on continued observation of the on-going results of this project.

2010/09/01 TO 2011/08/31 This was the first year of the three-year USDA-NIFA-OREI project, a period of establishment for these perennial fruit crops and imposition of the various initial organic research treatments. Therefore, it is premature to draw any conclusions or provide any outcomes at this stage.

PUBLICATIONS

2011/09/01 TO 2012/08/31 Lang, G., E. Hanson, and B. Gluck. 2012. Organic production of cherries and raspberries in high tunnels. Organic Broadcaster 20(5):7, 14.

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

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A Systems Approach to Control Gastrointestinal Nematodes in Organic Small Ruminant Production

Accession No.	0223256
Subfile	CRIS
Project No.	ARKW-2010-01884
Agency	NIFA ARKW
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21641
Proposal No.	2010-01884
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Burke, J. M.
Performing Institution	USDA, ARS DALE BUMPERS SMALL FARMS RESEARCH CENTER, 6883 SOUTH STATE HIGHWAY 23, BOONEVILLE, ARKANSAS 72927

NON-TECHNICAL SUMMARY

The objective is to examine systems of integrated strategies to control gastrointestinal nematodes (GIN) in organic small ruminants. The focus will be on farming systems that use a set of integrated tools for control of GIN and identification and selection of animals that are resistant to GIN. By reducing the need for deworming sheep and goats, the number of certified organic farms is expected to dramatically increase and profitability of organic sheep and goat production will be enhanced. The use of integrated strategies will be examined in a controlled setting and on-farm. Education of professionals and producers on adoption of organic GIN control strategies will be a priority. Organic production of wool, mohair, milk, and sheep and goat meat is growing, especially on small farms in the Eastern, Midwestern and Southeastern US. The National Organic Program does not address the issue of GIN anthelmintic resistance in small ruminants and accepted control measures have not been adequate.

OBJECTIVES

The objectives are to examine farm management systems for year round gastrointestinal nematode control, identify resistant animals to minimize problems with nematode infection, conduct on-farm studies on the feasibility of techniques developed from research studies, and educate outreach professionals and producers on adopting available organic gastrointestinal nematode control strategies in small ruminants by disseminating state-of-the-art knowledge and procedures.

APPROACH

Studies will be conducted at USDA, ARS, LSU, FVSU, and on-farm using pastures in transition and organic principles to examine forages and genetics to minimize the use of anthelmintics (antibiotics) to control GIN. A number of approaches will be used to evaluate producer\'s use of strategic control.

PROGRESS

2010/09 TO 2015/08 Target Audience:Organic and conventional sheep and goat producers, extension specialists, scientists, veterinarians. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Six graduate students and several undergraduate students were trained at University of Arkansas/USDA, Agricultural Research Service, Booneville, AR; Louisiana State University, Fort Valley State University. The American Consortium for Small Ruminant Parasite Control meetings were held twice yearly throughout the life of the grant. Professionals were in attendance, including animal and forage scientists, veterinarians, extension specialists, technology transfer specialists, and farmers. Research reports were disseminated, exhaustive discussions on changing central dogma to educate farmers on parasite control so that they can understand the issue is as standard as nutrition and should be integrated into all aspects of management. Various methods of training farmers were discussed including use of videos and webinars. Training occurred at the National Goat Conference (serves a diverse audience and is designed for goat and sheep producers, agricultural professionals and students; representatives of the 1890 and 1862 Land-Grant Institutions, community-based organizations as well as local, state and federal agencies attended), held in Greensboro, NC in September 2013. The PI presented parasite control in sheep and goats through the use of copper oxide wire particles. There was an estimated 500 participants, including a high proportion of minority farmers and nearly all participants had small farms. A co-PI presented information on sericea lespedeza as an aid to control parasites. The American Consortium for Small Ruminant Parasite Control Integrated Parasite Management Train-the-Trainer Symposium, Fort Valley, GA, May 2013. Information on the latest parasite control from veterinary parasitologists from around the world and research scientists was presented to 120 veterinarians, extension specialists and farmers from throughout the U.S., who will in turn relay information to their clients and other farmers. The PI presented a summary of research results on the use of copper oxide wire particles as a dewormer in sheep and goats; co-PIs presented the use of sericea lespedeza to control parasites in sheep and goats, and alternative methods of parasite control including vaccines and fungi. PIs resided on an interactive panel that responded to questions from attendees on any aspect of parasite control. Information disseminated throughout the U.S. will aid farmers in parasite control strategies that will save lives of animals and ultimately produce more income for farmers. Dissemination to professionals also occurred at the Southern Section and National American Society of Animal Science meetings to agricultural professionals, the multi-state research and extension (NCERA-214, Improving efficiency of sheep production; NRSP-8 National Animal Genome Research Program) or coordinating committee (SCC-81, Sustainable small ruminant production in the southeastern U.S.), the European Capara meeting (focuses on control of goat parasites in the European Union and internationally), International Goat Association, and the World Association for the Advancement of Veterinary Parasitology. How have the results been disseminated to communities of interest?Technical reports and fact sheets are available on the American Consortium for Small Ruminant Parasite Control website (www.wormx.info), the NCAT ATTRA website (www.attra.ncat.org), and the University of Maryland Sheep and Goat website (www.sheepandgoat.com). A decision tree to aid farmers in managing sheep and goats for parasitic worms was developed and tested by farmers during field days and workshops. The tool is available on the Ohio State University website (http://vet.osu.edu/extension/decision-tree). Wide dissemination of research results of this research project occurs to sheep and goat producers during extension activities. Extension activities occurred throughout the US, including the upper Midwest (Southeast, Southwest and North Michigan), Ohio, Arkansas, Louisiana, Georgia, Oklahoma, Tennessee, Texas, Iowa, the Southern SAWG meetings, farmer activities such as Goat Camp in Lohn, TX, the Sunbelt Expo in Georgia, field days at the LSU Ag Center, Baton Rouge, LA, the Katahdin Hair Sheep International Expos, goat buck tests Dissemination to professionals also occurred at the Southern Section and National American Society of Animal Science meetings to agricultural professionals, the multi-state research and extension (NCERA-214, Improving efficiency of sheep production; NRSP-8 National Animal Genome Research Program) or coordinating committee (SC-81, Sustainable small ruminant production in the southeastern U.S.), the European Capara meeting (focuses on control of goat parasites in the European Union and internationally), International Goat Association in Grand Canara, Spain, and the World Association for the Advancement of Veterinary Parasitology. 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 sheep and goat producers, extension specialists, research scientists, veterinarians. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? Training occurred at the National Goat Conference (serves a diverse audience and is designed for goat and sheep producers, agricultural professionals and students; representatives of the 1890 and 1862 Land-Grant Institutions, community-based organizations as well as local, state and federal agencies attended), held in Greensboro, NC in September 2013. The PI presented parasite control in sheep and goats through the use of copper oxide wire particles. There was an estimated 500 participants, including a high proportion of minority farmers and nearly all participants had small farms. A co-PI presented information on

sericea lespedeza as an aid to control parasites. The American Consortium for Small Ruminant Parasite Control meetings were held in Fayetteville, AR in May 2014, and in Fort Valley, GA in October 2014. Research reports were disseminated, an exhaustive discussion on changing central dogma to educate farmers on parasite control so that they can understand the issue is as standard as nutrition and should be integrated into all aspects of management. Various methods of training farmers were discussed including use of videos and webinars. The PI presented a summary of research results on the use of copper oxide wire particles as a dewormer in sheep and goats; co-PIs presented the use of sericea lespedeza to control parasites in sheep and goats, and alternative methods of parasite control including vaccines and fungi. PIs resided on an interactive panel that responded to questions from attendees on any aspect of parasite control. Information disseminated throughout the U.S. will aid farmers in parasite control strategies that will save lives of animals and ultimately produce more income for farmers. How have the results been disseminated to communities of interest? Technology transfer of organic methods of parasite control developed from research studies for farmers occurred in the form of two technical reports: Tools for Managing Internal Parasites in Small Ruminants: Animal Selection; Tools for Managing Internal Parasites in Small Ruminants: Pasture Management. These publications are available on the NCAT (www.ncat.org) and ACSRPC (www.acsrpc.org) websites for producers. An additional technical report on the control of coccidiosis in small ruminants is planned. Research on parasite control is widely disseminated through extension activities in the upper Midwest. An Integrated parasite management program was conducted with 3 sessions (Southeast, Southwest and North Michigan) occurring with a total of 108 participants. A 6 hour program on parasite management also took place which placed emphasis on integrated approaches; including infection monitoring, chemical treatment strategies, grazing management, and understanding animal susceptibility. Students learned through lectures, discussion, quantitative fecal egg counting lab experiences and FAMACHA training on a local farm. A decision tree to aid farmers in managing sheep and goats for parasitic worms was developed and tested by farmers during field days and workshops. The tool was made available on an Ohio State University website (http://vet.osu.edu/extension/decision-tree). Wide dissemination of research results of this research project occurs to sheep and goat producers during extension activities. Dissemination occurred at the Southern SAWG meeting in January 2014, Mobile, AL. An estimated 1,150 high-energy farmers (targets minority farmers) and community food activists, representing 37 states and the Virgin Islands attended the meeting. A poster was displayed on small ruminant production and parasite control and an ARS booth was widely attended by farmers and farmer support professionals. Dissemination to farmers also occurred at Goat Camp in Lohn, TX in October 2014, Sunbelt Expo in Georgia in October 2014, LSU Ag Center, Baton Rouge, LA, April 2014. Dissemination to professionals also occurred at the Southern Section and National American Society of Animal Science meetings to agricultural professionals, the multi-state research and extension (NCERA-214, Improving efficiency of sheep production; NRSP-8 National Animal Genome Research Program) or coordinating committee (SCC-81, Sustainable small ruminant production in the southeastern U.S.), the European Capara meeting (focuses on control of goat parasites in the European Union and internationally), International Goat Association, and the World Association for the Advancement of Veterinary Parasitology. Information was disseminated to goat producers in Wilburton, OK in September 2014, and to sheep producers in Clay Center, NE in August 2014. What do you plan to do during the next reporting period to accomplish the goals? Education modules are in development for live or online student training and online farmer training regarding the control of parasitic worms using organic and conventional methods. Data analyses, interpretation, and publication of several studies will occur during the next 12 months.

2012/09 TO 2013/08 Target Audience: Target audience reached included farmers, extension agents, agricultural professionals, scientists, and veterinarians. Changes/Problems: In Objective 1, when examining the use of sericea lespedeza to control worms, it was discovered that extended feeding (past 45 -- 60 days)to lambs and kids may reduce rate of weight gain. We inadvertently found that trace minerals in serum were changed compared with the control group of ewes/does or lambs/kids. We changed the feeding period in lambs/kids to 56 days rather than 112 days post-weaning. The reduction in weight gain may be dependent on environment and we will continue to investigate production responses to overcome negative outcomes. What opportunities for training and professional development has the project provided? Training occurred at the National Goat Conference (serves a diverse audience and is designed for goat and sheep producers, agricultural professionals and students; representatives of the 1890 and 1862 Land-Grant Institutions, community-based organizations as well as local, state and federal agencies attended), held in Greensboro, NC in September 2013. The PI presented parasite control in sheep and goats through the use of copper oxide wire particles. There was an estimated 500 participants, including a high proportion of minority farmers and nearly all participants had small farms. A co-PI presented information on sericea lespedeza as an aid to control parasites. The American Consortium for Small Ruminant Parasite Control Integrated Parasite Management Train-the-Trainer Symposium, Fort Valley, GA, May 2013. Information on the latest parasite control from veterinary parasitologists from around the world and research scientists was presented to 120 veterinarians, extension specialists and farmers from throughout the U.S., who will in turn relay information to their clients and other farmers. The PI presented a summary of research

results on the use of copper oxide wire particles as a dewormer in sheep and goats; co-PIs presented the use of sericea lespedeza to control parasites in sheep and goats, and alternative methods of parasite control including vaccines and fungi. PIs resided on an interactive panel that responded to questions from attendees on any aspect of parasite control. Information disseminated throughout the U.S. will aid farmers in parasite control strategies that will save lives of animals and ultimately produce more income for farmers. How have the results been disseminated to communities of interest? Technology transfer of organic methods of parasite control developed from research studies for farmers occurred in the form of two technical reports: Tools for Managing Internal Parasites in Small Ruminants: Animal Selection; Tools for Managing Internal Parasites in Small Ruminants: Pasture Management. These publications are available on the NCAT (www.ncat.org) and ACSRPC (www.acsrpc.org) websites for producers. An additional technical report on the control of coccidiosis in small ruminants is planned. Research on parasite control is widely disseminated through extension activities in the upper Midwest. An Integrated parasite management program was conducted with 3 sessions (Southeast, Southwest and North Michigan) occurring with a total of 108 participants. A 6 hour program on parasite management also took place which placed emphasis on integrated approaches; including infection monitoring, chemical treatment strategies, grazing management, and understanding animal susceptibility. Students learned through lectures, discussion, quantitative fecal egg counting lab experiences and FAMACHA training on a local farm. A decision tree to aid farmers in managing sheep and goats for parasitic worms was developed and tested by farmers during field days and workshops. The tool was made available on an Ohio State University website (http://vet.osu.edu/extension/decision-tree). Wide dissemination of research results of this research project occurs to sheep and goat producers during extension activities. Dissemination occurred at the Southern SAWG meeting in January 2013, Little Rock. An estimated 1,150 high-energy farmers (targets minority farmers) and community food activists, representing 37 states and the Virgin Islands attended the meeting. A poster was displayed on small ruminant production and parasite control and an ARS booth was widely attended by farmers and farmer support professionals. Dissemination to farmers also occurred at Goat Camp in Lohn, TX in October 2013, Sunbelt Expo in Georgia in October 2013. Dissemination to professionals also occurred at the Southern Section and National American Society of Animal Science meetings to agricultural professionals, the multi-state research and extension (NCERA-214, Improving efficiency of sheep production; NRSP-8 National Animal Genome Research Program) or coordinating committee (SC-81, Sustainable small ruminant production in the southeastern U.S.), the European Capara meeting (focuses on control of goat parasites in the European Union and internationally), International Goat Association in Grand Canara, Spain, and the World Association for the Advancement of Veterinary Parasitology. What do you plan to do during the next reporting period to accomplish the goals? Education modules are in development for live or online student training and online farmer training regarding the control of parasitic worms using organic and conventional methods. Data analyses, interpretation, and publication of several studies will occur during the next 12 months.

2011/09/01 TO 2012/08/31 OUTPUTS: Continuation of a long term study occurred at ARS in Booneville, AR (sheep), Louisiana State University (sheep), and Fort Valley State University (goats) to examine the long term effects of using sericea lespedeza and copper oxide wire particles in sheep and goats for parasitic worm control. The infection level and production are being examined to determine the benefits and consequences. This information is essential to sheep and goat producers who have no effective chemical dewormers. An experiment was conducted in Michigan to examine the effects of grazing birdsfoot trefoil on gastrointestinal nematodes and growth in lambs. Birdsfoot trefoil contains condensed tannins known to aid in the control of abomasal worms. This legume could offer northern producers options of parasite control during summer months. Selecting sheep resistant to gastrointestinal nematodes will diminish parasite challenges in pastures, leading to reduced infections. A study was initiated in 2009 and continued in 2010, 2011, and 2012 to examine the relationship between fecal egg counts (FEC) in the ewe during lambing and her offspring and develop breeding values for resistance. These relationships will help develop selection strategies for producers and reduce the reliance on chemical dewormers. A study occurred at Heifer Ranch, Heifer International in Perryville, AR in 2011 and 2012 to examine the use of sunn hemp for summer grazing of sheep. This high protein forage may lead to minimal need for deworming and increased body weight gains. Events and extension activities that targeted producers included: a draft of a Decision Making Support Tool (http://vet.osu.edu/decision-tree) to aid producers in management of parasites is being evaluated by producers and professionals; Parasite management and organic practices for small ruminants, Wooster, OH, 10/11; Selecting the right sheep for your operation, Wooster, OH, 10/11; Multiple strategies for U.S. farmers to control gastrointestinal nematodes, Limassol, Cyprus, 11/11; Sustainability of small ruminant production: Controlling parasitic nematodes, College Station, TX, 1/12; Organic and grass-fed sheep and goat production, Little Rock, AR, 1/12; Parasite resistance and resilience, Animal selection on a pasture based system, Wooster, OH, 8/12; Integrating FAMACHA, drugs and other alternative measures for controlling worms, Sheep and Goat Field Day, Booneville, AR, 10/11; GoatCamp, 10/11, Lohn, TX; Integrating measures for controlling nematodes in small ruminants, LSU/SU small ruminant field day, 5/12, Baton Rouge, LA; Strategies to minimize resistant internal parasites on your farm, 7/12, Spencer, IA; Sericea lespedeza

as an aid in the control of Eimeria in lambs, Canary Isles, Spain, 9/12; Sustainable Control of Internal Parasite Control presented in East Lansing, MI, Chatham, MI, and West Branch, MI in 2012. Webinars were also presented in 7/12: https://connect.msu.edu/p1mue1ro548/; https://connect.msu.edu/p25mpy362af/. Mentoring of six graduate students and several undergraduate students occurred at Louisiana State University, Fort Valley State University, University of Arkansas, and USDA, ARS, Booneville, AR. PARTICIPANTS: Not relevant to this project. TARGET AUDIENCES: Target audicence is organic sheep and goat producers and producers with a desire to obtain certification or use organic principles in the control of gastrointestinal nematodes. Audience includes professional students who will eventually serve sheep and goat producers. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: A long term study was initiated at ARS in Booneville, AR (sheep), Louisiana State University (sheep), and Fort Valley State University (goats) to examine the long term effects of using sericea lespedeza and copper oxide wire particles in sheep and goats for parasitic worm control. The infection level, amount of required deworming, production (weight gains and lamb/kid production), and blood parameters are being examined to determine the benefits and consequences of these alternatives to chemical deworming. This information is essential to sheep and goat producers who have no effective chemical dewormers. Selecting sheep resistant to gastrointestinal nematodes will diminish parasite challenges in pastures, leading to reduced infections. A study was initiated in 2009 and continued in 2010 and 2011 with additional funding to examine the relationship between fecal egg counts (FEC) in the ewe during lambing and her offspring. There was a positive relationship between FEC of lambs at 90 days of age and dams at 30 days post-lambing, and FEC of lambs at 120 days of age and dams at 60 days post-lambing. There was a negative relationship between FEC of dams at 60 days post-lambing and weight of offspring at 60 days of age. These relationships will help develop selection strategies for producers and reduce the reliance on chemical dewormers. A study occurred at Heifer Ranch, Heifer International in Perryville, AR to examine the use of sunn hemp for summer grazing of sheep. This high protein forage may lead to minimal need for deworming and increased body weight gains. Although pastoral conditions were dry in 2010 and 2011, the sunn hemp grew adequately; preference was high in 2010, but not in 2011. Body weight gains were similar in lambs grazing a pasture with sunn hemp compared to those grazing without. In another study, fecal samples were collected from sheep and their offspring to examine their fecal egg count relationship. Selection indices will be developed for producers to identify parasite resistant animals. Education of farmers occurred at Ohio State University consisting of three internet-based presentations/meetings and a field day (http://vet.osu.edu/extension/sare/parasite control) looking at the potential utility of chicory in managing gastrointestinal parasites in sheep. There were about 110 online attendees including 15 veterinarians representing the states of OH, IN, SD, FL, PA, and LA and 85 participants on site (one third were Amish farmers who probably did not participate in the internet-based presentation, but who are very interested in beginning or expanding a sheep flock in our region). Additional outreach occurred at several sheep and goat meetings and professional meetings in Arkansas (Hope, Booneville), Georgia (Fort Valley), Louisiana (Martinville, Baton Rouge), Michigan, Ohio (Wooster), Oklahoma (Langston), Tennessee (Nashville), Texas (Corpus Christi, Lohn), South Dakota (Spearfish), as well as internationally in Argentina and Cyprus. Information on organic production and parasite control in sheep and goats was sent via email to producers throughout the U.S. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Control of coccidia with sericea lespedeza. Coccidiosis is one of the most economically devastating parasitic diseases of small ruminants and other livestock. This protozoan disease is an infection of Eimeria spp. of the gastrointestinal tract that can cause diarrhea, dehydration, inappetence, weight loss, and death of young animals. Sericea lespedeza (SL; a legume forage) pellets have been reported to control gastrointestinal parasites in small ruminants, but no data existed on control of Eimeria spp in lambs. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, Fort Valley State University, GA, and Auburn University determined that feeding SL pellets controlled coccidiosis and reduced need for pharmaceutical treatment of the disease. This information is important to organic and conventional small ruminant producers, extension agents, and scientists and may have further impact on other livestock species, reducing death losses and chronic slow growth of young animals. Grass finishing systems for lambs born in fall and winter. There is a need to reduce off-farm inputs, including dewormer, feed supplements and soil amendments. Little is known about grass finishing systems of lambs in the southeastern U.S., especially considering the impact on parasite control management. Scientists at USDA, ARS in Booneville, AR, University of

Arkansas, and Louisiana State University determined that modest supplement benefitted ram but not ewe lambs grazing tall fescue and vetch, and parasitic nematode infection tended to be lower in the modestly supplemented compared with the grass fed only. This information is important for farmers considering management and marketing options for lambs in the southeastern U.S. Changes in body weight gain in lambs and goat kids fed sericea lespedeza (SL). SL has been used in recent years to aid in the control of gastrointestinal nematodes (GIN) in sheep and goats, but sometimes body weight gains are reduced when SL is fed for several weeks. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, Fort Valley State University, GA, and Auburn University determined that short term SL feeding can have positive effects on weight gain, but longer term feeding led to reduced growth rate, which could be related to mineral status of soils or forages. Understanding negative effects that can occur to animal production by using SL for GIN control helps to guide producers in using this product to maximize worm control and production. This information is important to organic and conventional small ruminant producers, extension agents, and scientists. Sunn hemp to increase protein in forage systems for small ruminants. This high protein forage may lead to minimal need for deworming and increased body weight gains. Scientists at USDA, ARS in Booneville, AR, Heifer Ranch, Heifer International, Perryville, AR, Auburn University and Louisiana State University determined that including sunn hemp in a goat forage system was extremely valuable in terms of meeting nutrient demands during warm summer months and managing internal parasites, but less so for sheep as palatability was mixed depending on time of year grazed. In addition, sunn hemp grew better than other summer annual forages (soybean, cowpea), especially when rainfall was available, and nutrient quality far exceeded grass pastures, and plays an important role for pollinator species. This information is important to organic and conventional small ruminant producers, extension specialists, scientists, and USDA conservation specialists. Control of gastrointestinal parasites in lambs with Birdsfoot trefoil. Birdsfoot trefoil is a cool season legume species that is well adapted to the upper Midwest and has been shown to have anti parasitic properties due to its possession of condensed tannins. Scientists at Michigan State University, Louisiana State University, and USDA, ARS in Booneville, AR determined that lambs that grazed pastures of 85% birdsfoot trefoil compared with primarily cool season grasses had lower gastrointestinal parasite infection, but were more susceptible to parasites upon removal. This suggests removal of the protective effect of the birdsfoot trefoil, similar to that observed when sheep and goats graze sericea lespedeza. This information is important to organic and conventional small ruminant producers, extension specialists, scientists, veterinarians, offering a management strategy to control primarily barber pole worm on cool season forages during warmer summer months. Breeding strategies to aid organic small ruminant production. As lead for a multi-institutional, multi-disciplinary team funded by NIFA\'s Organic Agriculture Research and Extension Initiative and the Small Business Innovation Research program, Booneville, Arkansas, scientists, along with Louisiana State University, Virginia Tech, Fort Valley State University, and the University of Arkansas, and cooperation from several farmers have developed selection tools to aid in the control of gastrointestinal nematodes for organic production, the greatest barrier to organic small ruminant production due to reduced weight gains and death. Research demonstrates that genetic selection for parasite resistance in sheep with heritability as high as 0.5 can eliminate most deworming, reduce mortality and morbidity, especially with good nutrition and pasture management. By selecting replacement stock from parasite resistant parents, determined by fecal egg counts around and after the time of lambing, fewer animals within the flocks required deworming. The team continues to search for genetic markers to eliminate the need to collect fecal samples. The research has resulted in published peer-reviewed articles, farmer friendly publications through the National Center for Appropriate Technology and the website of the American Consortium for Small Ruminant Parasite Control. Factors affecting susceptibility to parasitic nematodes in Katahdin ewes and their lambs around the time of birth. Ewes and lambs become very susceptible to parasitic nematodes around the time of birth, which can have detrimental effects on the flock if parasitized animals are left untreated. Scientists from USDA, ARS at Booneville, AR, Virginia Tech, Louisiana State University, Katahdin Hair Sheep International, and farmers from Arkansas, Georgia, Maine, New York, and Ohio determined that yearling ewes and those nursing multiple lambs were most susceptible to parasites 28 days post-lambing. Fecal egg counts can be determined around this time and from offspring around 90 to 120 days of age to select for resistant animals. This heritable trait is the most promising management tool for parasite management for organic and conventional flocks. This information is important to organic and conventional sheep producers, extension specialists, scientists, veterinarians, offering a means of flock selection to control gastrointestinal worms. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 Type: Journal Articles Status: Accepted Year Published: 2015 Citation: Acharya et al., 2015. Changes in hematology and serum biochemical profiles in lambs fed sericea lespedeza. J. Anim. Sci. 93, 1952-1961. Burke et al., 2012. Use of a mixed sericea lespedeza pasture system for control of gastrointestinal nematodes lambs and kids. Vet. Parasitol. 186, 328-336. Burke et al., 2012. Grazing sericea lespedeza for control of gastrointestinal nematodes in lambs. Vet. Parasitol. 186, 507-512. Burke et al., 2014. The effects of supplemental sericea lespedeza pellets in lambs and kids on growth rate. Livest. Sci. 159, 29-36. Burke et al., 2013. Sericea lespedeza as an aid in the control of Eimeria spp. in lambs. Vet. Parasitol. 193, 39-46. Burke et al., 2011. Dose titration of sericea lespedeza leaf meal

on Haemonchus contortus infection in lambs and kids. Vet. Parasitol. 181, 345-349. Burner and Burke, 2012. Survival of bristly locust (Robinia hispida L.) in an emulated organic goat silvopasture. Native

2013/09 TO 2014/08 What was accomplished under these goals? Examination of commercially available copper oxide wire particles for control of Haemonchus contortus in lambs. Alternatives to synthetic anthelmintics remain critical due to the prevalence of dewormer resistance. Some organic certifiers allow the use of copper oxide wire particles (COWP) to control barber pole worm, and recently two forms appeared on the market for small ruminants along with another from Australia. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, University of Arkansas, and Fort Valley State University determined that Copasure, available to treat copper deficiency in cattle and small ruminants, reduced the percentage of barber pole worm better than the other forms, and reduced fecal egg counts in lambs, a sign of worm infection. The results are important to organic and conventional farmers, extension specialists, and scientists with the aim of controlling barber pole worm in sheep and goats, which can save the industry lost income due to morbidity and mortality. Changes in serum trace minerals in sheep and goats fed sericea lespedeza (SL). SL has been used in recent years to aid in the control of gastrointestinal nematodes (GIN) in sheep and goats, but sometimes body weight gains are reduced when SL is fed for several weeks. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, Fort Valley State University, GA, and Auburn University determined that SL feeding was associated with changes in trace minerals, especially a reduction in molybdenum, selenium, and zinc found in the blood. Understanding negative effects that can occur to animal production by using SL for GIN control helps to guide producers in using this product to maximize worm control and production. This information is important to organic and conventional small ruminant producers, extension agents, and scientists. Effect of sericea lespedeza leaf (SL) meal pellets on adult female barber pole worm (Haemonchus contortus) in goats. The inability to control barberpole worm, a blood-sucking stomach parasite, in sheep and goats due to dewormer resistance has led to the use of SL as an aid in the control of this parasite. The mechanism of action has not been described, but is associated with the condensed tannins in SL. Scientists at USDA, ARS in Booneville, AR, Fort Valley State University, GA, Louisiana State University, North Carolina A&T, and Auburn University discovered that feeding SL pellets to goats led to cuticular surface damage of the adult worm in the stomach. This information is important to scientists working with condensed tannin plants and alternatives for the control of barberpole worm. Effect of fall-grazed sericea lespedeza (SL) on parasitic nematode infections, skin and carcass microbial load, and meat quality of growing goats. SL, grazed or dried, has been used recently to aid in the control of internal parasites and coccidiosis in goats and sheep. Tannin-containing plants such as SL have also been shown to have potential beneficial nutritional and anti-microbial effects in the diet of ruminants, but little is known about anti-microbial effects of grazing goats on SL. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, Fort Valley State University, GA, and Auburn University determined that feeding SL pellets had no effect on skin and carcass microbial loads and minimal effects on carcass quality of goats. This information is important to organic and conventional small ruminant producers, extension agents, and scientists. Grass finishing systems for lambs born in fall and winter. There is a need to reduce off-farm inputs, including dewormer, feed supplements and soil amendments. Little is known about grass finishing systems of lambs in the southeastern U.S., especially considering the impact on parasite control management. Scientists at USDA, ARS in Booneville, AR, University of Arkansas, and Louisiana State University determined that modest supplement benefitted ram but not ewe lambs grazing tall fescue and vetch, and parasitic nematode infection tended to be lower in the modestly supplemented compared with the grass fed only. This information is important for farmers considering management and marketing options for lambs in the southeastern U.S. Breeding strategies to aid organic small ruminant production. As lead for a multi-institutional, multi-disciplinary team funded by NIFA\'s Organic Agriculture Research and Extension Initiative and the Small Business Innovation Research program, Booneville, Arkansas, scientists, along with Louisiana State University, Virginia Tech, Fort Valley State University, and the University of Arkansas, and cooperation from several farmers have developed selection tools to aid in the control of gastrointestinal nematodes for organic production, the greatest barrier to organic small ruminant production due to reduced weight gains and death. Research demonstrates that genetic selection for parasite resistance in sheep with heritability as high as 0.5 can eliminate most deworming, reduce mortality and morbidity, especially with good nutrition and pasture management. By selecting replacement stock from parasite resistant parents, determined by fecal egg counts around and after the time of lambing, fewer animals within the flocks required deworming. The team continues to search for genetic markers to eliminate the need to collect fecal samples. The research has resulted in published peer-reviewed articles, farmer friendly publications through the National Center for Appropriate Technology and the website of the American Consortium for Small Ruminant Parasite Control. Factors affecting susceptibility to parasitic nematodes in Katahdin ewes and their lambs around the time of birth. Ewes and lambs become very susceptible to parasitic nematodes around the time of birth, which can have detrimental effects on the flock if parasitized animals are left untreated. Scientists from USDA, ARS at Booneville, AR, Virginia Tech, Louisiana State University, Katahdin Hair Sheep International, and farmers from several states determined that yearling ewes and those nursing multiple lambs were most susceptible to

parasites 28 days post-lambing. Fecal egg counts can be determined around this time and from offspring around 90 to 120 days of age to select for resistant animals. This heritable trait is the most promising management tool for parasite management for organic and conventional flocks. A manuscript is being prepared. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 Type: Other Status: Accepted Year Published: 2014 Citation: Kommuru, D.S., Whitley, N.C., Miller, J.E., Mosjidis, J.A., Burke, J.M., Gujja, S., Mechineni, A., Terrill, T.H., 2014. Effect of sericea lespedeza leaf meal pellets on adult female Haemonchus contortus in goats. Vet. Parasitol. (In Press). Acharya, M., Burke, J.M., Coffey, K.P., Kegley, E.B., Miller, J.E., Huff, G.R., Smyth, E., Terrill, T.H., Rosenkrans, C. Jr., 2015. Changes in hematology and serum biochemical profiles in lambs fed sericea lespedeza. J. Anim. Sci. (In Press). Mechineni, A., Kommuru, D.S., Gujja, S., Mosjidis, J.A., Miller, J.E., Burke, J.M., Ramsay, A., Mueller-Harvey, I., Kannan, G., Lee, J.H., Kouakou, B., Terrill, T.H., 2014. Effect of fall-grazed sericea lespedeza (Lespedeza cuneata) on gastrointestinal nematode infections of growing goats. Vet. Parasitol. 204, 221-228. Kommuru, D.S., Barker, T., Desai, S., Burke, J.M., Ramsay, A., Mueller-Harvey, I. Miller, J.E., Mosjidis, J.A., Kamisetti, N., Terrill, T.H., 2014.

2012/09 TO 2013/08 What was accomplished under these goals? Farm management systems: Coccidiosis is one of the most economically devastating parasitic diseases of small ruminants and other livestock. This protozoan disease is an infection of Eimeria spp. of the gastrointestinal tract that can cause diarrhea, dehydration, inappetence, weight loss, and death of young animals. Sericea lespedeza (SL; a legume forage) pellets have been reported to control gastrointestinal parasites in small ruminants, but no data existed on control of Eimeria spp in lambs. Scientists at USDA, ARS in Booneville, AR, Louisiana State University, Fort Valley State University, GA, and Auburn University determined that feeding SL pellets controlled coccidiosis and reduced need for pharmaceutical treatment of the disease. This information is important to organic and conventional small ruminant producers, extension agents, and scientists and may have further impact on other livestock species, reducing death losses and chronic slow growth of young animals. A combination approach of using selective deworming, supplemental sericea lespedeza to ewes/does during the peri-parturient period (around the time of birth), and copper oxide wire particles (COWP) as an anthelmintic were examined compared with a control of selective deworming with conventional anthelmintics. There was preliminary evidence that control of parasitic worms was greater using COWP alone or in combination with sericea lespedeza, and production appeared to be similar in general. However, extended feeding (past 45 -- 60 days) of sericea lespedeza to lambs and kids may reduce rate of gains. This reduction may be dependent on environment. A full data analysis and publication will occur. The mechanism of action of condensed tannins in sericea lespedeza on worms has not been determined. Adult worms recovered from sericea lespedeza fed goats were examined for evidence of surface damage using scanning electron microscopy. Although not consistently, there was damage to the outside surface on some of these worms, but no damage from worms recovered from control goats. This suggests a direct effect of sericea lespedeza on the cuticle of the Haemonchus contortus or barberpole worm. Data has been compiled on management practices of sericea lespedeza to harvest leaves for leaf meal, including the date of cutting and the order of cutting (first, second, third), to determine the possible effect on nutrients and condensed tannins. Plant samples from Georgia, Alabama, Louisiana and Texas were included in the study. Genetics: DNA was collected from Katahdin sires by sheep producers in the National Sheep Improvement Program to identify genetic markers for parasite resistance in collaboration with the USDA, ARS Beltsville Area Research Center (Beltsville, MD). Data was collected from several farms in Arkansas, Georgia, Maine, New York, and Ohio over the last three years of this project and on a smaller number prior to that. Fecal egg counts of ewes and their offspring were determined and breeding values for parasite resistance are being considered pending analyses. Work continues on estimates of economic losses from parasitic worms under current practices compared to organic or grass-fed production to provide a baseline from which to evaluate net revenue changes resulting from implementing chemical free control strategies examined in the project. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 Type: Journal Articles Status: Published Year Published: 2013 Citation: Burke, J.M., Miller, J.E., Terrill, T.H., Mosjidis, J.A., 2013. The effects of supplemental sericea lespedeza pellets in lambs and kids on growth rate. Livest. Sci. http://dx.doi.org/10.1016/j.livsci.2013.10.030. Whitley, N.C., Oh, S.-H., Lee, S.J., Schoenian, S., Kaplan, R.M., Storey, B., Terrill, T.H., Mobini, M., Burke, J.M., Miller, J.E., Perdue, M.A., 2013. Impact of integrated gastrointestinal parasite management training for U.S. goat and sheep producers. Vet. Parasitol. (In Press). Burke, J.M., Miller, J.E., Terrill, T.H., Orlik, S., Acharya, M., Mosjidis, J.A., 2013. Sericea lespedeza as an aid in the control of Eimeria spp. in lambs. Vet Parasitol 193, 39-46. Gujja, S., Terrill, T.H., Mosjidis, J.A., Miller, J.E., Mechineni, A., Kommuru, D.S., Shaik, S.A., Burke, J.M., 2013. Effect of supplemental sericea lespedeza leaf meal pellets on gastrointestinal nematode infection in grazing goats. Vet. Parasitol. 191, 51-58.

2011/09/01 TO 2012/08/31 It was determined that bristly locust could be successfully transplanted to a pasture system for goats, increasing browse options in a grass based pasture. Control of gastrointestinal nematodes in

organic small ruminant production worldwide and where anthelmintic resistance is prevalent must rely on more than just chemical deworming strategies. Sericea lespedeza grazing, copper oxide wire particles and the FAMACHA system are tools to use for nematode worm control, but using them in an integrated system has not been fully examined and grazing sericea lespedeza by lambs has not been explored. We have determined that integrated strategies work well for parasite control, may be more economical than reliance on chemicals, and production was greater than using conventional methods. This information is important to organic and conventional small ruminant producers, extension agents, and scientists.

2010/09/01 TO 2011/08/31 Impact has not been realized by this project at this date as research projects are long term and educational modules are being developed. The project evaluation has been very successful and occurred through phone calls, emails, and several meetings. The PIs discussed progress (many had not received funding until September 2011 and consequently were not able to work on research or outreach projects), problems, and potential solutions to obtain objectives listed in the project. Meetings, phone calls, and emails with a Producer Advisory Panel allowed for discussion of logistics of animal handling in research projects, progress on sample collection and analysis on producer project (Objective 2), and successful outreach.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Burner, D.M., Burke, J.M., 2011. Survival of bristly locust (Robinia hispida L.) in an emulated organic goat silvopasture. Native Plants J. (In Press). 2. Mosjidis, J.A., Burke, J.M., Hess, J.B., 2012. The facts about sunn hemp toxicity. Crop Sci. 52, 1469-1474. 3. Burke, J.M., Miller, J.E., Mosjidis, J.A., Terrill, T.H., 2012. Use of a mixed sericea lespedeza pasture system for control of gastrointestinal nematodes lambs and kids. Vet. Parasitol. 186, 328-336. 4. Burke, J.M., Miller, J.E., Mosjidis, J.A., Terrill, T.H., 2012. Grazing sericea lespedeza for control of gastrointestinal nematodes in lambs. Vet. Parasitol. 186, 507-512. 5. Terrill, T.H., Miller, J.E., Burke, J.M., Mosjidis, J.A., 2012. Experiences with integrated concepts for the control of Haemonchus contortus in sheep and goats in the United States. Vet. Parasitol. 186, 28-37. 6. Burke, J.M., Whitley, N.C., Pollard, D.A. J. Miller, J.E., Terrill, T.H., Moulton, K.E., 2011. Dose titration of sericea lespedeza leaf meal on Haemonchus contortus infection in lambs and kids. Vet. Parasitol. 181, 345-349. 7. Miller, J.E., Kaplan, R.M., Pugh, D.G., 2011. Internal parasites. In: D.G. Pugh (Ed.), Sheep and Goat Medicine (2nd Edition), Elsevier Saunders, Maryland Heights, MO, 106-125. 8. Miller, J.E., Burke, J.M., Terrill, T.H., Kearney, M.T., 2011. A comparison of two integrated approaches of controlling nematode parasites in small ruminants. Vet. Parasitol. 178, 300-310. 9. Miller, J.E., Burke,,. J.M., Garza, J., Terrill, T.H., Callahan, S., 2011. Comparison of copper oxide wire particles, copper sulfate and anthelmintic treatment for controlling gastrointestinal nematode infection in lambs. Proc. 23th International Conference World Association Advancement Veterinary Parasitology: 290. 10. Whitley, N.C., T.H. Terrill, J.E. Miller, J.M. Burke, K. Moulton, L. Townsend, J.R. Horton, J. French, and A.K. Cooper. 2011. Effect of sericea lespedeza (Lespedeza cuneata) leaf meal pellets fed to gastrointestinal nematode infected goats. J Anim Sci 89 E-Suppl. 1: 398. 11. Vest, J.L., Brown, M.A., Kohler, J.D., Hudson, M.D., Nusz, S.R., Burke, J.M., Miller, J.E., Mackown, C.T., Walker, E.L., 2011. Effects of feeding sericea lespedeza as a natural anthelmintic for Haemonchus contortus in lactating does. J Anim Sci 89 E-Suppl. 1, 696. 12. Whitley, N.C., Perdue, M.A., Schoenian, S., Kaplan, R.M., Story, B., Terrill, T.H., Burke, J.M., Mobini, S., Miller, J.E., 2011. Small ruminant integrated parasite management and FAMACHA training in the United States. J Anim Sci 89, E-Suppl. 2: 15. 13. Luginbuhl, J-M., Glennon, H.M., Miller, J.E., Terrill, T.H., 2011. Evaluation of sericea lespedeza grazed as a summer forage and natural gastrointestinal parsaite control for goats. J Anim Sci 89, E-Suppl. 2, 15. 14. Kommuru, D.S., Terrilol, T.H., Joshi, B.R., Mechineni, A., Gujja, S., Miller, J.E., Mosjidis, J.A., Burke, J.M., 2011. Effect of feeding sericea lespedeza leaf meal on establishment of gastrointestinal nematode larvae in goats. J Anim Sci 89, E-Suppl. 2, 15. 15. Miller, J.E., Burke, J.M., Garza, J., Callahan, S., Terrill, T.H., 2011. Comparison of copper oxide wire particles, copper sulfate and anthelmintic treatment for controlling gastrointestinal nematode infection in lambs. J Anim Sci 89, E-Suppl. 2, 16. 16. Burke, J.M., Miller, J.E., 2011. Influence of season of lambing on gastrointestinal nematode infection of lambs. J Anim Sci 89, E-Suppl. 2, 16-17. 17. Burke, J.M., Mosjidis, J.A., Miller, J.E., Casey, P., Terrill, T.H., 2011. Sunn hemp with chicory or pearl millet to minimize gastrointestinal nematode infection in weaned goats. J Anim Sci 89, E-Suppl. 2, 17-18. 18. Joshi, B.R., Kommuru, D.S., Terrill, T.H., Mosjidis, J.A., Burke, J.M., Shakya, K.P., Miller, J.E., 2011. Effect of feeding sericea lespedeza leaf meal in goats experimentally infected with Haemonchus contortus. Vet. Parasitol. 178, 192-197. 19. Gujja, S., Terrill, T.H., Mosjidis, J.A., Miller, J.E., Mechineni, A., Kommuru, D.S., Burke, J.M., 2011. Effect of supplemental sericea lespedeza leaf meal pellets on gastrointestinal nematode infection in grazing goats. Proc 56th Ann Meet Amer Assoc Vet Parasitol: 66. 20. Mechineni, A., Terrill, T.H., Mosjidis, J.A., Miller, J.E., Gujja, S., Kommuru, D.S., Burke, J.M., 2011. Effect of grazed Sericea lespedeza on gastrointestinal nematode infection in goats. Proc 56th Ann Meet Amer Assoc Vet Parasitol: 66-67.

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

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Organic Blackberry Production Systems for Improved Yield, Fruit Quality, and Food Safety in Fresh and Processed Markets

Accession No.	0222538
Subfile	CRIS
Project No.	ORE00409
Agency	NIFA ORE
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21264
Proposal No.	2010-01940
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Strik, B.; Bryla, D.; Zhao, Y.; Daeschel, M.; Perkins-Veazie, P.; Phister, T.; Safley, C.; Rejesus, R.; Fernandez, G.
Performing Institution	Horticulture, OREGON STATE UNIVERSITY, CORVALLIS, OREGON 97331

NON-TECHNICAL SUMMARY

The proposed research will addresses organic blackberry production in the northwestern and southern USA (represent 91% of US acreage). There is a strong, emerging market for fresh and processed organic blackberry fruit, yet a lack of information on suitable organic production systems. Growers interested in the processed blackberry market have questions as to whether labor-saving machine harvesting technology can be used in organic systems when even beneficial insects could be harvest contaminants. Machine-harvested fruit are thought to be of more uniform ripeness and of better sensory quality than hand-harvested fruit, although this has not been proven. Little is known about the impact of cultivar response to organic production systems on nutritive/phytochemical value of fresh or processed fruit. Enterprise budgets are needed to determine whether best organic blackberry production systems are economically sustainable. There are no data on what organisms, if any, might be of concern for food safety in organic blackberry fields and whether there is a greater risk of food-borne illness in hand- or machine-harvested fruit. Finally, the potential liability cost and demand impact of a food-borne illness/safety issue in the blackberry industry is unknown; a forecast of potential economic costs of a food safety issue, knowledge of potential food-borne organisms in blackberry production systems, and associated extension educational programming would likely be of great benefit. Many of our objectives , including those on weed, water, and nutrient management, as well as those on the impacts of hand vs. machine harvesting on fruit nutritive/phytochemical value and food safety, will be of great benefit to all blackberry growers using not only organic but also sustainable cultural practices. Our long-term goal is to develop organic production systems for processed and fresh-market blackberry that maximize plant growth, yield, fruit quality, and food safety; facilitate weed, water, and nutrient management; provide healthy and nutritious food; and provide economic benefit to growers. To meet the goals, research will be conducted at a certified organic site planted with blackberry at the Oregon State University North Willamette Research and Extension Center and validated in organic grower fields located in both OR and NC. Our extension activities will involve growers and industry clientele, such as processors, sellers, and marketers, in the development of outreach tools through eOrganic, workshops, portals on web sites, and extension publications. Major outreach products will include development of best management practices and enterprise budgets for production and food safety of organic blackberry, oral presentations at regional and national grower meetings, extension publications on organic production systems, educational

training events for growers and peers on methods to improve food quality and safety and production of organic blackberries for fresh and processed markets, papers in trade journals, newsletters, and refereed publications, and presentations to peers at national and international meetings.

OBJECTIVES

The long-term goal of the project is to develop organic production systems for processed and fresh blackberry that maximize plant growth, yield, fruit quality, and food safety; facilitate weed, irrigation, and nutrient management; provide healthy and nutritious food; and provide economic benefit to growers. To meet our project goal, two research activities are planned: i) an integrated production systems trial for machine-harvested trailing blackberry for processed markets on certified organic land at an experiment station in Oregon and ii) a trial of trailing, erect, and primocane-fruiting blackberry cultivars grown for hand-picked fresh markets on organic land at the experiment station and at organic grower cooperator farms in Oregon and North Carolina. The systems trial was designed in consultation with an industry advisory group. Research objectives of this project are to: Evaluate organic weed management, irrigation, and production systems for effectiveness and impacts on cane growth and production, root distribution, and availability of water and nutrients in machine-harvested trailing blackberry cultivars grown for processed markets. Assess the impact of organic production systems on incidence of insects and plant diseases in machine-harvested trailing blackberry. Measure and evaluate presence of any fruit contaminants and the impact on food safety in hand and machine harvested systems. Develop organically allowable post-harvest handling and processing practices to increase food safety as well as shelf-life of fresh fruit and quality of processed blackberry products. Determine the impact of organic production systems for various fresh and processed cultivars on the nutritional and health promotion (bioactive) compounds of blackberry fruit that are hand (processed and fresh) or machine harvested (processed) and measure the nutritional/phytochemical properties of organic blackberry fruit as affected by processing and packaging technology. Compare the effect of machine vs. hand harvesting on the sensory quality of processed organic blackberry fruit using a trained sensory panel. Extension and outreach objectives of the project are to: Develop economic enterprise budgets for establishment and management of organic blackberries for fresh and processed markets as affected by production method. Develop extension publications on reducing food-borne illness through pre- and post-harvest practices. Develop an economic model to assess the potential liability costs and demand impacts of a food safety issue in the fresh and processed blackberry industries in the U.S. Produce workshops, field days, publications, and web-based tools to effectively disseminate research findings to industry. Use eOrganic to facilitate communication of PDs and advisory board members and involvement of clientele during the project, and to package our research findings and traditional Extension activities (e.g. workshops, field days) into products that are useful to a national audience. Assess changes in grower knowledge, intentions, and practices resulting from the project.

APPROACH

A one-acre planting will be established on certified organic land at the NWREC (OSU) in spring 2010. Treatments will be in a split-split-plot with 5 reps: cultivars (Marion and Black Diamond); irrigation strategies (post-harvest and no post-harvest irrigation); weed management (weed mat, hand-hoed, and non-weeded); and primocane training date (Aug and Feb). Fish fertilizer will be applied continuously by fertigation from early April through June. The water and nutrient status of plants will be monitored seasonally and irrigation controlled and metered. Soil water content will be monitored using a neutron probe. Root development will be monitored using minirhizotrons near plants and using a digital camera system to capture images of roots growing along the tubes in the soil; only weedmat and hand-hoed plots will be used to avoid any confusion with weed roots. Standing root biomass will be estimated using cores. Percent weed coverage will be rated along with general weed species presence, and weed height. Fruit will be machine-harvested and data collected on marketable yield, berry weight, a rating of harvest contaminants, and machine-harvest efficiency. Floricanes will be pruned out near the end of August each year after harvest. Yield component data measured include cane length , cane number, and fruiting sites/lateral. Treatment effects on the incidence of purple blotch and septoria cane disease will be evaluated each spring by counting lesions on the bottom meter of each cane in the center plant of each plot. Fruit from each harvest date will be evaluated before and after IQF (individually quick freezing) for: drip loss, soluble solids concentration, juice pH, total acidity, total phenolics, anthocyanins, vitamin C, ORAC and FRAP values, and reddening. Specific flavonoid and phenolic acid qualification and quantification will be done on selected subsamples using mass spectrophotometer. Fruit harvested by hand and machine will be compared for fruit quality attributes, and evaluated by sensory panels to evaluate the visual and taste characters of IQF and pureed fruit. Five trailing blackberry cultivars and several erect and semi-erect cultivars will be evaluated in organic production systems at the NWREC and at grower collaborator sites in OR and NC. Tunnels will be evaluated in OR. Fruit will be

harvested by hand about every 7 days and assessed for firmness, leak, color, red discoloration, decay, and nutritive properties at pre- and post-storage for 3 to 7 days. Berries will be sampled for microbiological examination. E. coli, Salmonella, coliforms, and total bacterial load on fresh berries will be determined using established methods. We will collect pertinent blackberry production/consumption/price data and develop economic models to assess the potential impact of a food safety event (i.e. a food recall) on the industry. This project will build on the computer programs recently developed at NCSU and OSU for economic costs of conventional blackberries. These budgeting programs will be adapted to incorporate treatment effects and production techniques associated with growing organic blackberries for fresh or processed markets.

PROGRESS

2010/09 TO 2015/08 Target Audience:growers and other industry members (e.g. field reps, chemical/fertilizer company reps, processing/packing plant reps), scientist peers, consumers Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?Graduate students and postdoctoral research associate were trained in the skills of analyzing bioactive compounds, fruit physicochemical and sensory qualities, developed knowledge on organic production and its effect on fruit quality and postharvest storage life, and on organic production management methods. Graduate student training in various microbiological techniques was an important outcome as well as presenting the results at the National meeting of the Institute of Food Technologists. They were also trained in professional presentation skills by presenting research results in professional conferences. Undergraduate students gained skills in organic production systems and data collection. Postharvest evaluations and compositional analysis provided learning skills for undergraduate and graduate students.Further, application of high performance liquid chromatography provided an expansion of methodologies to discern among cultivars and effects.The graduate student further developed translational skills in health bioactives by learning to culture macrophage cells and test for anti-inflammatory effects.Another graduate student utilized the blackberry material to advance her training in molecular fingerprints of caneberries and to train an undergraduate student in the basics of molecular biology. Undergraduates were trained on organic aspects of blackberry production in a field trial. How have the results been disseminated to communities of interest?Results were presented at regional and national conferences, workshops, and field days (as described in Other Products) An organic production demonstration trial was established at a NCDA Research station. Each year, 1-2 workshops were held at this station to demonstrate organic production practices. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2012/09 TO 2013/08 Target Audience: growers and other industry members (e.g. field reps, chemical/fertilizer company reps, processing/packing plant reps), scientist peers, consumers Changes/Problems: (Strik) Project end date extension was approved in order to be able to complete the project's objectives (delayed due to planting establishment and sabbaticals or absences of one or more principal investigators). (Zhao) RE: Sensory analysis- In the original project narrative, one of the state objectives was "Compare the effect of machine vs. hand harvesting on the sensory quality of processed organic blackberry fruit using a trained sensory panel." This objective has been altered due to practical considerations to "Compare the effect of different agricultural practices on the sensory quality of processed organic blackberry fruit using an experienced sensory panel." Reasons for this change include the extreme financial cost of using a trained panel, and the fact that berries destined for the processed market are almost exclusively machine harvested, making a comparison less than useful for practical purposes. What opportunities for training and professional development has the project provided? (Bryla) Postdoctoral Scholar Higher Education Teaching Preparation Workshop, Office of Postdoctoral Programs, Oregon State University, winter term 2013. Attended by Luis Valenzuela. (Perkins-Veazie) Postharvest evaluations and compositional analysis provided learning skills for undergraduate and graduate students. Further, application of high performance liquid chromatography provided an expansion of methodologies to discern among cultivars and effects. The graduate student How have the results been disseminated to communities of interest? (Strik and Bryla) Results were presented at regional conferences, workshops, and field days (as described in Other Products) (Zhao) Presented the results at the annual conference of the Institute of Food Technologies, (Perkins-Veazie) Results of postharvest studies were presented at 2013 regional, national and international meetings as described in Other Products. What do you plan to do during the next reporting period to accomplish the goals? (Strik and Bryla) Continue research in certified organic trial (machine-harvested blackberries for processing) on the impact of weed management, irrigation, and training time of two cultivars on plant growth, nutrient allocation, yield, fruit quality, root growth, and plant and soil water status. (Zhao) Use an experienced sensory panel to assess the impact of organic production system on the sensory quality of processed blackberry fruit. (Perkins-Veazie) Studies on anti inflammation effects of blackberry extracts will be wrapped up and published. A publication on the storage and composition of organically grown blackberries is underway for submission to a peer reviewed journal. (ReJesus) Work on the potential liability cost and demand

impact of a food safety event in blackberry is on-going. (Sydorovych) Collect data and develop an economic enterprise budget for fresh and processed blackberry grown in Oregon.

2011/09/01 TO 2012/08/31 OUTPUTS: 1. Evaluate organic production systems For processed machine-harvest markets, Marion (M) and Black Diamond (BD) and 3 weed management treatments were compared. In 2011, weed presence reduced primocane number and leaf N, P, and K in both cvs. In 2012, weedy plots yielded half that of the weed mat; bare soil yielded less than weed mat. Plants in weedy plots had smaller fruit with less percent moisture and higher Brix. Nutrient loss in the harvested fruit was from 13-25, 3-5, 13-25, and 1-3 kg/ha of N, P, K, and Ca, respectively. Yield of BD was 20% greater than for M. At pruning, 32 and 41 kg N/ha were removed for BD and M, respectively. Plants are irrigated by drip and fertigated with fish emulsion. There is no evidence to date that fish emulsion is plugging the emitters. Postharvest irrigation increased water use by 42 percent in 2012 but had little effect on plant water potential. BD depleted soil water more quickly than M and required more irrigation. At a grower-cooperator site, fertilizer source had no effect on the yield, berry weight, or firmness of 4 fresh market cvs in 2011. Data was collected for a second year. 2. Evaluate any fruit contaminants in OR, aerobic microorganisms on handpicked fruit increased with harvest date. No increase in microorganisms was found on machines after harvest. In NC, enterobacters and several plant pathogens were identified on handpicked fruit, none dangerous to humans. 4. Develop post-harvest handling for food safety and fruit quality Qualities of handpicked Obsidian (O) and Triple Crown (TC), and machine-harvested M and BD were studied. Fruit moisture content of O and TC was greater than for M and BD. No color change occurred during storage. O and TC fruit reached 50 percent decay (at 4C) after 6 and 10 d storage, respectively. The potential for pathogenic bacteria to survive in blackberry juice and wine were evaluated. BD and M were pureed and pressed. Pasteurized juice and wine (4.2-5 percent alcohol) were inoculated with Salmonella enterica or E. coli O157:H7, but did not support the survival of either pathogen. 5.Impact of production systems on healthful properties of fruit Natchez, Ouachita, and Navaho blackberries harvested weekly from an organic grower in NC were stored at 1C for 14 d, followed by 2 d at 20C. Navaho berries were firmest and had the least mold or leak after storage. Ouachita was close to Navaho in quality while Natchez was least firm. Total FRAP, phenolic, and anthocyanin were highest in Natchez and lowest in Ouachita. Fruit picked slightly less ripe was higher in total anthocyanin, phenolics, and FRAP than riper fruit. Cyanidin-3-glucoside was the primary anthocyanin followed by cyanidin-3-rutinoside. After 15 day storage, the amount of cyandin-3-glucoside in berries increased by 30-60 percent. 6. Develop economic enterprise budgets A model was developed for organic blackberry production in NC with investment and sensitivity analysis. 7. Develop an economic model to assess potential liability costs We continue to streamline an ex ante, partial equilibrium supply/demand model as the framework for quantifying the demand impact of a blackberry food safety event. PARTICIPANTS: Bernadine C. Strik, Professor of Horticulture, Oregon State University David Bryla, Research Horticulturist, USDA-ARS, HCRL, Corvallis Yanyun Zhao, Professor, Dept. Food Science and Technology, OSU Mark Daeschel, Professor, Dept. Food Science and Technology, OSU Penelope Perkins-Veazie, Professor, Dept. Horticultural Science, NCSU Trevor Phister, Assistant Professor, Dept of Food Bioprocessing and Nutrition Sciences, NCSU Charles Safley, Professor, Department of Agricultural and Resource Economics, NCSU Roderick Rejesus, Assistant Professor, Department of Agricultural and Resource Economics, NCSU Gina Fernandez, Professor, Horticultural Science Dept., NCSU Emily Vollmer, Research Assistant, Dept. Horticulture, OSU Gil Buller, Senior Research Assistant, NWREC, OSU Luis Valenzuela, post-doctoral associate, USDA-ARS, HCRL and Dept. Hort., OSU George Cavender, post-doctoral associate, Dept. Food Sci., OSU Vaughn Walton, Extension Entomologist, Assistant Professor, Dept. Horticulture, OSU Chad Finn, Research Geneticist, USDA-ARS, HCRL, Corvallis John McQueen, Faculty Research Assistant, eOrganic, Dept. Horticulture, OSU Olha Sydorovych, Department of Agricultural and Resource Economics, NCSU Eric Pond, Riverbend Farms, Jefferson, Ore. Tom Avinelis, Chief Executive Officer, Homegrown Organic Farms, Cal. Derek Peacock, Hurst\'s Berry Farms, Ore. Josh Beam, SunnyRidge Farms, Fla. Anthony Boutard, Ayers Creek Farm, Ore. John Vollmer, Vollmer Farms, Bunn, NC Joe Bennett, Small Planet Foods, Wash. Partner organizations: North American Raspberry and Blackberry Association Oregon Raspberry and Blackberry Commission Northwest Center for Small Fruits Research USDA-ARS, HCRU, Corvallis Growers in Oregon, North Carolina, Georgia TARGET AUDIENCES: Commercial berry crop growers Organic growers Crop consultants Academic peers PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Research: 1. Evaluate organic production systems. Treatments being evaluated for processing: cvs. Marion and Black Diamond; with or without post-harvest irrigation; weed mat, hand-hoed, and non-weeded; and training in Aug. or Feb. The planting was established in May, 2010. Irrigation was with a single line of drip (1 gph at 24 in.) and fertigation with emulsified fish. By late summer, weed mat required 30% more irrigation than hand-weeded or not weeded plots. To date, we have no evidence that fish fertilizer plugged emitters. 2. Evaluate any fruit contaminants. Hand-picked Obsidian and Triple Crown fruit

showed a one log increase in aerobic microorganisms with harvest date. No increase was observed for yeasts and molds and all coliform data were reported as \<10 CFU/ml. Environmental samples were taken at 8 locations from a mechanical harvester, before (cleaned) and after 48h (uncleaned) harvest; there appeared to be no increase of microorganisms on harvester surfaces present post-harvest. 4. Develop post-harvest handling for food safety and fruit quality. Obsidian and Triple Crown were hand harvested from a grower site and evaluated during postharvest refrigerated storage at 2C and 85%RH. Fruit pH, TA, Brix, color, texture, weight loss, decay rate, and leakage were monitored and total phenolics and antioxidant activity extracted. 5. Impact of cultivar and production systems on healthful properties of fruit. Natchez, Ouachita, and Navaho blackberries harvested weekly from an organic grower in NC were stored at 1C for 14 d, followed by 2 d at 20C. Navaho berries were firmest and had the least mold or leak after storage. Ouachita was close to Navaho in quality while Natchez was least firm and had the most leaky berries. When berries were held 2 d at 20C, the percent moldy or leaky berries increased 30% in Navaho and Ouachita, and 50% in Natchez. Total FRAP, phenolic, and anthocyanin contents were highest in Natchez and lowest in Ouachita. Fruit picked slightly less ripe was higher in total anthocyanin, phenolics, and FRAP than riper fruit for all cultivars. Extension: 1. Develop economic enterprise budgets. A model was developed for organic blackberry production in NC. An investment and sensitivity analysis were included to help estimate the potential economic feasibility and profitability of the enterprise. The results will be presented to growers and will be available on-line in a format that will allow growers to make changes based on their specific circumstances. 2. Develop an economic model to assess potential liability costs. We began developing an ex ante, partial equilibrium supply/demand model as the framework for quantifying the demand impact of a blackberry food safety event. We have started collecting available production, price, and consumption data from USDA NASS and other sources to operationalize and implement this analysis. 3. Produce workshops, publications and web-based tools. We have given the following presentations: field days (2); grower meetings (2); scientific meetings (2). This project was highlighted at Caneberry Field Day at the NWREC. 4. eOrganic. We developed an eOrganic community of practice related to this project PARTICIPANTS: Bernadine C. Strik, Professor of Horticulture, Oregon State University David Bryla, Research Horticulturist, USDA-ARS, HCRL, Corvallis Yanyun Zhao, Professor, Dept. Food Science and Technology, OSU Mark Daeschel, Professor, Dept. Food Science and Technology, OSU Penelope Perkins-Veazie, Professor, Dept. Horticultural Science, NCSU Trevor Phister, Assistant Professor, Dept of Food Bioprocessing and Nutrition Sciences, NCSU Charles Safley, Professor, Department of Agricultural and Resource Economics, NCSU Roderick Rejesus, Assistant Professor, Department of Agricultural and Resource Economics, NCSU Gina Fernandez, Professor, Horticultural Science Dept., NCSU Emily Vollmer, Research Assistant, Dept. Horticulture, OSU Gil Buller, Senior Research Assistant, NWREC, OSU Luis Valenzuela, post-doctoral associate, USDA-ARS, HCRL and Dept. Hort., OSU Vaughn Walton, Extension Entomologist, Assistant Professor, Dept. Horticulture, OSU Diane Kaufman, Assoc. Professor, NWREC, OSU Chad Finn, Research Geneticist, USDA-ARS, HCRL, Corvallis John McQueen, Faculty Research Assistant, eOrganic, Dept. Horticulture, OSU Olha Sydorovych, Department of Agricultural and Resource Economics, NCSU Eric Pond, Riverbend Farms, Jefferson, Ore. Tom Avinelis, Chief Executive Officer, Homegrown Organic Farms, Cal. Derek Peacock, Hurst\'s Berry Farms, Ore. Josh Beam, SunnyRidge Farms, Fla. Anthony Boutard, Ayers Creek Farm, Ore. John Vollmer, Vollmer Farms, Bunn, NC Joe Bennett, Small Planet Foods, Wash. Partner organizations: North American Raspberry and Blackberry Association Oregon Raspberry and Blackberry Commission Northwest Center for Small Fruits Research USDA-ARS, HCRL, Corvallis Growers in Oregon, North Carolina, Georgia TARGET AUDIENCES: Commercial berry crop growers, Organic growers, Crop consultants, Academic peers PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? (Strik) A trailing blackberry planting was established at OSU\'s NWREC to evaluate cultivar, weed management practices, deficit irrigation, and training time on growth, yield, fruit quality, and nutrient and carbon allocation. The planting was managed for a machine-harvested, processed fruit market from 2010-15 and was certified organic. Weed management affected growth and yield in all years. Plants in plots that were hand-hoed and those with weed mat as a mulch in the row produced 50% more primocanes than in non-weeded plots, but above-ground biomass was highest in weed mat. Weed mat led to 25% and 100% greater cumulative yield than hand-weeded and non-weeded, respectively. Hand-weeding and weed mat increased net returns by 40% and 71% compared to non-weeded, respectively. Yields in the weed mat treatment were similar to what would be expected in conventional production. Weed management strategy affected many nutrients in the soil, leaves, and fruit with weed mat often having the highest concentrations. Total aboveground biomass gain was 5.0 to 6.5 t/ha/year, while C stock was 0.4 to 1.1 t/ha in late winter. Nutrient losses were often higher than what was applied through fertilization, especially for N, K, and B,

which would eventually lead to depletion of those nutrients in the planting. Black Diamond had higher yield than Marion during establishment but there was no difference in the mature planting. Black Diamond was more susceptible to infestation with raspberry crown borer. Primocane training time did not affect yield of Black Diamond while in Marion, greater winter injury occurred in Aug.-trained plants than in Feb.-training. There was no impact of withholding irrigation after fruit harvest on yield, saving about 1 million L/ha of water over the 2 years. It also resulted in less freeze damage in Marion during a cold winter. In a grower collaborator study, fertilizer source (liquid fish and molasses blend; soy meal; and processed poultry litter) had no effect on yield and fruit quality. (Bryla) Liquid fertilizers (fish emulsion and corn steep liquor) were easily applied by fertigation and resulted in only a minimal amount of emitter plugging. Most soil nutrients were concentrated within 6 in of the emitters following fertigation, particularly NO3-N, which was also greater under weed mat than with hand weeding in the spring. Other nutrients were also more available during fertigation with weed mat, including soil K, Mg, B, Cu, Fe, and Mn (but soil Ca and S were less available). Black Diamond produced fewer roots than Marion but maintained a higher water status without irrigation by producing a deeper root system. (Fernandez) An organic blackberry trial was established at the CEFS in Goldsboro NC, including 7 cultivars and is being used for workshops and interns to monitor pests and to learn pruning and training. (Rysin) Interactive organic blackberry enterprise production budgets for fresh market were developed for NC and OR. (Zhao) Plants fertilized with fish emulsion and soymeal had the highest levels of antioxidants in late-harvest and early- and mid-harvests, respectively, with little effect of processed poultry litter. For both cultivars, relative levels of antioxidants TMA and TPC in fruit increased the greatest during storage for fish emulsion harvested early in the season and poultry litter in the late harvest. Effects on antioxidant capacity (DPPH, ORAC, FRAP) depended mainly on cultivar. Glucose and fructose comprised the largest fractions of total sugars in fruit and sucrose levels comprised only a minor fraction (0-3%). Early harvest fruits tended to have slightly higher levels of fructose than glucose, a trend which was reversed in the middle and late harvests. Soymeal fertilized berries had the highest total sugar content in the early and middle harvests, while processed poultry litter berries had the highest contents in the late harvest. There was an effect of year but not fertilizer source on fruit TA, decay, leakage, or weight loss during storage. The interaction between fertilizer source, growing climate and/or plant maturity should be investigated in the future.An experienced panel found that the flavor intensity of Black Diamond appeared to be inversely related to phenolic and anthocyanin content, with weed mat resulting in the highest values. Different extraction conditions are necessary for anthocyanin rich fruits and ultrasound is an effective assistance for the extraction of polyphenols and anthocyanins. Anthocyanins from berry fruit extract can be stabilized through nano-encapsulation for various applications. (Perkins-Veazie) Organic Natchez, Ouachita, and Navaho fruit had excellent storage, with about 80% of shiny black stage marketable after 14 d. However, storage for 2 d following low temperature storage reduced marketable fruit by 20 to 30%.Cultivar and temperature strongly influence storage quality, as found in conventional production. A comparison of phenolic profiles before and after storage indicate that the siblings Ouachita and Navaho had similar profiles while Natchez differed. Cyanidin 3-glucoside was the predominant anthocyanin (88-95%); these cultivars could be useful in bioactive trials where natural food sources of individual predominant anthocyanins are compared for effectiveness. Storage increased the total amount of monomeric anthocyanins, primarily cyanidin 3-glucoside, as measured by HPLC. Hydroxybenzoic acid and flavanols increased consistently after fruit storage in shiny black fruit while flavonols increased in dull black fruit. No correlations were found amongphenolic compounds and subjective ratings of stored fruit.Use of total anthocyanin, total phenolic, and FRAP tests yielded less specific information and in some cases indicated no differences among treatments that were found significant using HPLC tests.Thus total assays of phenolics and pigments should be considered a first step in analysis but be followed up with more targeted chemical assays. At the cellular level, Natchez and Ouachita extracts were used to determine effectiveness in blocking macrophage cell inflammation.Both extracts were found to suppress the inflammation markers PGE2 and Cox-2 expression and reduced nitric oxide production, showing specific anti-inflammatory action of organically produced blackberry. (Daeschel) The potential for pathogenic bacteria to survive in Black Diamond and Marion juice and wine were evaluated to understand their importance in post-processing contamination. Juices and wines were inoculated with Salmonella enterica or E. coli O157:H7.Results indicated that processed fruit did not support the survival of either pathogen for a period longer than 108 h in juice or 40 min in wine. Blackberries are not an ideal environment for food borne pathogens. However, these microorganisms may be able to survive depending on the type of product and how it is stored. Constituents of blackberries may provide bactericidal activity, with organic acids appearing to have the greatest effect. (Massel) Bacterium and yeast were isolated and sequenced from \'Natchez\', \'Navaho\' and \'Ouachita\' berries. Many of the bacteria were opportunistic pathogens. A small number were pathogenic, these included Shigella spp.(causes diarrhea), Aspergillus fumigatus (causes respiratory difficulties), and Klebsiella ozaenae (respiratory difficulties). There were no large differences among the different cultivars. In 2013, the night before berries were collected, it rained 3 in. A comparison of previously picked, and post rain harvested fruit showed the bacterial load was lowered in the berries collected after the rain. Sequencing was done to identify the species isolated, none of which were pathogenic. (Rejesus) Developed an ex ante, partial equilibrium supply/demand model as the framework for quantifying the demand impact of a

blackberry food safety event and built an economic welfare model. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 No publications reported this period.

2012/09 TO 2013/08 What was accomplished under these goals? 1. Evaluate organic production systems (Strik) Collected a third year of data on the impact of weed management and cultivar on plant growth and production in organic blackberry, machine-harvested for processing. Hand removal of weeds in "weed-free" treatment required 38 and 90 h/ha in 2011 and 2012, respectively, compared to 1 h/ha in the weed mat. In 2011, plants in hand-weeded and weed mat plots produced nearly twice the primocanes as in non-weeded plots. Hence, when fruit were produced on floricanes the next year (2012) weed control increased yield by 67% with hand-weeding and 100% with weed mat. 'Black Diamond' and weed control also produced larger berries with a greater water content but a lower Brix. So far, weed mat was best suited to organic production of blackberries. After only one season of fruit production, the yield benefit of weed mat provided enough profit to warrant its use over no weeding or hand weeding. Most primocane leaf nutrient concentrations were within the range recommended for blackberry. Weeds reduced nutrient accumulation in the primocanes in both cultivars. Total nutrient content declined from June to August in the floricanes, primarily through fruit removal at harvest and senescence of the floricanes after harvest. Evaluations of the effect of post-harvest irrigation and training time continued in 2013. Two processing cultivars and two fresh market cultivars were studied at a grower collaborator site. There was little impact of fertilizer source on yield or fruit quality over the two-year study. (Bryla) Soil water content declined as expected with no post-harvest irrigation, but the treatment resulted in only a 13% reduction in plant water potential compared to continued irrigation after harvest in both cultivars. Observations with minirhizotrons indicated that fine roots were evenly distributed throughout the top 2 m of the soil profile but that post-harvest irrigation resulted in more roots than no post-harvest irrigation. It is not clear yet whether no watering after harvest is a viable option for reducing irrigation water use in blackberry. 2. Evaluation of production systems on shelf-life and antioxidants (Zhao) In general, plants fertilized with Fish emulsion blend had the highest levels of antioxidants during the late harvest, while those fertilized by soymeal had the highest levels during the early and mid-harvests. Processed poultry litter fertilizer had the least effect on harvest-time antioxidant levels. For both cultivars, relative levels of TMA and TPC increased the most during berry storage for fish emulsion in the early season, while poultry litter showed similar trends in the late harvest. Antioxidant capacity (DPPH, ORAC, FRAP) depended on cultivar, with the early/middle Triple Crown fruit fertilized with fish emulsion having the highest levels during storage, while the late-harvested fruit fertilized with poultry litter performed the best. The relative antioxidant capacity was highest in Obsidian fertilized with poultry litter during storage. Glucose and fructose comprised the largest fractions of total sugars and sucrose only a minor fraction (0-3%) in all harvests. Early harvested fruits tended to have slightly higher levels of fructose than glucose, the opposite of mid- and late harvests. Soymeal fertilized berries had the highest total sugar content in the early and mid- harvests, while poultry fertilized berries had the highest on late harvests. Mid- and late harvested berries tended to have sucrose level decline during storage, compared to little change in early harvested fruit. Fertilizer source had little effect on the TA, Decay Ratio, Leakage ratio and weight loss of berries during storage, 2012-13. In 2012, soymeal increased decay rates, while in 2013 decay rate only differed in mid- and late-harvested fruit with varying fertilizer and cultivar effects. This difference between harvest years suggests that there is a heretofore unknown interaction between fertilizer source, growing climate and/or plant maturity, which should be investigated in some future study. (Perkins-Veazie) The three cultivars (Natchez, Navaho, Ouachita) had similar responses to storage in both 2010 and 2011. All were highly acceptable after 2 weeks storage at 1 C and about 30-40% of fruit were unmarketable after 2 days storage at room temperature. These fruit were then utilized for studies of composition by high performance liquid chromatography. Fruit composition of fresh blackberries before and after storage. The cultivars exhibited high soluble solids content and relatively low TA after storage. Such changes are in line with other blackberries produced in areas where night temperatures during ripening routinely exceed 25 C. The primary anthocyanin found in the three cultivars was cyanidin-3-glucoside, accounting for 85-95% of all anthocyanin. Procyanidin and chlorogenic acid were the primary flavonoids found. 3. Food safety issues (Daeschel) Aerobic plate counts for 'Obsidian' and 'Triple Crown' ranged from 3.52-4.62 log CFU/g of berry with later harvests tending to have higher values. 'Triple Crown' mid-late harvest samples were higher than the early harvest samples. Yeasts and molds ranged from 3.01-4.73 log CFU/g of berry with later harvests having higher values. Coliforms were detected in 'Obsidian' mid-harvest and 'Triple Crown' early-harvest samples at 2.10 and 1.40 log CFU/g of berry, respectively. Escherichia coli O157:H7 and Salmonella spp. were not detected using rapid detection methods in evaluated 'Marion' and 'Black Diamond' samples. Escherichia coli O157:H7 was not detectable in fresh or frozen inoculated samples. Salmonella Typhimurium was detected in 2 frozen samples with 2.95 and 3.21 log reductions. Listeria monocytogenes was only detected in frozen samples and experienced log reductions ≥ 2.42. Staphylococcus aureus was detectable on every fresh and frozen berry inoculated with log reductions ranging from 0.67 to 3.48. The greatest reductions occurred in fresh samples. Growth of intentionally added microorganisms was not observed in any juice or wine samples. Maximum observed survival times in juices ranged from 12 h for L. monocytogenes to 108 h for Salmonella Typhimurium. Maximum survival times in wines were 40 m for both E. coli O157:H7 and Salmonella

Typhimurium, and 80 m for both L. monocytogenes and S. aureus. Adding ethanol to juice samples to equal that of their counterpart wines decreased survival time for all microorganisms evaluated by several hours. Increasing the pH of wines by approx.. one unit increased survival time from minutes to hours, and in some cases, days. Conclusions and key outcomes: The overall results suggest that blackberries are not an ideal environment for E. coli O157:H7, Salmonella Typhimurium, L. monocytogenes, and S. aureus to grow. However, these microorganisms may be able to survive depending on the type of blackberry product and its subsequent storage. Many constituents of blackberries may offer bactericidal activity, with organic acids appearing to have the greatest effect. Blackberries may be viewed as a low risk food in terms as a source of bacterial foodborne illness. However, food safety programs need to be in place for blackberry producers/processors to prevent any unforeseen microbial food contamination 4. Assess potential liability costs (ReJesus) Developed an ex ante, partial equilibrium supply/demand model as the framework for quantifying the demand impact of a blackberry food safety event. A preliminary model for assessment of liability cost and demand impact of a blackberry food safety event has been built. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 1. Type: Journal Articles Status: Published Year Published: 2013 Citation: Harkins, R.H., B.C. Strik, and D.R. Bryla. 2013. Weed management practices for organic production of trailing blackberry: I. Plant growth and early fruit production. HortScience 48:1139-1144. 2. Type: Journal Articles Status: Awaiting Publication Year Published: 2014 Citation: Harkins, R.H., B.C. Strik, and D.R. Bryla. 2013. Weed management practices for organic production of trailing blackberry: II. Accumulation and loss of biomass and nutrients. HortScience (in press). 3. Type: Conference Papers and Presentations Status: Published Year Published: 2012 Citation: Strik, B.C. and C.E. Finn. 2012. Blackberry production systems ? a worldwide perspective. Acta Hort. 946:341-347 4. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Harkins, R., B. Strik, and D. Bryla. 2013. Production Systems for Organic Blackberries for Processing ? Impact of Cultivar and Weed Management. Proc. North American Berry Conference, Jan. 27-30, 2013. Portland, OR (on web and disk). 5. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Fernandez-Salvador, J., B. Strik, and D. Bryla. 2013. Impact of Organic Fertilizer Source on the Yield and Quality of Blackberry Cultivars ? Results from a Grower-Cooperator Trial. Proc. North American Berry Conference, Jan. 27-30, 2013. Portland, OR (on web and disk). 6. Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Harkins, R. 2013. Weed, water, and nutrient management practices for organic blackberry during establishment. M.S. thesis, Oregon State University 7. Type: Theses/Dissertations Status: Published Year Published: 2013 Citation: Melissa M. Sales, An. 2013. M.S. Thesis, Oregon State University. Evaluation of Blackberry Harvest Sanitation and the Ability of Foodborne pathogens to survive in Blackberry Products 8. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: \Abstr\. Flavonoid profile and storage life of organically grown blackberry fruit. Kim, MJ, Perkins-Veazie, P., Fernandez, G. HortScience 9. Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: \Abstr\ Anthocyanin profile of organically grown blackberries Kim, MJ, Perkins-Veazie, P., Fernandez, G. HortScience

2011/09/01 TO 2012/08/31 The following questions were listed as research outcome goals; this study is relatively new to have many measurable outcomes: 1. What is the most effective way to control weeds and is weed control critical Results to date indicate that weeds compete with trailing blackberry reducing primocane growth, tissue nutrient concentration, floricane biomass, yield, berry weight, and fruit nutrient concentration. For maximum production, weed control is important. Weed mat shows promise for economical weed management. 2. Is organic production for processed markets sustainable with machine harvest We have one year of yield data. Yield of the best treatments (bare and weed mat) were very similar to expectations for conventional systems. We need more years to assess sustainability. 3. Can adequate fertility be maintained with only organic inputs Fertility with fertigation of fish emulsion maintained adequate tissue nutrients and growth in 2011-12. However, primocane growth was reduced in all treatments in 2012. We need to assess whether this is related to fertility or the relatively high yield in 2012 suppressing growth. 4. What microorganisms may be found on hand or machine-harvested fruit and are they a food safety risk Numbers of microorganisms associated with fresh blackberries increased over the growing season but no evidence of potential contamination by pathogens was observed. 5. What is impact of cultivar, harvest date and post-harvest handling (refrigeration storage and freeze-processing and storage) on fruit nutritional properties Changes in fruit indicate that active biosynthesis and turnover of anthocyanins are dependent on field and storage temperature and cultivar and ripeness 6. Do cultivars differ in suitability for organic production It is too early to tell. 7. Are the organic production systems sustainable in the long term It is too early to tell. 8. Can blackberries be grown economically using the recommended sustainable organic production systems Work is ongoing in OR. In NC, a publication was developed on the costs of organic blackberry production in NC. Results were presented to growers and are available on-line in a format that will allow growers to make changes based on their specific circumstances. 9. What would be the potential liability cost and demand impact of a food safety event Work in progress. We have given the following presentations to date: field days (7); grower meetings (2); scientific meetings (7); workshops (2). We developed an eOrganic community of practice related to this project

2010/09/01 TO 2011/08/31 The following questions were listed as research outcome goals; however this study is too new to have any measurable outcomes: 1. What is the most effective way to control weeds and is weed control critical 2. Is organic production for processed markets sustainable with machine harvest 3. Can adequate fertility be maintained with only organic inputs 4. What microorganisms may be found on hand or machine-harvested fruit and are they a food safety risk Numbers of microorganisms associated with fresh blackberries increased over the growing season but no evidence of potential contamination by pathogens was observed. 5. What is impact of cultivar, harvest date and post-harvest handling on fruit nutritional properties 6. Do cultivars differ in suitability for organic production 7. Are the organic production systems sustainable in the long term 8. Can blackberries be grown economically using the recommended sustainable organic production systems 9. What would be the potential liability cost and demand impact of a food safety event

PUBLICATIONS

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

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

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Tools for Organic Transition: Financial Data and Educational Resources for Farmers and Agricultural Professionals

Accession No.	0222571
Subfile	CRIS
Project No.	MIN-14-G12
Agency	NIFA MIN
Project Type	OTHER GRANTS
Project Status	EXTENDED
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Proposal No.	2010-01975
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Term Date	31 AUG 2015
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Grant Year	2010
Investigator(s)	King, R. P.; Nordquist, D. W.; Murray, H.
Performing Institution	Applied Economics, UNIV OF MINNESOTA, ST PAUL, MINNESOTA 55108

NON-TECHNICAL SUMMARY

As more farmers consider transition to organic production, the high cost of transition, coupled with uncertainty about those costs and subsequent returns, will be a significant impediment to growth in this promising market sector. There are few published studies on the economics of organic transition, and there is very limited access to actual farm data on costs and returns during and after transition. This integrated, long-term project has two inter-related goals that address the need for farm-based information on enterprise and whole-farm performance during the transition from conventional to organic production: 1. Collect data on farm performance measures during the transition to organic production and develop resources such as an online database and analysis tools to generate benchmark reports for crop and livestock enterprises and whole farm performance during transition. 2. Develop web-based and print materials to address the informational needs of farmers transitioning to organic production and the educational needs of agricultural professionals who advise them. Through on-farm research, data analysis, and a multifaceted outreach program that will involve direct interaction with producers and agricultural professionals as well as the development of web-based and print materials to reach a wider audience, this project will: produce data and information on farmer practices and experiences during organic transition and contribute to evaluation of potential economic benefits of organic production.

OBJECTIVES

This integrated project has two goals that address the need for farm-based information about enterprise and whole-farm financial performance during the transition from conventional to organic production: 1. Collect data on farm performance measures during the transition to organic production and develop resources such as an online database and analysis tools to generate benchmark reports for crop and livestock enterprises and whole farm performance during transition. 2. Develop web-based and print materials to address the informational needs of farmers transitioning to organic production and the educational needs of agricultural professionals who advise them. Expected outputs for the first goal are: a. Train 75 farm business management (FBM) instructors to deliver programming to producers transitioning to organic production. b. Educate 80 producers (50 transitioning and 30 newly certified) to understand and use farm financial records and benchmarking tools for their farming enterprise.

c. Establish a repository of farm-level data on the financial performance of farms during and after organic transition that can be used by researchers, agricultural professionals, producers, lenders, policy makers, and others. d. Foster a group of transitioning farmers who have a deeper understanding of their own financial condition during the years of transition and have access to similar benchmarking information about a peer cohort. e. Build a community of prospective organic farmers better informed about the financial conditions they could expect during transition and the requirements for organic certification. f. Prepare and disseminate four summary reports about participant performance. Expected outputs for the second goal are: a. Develop and disseminate training resources, survey results, and business plan examples to help more than 100 cooperative extension educators in the Upper Midwest and 75 FBM educators in Minnesota better serve the needs of their clients. b. Produce and disseminate articles, DVDs, and webinars to assist more than 300 Land Grant academics, other educators, organic interest groups, financial institutions, and government agencies already active in organic agriculture with the development of economic transition resources for their regions. c. Educate 350 + farmers, lenders, NRCS staff, educators and other agricultural professionals who attend break-out sessions at the annual Minnesota Organic Farming Conference. d. Distribute 2,000 printed copies of the Economic Planning Guide to Organic Transition to farmers and other stakeholders at annual conferences such as the Minnesota Organic Farming Conference and the Organic Farming Conference. e. Generate and disseminate resources to approximately 25 organic certifying agencies in the Upper Midwest who actively work with transitioning farmers. f. Train six farmers in the development of business plans and economic transition plans.

APPROACH

The following methods will be used to collect and analyze data on farm performance during transition. TRAINING: Project personnel will provide training on fundamentals of organic transition to all 75 Farm Business Management (FBM) instructors in the Minnesota State Colleges and Universities system. ENROLLMENT: Project personnel will work with organic producer networks and other cooperating organizations to recruit participants, whom instructors will enroll at the local level. We plan to enroll 20 new transitioning farms during year 1, 10 in year 2, 10 in year 3, and 10 in year 4. Enrolling some new farms each year will provide important information on how random variation in weather, pest pressures, and market conditions affect farms in different stages of transition. DELIVERY: Instructors will meet one-on-one with participating farmers. Sessions will include instruction on farm management principles, organic requirements, and certification procedures. At year-end, instructors and participants will assemble accounting and production records into a detailed analysis of whole farm and enterprise performance. ANALYSIS: Farm-level data will be validated and aggregated by FBM and Center for Farm Financial Management staff for inclusion in the FINBIN database. Users will be able to obtain cost and return data associated with farms transitioning to organic production and to compare the financial performance for various types of enterprises. They will also be able to benchmark financial performance of transitioning farms against that of conventional and certified organic operations. Project personnel will also analyze multi-year performance for transitioning farms over the entire transition period. OUTREACH: Annual reports will be shared with academics, producers, lenders, public policy makers, state and federal agriculture agencies, organic interest groups, nonprofit farm organizations, and other interested communities. MONITORING: The advisory team will provide ongoing monitoring and feedback on the project. Project personnel will survey participating farmers annually to identify critical challenges during the transition process. Information will be shared nationally through articles and webinars delivered through eOrganic.info and eXtension.org. The following methods will be used to develop educational materials for transitioning farmers and the professionals who advise them. SURVEY: An annual survey will identify trends among transitioning farmers, ascertain financial management and marketing challenges during the transition process, and measure outcomes of participation in the FBM program. INTERVIEW: In-depth interviews with up to 15 transitioning farmers will be conducted in Years 1-3, as a basis for educational profiles. LEARNING GROUPS: Participating farmers will meet in small groups four times throughout winter of years 2 and 3 to develop business plans for their transitioning operations that will serve as educational examples. WORKSHOPS: An annual workshop for producers and FBM educators will be used to disseminate survey results, explain organic requirements, and encourage a two-way exchange of information between farmers and educators. Progress 09/01/14 to 08/31/15 Outputs Target Audience:Target audiences for this project are farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. Changes/Problems:Work during the past year was conducted under a no-cost extension. What opportunities for training and professional development has the project provided?Project team members Tim Delbridge, Gigi DiGiacomo, and Robert King all attended the 2015 Minnesota Organic Conference. In addition to meeting with project farmers and and presenting a workshop on transition, we each had opportunities to attend breakout and plenary sessions on a variety of topics related to organic agriculture. How have the results been disseminated to communities of interest?Results from the project were disseminated to farmers, organic certifiers, lenders, crop insurance agents, and other agricultural professionals who support organic production through a workshop presentation at the Minnesota Organic

Conference in January 2015 as well as through the project web site. Two key publications from the project were released during this reporting period: \"Organic Transition: A Business Planner for Farmers, Ranchers and Food Entrepreneurs,\" and \"Making the Transition to Organic: Ten Farm Profiles.\" These are available in print and for free download on several web sites. Printed copies of the \"Planmner\" are being distributed by SARE, the report publisher, to national Association of State Organic Programs members, to all U.S. organic certifying agencies, and to select nonprofits. Postings on email list serves have been used to inform Farm Business Management instructors and farm management Extension educators about the availability of these publications. What do you plan to do during the next reporting period to accomplish the goals?This is the final reporting period for the project, but we have several outreach activities scheduled for 2016. These include a session on business planning for transition at the Minnesota Organic Conference in January 2016 and a webinar on \"Transitioning to Organic production\" for USDA Natural Resource Conservation Service/NRCS staff in April 2016. In addition we have one journal manuscript under revision and a second manuscript in preparation for submission. Impacts What was accomplished under these goals? This project is among the first, if not the first, to collect enterprise and whole farm financial performance data for farms transitioning to organic production. In this final year of the project, data collected over the life of the project and lessons for surveys and workshops with participating farmers were the basis for development of data resources and planning tools that, in years to come, will help farmers assess opportunities to transition to organic production. Resources developed through this project will also help lenders evaluate organic transition plans and will provide insights to policy makers on potential barriers to significant increases in organic production. Goal 1: Collect data on farm performance measures during the transition to organic production and develop resources such as an online database and analysis tools to generate benchmark reports for crop and livestock enterprises and whole farm performance during transition. Project team members have made adjustments to the FINPACK and FINBIN computer systems and associated data coding and entry procedures to facilitate capture of enterprise and whole farm data for transitioning farms. Farm Business Management instructors have been trained to use the new coding systems. It is now possible to generate enterprise reports for major field crops and dairy and whole farm reports for transitioning crop and dairy farms. This data resource will continue to grow in the future. Project team members presented a workshop on \"Who Is Transitioning and How?\' at the same Minnesota Organic Conference. Confidentiality restrictions for the use of farm record data in the FINBIN database and smaller than expected numbers of participating farms made it impossible to release annual summaries of farm financial performance results. A comprehensive summary of enterprise and whole farm performance that uses a novel form of ratio analysis to combine data from different years and locations was prepared and published in 2015 (Delbridge et al. 2015). In addition, a manuscript is currently under revision that presents a dynamic programming model of the transition process. This model uses yield, return, and cost data from long-term experiments at the Southwest Research and Outreach Center in Lamberton, MN as well as data from the farm records of project participants. It provides insights on the economic forces that shape the timing of the transition decision and conditions under which transitioning or certified farms might shift back to conventional production methods. Goal2: Develop web-based and print materials to address the informational needs of farmers transitioning to organic production and the educational needs of agricultural professionals who advise them. Project team members developed two new publications that are available in print and online. \"Organic Transition: A Business Planner for Farmers, Ranchers and Food Entrepreneurs\" (DiGiacomo, King and Nordquist 2015) is a comprehensive guide to business planning for transitioning farmers. Supplementary online resources for the Planner include a complete set of electronic worksheets and an \"Organic Transition\" business plan template in the AgPlan software. \"Making the Transition to Organic: Ten Farm Profiles\" (DiGiacomo and King 2015) is a collection of farm profiles that provide insigths on the challenges and rewards associated with the transition to organic production. Publications Type: Books Status: Published Year Published: 2015 Citation: DiGiacomo, G.;King, R.P.;Nordquist, D.W. 2015. Organic transition: a business planner for farmers, ranchers and food entrepreneurs. SARE Handbook Series 12, Sustainable Agriculture Research and Education Program. (http://purl.umn.edu/211871) Type: Other Status: Published Year Published: 2015 Citation: DiGiacomo, G.;King, R.P. 2015. Making the transition to organic: ten farm profiles. Department of Applied Economics, University of Minnesota. (http://purl.umn.edu/207981) Type: Other Status: Published Year Published: 2015 Citation: Delbridge, T.A.; King, R.P.; Nordquist D.W.; DiGiacomo, G.; and Moynihan, M. 2015. \"Farm performance during the transition to organic production: Analysis and planning tools based on Minnesota farm record data.\" Staff Paper P15-6, Department of Applied Economics, University of Minnesota. (http://purl.umn.edu/212429) Progress 09/01/10 to 08/31/15 Outputs Target Audience:Target audiences for this project were farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. Changes/Problems:A one-year no-cost extension made it possible to collect an additional year of farm record data. The greatly strengthened our results. What opportunities for training and professional development has the project provided?Project team members Delbridge, DiGiacomo, and King all attended the Minnesota Organic Conference in 2011, 2012, 2013, 2014, and 2015. Project team member Nordquist attended the conference in 2011, 2012, 2013, and 2014. Project Director King attended at NIFA/OREI Project Directors meeting in 2012 and the annual MOSES conference in

2013. Project team members Delbridge and King attended and made a presentation in an organized symposium on \"Expanding the U.S. Organic Sector\--Will Recent USDA Initiatives Help?\" at the annual meeting of the Agricultural & Applied Economics Association in Minneapolis, MN in July 2014. Attendance at these conferences and workshops gave project team members opportunities to broaden their knowledge of opportunities and challenges related to organic agriculture. How have the results been disseminated to communities of interest?As noted in the discussion of project accomplishments, results from the project have been disseminated to farmers, organic certifiers, lenders, crop insurance agents, and other agricultural professionals who support organic production through presentations at the Minnesota Organic Conference and the MOSES conference, as well as through the project web site. Two key publications from the project, \"Organic Transition: A Business Planner for Farmers, Ranchers and Food Entrepreneurs,\" and \"Making the Transition to Organic: Ten Farm Profiles,\" are available for free download on several web sites. Printed copies of the \"Planner\" are being mailed by SARE to National Association of State Organic Programs members, all U.S. organic certifying agencies, and select nonprofits. Postings on email list serves have been used to inform Farm Business Management instructors and farm management Extension educators about the availability of these publications. In addition, earlier versions of several of the farmer profiles included in the \"Making the Transition to Organic: Ten Farm Profiles\" publication were published in the MOSES Organic Broadcaster, which has a combined print and online circulation of 15,000. What do you plan to do during the next reporting period to accomplish the goals?The project has ended, but we have several outreach activities scheduled for 2016. These include a session on business planning for transition at the Minnesota Organic Conference in January 2016 and a webinar on \"Transitioning to Organic production\" for USDA Natural Resource Conservation Service/NRCS staff in April 2016. In addition we have one journal manuscript under revision and a second manuscript in preparation for submission. Impacts What was accomplished under these goals? This project was among the first, if not the first, to collect enterprise and whole farm financial performance data for farms transitioning to organic production. Data collected over the life of the project, along with findings and insights from surveys and workshops with participating farmers, were the basis for development of data resources and planning tools that will help farmers assess opportunities to transition to organic production. Resources developed through this project also will help lenders evaluate organic transition plans and will provide insights to policy makers on potential barriers to significant increases in organic production. Goal 1: Collect data on farm performance measures during the transition to organic production and develop resources such as an online database and analysis tools to generate benchmark reports for crop and livestock enterprises and whole farm performance during transition. (a) Project team members made adjustments to the FINPACK and FINBIN computer systems and associated data coding and entry procedures to facilitate capture of enterprise and whole farm data for transitioning farms. The 56 FBM instructors all received training on these procedures. A total of 22 instructors worked directly with transitioning or recently certified farms. (b) Over the course of the project team members recruited a total of 47 farms (36 transitioning and 11 recently transitioned) to participate in the FBM program. This was a smaller number than expected, largely due to a dramatic slowdown in the rate of transition to organic production during the project period. Between 2008 and 2014, USDA NASS reports that the number of organic farms in Minnesota declined from 543 to 508, while certified cropland increased slightly, from 122,428 acres to 133,033 acres. During that same period, certified field crop acreage declined from 90,556 acres to 82,549 and the number of dairy farms with certified organic cows increased only from 109 to 115. As noted in earlier annual reports, the farms that participated in this project managed 4,708 acres in transition, 1,761 recently certified acres, 7,418 acres that had been certified for three years or more and an additional 4,995 acres of conventional land. They had a total of 692 dairy cows in transition, 583 recently certified dairy cows, 945 organic dairy cows certified three years or more, and 255 conventional dairy cows. (c) Data collected from the participating farms are stored in the FINBIN data and, when minimum number of observations permits, can be accessed by researchers, agricultural professionals, producers, lenders and policy makers to generate enterprise and whole-farm reports. Even though the project has now ended, farms that identify themselves as transitioning to organic production will continue to be coded as such and will add to the available data resources. (d) All farms participating in the project were invited to participate in workshops at the annual Minnesota Organic Conference. This offered opportunities to communicate and explain project findings and to build a sense of community among the transitioning farmers. (e) Sessions on transition to organic production were presented at the MOSES annual conference in February 2013 and at the Minnesota Organic Conference in January 2015. Both were open to the broader community of producers. (f) Confidentiality restrictions for the use of farm record data in the FINBIN database and smaller than expected numbers of participating farms made it impossible to release annual summaries of farm financial performance results. An analysis of yield gaps between conventional and organic farms was prepared in 2014 (Delbridge and King 2014), and a comprehensive summary of enterprise and whole farm performance that uses a novel form of ratio analysis to combine data from different years and locations was prepared in 2015 (Delbridge et al. 2015) Goal2: Develop web-based and print materials to address the informational needs of farmers transitioning to organic production and the educational needs of agricultural professionals who advise them. (a) Results from intake surveys and four annual surveys of participating farms have been reported at organic conferences and published on the

project\'s eOrganic web site. Business plan examples for three transitioning farmers are available in the business planning publication (DiGiacomo, King, and Nordquist 2015) that is available online and in print. (b) In addition to having posted educational materials on the project\'s eOrganic web site, their availability has been announced on email lists of extension educators and organic interest groups. (c) Project team members have conducted breakout sessions on transition to organic production at the MOSES annual conference (2013, approximately 20 attendees), Agricultural and Applied Economics Association Annual Meeting (2014, approximately 20 attendees), and the Minnesota Organic Conference (2015, approximately 30 attendees). (d) The business planning publication, \"Organic Transition: A Business Planner for Farmers, Ranchers and Food Entrepreneurs,\" was published online in September 2015 and in print in October 2015. This publication is accompanied by online access to a complete set of planning worksheets, financial worksheets for projecting cash flows and key finaincial ratios, and an \"Organic Transition\" business planning template in the AgPlan software that was developed under this project. Copies of the \"Planner\" will be distributed at the 2016 Minnesota Organic Conference. In addition, \"Making the Transition to Organic: Ten Farm Profiles\" (GiGiacomo and King 2015) is a collection of profiles that provide insights on the challenges and rewards of transition to organic production. (e) Copies of \"Organic Transition: A Business Planner for Farmers, Ranchers and Food Entrepreneurs\" are being distributed by SARE to all U.S. organic certifying agencies. Publications Type: Books Status: Published Year Published: 2015 Citation: DiGiacomo, G; King, R.P.; Nordquist, D. 2015. Organic transition: a business planner for farmers, ranchers and food entrepreneurs. SARE Handbook Series 12, Sustainable Agriculture Research and Education Program. (http://purl.umn.edu/211871)

PROGRESS

2013/09 TO 2014/08 Target Audience: Target audiences for this project are farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. Changes/Problems: We requested and were granted a one-year no-cost extension for the project. This is making it possible to collect data for an additional year. What opportunities for training and professional development has the project provided? This project has provided graduate research assistant funding for Timothy Delbridge, who has been a key member of the project team. He completed his Ph.D. in July 2014 and will continue to work on the project as a post-doctoral researcher. How have the results been disseminated to communities of interest? The project team has undertaken a number of educational activities during the past year. In January 2014 we conducted a workshop for participating farmers that included a presentation on annual survey results, an overview of organic farm performance in Minnesota, preliminary findings on transitioning farm performance, and a panel discussion with two experienced farmers and a certifier. Work on a draft business planning manuscript, called the Transition Business Planner, continued in 2014. Project team members have worked with three farms to develop complete business plans that will be used as examples in the "Planner." As noted in last year's progress report, USDA's Sustainable Agriculture Research and Education (SARE) Program has agreed to co-publish the manuscript. Project team members also prepared three new profiles of transitioning farm operations that have been published in the project newsletter and posted on the project web site. Finally, project team members made a presentation on barriers to organic transition at the annual meeting of the Agricultural and Applied Economics Association. What do you plan to do during the next reporting period to accomplish the goals? 1. We will hold another farmer workshop at the Minnesota Organic Conference in January 2015. This session will be open to all conference attendees. 2. The \"Transition Business Planner\" was sent out for review in late October 2014. We expect it to be published during the first several months of 2015. 3. Data collection for the project will end in the spring of 2015. When all data are in, we will prepare reports and articles presenting the findings with regard to both enterprise and whole farm profitability of farms transitioning to organic production systems.

2012/09/01 TO 2013/08/31 Target Audience: Target audiences for this project are farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. Changes/Problems: We are preparing a request for a no-cost extension for the project. This will make it possible to collect an additional year of farm record data, which will greatly strengthen our results. What opportunities for training and professional development has the project provided? During the first three years of the project, team members have recruited 47 transitioning and recently certified farmers to participate in the project by enrolling in the state's Farm Business Management (FBM) program. Collectively, at the start of project participation, these 47 farms managed 4,708 acres in transition and 1,761 recently certified acres. They cultivated 7,418 acres that had been certified for three years or more and an additional 4,995 acres of conventional land. They had a total of 692 dairy cows in transition, 583 recently certified dairy cows, 945 organic dairy cows certified three years or more, and 255 conventional dairy cows. A total of 22 farm business management instructors are working with these farms. Project team members continue to make

adjustments to the FINPACK and FINBIN computer systems and the procedures used by instructors in order to facilitate capture of enterprise-level data on transitioning and recently certified farms. How have the results been disseminated to communities of interest? The project team has undertaken a number of educational activities during the past year. In January 2013 we conducted a workshop for participating farmers that included presentations on survey results and on preliminary research observations. The workshop included a farmer panel focusing on transition challenges and solutions. The panel - represented by three farmers of varying levels of organic management experience - was well received by workshop participants. Two of the panel members participated in a subsequent educational session moderated by project team members at the Midwest Organic and Sustainable Education Service (MOSES) conference in February 2013. A draft business planning manuscript, called the Transition Business Planner, was developed in 2013. Project team members tested the draft manuscript through a series of four business planning workshops with managers from four transitioning farms. The manuscript has since undergone subsequent revisions. USDA's Sustainable Agriculture Research and Education (SARE) Program has agreed to co-publish the manuscript pending further review and the inclusion of regionally-sensitive examples. Finally, project team members prepared four new profiles of transitioning farm operations that have been published in the project newsletter and posted on the project web site. One of these profiles also was published in Organic Broadcaster, the bi-monthly periodical of the Midwest Organic and Sustainable Education Service. What do you plan to do during the next reporting period to accomplish the goals? We will continue to collect and analyze data from the transitioning and recently certified farms that are enrolled through the project in the Farm Business Management program. In the coming year we expect to have results on crop yields, dairy production, and financial performance during transition that can be shared with the public and incorporated into publications. The annual survey of project participants is being conducted in November 2013. Summary results will be published on the project web site (http://eorganic.info/toolsfortransition/about) and will be shared with project participants. We will conduct an annual educational workshop for project participants at the Minnesota Organic Conference in January 2014. We will refine the dynamic programming model of transition and will prepare a manuscript on the model structure and results for publication in a refereed journal. We will do further testing of the Transition Business Planner, make final revisions in the manuscript, and publish it in cooperation with USDA\'s SARE program.

2011/09/01 TO 2012/08/31 OUTPUTS: During the first two years of the project, team members have recruited 37 transitioning and recently certified farmers to participate in the project by enrolling in the state\'s Farm Business Management (FBM) program. Collectively, at the start of project participation, these 37 farms managed 3,815 acres in transition and 990 recently certified acres. They cultivated 5,868 acres that had been certified for three years or more and an additional 4,850 acres of conventional land. They had a total of 507 dairy cows in transition, 583 recently certified dairy cows, 455 certified organic dairy cows, and 90 conventional dairy cows. A total of 17 farm business management instructors are working with these farms. Project team members continue to make adjustments to the FINPACK and FINBIN computer systems and the procedures used by instructors in order to facilitate capture of enterprise-level data on transitioning and recently certified farms. Project team members have analyzed 2011 financial and production records for participating farms. We also have administered two surveys - and intake survey and an annual survey - to all project participants. Analysis of farm record data and survey responses is being complemented by the development of the dynamic programming model of the transition process. This model currently uses yield, return, and cost data from long-term experiments at the Southwest Research and Outreach Center in Lamberton, MN, but data from the farm records of project participants will be integrated into the model in the future. At present, the model focuses on cropping operations, but it will be adapted to model transition decisions for dairy operations. This model can provide insights on the economic forces that shape the transition decision and on the effects alternative conservation and risk management policies may have on farmers\' decisions to transition. The project team has undertaken a number of educational activities during the past year. In January 2012 we conducted a workshop for participating farmers that included presentations on survey results and on financial performance results for certified organic producers who participate in the FBM program. Time was also set aside for small group discussion among project participants with a focus on transition challenges. Project team members also conducted a series of four business planning workshops with managers from two participating farms. These workshops were the first step in developing business planning materials for transitioning farmers that will complement general purpose farm business planning materials. Finally, project team members prepared two profiles of transitioning farm operations that have been published in the project newsletter and posted on the project web site. These profiles also were published in Organic Broadcaster, the bi-monthly periodical of the Midwest Organic and Sustainable Education Service. PARTICIPANTS: Project team members include: Robert Craven (U of M), Tim Delbridge (U of M), Gigi DiGiacomo (U of M), Robert King (U of M), Rann Loppnow (U of M), Meg Moynihan (Minnesota Department of Agriculture), Helene Murray (U of M), Dale Nordquist (U of M), and Jim Riddle (U of M). Project advisory committee members include: Ira Beckman (MnSCU), Ron Dvergsten (MNScu), Carmen Fernholz (farmer), Kent Hoehne (farmer), Loretta Jaus (farmer), Michelle Menken (Minnesota Crop Improvement Association), Carolyn

Olson (farmer), and Carissa Spencer (USDA/NRCS). TARGET AUDIENCES: Target audiences for this project are farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Much of the project team\'s time during this first year has been devoted to recruiting transitioning and recently certified farmers to participate in the project by enrolling in the Farm Business Management program. To date, we have enrolled 30 farmers in the project: 26 with at least some land and/or dairy cattle in transition and four with recently certified land and/or dairy cattle. Many of the transitioning farms already have some certified organic land or cows. Of these farms: 18 raise only crops, pasture, and hay; one has only dairy cows, and 11 raise crops, pasture, hay, and dairy cows. Collectively, these farms have 2,724 acres in transition and 400 recently certified acres. These farms cultivate 4,762 acres that have been certified for three years or more, and they cultivate an additional 3,754 acres of conventional land. These farms have a total of 422 dairy cows in transition, 433 certified organic dairy cows, and 90 conventional dairy cows. A total of 18 farm business management instructors are working with these farms. Project team members have made adjustments to the FINPACK and FINBIN computer systems to facilitate capture of enterprise-level data on transitioning and recently certified farms. Project team members also have begun preliminary analysis of financial and production records for farms that were enrolled in the Farm Business Management program prior to the start of this project. Project team members have used long-term experimental trial data from the Variable Input Crop Management Study (VICMS) at the Southwest Research and Outreach Center in Lamberton, MN in an analysis of whole farm profitability and risk under conventional and organic practices. This work will provide insights on differences in optimal farm sizes under these two systems. This is important because organic cropping operations may be smaller, though not necessarily less profitable, than conventional cropping operations. Finally, we have established an eOrganic web site that is currently used only for communication within the project team. In the future it will be used to communicate research results with other researchers and the public. PARTICIPANTS: Project team members include: Robert Craven (U of M), Tim Delbridge (U of M), Gigi DiGiacomo (U of M), Richard Joerger (MnSCU), Robert King (U of M), Rann Loppnow (U of M), Meg Moynihan (Minnesota Department of Agriculture), Helene Murray (U of M), Dale Nordquist (U of M), Jim Riddle (U of M). Project advisory committee members include: Ira Beckman (MnSCU), Ron Dvergsten (MNScu), Carmen Fernholz (farmer), Loretta Jaus (farmer), Robin Martinek (USDA/NRCS), and Michelle Menken (Minnesota Crop Improvement Association). TARGET AUDIENCES: Target audiences for this project are farmers, farm business management instructors, organic certifiers, agricultural professionals who support organic production, lenders, crop insurance agents, and policy makers. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2013/09 TO 2014/08 What was accomplished under these goals? With the end of the project approaching, we are no longer recruiting new farmer participants to the study. During the first three years of the project, team members recruited 47 transitioning and recently certified farmers to participate in the project by enrolling in the state's Farm Business Management (FBM) program. Collectively, at the start of project participation, these 47 farms managed 4,708 acres in transition and 1,761 recently certified acres. They cultivated 7,418 acres that had been certified for three years or more and an additional 4,995 acres of conventional land. They had a total of 692 dairy cows in transition, 583 recently certified dairy cows, 945 organic dairy cows certified three years or more, and 255 conventional dairy cows. A total of 22 farm business management instructors are working with these farms. Project team members have made adjustments to the FINPACK and FINBIN computer systems and the procedures used by instructors in order to facilitate capture of enterprise-level data on transitioning and recently certified farms. Project team members have analyzed all available financial and production records for participating farms. In some cases, these records are for years prior to the start of the project, since some participating farms were already enrolled in the Farm Business Management program when they were recruited. Confidentiality restrictions continue to limit our ability to release financial performance results until more data have been collected. This past year we were able to report findings from an analysis of crop yields for "split operation" farms that simultaneously grew the same crop under both organic and conventional management practices. We found that these farms have significantly lower conventional corn and soybean yields than the average farm in their county, which implies that there is a selection effect in the decision to transition to organic production. Our analysis also showed that there is a statistically significant, positive relationship between conventional yields and organic yields on the same farm. Together, these findings imply that data derived from farms that have chosen to adopt organic management likely understate the organic yield potential for the full

population of conventional crop producers. This has important ramifications both for business planning and for the design and implementation of organic crop insurance products. A manuscript is currently under review that presents a dynamic programming model of the transition process. This model uses yield, return, and cost data from long-term experiments at the Southwest Research and Outreach Center in Lamberton, MN as well as data from the farm records of project participants. It provides insights on the economic forces that shape the timing of the transition decision and conditions under which transitioning or certified farms might shift back to conventional production methods. The annual survey of TFT farmers identifies key management, regulatory, production and marketing issues. Results from the most recent survey, conducted in November and December 2013, identify significant problems facing transitioning and recently certified farmers. Overall time requirements, access to capital, current profitability, and cash flow challenges were identified as medium or big management problems by 10 or more survey respondents. Cost and availability of inputs, yields, weed management, and access to land were identified as medium or big problems by 10 or more survey respondents. No regulatory or marketing issues are identified as medium or big problems by 10 or more survey respondents. Complete survey results are posted on the project's eOrganic web site (http://eorganic.info/toolsfortransition/reports). **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Delbridge, T.A and King, R.P. 2014. ?The Conventional-Organic Yield Gap: Evidence from Farm-Level Data.? Selected paper presented at the Annual Meeting of the Agricultural and Applied Economics Association, Minneapolis, MN, July 2014. (http://purl.umn.edu/170561)

2012/09/01 TO 2013/08/31 What was accomplished under these goals? Project team members have analyzed all available financial and production records for participating farms. In some cases, these records are for years prior to the start of the project, since some participating farms were enrolled in the Farm Business Management program when they were recruited. Confidentiality restrictions continue to limit our ability to release financial performance results until more data have been collected, but we are able to report some preliminary enterprise analysis results. In order to combine data from multiple years, we have normalized crop yields by dividing them by the county average yield for the county in which each Tools for Transition (TFT) farm is located. Prior to transition, TFT farms had conventional alfalfa yields slightly above the county average. This slight yield advantage continues during transition and after certification. Prior to transition, conventional corn yields on TFT farms averaged 86 percent of their county average. During transition, that ratio drops to 76 percent of county average and after transition it falls to 72 percent of county average yield. Prior to transition, conventional soybean yields on TFT farms averaged 97 percent of their county average. During transition, that ratio drops to 76 percent of county average and after transition it falls to only 57 percent of county average yield. For dairy, pre-transition milk production, feed cost and net return per cow are all well below regional averages. During transition, milk production falls, feed costs rise, and net return falls relative to regional averages. After certification, production per cow and feed costs are below regional averages, and net return per cow is well above the regional average. The annual survey of TFT farmers identifies key management, regulatory, production and marketing issues. Results from the most recent survey, conducted in November and December 2012, identify significant problems facing transitioning and recently certified farmers. At least 40 percent of TFT farmers identify overall time requirements and cash flow challenges as medium or big management problems. Cost and availability of inputs, yields, and weed management are identified as medium or big problems by at least 40 percent of TFT farmers. No regulatory or marketing issues are identified as medium or big problems by at least 40 percent of TFT farmers. Analysis of farm record data and survey responses is being complemented by the development of the dynamic programming model of the transition process. This model currently uses yield, return, and cost data from long-term experiments at the Southwest Research and Outreach Center in Lamberton, MN, but data from the farm records of project participants also are being integrated into the analysis. This model can provide insights on the economic forces that shape the timing of the transition decision and conditions under which transitioning or certified farms might shift back to conventional production methods.

2011/09/01 TO 2012/08/31 Confidentiality restrictions limit our ability to release financial performance results until more data have been collected, but we can report some preliminary results. Prior to initiating organic transition, compared to Minnesota state average dairy farmers, Tools for Transition (TFT) project participants: (i) had smaller dairy operations (TFT farms milked an average of 94 cows before transition compared to the state average of 120 cows.), (ii) had lower production per cow (Annual conventional dairy production for TFT farms averaged 17,300 lbs/cow compared to nearly 21,000 lbs/cow for dairy producers statewide. TFT farms with certified herds average 13,300 lbs/cow of organic milk.), and (iii) were equally profitable. (Despite lower per cow production, TFT farms were able to achieve nearly equal rates of return on assets as the state conventional dairy average.) We also can make some qualitative observations about transition strategies. Transitioning TFT farmers generally fall into four groups: (i) conventional dairy farmers, most with relatively small farms and a median herd size of 80, (ii) conventional crop farmers using a diversified three- or four-year rotation prior to beginning

transition, (iii) certified organic crop farmers expanding by transitioning newly purchased or rented land or by transitioning additional acreage from conventionally managed cropland, and (iv) absentee landowners and part time farmers transitioning land that was previously fallow or enrolled in the Conservation Reserve Program. We observe the following transition strategies. (i) Dairy farmers almost always transition land first before transitioning the herd. The majority of dairy farmers keep land in alfalfa or other forage crops throughout transition. (ii) Crop farmers transition land gradually, many with two or three distinct transition periods for different fields. This gradual transition allows experimentation with management alternatives. (iii) Most livestock and crop producers plant land to alfalfa throughout the transition period and establish a rotation of row crops and small grains once land is certified. This facilitates weed control throughout transition, and a high-value crop can be planted in the first year that the land is certified. (iv) Landowners with acreage in long-term pasture or coming out of the Conservation Reserve Program can certify land immediately without an actively managed transition period. These farms have often changed ownership or are undertaking a significant shift in overall farm strategy. According to the survey results, a large percentage of TFT farmers purchased equipment, animals, or land and/or increased their use of hired labor and consultants when beginning to transition land. Some transitioning farmers increased the amount of rental land. Cash flow management and access to capital are the most important management challenges for TFT farmers. Cost and availability of inputs and weed management are the most important production problems. Finding buyers, proximity to markets, organic price volatility and high prices for conventional crops are the most important marketing challenges.

2010/09/01 TO 2011/08/31 At this early point in the project, we do not have significant outcomes or impacts for external audiences based on the farm record data we are collecting. Members of our project team have learned that there is much greater diversity than expected in the range of strategies farmers are using to transition to organic production. As financial and demographic data from the first year of the project starts to come in through FINPACK and farmer surveys during the winter of 2012, we will be better able to describe and quantify this diversity for audiences outside of our project. The Minnesota Guide to Organic Certification (originally published in 1998) has been updated as part of this project and has been made available to all participating farmers. Finally, the whole farm analysis of the VICMS trial data has yielded some interesting results. Starting with a fixed machinery set for tillage and grain harvesting, we find that the number of acres that can be farmed organically is considerably less than that for a conventional operation. From a profitability and risk management standpoint, however, the smaller organic operations would be preferred by all decision makers who are risk neutral or risk averse. This has important implications for farms in transition, since it suggests that they may downsize as part of the transition process. In many cases, this could mean terminating leases on some or all rented land. These results were distributed to team members via the eOrganic website and to broader audiences at an organic field day held in Lamberton, MN and at the annual meeting of the Agricultural & Applied Economics Association in Pittsburgh, PA.

PUBLICATIONS

2012/09/01 TO 2013/08/31 1. Type: Journal Articles Status: Published Year Published: 2013 Citation: Delbridge, T.A.; Fernholz, C.; King, R.P. and Lazarus, W. 2013. ?A whole-farm profitability analysis of organic and conventional cropping systems.? Agricultural Systems 122:1-10. 2. Type: Other Status: Published Year Published: 2013 Citation: DiGiacomo, G. 2013. ?Couple?s Determination Yields 1,300 Acres of Organic Cropland.? Organic Broadcaster 21(3):4,13.

2011/09/01 TO 2012/08/31 1. Delbridge, T.A. and King, R.P. 2012. Conversion to organic farm management: a dynamic programming approach. Poster presented at the annual meeting of the Agricultural & Applied Economics Association, Seattle, WA. (http://purl.umn.edu/124928) 2. DiGiacomo, G. 2012. Profile: Rory Beyer, Recently Certified Organic Dairy. Organic Broadcaster 20(4):1,10. 3. DiGiacomo, G. 2012. Walters Transition Dairy to Increase Profits. Organic Broadcaster 20(6):1,8.

2010/09/01 TO 2011/08/31 1. Delbridge, T.A., Fernholz, C., Lazarus, W.F., and King, R.P. 2011. A whole farm analysis of organic and conventional cropping systems. Paper presented at the annual meeting of the Agricultural & Applied Economics Association, Pittsburgh. PA. (http://purl.umn.edu/103790) 2. Riddle, J. and Gulbranson, L. 2011. Minnesota Guide to Organic Certification. University of Minnesota, Minnesota Institute for Sustainable Agriculture. (http://www.misa.umn.edu/prod/groups/cfans/@pub/@cfans/@misa/document s/asset/cfans asset 335916.pdf) ** **

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Organic Dry Bean Production Systems

Accession No.	0222485
Subfile	CRIS
Project No.	MICL05040
Agency	NIFA MICL
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21224
Proposal No.	2010-01904
Start Date	01 SEP 2010
Term Date	31 AUG 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Renner, K. A.; Taylor, E. C.; Kelly, J. D.; Sprague, C. L.; Mutch, D. R.; Rossman, D. J.; DiFonzo, C. D.
Performing Institution	Plant, Soil and Microbial Science, MICHIGAN STATE UNIV, EAST LANSING, MICHIGAN 48824

NON-TECHNICAL SUMMARY

Crops compete with weeds. The goal in all production systems is to tip the competitive balance to favor the crop over the weed. The choice of crop variety is of utmost importance in this battle. If a variety is \"competitive\" it will emerge well under stressful conditions, capture moisture, light, and available nutrients, suppress weeds, and be tolerant of insect pests and diseases. For centuries plant breeders have been selecting for varieties that have the highest yields under pest-free and nutrient-rich conditions. Organic farmers need varieties that perform well under their production systems which may differ in nutrient availability and pest pressure compared with conventional systems. In conventional production systems navy bean cultivars yield more than black bean cultivars. However, black beans produced greater yields than navy beans in organic trials. These yield differences in dry bean class and variety may in part be due to differences in nitrogen fixation and uptake by bean root systems. Nitrogen availability in organic systems is largely dependent on the crop rotation, including the planting of cover crops. Red clover is a common cover crop which when tilled into the soil supplies an available form of nitrogen for the following crop. Rye and oilseed radish are not legumes, but both may increase nitrogen availability to dry beans by mineralization of nitrogen during the summer months. By researching the incorporation of cover crops into organic dry bean production systems we will determine which cover crop (or lack thereof) supports the nodulation and uptake of nitrogen for optimum seed yield in organic dry bean production systems. Including cover crops prior to planting dry beans may help in weed suppression. Some cover crops such as cereal rye suppress germinating weed seedlings due to release of allelopathic compounds. However, weed suppression by these compounds is short-lived and therefore producers must manage emerging weeds by other means, including rotary hoeing and cultivation. The vigor of the dry bean variety is very important because it is difficult to cultivate weeds when the crop is not growing vigorously. Furthermore, cover crop residues may assist or hinder weed management by mechanical methods in the weeks following dry bean planting. On-farm trials will provide much needed information on how to manage weeds in cover crop/no cover crop residue situations in organic dry bean production. Organic dry bean producers must also manage insect and disease pests. In this regard cover crops can be either a help or a hindrance. For example, \"Colonel\" oilseed radish is a well known variety that suppresses nematode pests. On the other hand, if beans are planted too close to the incorporation of a cover crop insects like seed corn maggot can become a problem. Western bean cutworm is a relatively new pest that is

of concern to all dry bean producers. It is currently unclear what role dry bean variety and cover crops play in negating or enhancing the infestation of this pest.

OBJECTIVES

Our long term goal is to provide dry bean variety and pest management recommendations to improve organic dry bean production systems. Dry bean farmers (navy, black, pinto, kidney, cranberry, etc.) are \"row crop\" growers, rotating fields with corn, soybeans, and small grains. Dry beans are nodulating legumes but require additional nitrogen for optimum seed yield. Cover crops are an important component of organic production systems to suppress weeds, improve soil quality, and provide nutrients, including nitrogen, for optimum crop production. We need to develop dry bean varieties suited to organic production systems, and provide dry bean growers with weed and pest management recommendations to increase organic acreage and improve the profitability of organic dry bean production. Long term goals: -Provide information regarding varieties of dry beans that are best suited to organic production -Determine dry bean varieties that make the best use of atmospheric and soil-available nitrogen -Develop recommendations regarding the best species of cover crop(s) to plant prior to dry bean for synchronization of nitrogen release by the cover crop residues and nitrogen demand by the dry bean -Improve recommendations for weed and insect management in organic dry bean production following cover crops -Expand the dry bean breeding program to select for characteristics that favor organic cultural practices Our proposal has six objectives that encompass our overall goal to provide U.S. dry bean growers with variety, cover crop, and pest management recommendations to improve organic dry bean production systems. Our proposal includes on-farm research on six organic farms in Michigan, as well as research at two MSU experimental research stations with certified organic ground. We have numerous stakeholders involved in our proposal, including six organic producers that will have on-farm research during each year of the project, personnel at our university research locations, extension educators, farmers, and members of the Michigan Dry Bean Commission and the U.S. Dry Bean Council. Our specific objectives are as follows: 1. Identify dry bean varieties that are best suited for organic production, including nitrogen demand and nitrogen fixation through nodulation (1a and 1b), the ability to tolerate prolonged mechanical weed management (1a), and dry bean production and seed yield in cover crop systems (1a). 2. Measure soil nitrogen availability in dry beans planted in rotation following cover crops. 3. Determine if cover crops prior to dry beans influence weed emergence and growth and mechanical weed management 4. Evaluate key insects pests in organic dry bean production as influenced by variety and cover crops prior to planting. 5. Expand dry bean breeding activities to select for traits that are best suited to organic production. 6. Educate growers and the agricultural community on organic dry bean production through extension efforts.

APPROACH

Overall approach for Objectives 1a, 2, 3, and 4: This study has two types of experimental sites: MSU certified organic research land and on-farm organic grower land. The cover crops oilseed radish and cereal rye will be seeded following oats in the year prior to dry beans. Red clover will be frost-seeded into the oats. The cover crops will winter-kill or be controlled by tillage in the spring. The on-farm growers will select only one cover crop to plant. Dry beans will be planted in June and harvested at maturity. Zorro and Jaguar black bean and Vista and R99 navy bean will be planted at the two MSU research farm sites. At the on-farm locations, Zorro black bean and Vista navy bean will be planted. The dry beans will be harvested by hand at all plot locations. Seed weight, nitrogen, and percent moisture, will be determined. Objective 1a. All sites will be visited each week to manage the observations and measurements as outlined above. Objective 1b. At one MSU site and one on-farm site, an elite group of 30 advanced navy and black bean breeding lines will be evaluated under organic production management systems to identify superior individuals best adapted to this production system. Measurements will include: stand counts, flowering, maturity, plant height, lodging, occurrence of disease, yield, nitrogen fixation, total nitrogen, % protein, and processing quality. Objective 2. Soil nitrogen data, coupled nitrogen fixation capability will allow us to make recommendations about the importance of nitrogen and the timing of N availability in organic production systems with/without cover crops. Significant relationships between dry bean seed yield and soil nitrogen will be statistically determined. Objective 3. All cover crop planting and management information will be recorded in addition cover crop biomass, weed biomass and emergence, dry bean response to cultivation, and on-farm grower observations. Objective 4. At all locations and in all plots, insect pressure will be recorded regularly, specifically looking for seed corn maggot, armyworm, leaf hopper, bean leaf beetle, Japanese beetle, and western bean cutworm. These observations will be used to determine resistant varieties of beans and if and when organic herbicides need to be applied. All insect data will be analyzed to determine the influence of cover crop and dry bean variety on insects. Objective 5. A combination of field and greenhouse screening will be used to phenotype populations for ability of individual RILs to fix N. Winter nurseries at the Univ. of Puerto Rico,

Mayaquez will be used to gather additional data. To complement this work the same RIL populations will be genotyped with microsatellite markers to identify QTL associated with the nitrogen fixation trait. Significant QTL will be used in future breeding programs to improve the nitrogen fixation capacity in a broader range of bean seed types. Objective 6. The research-based information on dry bean production in organic systems will be delivered to growers and the agricultural community using various web-based and printed materials as well as through presentations.

PROGRESS

2010/09 TO 2015/08 Target Audience:The target audience was organic growers in the Midwest, and those interested in organic production throughout the U.S., including other researchers. We had field days in Michigan that farmers attended in 2013 and 2014. We had a webinar in 2014 that was attended by 105 people (live), and archived on the eOrganic web site. We have presented papers at various conferences on the results of this research, regionally and nationally. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?We presented a webinar in March 2014 \'Breeding efforts and cover crop choices for improved organic dry bean production systems in Michigan.\' We had farmer field days in 2013. We presented our results at professional meetings in 2013 and 2014 and at the Organic Ag Research Symposium at Lacrosse WI in 2015. Two Ph.D. student disserations were published from this research. How have the results been disseminated to communities of interest?We presented a webinar in March 2014 \'Breeding efforts and cover crop choices for improved organic dry bean production systems in Michigan.\' We had farmer field days in 2013. We presented our results at professional meetings in 2013 and 2014 and at the Organic Ag Research Symposium at Lacrosse WI in 2015. Two Ph.D. student disserations were published. Two refereed journal articles are in press; three additional refereed journal articles are planned for 2016. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2013/09 TO 2014/08 Target Audience: Target audience has been organic growers in Michigan, those interested in organic production throughout the US, including other researchers. We had field days where farmers attended and we had a webinar that was attended live by 105 people and was archived on the eOrganic web site. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? eOrganic webinar was produced byour research group produced in March 2014, entitled, "Breeding efforts and cover crop choices for improved organic dry bean production systems in Michigan." How have the results been disseminated to communities of interest? eOrganic webinar by our research group was produced in March 2014, entitled, "Breeding efforts and cover crop choices for improved organic dry bean production systems in Michigan." . In 2014 we presented ata meeting by an organic processor group in MI that was attended by 60 individuals. We also presented at a Bean Improvement Cooperative meeting in October. What do you plan to do during the next reporting period to accomplish the goals? We will be completing our last year and disseminating our results at professional meetings, submitting to refereed journals the results of our research, and presenting to growers in various venues, including the Organic Ag Research Symposium in February 2015 at Lacrosse, WI

2012/09 TO 2013/08 Target Audience: Organic producers of dry edible beans, agronomists, and other researchers and extension personnel in Michigan and the U.S. were target audiences with presentations during this reporting period. 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? We have presented at professional society meetings the results of our research and will continue to do so. We have held organic grower field days in MI; in the summer of 2013 we had four field days where a total of 70 organic producers attended. We will analyze and summarize three years of research data in the next nine months and submit our data for publication in refereed journals and provide information to farmers throughout the U.S. in an appropriate format. What do you plan to do during the next reporting period to accomplish the goals? We have presented at additional professional society meetings in late fall 2013 and in 2014. We will summarize our data and publish in referred journals the results of our research. We will also present a summary of our data to organic producers during the next 9 month period.

2011/09/01 TO 2012/08/31 OUTPUTS: This research includes the development of organic black and navy bean varieties, and research on organic production systems, including cover crops and their impact on nutrient and pest management. Seed classes that yielded well in the organic system in previous research included the black-seeded genotypes; black beans also had high seed N accumulation(36%). A field experiment was conducted at two Ag Bioresearch locations in Michigan in 2011 and 2012. The cover crops studied included: medium red

clover, oilseed radish, and cereal rye; a no cover treatment was also included. Within each cover crop treatment there were four bean varieties: \'Zorro\' and \'Black velvet\' black beans and \'Vista\' and \'R-99\' (non-nodulating mutant) navy beans. In 2011, the clover cover crop and the no cover crop treatments (weed infestation only) had the greatest peak biomass production (3500 kg/ha) at the Kellogg Biological Station (KBS), followed by oilseed radish (2,200 kg/ha) and rye (1,800 kg/ha). At the Student Organic Farm (SOF), rye was not controlled in early spring because of continuous rainfall patterns, resulting in the greatest peak biomass. In both years, bean chlorophyll florescence at V2 was highest following a clover cover crop, though the difference between cover crop treatments was not always significant. Soil nitrogen was greater in in the clover treatments in both years at KBS and at the SOF in 2012 only, when measured at planting and when beans were at the second trifoliate growth stage. At the SOF, bean yields following oilseed radish (2,700 kg/ha), clover (2,300 kg/ha), and no cover (2,200 kg/ha) were higher than beans following rye (1,500 kg/ha) in 2011. Reduced bean yields following rye may be the result of rye reducing soil moisture early in the season and immobilizing nutrients. Cover crops did not influence bean yield at KBS in 2011. In 2012, bean yields were greater in the no cover and oil seed radish plots at the SOF; at KBS yields were greatest in the oil seed radish plots. PARTICIPANTS: Karen Renner James Kelly Christy Sprague Dale Mutch Dan Rossman Chris Difonzo Erin Taylor Jim Heilig TARGET AUDIENCES: Organic bean producers Farmers that utilize cover crops in bean production systems Agribusiness personnel in dry bean production regions PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: Research at the Michigan State University Student Organic Farm (East Lansing, MI), at the Kellogg Biological Station (Hickory Corners, MI) during the 2010-2011 growing season, and at nine on-farm locations determined the effect of cover crops on weed suppression, nitrogen availability, dry bean populations, and yields in organic farming systems. Cover crops included medium red clover, oilseed radish, and cereal rye; and a no cover treatment was also included. On-farm locations planted one cover crop; research farm sites had all cover crops planted. At the research farms there were four bean varieties: Zorro and Black Velvet black beans and Vista and R-99 (non-nodulating mutant) navy beans. At the nine on-farm locations, Zorro black bean and Vista navy bean were planted in early to late June and harvested in late September and October. Seeding rates were 296,400 seeds ha-1, a 20% higher seeding rate than recommended in conventional dry bean production systems to account for crop removal with mechanical weed control measures. Weed biomass and populations by species were recorded at two times, 1) V2 bean stage- after early season weed management was complete (i.e. tined weeding and rotary hoeing) 2) R5 bean stage- following final cultivation. Throughout the course of the experiment several methods were used to monitor nitrogen availability, including the use of a chlorophyll meter at numerous stages of bean development (V2, R1, and R5). Dry bean populations were recorded at the V2 stage and at harvest prior to taking yields. There was a wide range of weed management practices at the nine farm locations. Weeds were effectively managed in organic black and navy bean production at six of the nine locations by rotary hoeing or tine weeding once, followed by either one or two cultivations. At three locations black beans yielded 3,100 to 3,500 kg ha-1, three locations had yields from 2,400 to 2,800 kg ha-1, and three locations had yields from 1,600 to 1,900 kg ha-1. The three low-yielding farms rotary hoed and cultivated more frequently than the other six farms because of greater weed populations as measured by weed biomass at the V2 growth stage of dry beans. There was only a significant difference among covers for weed suppression at the V2 bean stage at the KBS research location. At both the V2 and R1 stages, bean chlorophyll florescence was highest in the beans following a clover cover crop, though the difference was not always significant. At the Student Organic Farm, bean yields following oilseed radish were higher (2,700 kg ha-1), clover (2,300 kg ha-1), and no cover (2,200 kg ha-1) were higher than beans following rye (1,500 kg ha-1). These reduced yields could be the result of the rye reducing soil moisture early in the season and immobilizing nutrients. No differences in yield based on cover crop treatment were observed at the Kellogg Biological Station. Outputs: None to date. PARTICIPANTS: Karen Renner, Professor; Christy Sprague, Associate Professor; Erin Taylor, Research Assistant. TARGET AUDIENCES: Farmers PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/08 What was accomplished under these goals? Seventy-nine black and navy bean elite breeding lines and commercial varieties were evaluted for yield in certified organic fields atthree locations over a three year period. The same genotypes were also assayed for nodulation characteristics. The percent of nitrogen in the grain derived from the atmosphere in the greenhouse was correlated with seed yield, N grain yield, and field N fixation, suggesting that enhanced symbiotic nitrogen fixation traits could improve productivity in organic systems. The inheritance of enhanced symbiotic nitrogen fixation was investigated in the greenhouse and in the field, and a quantitative trait loci (QTL) analysis of the phenotypic data was conducted using single nucelotide

polymorphism (SNP) markers developed through the BeanCAP. Nineteen QTLs associated with symbiotic nitrogen fixation traits were identified. The majority of QTLs associated with genes expressed in the root or nodule were derived from Puebla 152 while QTLs associated with genes with enhanced expression in pods were associated with Zorro black bean. This follows a pattern where Puebla 142 has superior symbiotic nitrogen fixation ability, whereas Zorro is highly efficient in partitioning the fixed N into the seed. The QTLs described will serve as potential targets for improved nitrogen fixation in adapted commercial dry bean genotypes. In our three year field study, navy bean and black bean responded to cover crops similarly and showed few differences with regard to nodulation, tolerance of mechanical weed control, and yield. The non-nodulating variety R-99 had less total grain N and yield, showing the benefit of symbiotic nitrogen fixation. Cover crops influenced soil inorganic N. Soil inorganic N increased following red clover by as much as 34 kg/ha at planting and 55 kg/ha at the V2 dry bean growth stage compared with the no cover crop control. Bean yield did not increase compared to the no cover control, but grain N increased by up to 32% in some site-years following red clover. Cereal rye reduced soil inorganic N in some instances and caused early maturity of beans in two of six site-years. Grain N was not affected. Oilseed radish had very little impact on soil inorganic N, bean maturity, yield or grain N. Cereal rye and oilseed radish did not impact weed biomass during the dry bean growing season. A red clover cover crop increased weed biomass in dry bean when soil inorganic N increased due to a clover biomass that exceeded 5 Mg/ha. Weed seed persistence was influenced by cover crop residues in some years. Common lambsquarters seed persistence decreased in one year following red clover; giant foxtail and velvetleaf seed persistence increased in one year following cereal rye, as compared to the no cover control. Western bean cutworm damage was not influenced by dry bean variety or presence of a cover crop in the one year of research. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/08 1. Type: Theses/Dissertations Status: Accepted Year Published: 2015 Citation: Hill, E. 2015. Cover crop influence on nitrogen availability, weed dynamics, and dry bean (Phaseolus vulgaris) characteristics in an organic system. pp. 224. 2. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: Hill, E.C., K.A. Renner, C. L. Sprague, and A. S. Davis. 2015. Cover crop impact on weed dynamics in an organic bean system. Weed Sci. 64: in press. 3. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: Hill, E. C. , K. A. Renner, and C. L. Sprague. 2016. Cover crop impact on nitrogen availability and dry bean in an organic system. Agron. J. 108:1-13. 4. Type: Theses/Dissertations Status: Accepted Year Published: 2015 Citation: Heilig, J. A. 2015. QTL Mapping of symbiotic nitrogen fixation in dry bean: evaluation of dry bean genotypes under organic production systems.

2013/09 TO 2014/08 What was accomplished under these goals? Our dry bean variety research suggests that black beans tend to yield more than navy beans in organic production systems. The nitrogen derived from the atmosphere does not appear to differ between black and navy bean genotypes indicating that perhaps other mechanisms may be involved in the yield difference seed in black and navy beans. Selection of appropriate dry bean varieties for resistance to diseases such as common bean blight is important to help improve yield. Several of the lines from the Puebla 152/Zorro population (such as B11603, B11551, and B11569) produced above average yields for the populationwhile half of the nitrogen found in the seed was derived fromthe atmosphere through fixation. Cover crops sometimes altered the soil environment during the dry bean growing season by changing soil moisture at planting and by influencing soil inorganic nitrogen throughout the growing season. Soil inorganic nitrogen often increased following red clover (\< 2.5 tons acre-1 dry biomass at the time of incorporation) compared with the no cover crop control, resulting in some instances in increased weed density and biomass, increased chlorophyll content in bean leaves and greater grain nitrogen content; dry bean yield however was not affected. Cereal rye reduced soil inorganic nitrogen and bean leaf chlorophyll in some instances, and caused early maturity of the beans. At maximum biomass production (5.4 tons acre-1), rye reduced dry bean yield. Oilseed radish occasionally increased inorganic nitrogen availability and populations at the V2 dry bean stage, but had no impact on nodule numbers, percent nitrogen derived from the atmosphere, chlorophyll readings, maturity, yield, or grain nitrogen. **PUBLICATIONS (not previously reported):** 2013/09 TO 2014/08 Type: Conference Papers and Presentations Status: Published Year Published: 2014 Citation: Hill, E., K. Renner, and C. Sprague. 2014. Impact of cereal rye and red clover on weed seed mortality. Weed Science Society of America annual meeting. 63. Vancouver, BC. Poster.

2012/09 TO 2013/08 What was accomplished under these goals? 1) and 5) A black bean recombinant inbred line (RIL) population resulting from a cross of the landrace selection Puebla 152 and the commercial black bean variety Zorro was developed to study the genetics of BNF and transfer the enhanced BNF ability of Puebla 152 (Type III growth habit) into the efficient Zorro (Type II). RILs were genotyped using the SNP (single nucleotide polymorphism) markers developed by the BeanCAP project. Phenotypic data was recorded in the field, greenhouse, and lab. Quantitative trait loci (QTL) analysis for traits such as root biomass and distribution, biomass, and percent N derived from the atmosphere (Ndfa) associated with BNF was conducted. Agronomic

and BNF traits tended to colocalize, with several QTL for traits such as shoot to root ratio, shoot height, N in biomass and harvest index all being located between SNP markers ss715645852 and ss715650565 on bean chromosome Pv01; maturity, Ndfa in roots, root biomass, and percent N in seed between SNP markers ss715647551 and ss715645213 on Pv03; percent N in biomass and vigor between SNP markers ss715645785 and ss715650222 on Pv06; yield and N yield in seed between SNP markers ss715645234 and 22715644972 on Pv07; harvest index, N yield in seed, Ndfa seed, and percent N in seed between SNP markers ss715648540 and ss715646686 and N yield in seed, percent shoot N, flowering, lodging, vigor, biomass, and N yield in seed between SNP markers ss715646764 and ss715648408 on Pv08. These QTL will be utilized in breeding future bean genotypes with enhanced BNF. 2) - 4) Bean chlorophyll meter readings were highest following a clover cover crop. Later in the season, at R5, beans following a rye cover crop had lower readings than the other covers. Soils samples throughout the season (and ion exchange resin samples, at some timings and locations) also support that there was more available nitrogen following a clover cover crop. A rye cover crop reduced the amount of available soil nitrogen to beans, particularly in the form of nitrate. Bean populations at V2 and at harvest were higher following rye and oilseed radish cover crops than clover and no cover. Bean yields were lowest following a rye cover crop, due to nutrient immobilization. Though beans following clover did not have improved yields compared with oilseed radish and no cover, analysis of the grain showed an increase of 6 µg N/mg of grain following clover. A third year of data collected in 2013 will be included in our final data analysis 6) Organic field tours were held at 4 locations with a total of 70 organic bean growers in attendance. Results of the research to date were discussed. **PUBLICATIONS (not previously reported):** 2012/09 TO 2013/08 Type: Conference Papers and Presentations Status: Published Year Published: 2013 Citation: Taylor, E., K. Renner, and C. Sprague. 2013. Cover crop influence on weeds in organic dry beans. Weed Science Society of America annual meeting. 125 Taylor, E. K. Renner, and C. Sprague. 2013 Cover crop influence on weeds in organic dry beans. \@013 Michigan State University Organic Reporting Session. Hill, E. 2013. Cover crop influence on organic dry beans (two years of OREI project results, third year observations). Plot tours at 3 locations attended by a total of 70 farmers

2011/09/01 TO 2012/08/31 The results of this research will allow organic bean producers to choose bean classes and varieties that yield well in organic production systems. Organic growers will see the impact of cover crops on nutrient and pest management in organic production systems, allowing them to design a production system that optimizes nutrient and pest management and bean yield and quality.

2010/09/01 TO 2011/08/31 None to date. This project just started.

PUBLICATIONS

2011/09/01 TO 2012/08/31 1. Taylor, E., K. Renner, and C. Sprague. 2012. Cover crop influence on nitrogen availability for organic dry beans. ASA, CSSA, and SSSA International Annual Meeting. 141-3. Cincinnati, OH. Oral presentation. 2. Heilig, J.A., and J.D. Kelly. 2012. Performance of dry bean genotypes grown under organic and conventional production systems in Michigan. Agron. J.104:1485-1492. doi:10.2134/agronj2012.0082.

2010/09/01 TO 2011/08/31 1. Taylor, E.C., K.A. Renner, and C. L. Sprague. 2011.Incorporating cover crops into organic dry bean production systems. Proc. North Central Weed Sci. Soc. 66:227. 2. Renner, K.A., E. C. Taylor, and C. L. Sprague. 2011. Organic Farmers Weed Control Strategies in Dry Beans. Proc. North Central Weed Sci. Soc. 66:2.

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Using Winter Cover Crops to Enhance the Organic Vegetable Industry in the Mid-atlantic Region

Accession No.	0222422
Subfile	CRIS
Project No.	MD-ENTO-0525
Agency	NIFA MD.
Project Type	OTHER GRANTS
Project Status	EXTENDED
Contract / Grant No.	2010-51300-21412
Proposal No.	2010-01954
Start Date	01 SEP 2010
Term Date	28 FEB 2015
Grant Amount	$0
Grant Year	2010
Investigator(s)	Hooks, C. R.; Wang, K. H.; Brust, G.; Mathew, S.
Performing Institution	Entomology, UNIV OF MARYLAND, COLLEGE PARK, MARYLAND 20742

NON-TECHNICAL SUMMARY

Many small- or intermediate scale farmers have limited land and thus tend to grow similar crops in the same fields for several consecutive years and also may grow two crops in a field during the same growing season. This double cropping practice may elevate pest problems and require more off farm inputs, thus increasing production costs. For example, plant diseases incited by soilborne fungi and nematodes are common occurrences in many vegetables. Root diseases are most severe and cause considerable losses to vegetables when soil conditions are poor such as low soil fertility, high compaction with inadequate drainage or low organic matter content. Root diseases are also prevalent when susceptible crops are grown continuously in the same fields. This practice is also suitable for the proliferation of several weed species. Cover crops can be used to reduce disease and weed incidence by reversing soil characteristics that make conditions more conducive to weed proliferation and plants more susceptible to soilborne diseases. Traditionally, mid-Atlantic vegetable farmers who use cover crops as part of their production practices, grow cover crops during the off season (fall and winter) and till the entire stand under prior to planting their cash crop in late spring or summer. However, inter-planting a cash crop into the cover crop could offer one alternative to reduce below (e.g., fungal diseases, plant-parasitic nematodes, weed seeds) and above ground pests for two cropping cycles. A better management approach is to till in row areas only where the cash crop is to be planted and use the remaining cover crop as a surface residue and/or living mulch. After the first crop is harvested, cover crop rows that remained during the initial crop planting can be strip-tilled and the second cash crop planted into the newly tilled strips. A similar approach was successfully used in cotton to manage nematodes. A second cotton crop was planted in the alley between previous cotton rows. By season end, plant-parasitic nematode densities were lower in the new cotton rows than the initial in-row planting areas. However, we are proposing a more novel advanced \"row-switching\" approach that will further pest suppression and concurrently enhance soil quality and health. Expectations are 1) growers become more aware of cover cropping overall benefits, 2) organic farmers and others become more familiar with how to use cover crops to increase their economic sustainability, 3) cover cropping become a integral component of organic farms, 4) more growers transition from conventional to organic farming, 5) an increase in the economic viability of organic crops, and 6) future research-based organic information and locally produced organic foods more closely match the needs of local producers and consumers. As such, more agribusinesses, growers, pest control professionals, crop advisors, and consumers will be enlisted into the project so that organic stakeholders\' needs can be

addressed timely. A continuous effort will be made to promote the exchange of ideas and information between growers, grower participants, extension specialists, grower groups, consultants and others.

OBJECTIVES

GOALS/OBJECTIVES: The main goal is to demonstrate how cover crops (e.g., crimson clover, Trifolium incarnatum; barley, Hordeum vulgare, etc.) can be used as surface residue, green-manure, and living mulch within the same field to increase the productivity of double-cropped organic vegetable systems. Specific objectives are to: 1) examine the direct and indirect effects of winter cover cropping on insect, plant diseases, and the weed community; 2) study how winter cover cropping impact beneficial organisms; 3) determine the impact of winter cover cropping on soil quality and health; 4) assess winter cover crop impact on vegetable productivity and yield; and 5) provide organic vegetable producers a comprehensive best management practice plan. The long-term goal is to introduce production strategies that will prolong and improve the productivity, quality, environmental health and size of organic farms resulting in greater ecological and economical sustainability for the entire organic industry. This will be accomplished through research and outreach activities OUTPUTS: Several avenues will be used to help expand organic vegetable production. This will include 1) providing training sessions in persons and through a DVD mini series on organic vegetable farm tactics, 2) creating grower-based demonstration/training plots emphasizing cover crop use, and 3) constructing an organic vegetable section within the University of Maryland IPM website that links to the Maryland Vegetable Growers Association, Maryland Organic Food and Farming Alliance, and other associated websites, and 4) creating paid organic farm internships. To further disseminate information to local stakeholders, findings obtained from field experiments and demonstration plots will be presented with the aid of grower participants at organic meetings and conferences, joint conference/field day events, and via brochures, newsletters, interviews, and broadcast information on web-based sites. For mid-Atlantic stakeholders, significant findings will be announced on the electronic IPM news group and the University of Maryland web based PEST Net site. Expectations are 1) growers become more aware of cover cropping overall benefits, 2) organic farmers and other stakeholders become more familiar with how to use cover crops to increase their economic sustainability, 3) cover cropping become a integral component of organic farms, 4) more growers transition from conventional to organic farming, 5) an increase in the economic viability of organic crops, and 6) future research-based organic information and locally produced organic foods more closely match the needs of local producers and consumers. As such, more agribusinesses, growers, pest control professionals, crop advisors, and consumers will be enlisted into the project so that organic stakeholders\' needs can be addressed timely. However, throughout the project and beyond, a continuous effort will be made to promote the exchange of ideas and information between growers, grower participants, extension specialists, grower groups, consultants and other stakeholders at annual workshops.

APPROACH

Research Methods: Main research activities will be conducted at an organically certified farm site. Participatory demonstrations with more vegetable and cover crop mixtures will be set up at five commercial fields representing different growing environments. Farmer participatory fields will also serve as training sites where owners will be directly involved in stakeholders training. Cover crop plots will be established and grown during the fall and winter months. In the spring, these plots will be strip-tilled. Plots with grain cover crops will be mowed and strips of the mowed cover crop will then be tilled under to create rows for planting the vegetable crop. Vegetable plants will then be inter-planted into the incorporated strips. The remaining cover crop will be allowed to grow during the vegetable cropping cycle as living mulch. After the first crop is harvested, cover crop rows that remained during the initial cropping cycle will be mowed and strip-tilled, and the second crop will be planted into the newly tilled strips. The second crop will be planted into the same field plots to mimic a common double-cropping practice. For the monoculture treatment, the second crop will be planted into the same rows as the previous crop to duplicate traditional double cropping practices. Insect, disease, and weed pests will be monitored throughout each cropping cycles as well as soil health and quality parameters. Extension and Outreach: To disseminate information to local stakeholders, findings obtained from field experiments and demonstration plots will be presented with the aid of grower participants at organic meetings and conferences, joint conference/field day events, and via brochures, newsletters, interviews, and broadcast information on web-based sites. For mid-Atlantic stakeholders, significant findings will be announced on the electronic IPM news group. Conference/field day meetings and public farm tours will be conducted in partnership with farm managers, organic farmer participants, county agents, and other stakeholders. Outcome Assessments: Surveys and interviews will be conducted to assess stakeholders\' knowledge base before project initiation and yearly thereafter including beyond the project completion period. Surveys will be administered at local vegetable conferences, grower meetings, farm visits and field day events. New interactive technology (i.e., audience response systems or clickers; Turning Technologies, LLC) will be used

also to gain immediate feedback from stakeholders at each outreach event. In addition to the performance measure listed above, an IDM transition index through stakeholders\' response will be used to evaluate the project performance. The IDM transition index will be based on a scale of 0-5 and will provide us information on the level of farmer participant\'s implementation. Statistical analysis: Insect, plant growth and yield data will be statistically analyzed as a split plot with the cover crop treatment as the main plot and the biopesticide spray as the split-plot factor. Differences between treatments will be analyzed by analysis of variance and orthogonal contrasts.

PROGRESS

2010/09 TO 2015/02 Target Audience: Commercial vegetable growers (organic and conventional practicing organic IPM), consultants and scouts, extension educators and specialists, university scientists, Growers association (e.g., Maryland Vegetable Growers Association, Maryland Organic Food and Farming Association), Maryland Horticultural Society, master gardeners, consumers, and the general public. We work in all state jurisdictions including those with racial and ethnic minorities and those that are socially, economically, or educationally disadvantaged. Large, mid-sized and small growers, and future orgainic educators (e.g., student interns, graduate students, postdocs) Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? In additon to 10 undergraduates interns, four postdoctoral fellows and five graduate students have worked on various aspects of the project which included research and information dissemination to endusers via field days, presentations at commodity meetings, local and regional conferences and extension articles. How have the results been disseminated to communities of interest? Information dissemination and implementation. Several avenues were used to help transfer information to producers and other stakeholders to keep them informed and involved. This included 1) wagon tours at university research stations, 2) direct consultation via farm visits and email correspondences, 3) constructing an organic vegetable production site within the University of MD extension website, 4) uploading information on the Maryland Organic Food and Farming Association (MOFFA) website, 6) integrating project recommendations in the multi-state EB-236 Commercial Vegetable Production Recommendation guide, and 7) presentations via local, regional, national and international conferences. 1. Field day events. Field days/twilight tours (3 per year in late summer) were conducted in Southern, Western and Eastern MD during each year of the project. This included separate organic twilight tours which specifically catered to organic stakeholders. Crowds at these field day events range from 40 - 125 participants. Main goals of our field day events were to: 1) increase stakeholders\' awareness of the potential use of cover crops, conservational tillage, banded herbicide sprays and the stale seedbed method in vegetable production to manage weeds organically; 2) publicize findings of the proposed research project and address questions; 3) increase audience knowledge base on the benefits of combining tactics to managed weeds, insects, disease and soil quality and health; 4) demonstrate how innovations such as strip tillers and flail mowers can be used to manipulate cover crops so that they can provide producers more ecosystem services; and 6) encourage and heighten collaboration between project participants, extension personnel, growers and the organic community. 2. Annual Commodity Meetings. Findings from field plots were presented at local and regional commodity meetings. During winter months, there were 4 annual vegetable commodity meetings held throughout MD. The average attendance at these meetings were 50 to 60 individuals. Two additional local organic meetings that were held in MD (MOFFA Winter Meeting and The Organic Grain, Forage, and Vegetable Production Meeting (http://www. kingsagriseeds.com/event/8th-annual-organic-grain-vegetable-production-training /) in which attendance ranged from 45 to 60 persons at each venue. Regionally findings were presented at the Mid-Atlantic Fruit and Vegetable Convention (Organic section) in Hershey, Pennsylvania. 3. Extension publications. A popular UMD extension publication is Vegetable and Fruit Headline News (VFHN), which is read by \~ 2500 stakeholders, respectively in DE, PA, and VA. There is a special research issue of VFHN published at the end of the growing season that provided research updates on the project. We used this publication to provide up-to-date findings on research in real time to thousands of endusers. 4. Farmer participatory extension program. In addition to researchers, farmers shared their knowledge with other farmers not in attendance at ourteach events. Farmers report that other farmers are their main source of information. In February 2015, the project leader gave a presentation at the Southern and Central Maryland Fruit and Vegetable Growers Conference on the use of minimum tillage practices to manage weeds. One of the survey questions asked at the end of the conference was: Will you share any information in today\'s session on cover crops or minimum tillage for weed management with other farmers. Of the 51 respondents, \~ 56.9% indicated yes, 37.2% answered if the opportunity arises, and 5.9% replied no. Thus, information that farmers obtain from our extension activities was disseminated widely to fellow farmers. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2011/09 TO 2012/08 OUTPUTS: Outputs include the completion of three separate field studies of different cropping systems (broccoli, tomato and snap beans) at the university research station since the last report. Information was disseminated via commodity meetings, local conferences, and workshops held in Maryland, Delaware and Virginia. Additional information was disseminated through two field day events. One event was attended by conventional and organic producers and the second field day event targeted organic producers. On farm field trials were conducted on growers\' farms (4) to help them manage difficult insect and weed pests. PARTICIPANTS: G. Brust focus mostly on outreach activities associated with the project such as working directly with farmer participants and conducting on farm trials. S. Mathew also focus most on extension activities and working with farmer participants located in eastern Maryland. K.-H. Wang main contribution is the identification of soil health organisms and the planning of research activities that can be used to enhance their numbers and disseminating information on how cover crops can be used to enhance soil biodiversity. C.R.R. Hooks focus mainly on activities associated with the field studies but also participate in dissemination of information and working with farmer participants. Professional development include the mentoring of 7 undergraduate (interns), 3 Post doctoral fellows, and 4 graduate students contributed to the project. TARGET AUDIENCES: Targeted audience included organic producers and those persons who are interested in becoming organic producers. Because an additional aim included getting more persons confidence in transitioning land to organic farming, we also targeted conventional producer. In some instance the goal was to help those producers who are reluctant to become organic producers to at least adopt some organic management approaches. Most of the effort was through winter commodity meetings in which attendance often surpassed 75 individuals. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2010/09/01 TO 2011/08/31 OUTPUTS: This is the 1st complete year of a research/extension project in which the long-term goal is to introduce production strategies that will prolong and improve the productivity, quality, environmental health of organic farming systems resulting in greater ecological and economical sustainability. The main goal of the research portion of this project included demonstrating how cover crops can be used as surface residue, green-manure, and living mulch within the same field to increase the productivity of double-cropped vegetables grown organically. The initial field experiment was completed without any major pitfalls. Data collected on insect pests and beneficial arthropods, and the weed community is currently being input for data analysis and organisms collected below the soil are currently being identified and quantified. In addition, separate demonstration/study sites were established at four commercial organic farm sites in MD to address other issues faced by organic producers that are not being addressed at the large research site. We are currently working with a collaborator at Delaware State University so as to expand our outreach efforts to farmer participants in Delaware. During the course of the study, one twilight tour was conducted at the research facility where the study was highlighted. Three presentations that covered topics related to this project were also made a three local conferences. Two where directed solely at an organic audience and the others to minority farmers. One book chapter in which its content center on the project goals was published and another submitted for publication in an organic production manual. PARTICIPANTS: Cerruti RR Hooks - participate in all aspect of the projects Gerald Brust - mainly work with farmer participant in southern MD and plant and soil quality aspects of the field experiment. Sudeep Mathew - mostly help with information dissemination and working with farmer participants on eastern shore of MD Koon-Hui Wang - contribute to publication and soil health issues related to the field experiment Additional Collaborator from Delaware State University Dr. Rose A. Ogutu. Dr. Ogutu will help us disseminate information to organic producers in the state of Delaware and work directly with two farmer participants in the state of Delaware. TARGET AUDIENCES: Audiences mainly being targeted by this project are organic producers but information associated with the project is being disseminated to conventional growers also. Efforts to disseminate information include field day twilight tour event, field day/hand-on participation with a group of undergraduate scholars, presentations at local conferences (organic and minority), and publication through University of Marylands\' organic extension site. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

IMPACT

2010/09 TO 2015/02 What was accomplished under these goals? 1) A mentoring program was established in conjunction with Future Harvest CASA (Chesapeake Alliance for Sustainable Agriculture) of Maryland to help train 1st year organic growers whom have gone through a two year training/apprentice program administered by Future Harvest. A University of Maryland (UMD) project participant in coordination with the UMD extension program visited several organic farm sites once a week during the growing season to help growers via encouragement, advice, diagnostics, addressing pest management questions, etc. If there were problems visitations were more frequent and project participants worked with farmers to devise solutions. Much of this work

included proper diagnostics as we needed to determine the cause of the problem before developing a solution. In other instances, we listen to farmer ideas and advised them how to test their hypothesis on their farms. Training and information sessions were conducted also via annual vegetable meetings held in Maryland for organic and conventional producers. 2) We have developed a permanent organic demonstration/training site at the Central Maryland Research and Education Center-Upper Marlboro facility. We test different cover crop combinations with different tillage and no-tillage practices to develop a viable program for insect, disease and weed management in organic vegetable production systems. We also demonstrate different cover crop termination techniques (roller crimper, flail mower, cultivation, dying mulch) and display how these different termination techniques impact weed suppression. Other demonstrations include new control programs for certain hard-to-control pests in Maryland such as striped cucumber beetles, squash bugs and flea beetles as well as diseases such as phytophthora and late blight. We conduct evening field days at the beginning of August each year to show growers each of the new management programs and showcase organic research projects. We then conduct specific training sessions for growers interested in learning how to implement any of the newly introduced techniques. These training sessions occur in the November and run through the winter months and into the spring. They include field visits to growers\' farms for continued cooperation throughout the growing season. In addition to the permanent demonstration site, we developed annual demonstration/training plots in other areas of Maryland such as the eastern shore and western MD to provide information to clientele who may not make the trip to the central Maryland site. 3) The first University of Maryland operated organic vegetable production website was developed within the UMD extension webpage. In addition, project participants have had various extension articles uploaded to the Maryland Organic Food and Farming Alliance (MOFFA) webpage. A web-based tutorials for new no-tillage and weed control methods for vegetable production systems has had over 500 visitors and 18 follow-up emails or phone calls from growers or university personnel wanting more information about the program. 4) During the 4 year project, there has been \~ 10 undergraduate paid interns trained on various aspect of organic research/farming. This training included intern involvement in outreach activities such as twilight tours, commodity meetings and extension publications. 5) We formed a partnership between the University of Maryland and the Maryland Organic Food and Farming Association (MOFFA). One participant of the project is now a board member of MOFFA and helps shape their policies. 6) Another expectation was to get farmers more involved in information dissemination. A presentation was given at the Southern and Central Maryland Fruit and Vegetable Growers Conference on the use of minimum tillage practices to manage weeds in organic vegetable. One of the survey questions asked at the end of the conference was: Will you share any information in today\'s session on cover crops or minimum tillage for weed management with other farmers. Of the 51 respondents, \~ 56.9% indicated yes, 37.2% answered if the opportunity arises, and 5.9% replied no. Thus, information that farmers obtained from our extension activities is being widely disseminated to fellow farmers. 7) Information we have obtained from our field studies over the duration of the project is of benefit and being integrated into farmers current operations. An organic conference was held by UMD extension in 2014 at which attendees were asked in a blind survey whether today\'s session on organic production will benefit you and your operation. Of the 31 respondents \~ 90.5% said yea and \$6.5% indicated they were not sure. This suggest our goal of providing information that would benefit organic farmers was being reached. 8) Another goal was to provide conventional farmers the confidence to transition greater land to organic production. One strategy included showing them how cover crops can be used as an alternate to synthetic compounds for managing insect and weed pests. At a conventional vegetable conference in Sothern Maryland the question was asked how likely are you to use cover crops in your practices as a result of todays presentation/training session? Of the 30 respondents, 62% and 8% said very likely and somewhat likely, respectively. Twenty three percent of the respondents mentioned that they used cover crops already some of which were prompted by prior years outreach training and 8% indicated that they are unlikely to change to using cover crops. This suggest that these types of outreach events alone resulted in a 40% increase in farmers integrating cover crops into their production system. 9) A total of six extension articles, 14 talks and other professional papers presented, 15 field day presentations, 3 workshops, 6 additional outreach/training events, one public media, several blogs, three refereed papers published with two currently in preparation and an additional one being planned all contributable to this project thus far. Research: A total of 9 field studies were conducted during 4 growing seasons to examine the impact of cover crops (barley, crimson clover, barley+crimson clover mix) on pests, benficials and soil health. Crops studied included snap beans, broccoli and squash. Preliminary findings from these studies indicate that the response of cover crops to weeds, insect and soil health may differ according to whether a grass, legume or grass/legume mix is used as a winter cover crop in rotation with vegetable crops. However, results seem to indicate that greater ecosystem services can be obtained by using a grass/legume cover crop mix. We determined also that using a legume cover crop + organic fertilizer (chicken manure) resulted in greater soil health for an extended period of time than using the organic fertilizer or legume cover crop alone. This is important as soil health is one of the greatest concern of organic producer who mainly rely on tillage to manage weeds. We found that the lowest number of contaminants per harvested broccoli head were found in plants grown in plots consisting of crimson clover and the highest in plots containing a barley cover crop. We developed also a model double crop cover crop system. A major goal of

this project was to increase the acreage of cover crops grown in the state.The Maryland Department of Agriculture provided cost-share support for MD producers to plant 478,000 acres of cover crops in 2014. This just covers those participating in the cost-share program and does not include cover crop acreage for producer who are not registed with the cost-share program. This is a record acreage of cover crops planted in MD cover crop program. Although, the purpose of the program is for protecting water quality such as the Chesapeake Bay and sensitive water ways, our efforts in showing the pest suppression and soil health benefits of using cover crops contributed to this increase in interest and acreage. **PUBLICATIONS (not previously reported):** 2010/09 TO 2015/02 1. Type: Journal Articles Status: Published Year Published: 2013 Citation: Hinds, J. and C.R.R. Hooks. 2013. Population dynamics of arthropods in a sunn hemp zucchini interplanting system. Crop Protection. 53:6-12. 2. Type: Journal Articles Status: Accepted Year Published: 2013 Citation: Hinds, J., K.-H. Wang, S.P. Marahatta, S.L.F. Meyer and C.R.R. Hooks. 2013. Sunn hemp cover cropping and organic fertilizer effects on the nematode community under temperate growing conditions. J. Nematol. 45:265-71. 3. Type: Journal Articles Status: Accepted Year Published: 2015 Citation: Hinds, J., K.H. Wang and C.R.R. Hooks. 2015. Growth and yield of zucchini squash (Cucurbita pepo L.) as influenced by a sunn hemp living mulch. Biol. Agri. Hort. 10.1080/01448765.2015.1017736 4. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: Buchanan, Kolb, and Hooks. Weed suppression by winter cover crops: effects of cover crop identity and diversity in organic vegetable systems 5. Type: Journal Articles Status: Awaiting Publication Year Published: 2015 Citation: Buchanan and Hooks. Winter cover crops influence insect pest pressure and crop performance in organic cropping systems

2011/09 TO 2012/08 Organic growers are now aware that cover crops can be used concurrently to improve soil health and help manage insect and weed pests. Prior to the project must only viewed cover crops as a means to protect the soil from erosion during non crop period and most was unaware that cover crops could be used a tactic to manage insects. Farmers relied mostly on tillage, row covers and pesticides for managing insect and weed pests. Out of a survey of 45 in attendance at the organic field day, 42% mentioned they would try one or more of the research ideas presented to them at the organic field day and 92% found at least one piece of information useful to try on their farm or disseminate to clients. On farm trials showed new management programs work better than what growers were using but still need more refinement. However, the impact has gone beyond organic producers as conventional growers are planting 100s more acreage in cover crops. This helps protect sensitive water ways and tributaries such as the Chesapeake Bay and helps preserve wildlife. As a partial result of our efforts, one of the local commodity groups has now listed evaluating cover crop mixes as a priority in their granting RFA. This was not consider a research priority in the past. Implications are the impact goes beyond individuals farmers but now impacts scientific researchers which will subsequently result in healthier farming communities. **PUBLICATIONS (not previously reported):** 2011/09 TO 2012/08 Brust, G. 2012. Organic management of seedcorn maggots in crucifers. Vegetable and Fruit Headline News. Brust, G. 2012. spotted wing drosophila management in organic blueberries. Vegetable and Fruit Headline News.

2010/09/01 TO 2011/08/31 Its too early at this time to measure the project impacts as we have just completed one field experiment and have yet to widely disseminate our findings. However, feed back and questions obtained during the twilight field day tour event, and presentations at local conferences appears to suggest that stakeholders are opting to trying some of the production practices that we are investigating on a pilot basis. Survey data taken at one local conference indicated that many audience members 62% felt they obtained considerable new information while 23% felt they obtained some new information.

PUBLICATIONS

2010/09/01 TO 2011/08/31 1. Wang, K.-H. and C. R. R. Hooks. 2011. Managing Soil Health and Soil Health Bioindicators through the Use of Cover Crops and other Sustainable Practices. In G. E. Brust and T. Mertz \eds\. Organic Vegetable Production Manual, Published by Univ. of MD Ext. College Park,MD. http://www.mdorganicveg.umd.edu/files/Chapter4-Web Version.pdf 2. Kolb, L. and C.R.R. Hooks. 2011. Summary 2: Organic Weed Control and Ecology at CMREC. University of Maryland Extension Vegetable and Fruit Headline News, Fall 2011, pg. 12.

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