ORG Project Details

Award Year 2014

7 Research Projects

PROJECT INDEX

Strategies to Enhance De Novo Biosynthesis of Methionine for Organic Poultry

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Subfile	CRIS
Project No.	GEOW-2014-03379
Agency	NIFA GEOW
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22093
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Investigator(s)	Aggrey, S. E.
Performing Institution	POULTRY SCIENCE, UNIVERSITY OF GEORGIA, 200 D.W. BROOKS DR

NON-TECHNICAL SUMMARY

L-Methionine is an essential amino acid that is required for normal growth and development, and plays an essential role in methylation. Poultry diets are supplemented with synthesized methionine to meet requirements. The National Organic Program does not permit synthetic amino acids in organic poultry feeds although methionine is permitted with sunset date of October 2017. It is thought that the methionine pathway can be manipulated to enhance synthesis of methionine de novo. This proposal integrates nutrigenomics, classical nutrition and metabolomics, and outreach through eXtension and eOrganic and student education to ameliorate the supplementation of synthetic methionine through de novo synthesis. Our project objectives are: 1. Determine nutrient composition and bioavailability and elucidate the combination of organic feed ingredients to synthesize de novo methionine; 2. Evaluate de novo methionine requirements for starter and finisher diets in organic broilers and layers; 3. Determine the global gene methylation in organic broilers and layers when the de novo methylation strategy is employed, and 4. Perform on-farm translation of results of objectives 1-3 and development of technology transfer applications to communicate study findings to organic poultry producers, and policy markers and educate emerging students. In the long term, the outcomes of this project will elucidate the viability of commercially available organic feed ingredients not on teh National List in synthesizing de novo methionine in a cost effective way for organic poultry. We also plan on incorporating the nutrient levels of organic feed ingredients in our feed formulation program to enable practical nutritionists formulate feeds to meet requirements for organic poultry.

OBJECTIVES

Our overaching long term goal is to elucidate and decipher the viability of commercially available organic feed ingredients not on the OFPA list in generating de novo L-Methionine in a cost-effective way for organic poultry producers.Our objectives are:1. Determine nutrient composition and bioavailability and elucidate the combination of organic feed ingredients to synthesize de novo methionine2. Evaluate de novo methionine requirements for starter and finisher diets in organic broilers and layers3. Determine the global gene methylation in organic broilers and layers when the de novo methylation strategy is employed4. Perform on-farm translation of results of

objectives 1-3 and development of technology transfer applications to communicate study findings to organic poultry producers, and policy markers and educate emerging students

APPROACH

1. We will sample organic ingredients, mostly corn, soybean, wheat, wheat middling, peas, sugar beet alfafa meal and spinach. The samples will be analyzed for proximate analysis, total amino acids, betaine, choline, folate, calcium and phosphorus; We will also perform ingredient bioavailability of amino acids, betaine, choline and folate. This information will be used to build a program for feed formulation for organic poultry. We will formulate diets for this study based on the ingredient composition and bioavailability. Our major goal is to use the re-methylation pathway to regenerate methionine de novo.2. We will determine biological responses to methyl nutrients of organically fed broiler and layer. We will determine folate requirement using a 2-D rotational design with 5 levels of folate and dietary protein; Hereafter, we will design a 3-D rotational design using 5 levels of dietary protein, folate and betaine. The design will include 2 positive controls (NRC and NOSB levels). We will measure production characeristics and analyze with PROC GLM, PROC CATMOD and PROC POWER. We will generate surface responses.3. We will determine the global gene methylation of methyl nutrtion in organic broilers and layers by undertaking global methylation and transcriptomic experiments. We will laso determine the levels of SAM, dCSAM, GSH, rGSH, SAH and HCY in liver and muscle tissues will be sampled from the optimized de novo group, and the two positive control groups. This is to ascertain whether, the de novo approach is generating the necessary SAM for physiological and metabolic processes.4. We will develop technological transfer applications to communicate our findings to organic poultry producers, policy makers and emerging students. This will be accomplished by by holding county-based workshops, distance learning (webinars, podcasts and Wimba Horizaon). We will also partner with eXtension and eOrganic for the delivery of research based information. We will undertake 2 on-farm trials based on the outcomes of this project. We will include graduate students, young scholars from high school, and emerging undergraduate students and both research and technology transfer.

PROGRESS

2014/09 TO 2018/08 Target Audience:Our target audience for this project were: 1. Organic poultry farmers 2. Organic feedmill and feed manufacturers 3. eOrganic and eExtension 4. Graduate and undergraduate students interested in alternative poultry production Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The projec offered training and development for the following graduate students: James Foutz, Bryan Aguanta, Eduardo Ortega and Gustavo Schneiders who worked with Dr. Aggrey, formulating diets, raising chickens, analyzing ingredients and undertaking molecular assays. Haden Ellis worked under Dr. Ritz and Dunkley in developing educational materials for organic agriculture. Darlene Bloxham is also a professional who worked under Dr. Pesti, and later became a graduate student of Dr. Pesti working on the project. Dr. Carlie Milfort also worked on this project assisting in development of molecular assays. There are several undergraduate students that were trained during the different phases of this project. How have the results been disseminated to communities of interest?We have submitted a paper to poultry science which is under review then. We have a feed formulation app for organic producers We have made 3 conference presentation on our results We have articles under review from eOrganic We have an article in the Extension Bulletin of the University of Georgia What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2014/09 TO 2018/08 What was accomplished under these goals? Amino acid availability is an important measure of protein quality. The composition of feed ingredients is important, but composition does not equate to availability. Formulation of diets on a digestible amino acid basis decreases feed costs, lower feed safety margins, and decrease nitrogen excretion into the environment. We therefore determined the amino acid availability of organic ingredients to enable us to formulate diets based on digestible amino acids. True amino acid digestibility of ingredients was determined using total fecal collection precision-fed caecetomized rooster assay. Proximate analysis and amino acid content of excreta were determined at the Agricultural Experimental Station Chemical Laboratories, University of Missouri-Columbia, MO. Percentage and (digestible) lysine and methionine in organic corn, organic soybean meal, organic sunflower meal and organic Brazil nut powder were as follows: Lysine \corn 0.250 (0.190); soybean meal 2.965 (2.709); sunflower meal 0.840 (0.713); Brazil nut 1.505 (1.317); Methionine \corn 0.165 (0.146); soybean meal 0.660 (0.594); sunflower meal 0.505 (0.469); Brazil nut

3.450 (3.360). Of these organic ingredients, inclusion of about 9.32 % Brazilian nut powder would be adequate to meet the sulfur amino acid requirement in a broiler starter diet with lysine and threonine supplementations. Based on the analysis of these ingredients, we formulated several feed formulation strategies to meet the sulfur amino acid requirements of poultry, both broilers and layers without exogenous supplementation of methionine. For the first time, we have been able to formulate organic poultry diets based on available or digestible nutrients. We formulated three diets (Diet 1: conventional commercial diet based on conventional ingredients; Diet 2: NOSP diet with 0.1% Methionine; Diet 3: Organic diet with no added methionine). We hatched Ross308 chicks for this experiment. Starter Diet Ingredient Conventional NOSB Organic 100% Organic Corn 54.80 38.00 61.20 Soybean 38.11 28.70 22.93 Soybean Oil 3.00 3.50 0.00 Sunflower 0.00 22.05 0.00 Brazil Nuts 0.00 0.00 12.00 DL-Methionine 0.29 0.10 0.00 Crude Protein, % 23.33 23.35 23.33 ME, Kcal/g 3.06 3.04 3.06 MET, % 0.62 0.43 0.63 CYS, % 0.39 0.27 0.32 Grower Diet Ingredient Conventional NOSB Organic 100% Organic Corn 58.23 47.75 64.73 Soybean 34.20 25.00 20.75 Soybean Oil 3.00 3.50 0.25 Sunflower 0.00 22.05 0.00 Brazil Nuts 0.00 0.00 10.75 DL-Methionine 0.25 0.10 0.00 Crude Protein, % 21.75 21.69 21.64 ME, Kcal/g 3.10 3.10 3.10 MET, % 0.56 0.41 0.58 CYS, % 0.29 0.25 0.30 Finisher Diet Ingredient Conventional NOSB Organic 100% Organic Corn 61.88 42.00 66.00 Soybean 29.90 21.25 18.00 Soybean Oil 3.85 5.25 2.00 Sunflower 0.00 25.00 0.00 Brazil Nuts 0.00 0.00 10.50 DL-Methionine 0.25 0.10 0.00 Crude Protein, % 19.97 20.22 20.07 ME, Kcal/g 3.20 3.20 3.20 MET, % 0.54 0.40 0.56 CYS, % 0.27 0.24 0.28 We assigned 200 birds per treatment; 4 replicates per treatment and 50 birds per replicate. Birds were grown in our organic facility where birds had access to pasture. Additional 200 birds were fed diet 1 and raised in standard commercial environment with no access to pasture. The birds were raised for 8 weeks. At the end of the experiment, the body weights were 2.62 kg, 2.55 kg, 2.52 kg and 2.26 kg for the organic, NOSP, conventional diet in organic environment and conventional diet in conventional environment, respectively. There were no differences in growth among diets for birds that were organically grown. All the organically grown birds had significant higher growth than their counterpart grown under conventional environment. There were no differences in feed conversion ratio and carcass yield among all treatments. Surface color of the left ventral part of Pectoralis major muscle was measured in triplicate for initial and final pH, lightness (L*), green to red (a*) and from blue to yellowness (b*). The initial and final pH and lightness were similar among treatments, however, the NOSP diet had significantly lower a* and b* values compared to the other treatments. We have ascertained the expression levels of genes in the methionine pathway when fed the NOSB and 100% organic diet. We used the conventional diet as a control. The genes we studied were S-adenosyl-L-homocysteine (AHCY), betaine-homocysteine S methyltransferase (BHMT), glycine N-methyltransferase (GNMT), methionine adenosyltransferase 1, alpha (MAT1A), MAT2B, 5-methyltetrahydrofololate-homocysteine methyltransferase (MTR), 5-methyltetrafolate-homocysteine methyltransferase reductase (MTRR), and cystathione beta synthase (CBS). Gene expression was conducted at days 10 and 35. All the genes in the methionine pathway was expressed downwards compared to the conventional control in the ileum both for the NOSB and 100% organic diets. This indicate that dietary methionine may not be adequate. However, expression levels in the breast muscle was normal. At day 35, gene expression levels appear to be at par with the conventional diet in the ileum and breast muscle. It is possible to formulate organic poultry diet based on digestible amino acids using Brazil nuts without the inclusion of synthetic methionine. In the starter and grower phases, the group on 100% organic diet fell behind in growth, however, they compensated for the growth in the finisher phase. In the finisher phase the 100% organic feed had slightly better FCR though not significant over the NOSP diet. The 100% organic diet also had comparable carcass yield and meat quality. Birds grown in organic environment with access to pasture perform better than their counterparts grown under conventional environments. First, during the starter phase of broiler production, a diet adhering to NOSB guidelines of only 0.1% DL-Methionine does not provide an adequate amount of methionine to a broiler, resulting in increased feed intake and decreased growth. Additionally, broilers fed organic Brazil nut meal as a methionine source do not meet the growth of broilers fed conventional feed. These observations on growth and performance are backed by gene expression data, where genetic expression of important enzymes show a methionine deficiency. However, the conclusion that can be made over an 8-week time period, broilers fed a diet adhering to NOSB guidelines or a diet containing Brazil nut meal both meet the growth of broilers fed a conventional diet when raised organically. Broilers fed a diet containing Brazil nut meal additionally met performance of conventionally fed broilers and outperformed broilers fed a NOSB diet. Genetic expression corroborates these observations, where little differences were seen in gene expression of major enzymes in methionine metabolism. Further, growth and performance data suggest organic production of broilers yields heavier broilers than broilers raised conventionally. Genetic data supporting this result show relative corroboration. However, investigation into enzyme activity and metabolite concentration is needed to further strengthen these claims **PUBLICATIONS (not previously reported):** 2014/09 TO 2018/08 Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Milfort, M. C., Foutz, J., Dunkley, C., Davis, A. J., Rekaya, R., and Aggrey, SE, 2017. Amino acid composition and digestibility of organic feed ingredients. Poult. Sci. 95:156 Foutz J. C., M. C. Milfort, A. L. Fuller, W. K. Kim, R. Rekaya and S. E. Aggrey, 2018. Performance of broiler chickens fed diet with or without exogenous methionine and raised in conventional or organic production environment. International

Poultry Scientific Forum Dunkley, C.S., J. Fowler and S. E. Aggrey, 2018. Amino Acid Content in Organic Soybean Meal for the Formulation of Organic Poultry Feed. University of Georgia Cooperative Extension Bulletin. Progress 09/01/16 to 08/31/17 Outputs Target Audience:The target audience reached are organic feed manufacturers, organic ingredient growers, organic educators and extension personnel, and organic poultry producers Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project has offered training and development for the following students so far. James Foutz and Bryan Aguanta are working with Dr. Aggrey, formulating diets, raising chickens and will be undertaking the molecular assays. Haden Ellis is working under the direction of Dr. Ritz and Dunkley developing educational materials for organic agriculture involving poultry. Dr. Carlie Milfort is also working with Dr. Aggrey developing molecular assays. Darlene Bloxham is a laboratory professional working under Dr. Pesti responsible for ingredient assays. How have the results been disseminated to communities of interest?We are preparing material for eOrganic, and also manuscipt for publication. What do you plan to do during the next reporting period to accomplish the goals?1. Complete all your trials 2. Disseminate our data through eOrganic, conferences and publication 3. Conduct laboratory experiments do determined whether the diets formulated generated the needed tissue methionine and SAM 4. Develop education materials Impacts What was accomplished under these goals? For the first time, we have been able to formulate organic poultry diets based on available or digestible nutrients. We formulated three diets (Diet 1: conventional commercial diet based on conventional ingredients; Diet 2: Current organic diet with 0.1% Methionine; Diet 3: Organic diet with no added methionine). We hatched Ross308 chicks for this experiment. We assigned 200 birds per treatment; 4 replicates per treatment and 50 birds per replicate. Birds were grown in our organic facility where birds had access to pasture. Additional 200 birds were fed diet 1 and raised in standard commercial environment with no access to pasture. STARTER DIET Main Ingredients CONV Current ORG 100% Organic Corn 54.80 38.00 61.20 Soybean 38.11 28.70 22.93 Soybean oil 3.00 3.50 0.00 Sunflower 0.00 22.05 0.00 Brazil Nuts 0.00 0.00 12.00 DL-Methionine 0.29 0.10 0.00 Crude Protein (%) 23.33 23.35 23.33 ME (kcal/g) 3.06 3.05 3.06 MET (%) 0.62 0.43 0.63 CYS (%) 0.30 0.27 0.32 GROWER DIET Main Ingredients CONV Current ORG 100% Organic Corn 58.23 42.75 64.73 Soybean 34.20 25.00 20.75 Soybean oil 3.00 3.50 0.25 Sunflower 0.00 22.05 0.00 Brazil Nuts 0.00 0.00 10.75 DL-Methionine 0.25 0.10 0.00 Crude Protein (%) 21.75 21.69 21.64 ME (kcal/g) 3.10 3.10 3.10 MET (%) 0.56 0.41 0.58 CYS (%) 0.29 0.25 0.30 FINISHER DIET Main Ingredients CONV Current ORG 100% Organic Corn 61.88 42.00 66.00 Soybean 29.90 21.25 18.00 Soybean oil 3.85 5.25 2.00 Sunflower 0.00 25.00 0.00 Brazil Nuts 0.00 00.00 10.50 DL Methionine 0.25 0.10 0.00 Crude Protein (%) 19.97 20.22 20.07 ME (kcal/g) 3.20 3.20 3.20 MET (%) 0.54 0.40 0.56 CYS (%) 0.27 0.24 0.28 We feed the starter diet from day 0 till 14. We then fed the grower diet from day 14 till day 28. The finisher diet was fed from day 28 till 56. The experiment is stil ongoing. However, we have data up to day 42. Table 1. Growth Analysis of broiler chickens fed organic or conventional diet and raised in organic or standard diet1 Treatment Environment Hatch wt (g) BW at 14 d BW at 28 d BW at 42 d CONV ORG 42.31 429.12b 1,445.30b 2,758.63b Current Org ORG 42.12 422.48b 1,450.93b 2,747.36b 100% Org ORG 42.25 387.07a 1,368.30a 2,672.61ab CONV CONV 42.28 437.63c 1,432.35b 2,632.54a SEM 0.21 3.70 12.80 28.58 1Means within columns with the same supercript are significantly different (P\<0.05) We are still collecting data on these birds. However, up to day 42, we can draw the following conclusions \1\ The body weight of birds fed 100% organic diet (Diet with brazil nuts) without supplementation with any exogenic methionine did not statistically differ from birds grown on either conventional feed or currently recommended 0.1% methionine \2\ Birds fed conventional diet and raised in an organic environment with access to pasture grew significantly better at day 42 than their counterparts raised in conventional environment Publications Progress 09/01/15 to 08/31/16 Outputs Target Audience:The target audience reached include organic poultry producers, feed millers, organic poultry ingredient growers. We have also made effort to reach organic educators Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project has offered training and development to three graduat students so far. Haden Ellis under the direction of Dr. Ritz and Dunkley, developming educational materials for organic agriculture involving poultry. James Foutz and Bryan Aguanta are working under Dr. Aggrey and developing the digestible nutrient analysis and feed formulation with the assistance of Dr. Pesti. Darlene Bloxham is a laboratory professional that has trained to developed various assays pertaining to feed ingredients. How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals?1. We will disseminate ingredient analysis and outcome of digestibility of organic ingredient to organic outlets, regular academic publication and organize extension programs 2. Formulate several cost effective diets based on our feed ingredient analysis and understand digestibility based on formulated diets 3. Conduct a broiler trial and collect tissues for Nutrigenomics 4. Develop educational materials Impacts What was accomplished under these goals? The quality of protein use in formulating poultry diets varies. Amino acid availability is an important measure of protein quality. The composition of feed ingredients is important, but composition does not equate availability. Therefore, poultry diets based on available or digestible amino acids would be closer to the needs of the bird than the composition of the feed ingredient. Feed formulation based on availability values should allow higher dietary inclusion levels of feed ingredients of lower quality. Formulation of diets on a digestible amino acid

basis may decrease feed costs, lower feed safety margins, and decrease nitrogen excretion into the environment. We therefore determine the amino acid availability of organic ingredients to enable us formulate diets based on digestible amino acids. Organic ingredient % methionine+cysteine % available methioin+cysteine Soybean meal (45.80% CP) 0.660+0.685 0.594+0.560 Corn (6.29% CP) 0.165+0.145 0.146+0.108 Wheat (13.60% CP) 0.220+0.280 0.187+0.233 Wheat middlings ((16.05% CP) 0.245+0.290 0.182+0.200 Alfafa meal (14.85% CP) 0.195+0.135 0.123+0.031 Sunflower meal (21.30 % CP) 0.505+0.467 0.360+0.291 Sugar beet root powder (12.75 % CP) 0.075+0.090 0.028+0.000 Spinach powder extract (31.25 % CP) 0.425+0.385 0.348+0.223 Brazil nut powder (51.75 % CP) 3.450+1.180 3.360+1.054 Folate (mg/kg) Betaine (nmols/g) Choline (nmols/g) Alfafa 2.30 130,000 4600 Spinach 22.0 Sugar beet root powder 115,000 3000 From these organic ingredients, inclusion of about 10% Brazilian nut powder would be adequate to supply the sulfur amino acids requirement in a broiler starter diet with lysine and threonine supplementation. Based on the analysis of these ingredients, we will evaluate several feed formulation strategies to meet the sulfur amino acids requirements of poultry, both broilers and layers without exogenous supplementation of methionine. Publications Progress 09/01/14 to 08/31/15 Outputs Target Audience:The target audiece reached include organic poultry producers; organic poultry ingredient growers, organic feed plant managers. We have also make concerted effort to reach organic educators. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project has offered training and professional development to two graduate students so far. Haden Ellis under the direction of Drs. Ritz, Dunkley and Beckstead is developing educational materials for organic agriculture involving poultry. Darlene Bloxham is a laboratory professional that has been trained in choline and other nutrient assay development by Dr. Pesti Bibek Regmi is a graduate student in Nutrition and NutriGenomics being trained in laboratory techniques need to assess optimum methylation How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals?1. We plan to disserminate the information on nutrient ingredient analysis to e.Organic and other outlets including publications and extension related activities 2. We plan to continue with the nutrient availability experiment and subesquently feed formulation 3. We plan to run broiler experiment using feed our feed formulation 4. We plan to collect tissue for Nutrigenomics 5. We plan to develop educational materials in organic farming pertaining to organic agriculture Impacts What was accomplished under these goals? Objective 1 Table 1 Essential amino acids (+cysteine) profile of some organic ingredient for poultry Essential Amino Acids and Cysteine Ingredient CP MET CYS LYS THR TRY ISO ARG VAL Alfafa meal 16.25 0.31 0.23 1.07 0.83 0.28 0.71 0.86 0.95 Soybean meal 47.00 0.58 0.59 2.90 1.74 0.70 1.78 3.33 1.93 Wheat middles 16.00 0.23 0.29 0.63 0.45 0.18 0.39 0.90 0.59 Hommy 9.00 0.19 0.19 0.46 0.34 0.07 0.25 0.57 0.39 Corn 8.20 0.14 0.14 0.24 0.20 0.06 0.17 0.28 0.25 Barley 10.50 0.19 0.21 0.43 0.34 0.11 0.33 0.52 0.47 Canola meal 40.70 0.53 0.57 1.45 1.09 0.38 0.87 1.48 1.16 Field peas 22.00 0.21 0.27 1.41 0.70 0.18 0.70 1.53 0.82 Milo 11.00 0.17 0.15 0.24 0.29 0.08 0.31 0.33 0.40 Sunflower meal 27.40 0.50 0.40 1.02 0.87 0.32 0.79 1.60 1.00 Oats 10.00 0.15 0.23 0.41 0.28 0.09 0.27 0.54 0.39 Flaxseed 32.00 0.38 0.34 0.88 0.75 0.36 0.75 1.97 0.96 Millet 11.50 0.28 0.20 0.42 0.40 0.16 0.45 0.61 0.58 We compared the composition of corn and soybean meal with corn used in conventional poultry feeds. The CP for the conventional corn was 8.15%, whereas methionine and cysteine were 0.17 and 0.19% respectively. The total sulfur amino acid (methionine + cysteine) for the conventional corn was 0.35% whereas that of organic corn was 0.28%. Whereas, lysine content was similar, threonine, tryptophan, isoleucine, arginine and valine content of the organic corn was lower than that of the conventional corn. The conventional soybean meal had a crude protein content of 47.67% compared to 47% of the organic soybean meal. The methionine and cysteine contents were 0.65 and 0.74% respectively, which were higher than the organic soybean. Similarly, lysine content of the conventional corn was 3.0% which was also higher than that of the organic ingredient. The threonine, arginine, isoleucine and valine content of the conventional soybean were 1.86, 3.52, 2.16 and 2.26 % which were all higher than the 1.74, 3.33, 1.78 and 1.93% from the organic soybean. The organic soybean had 0.70% tryptophan compared to 0.65% from the conventional soybean. The industrially produced flaxseed has 0.35 and 0.42 methionine and cysteine, respectively compared to the 0.38 and 0.34, respectively in the organic samples. Similar variability was found in other analyzed feed ingredients. This part of the research is still ongoing. Publications

↑ Return to Index

Evaluating the Effect of Muskmelon Cultivar and Cover Crops on Soil Biodiversity, and Plant and Human Disease Suppression During Organic Pro

Accession No.	1003523
Subfile	CRIS
Project No.	MD.W-2014-03389
Agency	NIFA MD.W
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22090
Proposal No.	2014-03389
Start Date	01 SEP 2014
Term Date	31 AUG 2017
Grant Amount	$499,995
Grant Year	2014
Investigator(s)	Micallef, S. A.
Performing Institution	Plant Science & Landscape Arch, UNIV OF MARYLAND, COLLEGE PARK, MARYLAND 20742

NON-TECHNICAL SUMMARY

The use of no-till cover crops and green manures impact soil microbial communities, but their influence on specific microbial community functions, such as nutrient cycling, plant growth promotion, phytopathogen and human pathogen suppression, and reduction of greenhouse gas emissions, remains unclear. We lack the scientific knowledge to understand how to best exploit these systems for our agricultural and environmental gain. As growers adopt organic practices and transition land from conventional management, it is crucial that they take advantage of the benefits of cover crops. In this study, we will assess the effect of four green manure no-till cover crop systems - hairy vetch, clover, hairy vetch+rye, clover+rye - on soil functions during cultivation of various muskmelon (cantaloupe) cultivars, a valuable crop susceptible to both plant diseases and colonization by human foodborne pathogens. We will adopt a multidisciplinary approach, integrating molecular microbiology to compare soil microbial and functional gene diversity, horticulture, phytopathology, food safety microbiology, entomology and food quality, to achieve our goals. A strong outreach program will develop new educational resources that extend research-based knowledge. These resources will be available locally in addition to the eOrganic site through collaboration with eXtension. We will conduct local demonstrations to train growers and extension educators in practices that reduce disease and food safety risks on muskmelon grown on land transitioning to organic production. Through this project, we will contribute to ORG\'s goals by assessing microbial ecosystem services of cover crop systems, evaluating production practices for muskmelons - including food safety, while developing a strong outreach program.

OBJECTIVES

Four green manure cover crop systems in an organic and a transitioning farm system, and a control bare ground system, will be evaluated. We will assess and compare (1) soil microbial communities and their functional gene diversity, (2) plant pathogens and (3) human foodborne pathogens; and determine how these cover crops can be used on soil that is transitioning to organic management for optimal cultivation of the best out of ten muskmelon

cultivars in the mid-Atlantic region. Palatability of the best-adapted muskmelon cultivars will be assessed through flavor and texture analysis. Additionally, we will provide extensive outreach at grower meetings, a series of organized, in-depth \"twilight\" classes for small groups, and through collaboration with eOrganic. We will develop articles on organic management of muskmelon diseases, and food safety risks in muskmelon production, videos on disease scouting, cantaloupe disease identification, production methods to minimize disease in organic production, and best practices for cantaloupe produce safety.

APPROACH

Field preparation: For objectives 1 and 2, field trials will have four replications, and each plot will consist of a single raised bed. Surface installed (non-tilled cover crop treatments) or below plastic installed (bare ground treatment) drip irrigation will be used to maintain adequate soil moisture. Objective 1: Four non-tilled cover crops will be planted in late fall, grown on raised beds, and flail mowed the following spring. A commercial standard muskmelon cultivar (such as \'Athena\') will be started in late spring and transplanted at the three-leaf stage into the raised beds in early summer. Main-plot treatments will be bare ground or a non-tilled cover crop, subplot treatments will be food safety inoculation plots. Objective 2: Ten muskmelon cultivars will be seeded in a greenhouse in late spring and transplanted at the three-leaf stage into raised beds in early summer. Hairy vetch will be planted in late fall, grown on raised beds, and moldboard-plowed in the soil (tilled treatment) and black polyethylene mulch installed over raised beds, or flail mowed (non-tilled treatment) the following spring. Fruit size uniformity will be visually assessed at each harvest and measured using a linear scale. Following final fruit harvest, plants will be destructively sampled and total above-ground dry biomass for each cultivar will be determined. Disease assessment: Fungal foliar diseases (anthracnose, gummy stem blight and Alternaria leaf blight) will be visually assessed weekly and measured as a percentage of symptomatic foliage based on the whole plot using a Horsfall-Barratt scale. Incidence of bacterial wilt will be measured as a % of diseased plants in a whole plot. Other diseases (such as powdery mildew and downy mildew) will be visually assessed using the Horsfall-Barratt scale as they appear. The % of all fruit with one or more lesions of anthracnose will also be evaluated for each plot at harvest. ANOVA will be conducted on foliar fungal and bacterial diseases and pest incidence. The effect of bio-rational pesticide and biofungicide use on disease incidence and severity (anthracnose, gummy stem blight, Alternaria leaf blight, powdery mildew and downy mildew) and on yield and number of marketable fruit per plant will be measured. Field and Growth Chamber Pot Inoculations: Indicator bacteria will be applied to the field before sowing the cover crop seeds in the fall during year 1 and 2. The bacterial cocktail will be sprayed evenly on the surface of the treatment plots using a handheld sprayer boom. Following the inoculation, fields will be seeded with cover crop, according to recommended seeding rates. Muskmelon transplanting will occur in the spring. Soil will be collected weekly for bacterial enumaration , and once muskmelon fruit sets, fruit samples will be collected also. For growth chamber experiments, soil from the different field treatments will be transported to the lab and placed in 6\"pots in climate controlled BSL-2 growth chambers Pots will be inoculated separately with 10 ml aliquots of pathogen suspensions. Soil samples will be collected weekly for pathogen detection. Pathogens will be quantified by MPN, and when no longer detectable, enriched in appropriate enrichment broths using FDA-BAM protocols. Muskmelon Spot Inoculation with Foodborne Pathogens: Outbreak strains of S. Typhimurium, S. Newport and L. monocytogenes with antibiotic resistance will be used for muskmelon spot inoculation. After three days, 5 cm discs of inoculated rind will be cut out using a sterile cutter and processed as described below. Total Microbial Community DNA Extraction and T-RFLP: Total microbial DNA from soil samples will be isolated from soil.DNA will be used for community fingerprinting using T-RFLP performed on a 3730xl Genetic Analyzer.Microarray Analysis on GeoChip 5.0: Microarray analysis will be performed on microarray slides from IEG. This analysis will involve DNA extraction and labeling with the fluorescent Cy5 dUTP.The labeled DNA will be sent for microarray hybridization and image processing. Sensorial Testing of muskmelon: Ten panelists, who will be recruited from students and employees from UMD and BARC campus, will undergo ten one-hour training sessions, over a period of 3 to 4 weeks. During training sessions, panelists will define the terminology for appearance, flavor, and texture that will best address the project objectives. Flavor, sweetness and texture attributes are will be assessed. Twilight Meeting Education Resource: We will administer pre- and post-meeting surveys at the extension twilight meetings in years 1 and 3. Pre-meeting surveys will ask questions about grower perceived challenges in use of cover crops and organic muskmelon production; post-meeting surveys will ask questions about the likelihood of grower adoption of showcased agricultural practice(s). Responses will be recorded anonymously using ResponseCard RF electronic clickers (Turning Technologies, Youngstown, Ohio). Packets of organic muskmelon seed from cultivars evaluated in this research project will be provided to attendees of the meetings in years 1 and 2; they will be encouraged to evaluate it in their own operations. In years 2 and 3, growers who previously received muskmelon seed will be sent a targeted questionnaire, asking about pesticide use, production challenges, interest in growing these cultivars again, etc. Evaluation: Progress in accomplishing research and outreach goals will be monitored by maintaining close cooperation with grower collaborators and our advisory panel. In addition, we will work with

University of Maryland Extension\'s (UME) Assistant Director of Evaluation and Assessment to develop surveys to assess our progress. Our evaluations of muskmelon production adoption will include numbers of cooperators participating in on-farm trials, evaluations, and demonstrations; a survey of the organic and muskmelon/vegetable industry will be completed at the end of the project to evaluate implementation of practices on farms and to assess changes in grower beliefs on, and understanding of, produce food safety in organic production. We will make sure that the microbiology research we propose to do is \'translated\' into findings that are useful to growers, by presenting data at local grower meetings and soliciting input from our ad hoc advisory panel.

PROGRESS

2014/09 TO 2018/08 Target Audience:The scientific community, Extension agents focusing on organic production of vegetables, organic and conventional vegetable grower especially targeted to growers in the mid-Atlantic region, government officials interested in food safety research needed to inform policy. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?The project provided opportunities for training and professional development at all levels. Students and postdocs were trained in experimental design, field sampling, plant pathology and microbial food safety methods (inoculation of melons with foodborne pathogens, and co-inoculation of melons with foodborne pathogens and Fusarium spp.; disease scoring, bacterial enumeration, molecular biology methods etc.). Two post-docs were trained during this project, Dr. Neiunna Reed-Jones conducted research on food safety microbiology. Dr. Sasha Marine focused on agricultural production systems and phytopathology. A PhD student Robert Korir will complete his dissertation and graduate in June 2018. He conducted food safety and phytopathology research focusing on cultivar variation in food safety traits (association with Salmonella enterica) and influence of the fruit pathogen Fusarium spp. on the ability of Salmoenlla enterica to associate with and enter melon fruit. Another PhD student, Xingchen Liu worked on till/no till systems and fruit melon microbial communities. A technician (Samantha Bolten) worked on the sensory evaluation objective of this project and was trained by Eunhee Park and Dr. Sunny Luo at USDA ARS in sensory evaluation methodologies including biochemical tests and conducting consumer and sensory trained panels. Several undergraduates were able to complete laboratory and field-based undergraduate research experiences gaining developing microbiology laboratory skills under the supervision of Dr. Shirley Micallef. The work was incorporated into a class in formal student training; students in PLSC689N Field Plant Pathology course at the Wye REC in June, 6 2016 discussed research at the research plots with eight cultivars that were planted on a tilled green manure cover crop and no-till systems. Extension educators and vegetable specialists were presented with results of the study and how they could use these results for their clientele. Several faculty, scientists, students and technical personnel have had the opportunity to present at various conferences (scientific meetings), twilight meetings (grower meetings and demonstrations) and webinar and other online platforms (see dissemination of research and publications). Gradaute students and postdocs had the opportunity to write manuscripts for peer reviewed publications and fact sheets and other Extension publications. How have the results been disseminated to communities of interest?Talks Local/ Regional Conferences: \-- Cover Crops and Disease Suppression. 2016 Southern SARE Cover Crops Conference. Mount Olive NC July 18, 2016 \--Micallef SA. Investigating Plant-Microbe Associations for Safer Salads. JIFSAN Advisory Council Meeting, 4th May 2017, Greenbelt, MD. \--G. Brust,Managing bacterial wilt in cucurbits organically. Mid-Atlantic fruit and Vegetable Conference, Hershey PA, Jan 2018. \--Micallef SA, Sustainability of Food Safety, as part of the Sustainable Ag Tuesdays series at the Institute of Applied Agriculture, University of Maryland, 6th Mar 2018. \--Everts, KL, NJ Agricultural Convention and Trade Show (NJ Vegetable Growers Meeting) Feb. 6, 2018. Utilizing Cover Crops for Soil Disease Suppression. Talks International Conferences: \-- Reed-Jones, NL, Marine, SC, Everts, K and Micallef, S, 2015. Evaluating the effect on the survival and growth dynamic of food borne Bacterial indicators in the soil and on cantaloupes grown organically. International Association of Food Protection (IAFP) National Conference, 2015, 25-28 July, Portland Oregon. \--Pang H, Micallef SA, Everts K, Pradhan AK. Evaluation of Cover Cropping, Farming System, and Meteorological Factors on the Survival of Generic Escherichia coli and Listeria innocua in Produce Fields. IAFP Annual Meeting, 9-12 July 2017, Tampa, FL. \--Brust, G. 2017. Multiple biostimulent applications are needed to increase vegetable yields and quality. 3rd Biostimulants World Congress, Miami, FL \--Brust, G. 2017. Beauveria bassiana reduces the incidence of cucurbit bacterial wilt vectored by the strip cucumber beetle (Acalymma vittatum) in cantaloupe. Entomological Society of America Meeting, Denver CO. \--Micallef SA. Production practices, consumer preferences and microbial safety of melons. 10th Mini Summit on Food Safety, Policy and Sustainability, October 29-31, 2017, University of Maryland, College Park, Maryland, USA \--Korir R, Impact of Fusarium fruit rot caused by Fusarium fujikuroi and Fusarium oxysporum on Salmonella enterica Newport colonization and growth on melon. International Association for Food Protection (IAFP) Annual Meeting, 8-11 July 2018, Salt Lake City, UT. \--G. Brust, 2018. Alternative methods of control for truck gardens. Ontario Fruit and Vegetable Convention. Niagara Falls, Ontario, Canada (Feb 2018). Posters at Regional and International Conferences: \-- Reed-Jones N, Marine, SC, Everts, K and Micallef, S 2014. Evaluating the effect on the survival and growth dynamics of food borne

bacterial indicators in the soil and on cantaloupes grown organically. Poster Presentation. USDA Beltsville Agricultural Research Service Research Symposium, 2014, 13 November, Beltsville, MD. \-- Korir RC, Everts KL, Micallef SA, Whittington J. Common Fusarium spp. Causing Fruit Rots on Cucumis melo in the Mid-Atlantic Region of the U.S. 2017 Potomac Division 73rd Annual Meeting for The American Phytopathological Society, March 22 - 24, 2017, Morgantown, WV. \--Park E, Bolten S, Marine SC, Reed-Jones N, Everts KL, Micallef SA, Luo Y. Consumer preference and physicochemical evaluation of organically grown muskmelon in Maryland. Institute of Food Technologists Annual Meeting and Food Expo, IFT17 June 25-28, 2017, Las Vegas, Nevada. \-- Korir R, Everts K, Micallef SA. Interactions between Salmonella enterica Newport and plant pathogenic fungi of the genus Fusarium on melons. International Association for Food Protection (IAFP) Annual Meeting, 9-12 July 2017, Tampa, FL. \--G. Brust. November, 2017. Biostimulants and kaolin clay reduce bacterial wilt incidence in cantaloupe. Entomological Society of America Annual Meeting. Virtual Poster. Denver, Colorado. \-- Korir, RC, Everts, KL and Micallef, S. Impact of two Fusarium spp. causing melon rot on Salmonella enterica Newport Survival and growth on melon rinds. 2018 Annual Meeting of the Potomac Division of the American Phytopathological Society. Ocean City, MD \-- Korir, RC, Everts, KL and Micallef, S. Internalization of Salmonella enterica Newport on smooth surface melon (\'honeydew\'-type) and netted melon (\'cantaloupe\'-type), along or in the presence of Fusarium fruit rot caused by Fusarium spp. 2018 Mid-Atlantic Section of the American Society of Plant Biologists. College Park, MD Talks Maryland (Grower Meetings): \-- 2014 muskmelon cultivar experiment: Trials and Tribulations. Presentation by S.C. Marine at Delaware Agriculture Week, Harrington, DE 13 Jan 2015. \-- Impacts of green manures and variety selection in muskmelon production. Presentation by SC Marine at Southern Maryland Vegetable and Fruit meeting, Clements, MD, 4 Feb 2015. \-- Marine, SS and Reed-Jones, NL. Organic Vegetable Field Day. Field presentations on results obtained for objectives 1 and 2 in front of research plot of eight muskmelon cultivars at Central Maryland Research andEducation Center. 13 August 2015. Upper Marlboro, MD. \--University of Maryland Extension Agronomy and Horticulture In-Service. Update - Vegetable pathology and applied research. June 15, 2016 \-- UMD Lower Eastern Shore Research and Education Center Twilight Tour. Organic melon production and food safety. Aug 10, 2016. (presented by graduate student Robert Korir) \-- UMD Sustainable Agriculture and Organic Twilight Meeting Tour, Upper Marlboro Research and Education Center. Organic melon (cantaloupe) production. Aug. 11, 2016 \-- UMD Queen\'s County Organic Production Meeting. Cover Crops that Improve Vegetable Health. Wye Mills, MD, 17 Mar, 2016. \-- Korir R, UMD Horticultural Twilight Meeting and Tour, Melon Food Safety, Research and Education Center, Keedysville, MD. Aug. 18, 2016 \-- UMD Summer Fruit and Vegetable Twilight Meeting, Organic Melon Production and Food Safety. Queenstown, MD Aug. 24. 2016 Everts K, Professor, Vegetable Pathology - Organic cantaloupe production Brust G, Senior Agent, UM State Vegetable Specialist - Organic cantaloupe production Reed Jones N, Research Associate - Microbial Safety of melons. \--Brust, G. Controlling striped cucumber beetles with and without synthetic chemicals. DE Ag Week 2016. Harrington, DE. \-- Brust, G. Cucumber beetle control. 2016 Central MD Vegetable and Fruit Growers Meeting. Foreston, MD. \-- Brust, G. Using endophytes in pest management systems. 2016 Mid-Atlantic Vegetable and Fruit Meeting, Hershey, PA. \-- Brust, G. Bacterial wilt: more pieces to the puzzle. 2016 Southern MD Vegetable and Fruit Growers Meeting. Ann Arundel Co. MD. \-- Brust, G. Endophytes in vegetable systems. 2016 Small/beginning farmer Training. Cockysville, MD. \-- Brust, G. Organic cantaloupe production. Fauquier Co. Oak Shade Farm VA. \--bBrust, G. 2017. Using biostimulents in vegetable production systems. Central MD Vegetables Growers Meeting, Eastern Shore Vegetable and Fruit Growers Meeting and Southern MD Vegetable and Fruit Meeting. Cambridge, MD. \-- Brust, G. 2017. Beauveria bassiana as an endophytic biological control in vegetables. Future Harvest Training. Jarrettsville, MD and New Holland Growers Assoc. Lancaster, PA. \-- Brust, G. 2017. Organic management of bacterial wilt disease in vine crops. MOFFA Farmer Training. Dentsville, MD and New/beginning Farmer Training. Hamstead, MD. and Berks/Schuylkill Vegetable Twilight Meeting. Fairfield, PA.. \-- Brust, G. 2017. Working with biostimulents in vegetable systems. CMREC-UMF Field Day. UMF, MD and St. Mary\'s Co. twilight growers meeting. Loveville, MD. \-- Brust, G. Biostimulents in organic vegetable production systems. Organic field day. CMREC, MD and Special training session for Maryland Vegetable Grower Association group. Marydel, MD.. \-- Everts, KL,Mt. Top Fruit and Vegetable Meeting, Accident, MD, Cover Crops and Disease Suppression in Vegetable Crops. Dec. 15, 2017 \--Webinar: https://articles.extension.org/pages/74584/melon-medley:-organic-production-pra ctices-microbial-safety-and-consumerpreferences-of-various-melo ? What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2017/09 TO 2018/08 Target Audience:The scientific community, Extension agents focusing on organic production of vegetables, organic and conventional vegetable grower especially targeted to groers in the mid-Atlantic region, government officials interested in food safety research needed to inform policy. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?- Experimental design, laboratory techniques, data collection, management and analysis for gradaute students and technical staff. - Sensory Trained panelists and panelists through consumer panel(n=80) in BARC - Opportunity to prepare manuscripts for peer-reviewed publicationsfor gradaute students and technical staff. Opportunities to present

talks, demonstations and posters on a wide range of platforms: international meetings, regional meetings, webinars, grower meetings and other Extension events. - The project served as the basis for 1 Ph.D. to graduate in Spring 2019. How have the results been disseminated to communities of interest?Webinar: https://articles.extension.org/pages/74584/melon-medley:-organic-production-pra ctices-microbial-safety-and-consumer-preferences-of-various-melo Talks: Impact of Fusarium fruit rot caused by Fusarium fujikuroi and Fusarium oxysporum on Salmonella enterica Newport colonization and growth on melon. International Association for Food Protection (IAFP) Annual Meeting, 8-11 July 2018, Salt Lake City, UT. (Robert Korir) Evaluating the effect of muskmelon cultivar and cover crops on soil biodiversity, and plant and human disease suppression during organic production. American Society for Horticultural Science (ASHS) 2018 Annual Conference, July 30-August 3 2018, Washington D.C. (Shirley Micallef) Microbial dynamics on fresh produce farms - A food safety perspective. Visit of the Union de Gremios de la Producción, Paraguay to AGNR, University of Maryland. 12th April 2018 (talk delivered in Spanish). (Shirley Micallef) Sustainability of Food Safety, as part of the Sustainable Ag Tuesdays series at the Institute of Applied Agriculture, University of Maryland, 6th March 2018. (Shirley Micallef) Production practices, consumer preferences and microbial safety of melons. 10th Mini Summit on Food Safety, Policy and Sustainability, October 29-31, 2017, University of Maryland, College Park, Maryland, USA (Shirley Micallef) January, 2018. Managing bacterial wilt in cucurbits organically. Mid-Atlantic fruit and Vegetable Conference, Hershey PA. (G. Brust) February, 2018. Alternative methods of control for truck gardens. Ontario Fruit and Vegetable Convention. Niagara Falls, Ontario, Canada (G. Brust) NJ Agricultural Convention and Trade Show (NJ Vegetable Growers Meeting) Feb. 6, 2018. Utilizing Cover Crops for Soil Disease Suppression. (Everts, K.L.) Mt. Top Fruit and Vegetable Meeting, Accident, MD, Cover Crops and Disease Suppression in Vegetable Crops. Dec. 15, 2017 (Everts, K.L.) Extension Publications: Vegetable Growers News: Managing bacterial wilt in cantaloupe using kaolin clay, G. Brust, May, 2018 edition. Meister Pub. Co. Article in Weekly Crop Update: Using kaolin clay to reduce striped cucumber beetle damage in cucurbits, G. Brust, June 8, 2018 edition. UDEL pub. Poster Presentations: 1. 2017 IFT meeting poster presented:\" Consumer preference and physicochemical evaluation of organically grown melons in MD\", Eunhee Park, Samantha Bolten, Sasha C. Marine, Neiunna Reed-Jones, Kathryne L. Everts, Shirley A. Micallef, Yaguang Luo, Xiangwu Nou, Gene in IFT 17 Las Vegas, NV June 27, 2017. 2.G. Brust. November, 2017. Biostimulants and kaolin clay reduce bacterial wilt incidence in cantaloupe. Entomological Society of America Annual Meeting. Virtual Poster. Denver, Colorado. 3. Korir, R.C., Everts, K.L. and Micallef, S. Impact of two Fusarium spp. causing melon rot on Salmonella enterica Newport Survival and growth on melon rinds. 2018 Annual Meeting of the Potomac Division of the American Phytopathological Society. Ocean City, MD 4.Korir, R.C., Everts, K.L. and Micallef, S. Internalization of Salmonella enterica Newport on smooth surface melon (\'honeydew\'-type) and netted melon (\'cantaloupe\'-type), along or in the presence of Fusarium fruit rot caused by Fusarium spp. 2018 Mid-Atlantic Section of the American Society of Plant Biologists. College Park, MD Field Demonstrations: 1. Presentation at Horticultural Crops Twilight Meeting, Wye REC, Queenstown MD, July 25, 2018, \"Organic Muskmelon production and food safety implications\" Shirley Micallef. 2. Presentation at Horticultural Crops Twilight Meeting, Wye REC, Queenstown MD, July 25, 2018. Interactions between Salmonella enterica Newport and plant pathogenic fungi; Fusarium spp. on melons. Robert C. Korir, Kathryne L. Everts, and Shirley Micallef 3. Presentation at Horticultural Crops Twilight Meeting, Wye REC, Queenstown MD, July 25, 2018. Managing foliar and fruit diseases in organic melons Kathryne Everts. 4.Presentation at Horticultural Crops Twilight Meeting, Wye REC, Queenstown MD, July 25, 2018. Best Management PRactices for Beetles on melons and oher cucurbits. Gerald Brust. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2015/09 TO 2016/08 Target Audience:The scientific community, extension agents focusing on organic production of vegetables, organic and conventional vegetable growers. Changes/Problems:A problem was encountered when comparing till and no till systems, as muskmelons on the no till systems grew very poorly. The cold spring/early summer weather may have contributed to this poor growth. We are repeating this objective in summer 2017. What opportunities for training and professional development has the project provided?Trainng and support is being provided to a graduate student Robert Korir, in the Dept of Plant Science and Landscape Architecture at UMD. His project involves assessing the impact of post-harvest muskmelon pathogens on Salmonella colonization, and he has developed a series of coinoculation studiesto address this issue. This project has provded summer training for aPhD student (Xingchen Liu) and a recent graduate (Samantha Bolten) infood safety microbiology.Students learnt how tosample muskmelon,prepare Salmonella inocula of known concentration,apply inocula by spot inocualtion, and retrieve and enumerate target cells after a period of incubation.Samantha Bolten was also trained at USDA ARS in sensory evaluation methodologies.We also trained students in PLSC689N Field Plant Pathology course at the Wye REC in June, 6 2016. We discussed research at the research plots with eight cultivars that were planted on a tilled green manure cover crop and no-till. Extension educators and vegetable specialists were presented with results of study and how they could use these results for their clientele. How have the results been disseminated to communities of interest?Talks Regional (Invited): Cover Crops and Disease Suppression. 2016 Southern SARE Cover Crops Conference. Mount Olive NC July 18,

2016 Talks Maryland (extension): University of Maryland Summer Fruit and Vegetable Twilight Meeting, Organic Melon Production and Food Safety. Queenstown, MD Aug. 24. 2016 University of Maryland Horticultural Twilight Meeting and Tour, Melon Food Safety, Research and Education Center, Keedysville, MD. Aug. 18, 2016 (presented by Graduate student Robert Korir) University of Maryland Sustainable Agriculture and Organic Twilight Meeting Tour, Upper Marlboro Research and Education Center. Organic melon (cantaloupe) production. Aug. 11, 2016 University of Maryland\'s Lower Eastern Shore Research and Education Center Twilight Tour. Organic melon production and food safety. Aug 10, 2016. (presented by graduate student Robert Korir) The University of Maryland Queen\'s County Organic Production Meeting. Cover Crops that Improve Vegetable Health. Wye Mills, MD 17 Mar, 2016. In-Service University of Maryland Extension Agronomy and Horticulture In-Service. Update - Vegetable pathology and applied research. June 15, 2016 Brust, G. Controlling striped cucumber beetles with and without synthetic chemicals. DE Ag Week. Harrington, DE. Brust, G. Cucumber beetle control. Central MD Vegetable and Fruit Growers Meeting. Foreston, MD. Brust, G. Using endophytes in pest management systems. Mid-Atlantic Vegetable and Fruit Meeting, Hershey, PA. Brust, G. Bacterial wilt: more pieces to the puzzle. Southern MD Vegetable and Fruit Growers Meeting. Ann Arundel Co. MD. Brust, G. Endophytes in vegetable systems. Small/beginning farmer Training. Cockysville. Brust, G. Organic cantaloupe production. Fauquier Co. Oak Shade Farm VA. Progress updates werewere presented at the advisory panel meeting at Wye Research and Education center, Queenstown, MD in December 2015. What do you plan to do during the next reporting period to accomplish the goals?PIs will continue evaluation efforts in 2016-2017, where we will examine two cover crops both tilled and no-tilled for on insect pest populations, human pathogens, foliar disease, and fruit yield and quality. For cucumber beetle, we plan to conduct the third year of the research trials adjusting the research based on the previous 2 years of results. We also plan to continue our work on objective 1a to assess microbial diversity and function in cover crop systems. For the sensory evaluation of muskmelon, we will be analyzing our datain detail to evaluate the eating quality of the melons from October, 2016 to January 2017. If an opportunity is given in the future, melon cultivars with preferable sensorial attributes and physicochemical properties should be evaluated for retention of quality attributes during MAP storage with trained in-house panel or untrained consumer preference tests. We plan to continue with ouroutreach program to growers and Extension personnel. We are currently preparing a manuscript on the differences between the organic and transitional fields observed in 2015 and 2016. (Sasha C. Marine, Robert C. Korir, Shirley A. Micallef and Kathryne L. Everts), Impact of green manure on insect pests, foliar diseases and yield in a transitional organic muskmelon production system). Other planned manuscripts focus on dissmeniation of Listeria and E. coli onto cantaloupe in the field, effect of green manures on pathogen survival on muskmelon, and effect of cultivar on pathogen survival on muskmelon surfaces. A manuscript summarizing the seonsory qualities of muskmelons is also being prepared.

IMPACT

2014/09 TO 2018/08 What was accomplished under these goals? -- Assessment of the impact of cover crops on the persistence and dynamics of the food safety indicator bacteria E. coli and Listeria innocua in organic soils. We found that cover crops did not appreciable increase or decrease risk of persistence of bacteria in soil - Assessment of melon cultivar susceptibility to human pathogen association (Salmonella enterica, Listeria monocytogenes, Escherichia coli O157:H7). We found that netted melons support higher populations of foodborne pathogens. - Assessment of green manures and till, no till organic systems on the susceptibility of Salmonella enterica association with melons. We found that no till systems were not efficient for melon production and therefore this could not be assessed. - Evaluation of the impact of green manures on the dispersal of E. coli and Listeria innocua from soil to fruit. We found that dispersal of Listeria from soil to fruit was very high regardless of green manure system. - Assessment of the impact of fruit soft rot caused by Fusarium spp. on Salmonella association with cantaloupe, honeydew and canary melons. We found that Salmonella grew, but was not affected by the presence of Fusarium. - Assessment of Internalization potential of Salmonella into cantaloupe and honeydew melons and impact of infection with Fusarium spp. We found that Salmonella internalized easily into melons, independent of weak Fusarium infection. - A survey of Fusarium spp. associating with melons grown in fields in MD and De. One hundred and forty putative Fusarium isolates were obtained from the 250 fruit collected. Several Fusarium species were identified, eg. F. proliferatum, F. fujikuroi, F. oxysporum and F. verticilloides. Evaluation of cover crop system on organically grown melon yield, disease resistance and pest resistance. We found that hairy vetch and crimson clover had positive effects on organic melon systems. Development of best management practices (BMPs) for production, disease and pest management, food safety and best cultivar selection for organic cropping systems. - Eight muskmelon cultivars were evaluated for insect pests, foliar diseases and fruit yield and quality in an organic till and no-till hairy vetch cover crop system in Maryland. We found that average fruit weight was significantly different by production practice (tillage versus no tillage) with fruit

from the no-till section weighing less. Cultivar was a significant factor for average fruit weight and soluble sugars in both the till and no-till sections. Insect pest populations were also significantly different by production practice with more cucumber beetles observed on muskmelon plants in the till section. - A webinar was presented in collaboration with eOrganic on BMPs for melons. - BMPs for beetles were developed, over 235 growers were shown how to use kaolin clay in cucurbits to reduce striped cucumber beetle damage and limit bacterial wilt infection and plant death in cucumbers and cantaloupe. - Sensory evaluation of various melons to determine the consumer preference among four melon cultivars \\'Athena\' (C. melo var. reticulatus), \'Sivan\' (C. melo var. cantalupensis), \'Dulce\' and \'Jaune\' (C. melo var. inodorus)\ grow in an organic, hairy vetch cover crop system and to select the most sustainable melon based on the marketability, critical quality attributes from sensory evaluation and physicochemical measurements. Although it was not easy to determine which melon is best suited for the local growing conditions, as well as melon marketability, the melon that had the most positive sensory and physicochemical traits among the cultivars investigated in this study was \'Sivan\'. Consumers preferred \'Sivan\' that was the most consistent cultivar across the two years, in terms of the physicochemical parameters. **PUBLICATIONS (not previously reported):** 2014/09 TO 2018/08 1. Type: Other Status: Published Year Published: 2015 Citation: Marine, S. and K. Everts. 2015. Cantaloupe (muskmelon) in Maryland. Fact Sheet. University of Maryland Extension:Organic Vegetable Production webpage. http://extension.umd.edu/sites/extension.umd.edu/files/ docs/programs/mdvegetab les/Muskmelon factsheet 16Jan15 FINAL.pdf 2. Type: Journal Articles Status: Published Year Published: 2016 Citation: Reed-Jones N, Marine SC, Everts K and Micallef SA, 2016. Effect of cover crop species and season on population dynamics of Escherichia coli and Listeria innocua in soil. Applied and Environmental Microbiology 2016 Jan 4;82(6):1767- 77. Accepted manuscript posted online 4 January 2016. doi: 10.1128/AEM.03712-15. PMID: 26729724 3. Type: Journal Articles Status: Published Year Published: 2016 Citation: Marine, SC, Newark MJ, Korir RC and Everts KL. 2016. Evaluation of rotational biopesticide programs for disease management in organic cucurbit production. Plant Dis. 100:2226-2233 4. Type: Journal Articles Status: Published Year Published: 2016 Citation: Field evaluation of muskmelon cultivars for susceptibility to anthracnose, powdery mildew and downy mildew when grown in organic no-till and plastic-mulch production systems in Maryland, 2015. Author(s): K.L. Everts, S.C. Marine, R.C. Korir. Plant Disease Management Report (PDMR) Report 10:V090. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Marine, S.C., and Everts, K.L. 2016 Evaluation of organically produced melon cultivars for powdery mildew and downy mildew severity in Maryland, USA. Proceedings of the Cucurbitaceae 2016, XIth Eucarpia Meeting on Cucurbit Genetics & Breeding, July 24-28, 2016, Warsaw, Poland, 2016 pp.305-307 ref.4 E.U. Kozik & H.S. Paris, editors. 6. Type: Other Status: Published Year Published: 2016 Citation: Everts, K. Fungicide Products for Managing Powdery Mildew on Cucurbit Crops. Vegetable and Fruit Headline News, University of Maryland Extension Vol 7(1) May 13, 2016. 7. Type: Other Status: Published Year Published: 2016 Citation: K. Everts, 2016. Fungicide Products for Managing Powdery Mildew on Cucurbit Crops. University of Delaware Cooperative Extension webpage. https://extension.udel.edu/weeklycropupdate/?p=8942 8. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Everts KL and Micallef S, 2016. Cover Crops and Chlorination: Effects on microbial contamination of soil. Great Lakes Fruit, vegetable and Farm Market EXPO, Grand Rapids, MI. online at http://www.glexpo.com/summaries/2016summaries/FoodSafety.pdf 9. Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. Striped cucumber outbreak this summer-how do you reduce their numbers? Weekly Crop Update. Delaware, MD, NJ, PA newsletter (E. Ernest Ed.). 10. Type: Journal Articles Status: Published Year Published: 2018 Citation: Eunhee Park, Yaguang Luo, Sasha C. Marine, Kathryne L. Everts, Shirley A. Micallef, Samantha Bolten, John Stommel, Consumer preference and physicochemical evaluation of organically grown muskmelon Postharvest. Biol. Technology, volume 141, July 2018, pages 77-85. 11. Type: Journal Articles Status: Other Year Published: 2019 Citation: Robert C. Korir, Kathryne L. Everts, Micallef Shirley A. Interactions between Salmonella enterica Newport, and plant pathogenic fungi of the genus Fusarium on and melon types.in preparation 12. Type: Theses/Dissertations Status: Under Review Year Published: 2019 Citation: Common Fusarium Spp. Causing Fruit Rots On Cucumis Melo In The Mid-Atlantic Region Of The Us And Their Impact On Salmonella Enterica Newport Survival, Growth, And Internalization On Various Melon Cultivars - Ph.D. Dissertation, Robert Korir University of Maryland.

2017/09 TO 2018/08 What was accomplished under these goals? Internalization ofSalmonella into melons: This study investigated the impact of infection of cantaloupe and \'honeydew\', by Fusarium spp. on internalization and subsequent proliferation of the human pathogen Salmonella enterica Newport. Melon fruit were inoculated with (1) either F. oxysporum alone followed by nonsimultaneous inoculation with S. Newport four days later, or water followed by S. Newport four days later, and (2) F. oxysporum plus S. Newport simultaneously, or, S. Newport alone. On days 5 and 10, melons were first subdivided into four transverse segments (rind/surface, exocarp, mesocarp and endocarp/seed cavity) and processed separately. Results were variable, but we observed that S. Newport was able to penetrate all types of melons down to the seed cavity both in the presence and absence of Fusarium infection. Since we were detecting so much postharvest Fusarium infection on melon that was

hindering production, we decided to survey the fungal pathogen in the research areas we were using for melon production. Fruit with visible symptoms of Fusarium fruit rot (white, tan or brown sunken areas on fruit) were collected and transported to the plant pathology lab for Fusarium isolation and identification from each location and field. One hundred and forty putative Fusarium isolates were obtained from the 250 fruit collected. Four Fusarium species were identified:F. proliferatum, F. fujikuroi, F. oxysporum and F. verticilloides. The majority of strains were not observed to be aggressive pathogens on melons. BMPs for beetles: Over 235 growers were shown how to use kaolin clay in cucurbits to reduce striped cucumber beetle damage and limit bacterial wilt infection and plant death in cucumbers and cantaloupe. Surveys after meetings showed that 37% of growers said they would try the new method of control for cucumber beetles. University Extension and research specialists as well agricultural consultants are aware of, and 23% plan to integrate the new control with their growers. Extension Activity. A grower meeting at the Wye Research and Education Centre was help in July 2019 summarizing the results of the project, including presentations and discussions on best management practices for production, disease and pest management, food safety and best cultivar selection for organic cropping systems. A webinar in collaboration with eOrganic took place on January 31, 2019. The link is provided in the section \"Dissemination of Results\". **PUBLICATIONS (not previously reported):** 2017/09 TO 2018/08 1. Type: Journal Articles Status: Other Year Published: 2019 Citation: Robert Cheruiyot Korir, Kathryne L Everts, Shirley Ann Micallef. Internalization of Salmonella enterica Newport in Smooth Surface and Netted Melons, alone or in the Presence of Fusarium Fruit Rot Caused by Fusarium spp. 2. Type: Journal Articles Status: Other Year Published: 2019 Citation: Robert C. Korir, Micallef Shirley A., Kathryne L. Everts. Common Fusarium spp. causing fruit rots on Cucumis melo in the mid-Atlantic region of the US. 3. Type: Journal Articles Status: Under Review Year Published: 2019 Citation: Marine, S.C., Korir, R.C., Micallef, S.A. and Everts, K.L. 2019 Impact of green manure on insect pests, foliar diseases and yield in an organic and a transitional organic muskmelon production system. 4. Type: Journal Articles Status: Published Year Published: 2018 Citation: Eunhee Park, Yaguang Luo, Sasha C. Marine, Kathryne L. Everts, Shirley A. Micallef, Samantha Bolten, John Stommel, â¿¿Consumer preference and physicochemical evaluation of organically grown muskmelonâ¿ Postharvest. Biol. Technology, volume 141, July 2018, pages 77-85. 5. Type: Journal Articles Status: Other Year Published: 2019 Citation: Robert C. Korir, Kathryne L. Everts, Micallef Shirley A. Interactions between Salmonella enterica Newport, and plant pathogenic fungi of the genus Fusarium on and melon types. in preparation. Progress 09/01/16 to 08/31/17 Outputs Target Audience:The scientific community, extension agents focusing on organic production of vegetables, organic and conventional vegetable growers. Changes/Problems:To comapre whether growing melons in till versus no till systems would impact melon fruit susceptibility to colonization with foodborne pathogens we conducted a field trial and a high tunnel trial between 2015 and 2017. We had difficulty in growing good quality melons in no till systems. These melons were also later than till system-grown melons. These problems made it difficult to conduct experiments as melons from the two systems were not available at the same time and were not of comaprable quality. We also noted that, due to the poor quality of melons from the no till systems, it would be unlikely that a grower would opt for this cropping method. We therefore will not be repeating this trial. What opportunities for training and professional development has the project provided?Two Ph.D. students and an undergraduate/technichian(X. Liu, R. Korir, S. Bolten) have been trained in experimental design andplant pathology andmicrobial food safety methods (inoculation of melons with foodborne pathogens, and coinocualtion of melons with foodborne pathogens and Fusarium wilt; disease scoring). Several students and technical personnel have had the opportunity to present at various conferences and twilight meetings (see publications). Several faculty have had professional development opportunities as a result of these grants, including conferences, grower meetings and field demonstrations. Brust, G. 2017. Using biostimulents in vegetable production systems. Central MD Vegetables Growers Meeting, Eastern Shore Vegetable and Fruit Growers Meeting and Southern MD Vegetable and Fruit Meeting. Cambridge, MD. (0.02 FTE). Brust, G. 2017. Beauveria bassiana as an endophytic biological control in vegetables. Future Harvest Training. Jarrettsville, MD and New Holland Growers Assoc. Lancaster, PA. (0.01 FTE). Brust, G. 2017. Organic management of bacterial wilt disease in vine crops. MOFFA Farmer Training. Dentsville, MD and New/beginning Farmer Training. Hamstead, MD. and Berks/Schuylkill Vegetable Twilight Meeting. Fairfield, PA. (0.02 FTE). Brust, G. 2017. Working with biostimulents in vegetable systems. CMREC-UMF Field Day. UMF, MD and St. Mary\'s Co. twilight growers meeting. Loveville, MD. (0.01 FTE). Brust, G. Biostimulents in organic vegetable production systems. Organic field day. CMREC, MD and Special training session for Maryland Vegetable Grower Association group. Marydel, MD. (0.02 FTE). How have the results been disseminated to communities of interest?Our team has attended several international and national conferences to disseminate various aspects of our research on pathology,crop protection, food safety and food quality. Several Newsletter articles in weekly crop updates to growers have been submitted and published. We have made use of Extension webpages to further dissemiante findings from the research. We have participated in several grower meetings to further disseminate our research to growers and Extension agents. Data through sensory analysis (descriptive and consumer) and physicochemical analysis for the results in this study was statistically analyzed and integrated to provide the scientific information for the organic melon industry and aid growers in the selection of optimal cultivar. Food quality data presented as

aposter at IFT 2017 meeting reached more than 23,000 participants representing food science professionals from over 90 countries across the globe. Research on Fusarium and Salmonella on melon dissemianted at the International Assocaition for Food Protoection 2017 Meeting in Tampa FL reached aninternational audience of more than 3,600 registered attendees representing 59 countries, 48 states and five Canadian provinces. The meeting has earned recognition as the leading food safety conference. What do you plan to do during the next reporting period to accomplish the goals? Investigate whether Fusarium disease causes internalizaton of Salmonella into melon fruit. Demonstrate best methods of management in cantaloupe for disease prevention in the crop and produce. Disseminate the results to growers, university and government personnel at meetings and field days. Several publications are planned in 2018, including a manuscript in Postharvest Technology Journal on the sensory evaluation objective, a manuscript in Journal of Food Protection on melon cultivar susceptibility to various foodborne pathogens and another on cropping practices and food safety. Impacts What was accomplished under these goals? Melon Disease and Food Safety: Several melon varieties have been tested to determine susceptibilities to foodborne pathogens. We found that smooth varieties tend to be the least colonized, particularly the less sweet cultivars such as canary melons. Growth in field versus high tunnel had no effect on susceptibility of melons to foodborne pathogen colonization. Till versus no till appeared to have no effect, although this compaison was very difficult as yield and quality in no-till systems was very poor. In the field we found several species of Fusarium that cause post-harvest disease of fruit. We investigated the possiblity of enhanced melon susceptibility to Salmonella colonization in the presence of infection, manifested as lesions on the rind. Food Quality: This study was to determine the consumer preference among four melon cultivars \\'Athena\' (C. melo var. reticulatus), \'Sivan\' (C. melo var. cantalupensis), \'Dulce\' and \'Juane\' (C. melo var. inodorus)\ grow in an organic, hairy vetch cover crop system and to select the most sustainable melon based on the marketability, critical quality attributes from sensory evaluation and physicochemical measurements. Although it was not easy to determine which melon is best suited for the local growing conditions, as well as melon marketability, the melon that had the most positive sensory and physicochemical traits among the cultivars investigated in this study was \'Sivan\'. Consumers preferred \'Sivan\' that was the most consistent cultivar across the two years, in terms of the physicochemical parameters.The selection of optimal cultivar through sensory analysis (descriptive and consumer) and physicochemical analysis were determined. Extension: Over 112 Growers, 4 Extension specialists and 9 Extension Educators were trained in the best methods to scout, recognize and manage plant diseases and the vectors of bacterial wilt in organic cantaloupe production systems. Instead of multiple insecticide applications to cantaloupe plants, biostimulents were used to reduce the spread and infection of plant pathogenic bacteria into cantaloupe plants, which significantly reduced bacterial wilt disease, responsible for major yield losses in organic cantaloupe. Publications Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Everts KL and Micallef S, 2016. Cover Crops and Chlorination: Effects on microbial contamination of soil. Great Lakes Fruit, vegetable and Farm Market EXPO, Grand Rapids, MI. online at http://www.glexpo.com/summaries/2016summaries/FoodSafety.pdf (30 min. 104 attendees, Dec 6, 2016) Type: Conference Papers and Presentations Status: Other Year Published: 2017 Citation: Korir R, Everts K, Micallef SA. Interactions between Salmonella enterica Newport and plant pathogenic fungi of the genus Fusarium on melons. International Association for Food Protection (IAFP) Annual Meeting, 9-12 July 2017, Tampa, FL. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Park E, Bolten S, Marine SC, Reed-Jones N, Everts KL, Micallef SA, Luo Y. Consumer preference and physicochemical evaluation of organically grown muskmelon in Maryland. Institute of Food Technologists Annual Meeting and Food Expo, IFT17 June 25-28, 2017, Las Vegas, Nevada. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Korir RC, Everts KL, Micallef SA, Whittington J. Common Fusarium spp. Causing Fruit Rots on Cucumis melo in the Mid-Atlantic Region of the U.S. 2017 Potomac Division 73rd Annual Meeting for The American Phytopathological Society, March 22 - 24, 2017, Morgantown, WV. Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Marine, S.C., and Everts, K.L. 2016 Evaluation of organically produced melon cultivars for powdery mildew and downy mildew severity in Maryland, USA. Pages 305-308. Proceedings of the Cucurbitaceae, 2016 El?bieta U. Kozik & Harry S. Paris, editors. Warsaw, Poland Type: Conference Papers and Presentations Status: Other Year Published: 2017 Citation: Brust, G. 2017. Multiple biostimulent applications are needed to increase vegetable yields and quality. 3rd Biostimulants World Congress, Miami, FL. Type: Conference Papers and Presentations Status: Other Year Published: 2017 Citation: Micallef SA. Investigating Plant-Microbe Associations for Safer Salads. JIFSAN Advisory Council Meeting, 4th May 2017, Greenbelt, MD. Type: Conference Papers and Presentations Status: Other Year Published: 2017 Citation: Pang H, Micallef SA, Everts K, Pradhan AK. Evaluation of Cover Cropping, Farming System, and Meteorological Factors on the Survival of Generic Escherichia coli and Listeria innocua in Produce Fields. International Association for Food Protection (IAFP) Annual Meeting, 9-12 July 2017, Tampa, FL. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Brust, G. 2017. Beauveria bassiana reduces the incidence of cucurbit bacterial wilt vectored by the strip cucumber beetle (Acalymma vittatum) in cantaloupe. Entomological Society of America Meeting, Denver CO. Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. Cucumber

beetle troubles in cucurbit crops. Vegetable and Fruit Newsletter (Mid-Atlantic (D. Myers Ed.). Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. Striped cucumber outbreak this summer-how do you reduce their numbers? Weekly Crop Update. Delaware, MD, NJ, PA newsletter (E. Ernest Ed.). Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. Using biostimulents in organic vegetable systems. Weekly Crop Update. Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. How to use Beauveria bassiana to reduce disease and increase yields in cantaloupe production systems. Pennsylvania Fruit and Vegetable Newsletter (T. Jennings Ed.) Type: Other Status: Published Year Published: 2017 Citation: G. Brust. 2017. Reducing bacterial wilt incidence in vining crops.Vegetable and Fruit Newsletter. Type: Websites Status: Published Year Published: 2017 Citation: Maryland Vegetables web site: http://extension.umd.edu/mdvegetables Using biostimulents in organic vegetable systems

2015/09 TO 2016/08 What was accomplished under these goals? Objective 1a: Four species of cover crops (winter wheat, hairy vetch, rapeseed and mustard) and bare ground were planted in the fall of 2015 at the Wye Research and Education Centre in a RCBD. Rhizosphere soil samples were collected in spring 2016. DNA was extracted from soil and subjected to ARISA analysis. Data is currently being analyzed. Objective 1b: Research was conducted to determine the effect of three green manure cover crop treatments (cereal rye, crimson clover, and crimson clover + rye) and bare ground on insect pest populations, foliar diseases, and fruit yield and quality in an organic and a transitional muskmelon production system at the Lower Eastern Shore Research and Education Center (Salisbury, MD). Muskmelon in the transitional organic field had significantly more anthracnose than plants in the organic. However, powdery mildew severity was statistically equivalent between fields. Anthracnose disease severity also varied by green manure treatment, but was highest on muskmelon in crimson clover plots in both the organic and transitional organic field. Green manure treatment did not affect powdery mildew disease severity in either field. Objective 1c: Four cultivars of muskmelons (cultivars\'Sivan\', \'Edens Gem\', \'Athena\' and \'Dulce\') were planted in tilled andno till plots of hairy vetch. Ripe muskmelon wereharvested and taken to the lab for Salmonella enterica Newportspot inoculation, to determinewhether till and no till green manure impacts Salmonella survival on fruit surfaces. Preliminary results were hard to interpret as the no till muskmelons grew poorly. This objective will be repeated in summer 2017. Objective 2a: Field trials were also conducted to evaluate eight muskmelon cultivars for insect pests, foliar diseases, and fruit yield and quality in an organic till and no-till hairy vetch cover crop system at the UM Wye REC in Queenstown, MD. Data analysis is ongoing. Research was conducted for the 2nd year looking at alternative organic controls for striped cucumber beetles in cantaloupes. Data were taken and analyzed. Objective 2b: Sensory evaluation of muskmelons (four cultivars \'Athena\', \'Sivan\', \'Juane\', and \'Dulce\') by ARS-Food Quality Laboratory in Beltsville, MD, has progressed as planned during 2016.In 2016, evaluation of consumer\'s preference for melons was conducted using a 120-member untrained consumer panel (August 2016). In addition, physicochemical analysis of color, firmness, soluble solids content, and acidity was also performed, and statistical analysis conducted. These activities contributed significantly to achieving the goals of assessing of the marketability of the cultivars based on consumer appraisal of the eating quality of fruit cultivars through sensory evaluation. Initial findings: Preliminary statistical analysis of the sensory evaluation data showed the following findings: The cultivars, \'Sivan\' and \'Athena\' received the highest overall quality scores, while \'Juane\' received the lowest overall quality scores.The panelists found significant differences among the cultivars. Different from the last year result (honeydew type melon \> cantaloupe type melon), this year study showed that honeydew type melon had a lower rating on texture, flavor and overall eating quality, compared with cantaloupe type melon. It should be noted that Honeydew type melon in 2016 exhibited significantly higher flesh firmness than those in 2015. Instrumental measurement showed that the firmness of muskmelon was higher in 2016 than in 2015, except \'Sivan\'. However, the cultivars \'Athena\' and \'Juane\' received almost the same scores from the trained panel in 2015 and from the consumer panel in 2016 for overall quality. This study showed that the correlations of flavor score and overall quality score were almost the same with that of the 2015 year (r=0.96). Visual juiciness intensity was highly correlated with textural juiciness intensity (r=0.84) Instrumental measurements (texture analyzer, color, SSC, pH, and TA) showed that this year\'s data (measurements) for cultivar \'Sivan\' were very similar to last year\'s data. It may be concluded that \'Sivan\' was grown consistently in organic fields during the 2 seasons. Objective 3: Findings from year 1 and 2 will be assessed in year 3. Objective 4: Outreach was conducted at the University of Maryland Summer Fruit and Vegetable Twilight Meeting at WyeREC in Queenstown, MD. The field research plots had eight cultivars that were planted on a tilled green manure cover crop and no-till. We demonstrated that both green manure cover crop treatment and muskmelon cultivar differentially impacted diseases. We presented information on both plant pathogens and human contaminants of plants. Results from the cucumber beetles portion of the study were presented to growers as well. We presented our research at a second event at University of Maryland\'s Lower Eastern Shore Research and Education Center Twilight Tour, and a third at University of Maryland Horticultural Twilight Meeting and Tour. The organic and transitional field provided a backdrop to share information and research results. Another field day was conducted at our University of Maryland Upper Marlboro Research & Education Centre at the Sustainable Agriculture & Organic Twilight

Meeting Tour in August 2016. Research field experiments were conducted at the Lower Eastern Shore Research and Education Center (Salisbury, MD) to: evaluate the effect of green manure cover crops on insect pest populations, foliar disease, and fruit yield and quality in an organic and transitional production system (objective 1b). Other outreach accomplishments include newsletter articles about the organic cantaloupe alternatives, updates on UME organic web site about the project and winter presentations to growers of the study results. **PUBLICATIONS (not previously reported):** 2015/09 TO 2016/08 1. Type: Journal Articles Status: Published Year Published: 2016 Citation: Reed-Jones N#, Marine SC, Everts K and Micallef SA, 2016. Effect of cover crop species and season on population dynamics of Escherichia coli and Listeria innocua in soil. Applied and Environmental Microbiology 2016 Jan 4;82(6):1767-77. Accepted manuscript posted online 4 January 2016. doi: 10.1128/AEM.03712-15. PMID: 26729724 2. Type: Journal Articles Status: Published Year Published: 2016 Citation: Marine, SC, Newark MJ, Korir RC and Everts KL. 2016. Evaluation of rotational biopesticide programs for disease management in organic cucurbit production. Plant Dis. 100:2226-2233 3. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Marine, S.C., and Everts, K.L. 2016 Evaluation of organically produced melon cultivars for powdery mildew and downy mildew severity in Maryland, USA. Pages 305-308. Proceedings of the Cucurbitaceae, 2016 El?bieta U. Kozik & Harry S. Paris, editors. 24-28 July, Warsaw, Poland. 4. Type: Other Status: Published Year Published: 2015 Citation: S.C. Marine, R.C. Korir and K.L. Everts, Field evaluation of muskmelon cultivars for susceptibility to anthracnose, powdery mildew and downy mildew when grown in organic no-till and plastic-mulch production systems in Maryland, 2015. Plant Dis. Manag. Rep. 10:V090. 5. Type: Other Status: Published Year Published: 2016 Citation: Everts, K. Fungicide Products for Managing Powdery Mildew on Cucurbit Crops. Vegetable and Fruit Headline News, University of Maryland Extension Vol 7(1) May 13, 2016. PROGRESS: 2014/09 TO 2015/08 Target Audience:The scientific community, extension agents focusing on organic production of vegetables, organic and conventional vegetable growers. Changes/Problems:No Major problems have been encountered. Since insect pest populations were not significantly different by green manure cover crop treatment in year 0 (preliminary) or year 1 of this project (p=0.393 and p=0.685, respectively), insect assessments at LESREC will not be repeated in year 2. What opportunities for training and professional development has the project provided?Two post-docs were trained during this period. Dr. Neiunna Reed-Jones conducted research on food safety microbiology. Dr. Neiunna Reed-Jonespresented her work in a technical talk at the International Association For Food Protection in Portland Oregon in 2015. Dr. Sasha Marine focused on agricultural production systems and phytopathology. Several undergraduates were able to complete undergradaute research studies through a lab course that provides opportunity for lab research/training.(University of Maryland PLSC399 Special Problems in Plant Science: Food Safety of Fresh Produce; instructor: Dr. Shirley Micallef).A PhD student has also joined the program (2015)and will be conducting food safety and phytopathology research on this cover crop/green manure muskmelon system. How have the results been disseminated to communities of interest?Results have been disseminated to growers and extension agents atvegetable production twilight meetings, grower meetings, and to the scientific communityat conferences. Results have been published in extension publications. Details are in relevant sections of this document. What do you plan to do during the next reporting period to accomplish the goals?Work will commence on objective 1a. Soil samples are frozen, and new samples will be collected in spring 2016. Growth chamber studies with human pathogens and cover cops will be repeated. Other evaluation efforts will also continein the field in2015-2016 by repeating objective 1b in the same field locations at LESREC, focusing on a subset of green manure cover crop treatments (crimson clover, rye, crimson clover + rye and bare ground) and their effect on muskmelon foliar disease, fruit yield and quality. Evaluation efforts will continue in 2015-2016 by repeating objective 2a at the Wye Research and Education Center (Queenstown, MD), installing a till and no-till hairy vetch cover crop system and evaluating the same eight muskmelon cultivars from year 1. For objective 2c, resaerch will continue toexamine the endophytes with the foliar insecticide treatments for a true integrated approach to STCB control, as well as different methods of introducing the endophytes into the cantaloupe plants. For sensory evaluation, during October, 2015 to January 2016, all data will be analyzed in detail to evaluate the palatability of the melons and to select the treatment groups (melon cultivars) for consumer panel in year 2. In year 2, four or five melon cultivars with preferable sensorial attributes and physicochemical properties will be selected for evaluation in 2 untrained consumer preference tests each made up of 60 untrained volunteers with no prior knowledge of the objective in year 1. Consumer panelists, students and employees recruited from ARS and BARC campuses, will evaluate treatment groups using the same attributes and scales developed by trained panelists through quantitative descriptive analysis. Instrumental measurements will also be performed as in year 1, including color, texture, soluble solids and titratable acidity. Data will continue to be gathered to prepare for objective 3 to be conducted in year 3. IMPACT: 2014/09 TO 2015/08 What was accomplished under these goals? Objective 1b: The effect of five green manure cover crop treatments (hairy vetch, cereal rye, crimson clover, hairy vetch + rye, and crimson clover + rye) and bare ground on insect pest populations, foliar diseases, and fruit yield and quality in an organic and a transitional muskmelon production system were determined at the Lower Eastern Shore Research and Education Center (LESREC) (Salisbury, MD). Cover crops were seeded in September 2014 and tilled into the soil in May 2015. Muskmelon cv. \'Sivan\' were transplanted in June. Both green manure

treatment and muskmelon cultivar differentially impacted phytopathogens and other aspects of vegetable production.Cover crop biomass (both wet and dry weight) was significantly different by farming system (organic versus transitional; p\<0.001) with cover crops in the transitional field having less biomass. All cover crop treatments had significantly more dry weight biomass than bare ground, but cover crop treatments were statistically equivalent. Average fruit weight was significantly different by farming system (organic versus transitional; p\<0.001) with fruit from the transitional field weighing less. Green manure treatment was a significant factor for average fruit weight in the organic field (p=0.001) but not in the transitional field (p=0.060). Green manure treatment was not a significant factor for soluble sugars in either farming system. Objective 1c: Survival of enteric bacteria in five cover crop/green manure systems and muskmelon cv. \'Sivan\' was studied.Fields were inoculated with non-pathogenic Escherichia coli and Listeria innocua using a handheld sprayer in fall 2014.Bacterial levels in soil and fruit samples revealed that cover crop/green manure treatment may favor the survival of enteric bacteria in soil and subsequent dispersal onto melon. Time was a factor for both bacteria in organic and transitional fields. Tillage but not green manure had a positive effect on bacterial population but recovery was seen after 2-4 weeks. Growth chamber studies were conducted using cereal Rye, hairy vetch, oilseed radish andcrimson cloverwith foodborne pathogens. Cover crops pots were inoculated with bacterial cocktails of Listeria monocytogenes and E.coli O157:H7. Soil was analyzed for bacterial levels. A decline in bacterial populations over time was seen in all treatments however further analysis is required to detect differences among treatments. In rhizosphere soil, L. monocytogenes persisted in crimson clover and hairy vetch pots. Objective 2a: Eight muskmelon cultivars were evaluated for insect pests, foliar diseases, and fruit yield and quality in an organic till and no-till hairy vetch cover crop system at LESREC and in an organic till system at the Central Maryland Research and Education Center CMREC (Upper Marlboro, MD). Average fruit weight was significantly different by production practice (tillage versus no tillage; p\<0.001) with fruit from the no-till section weighing less. Cultivar was a significant factor for average fruit weight and soluble sugars in both the till and no-till sections (p\<0.001). Insect pest populations were also significantly different by production practice (tillage versus no tillage; p\<0.001) with more cucumber beetles observed on muskmelon plants in the till section. Objective 2a.v. Cultivar Study: Assessments were conducted to determine whether genetic variation among seven cultivars (\'Athena\', \'Escorial\', \' Sivan\',\' Juane\',\' Sunbeam\', \' Dulce\' and \'Snowmass\') and the use of tilled or no-till hairy vetch as a cover crop, had any protective effect on muskmelon colonization by the outbreak stains of human pathogens Salmonella Newport, Listeria monocytogenes and E.coli with antibiotic resistance plus Green Fluorescent Protein (GFP). Netted and honeydew melons support higher levels of pathogen colonization compared to canary melon varietals. Objective 2b: Sensory evaluation of melons at Agricultural Research Service (ARS) Food Quality Laboratory (FQL) has progressed as planned. The first year tasks towards the goal of evaluating consumer\'s preference of melon cultivars included the development of a trained sensory panel, sensory evaluation and physicochemical analysis of melons which were harvested in summer of 2015. Ten panelists were trained.and developed descriptive profiling and fine-tuned scales to analyze specific melon attributes and assisted in the development of a ballot.Harvested melons from two locations, CMREC-UMF and LESREC were transferred to FQL, ARS and stored at 1°C for one or two days.A total of 4 sensory panels were held on five cultivars (\'Athena\',\' Sivan\',\' Juane\',\' Sunbeam\' and\' Dulce\'). Five to six fruits per cultivar were sanitized, processed, peeled and sliced with seeds removed for evaluation. All fruits were tested for ripeness by measuring soluble solid content using a refractometer and organized by soluble solid contents (high, medium and low).Panelists rated 17 attributes, from 4 categories including appearance (ripeness, color uniform, juiciness, color intensity), texture (juiciness and firmness), flavor (sweetness, sourness, vegetable, fruity, fermented, musky/earthy and aftertaste) and acceptability of texture, flavor and overall quality. The physicochemical evaluation of color, firmness, soluble solid content, and acidity were conducted to complement the sensory data. Initial findings showed: (1) cultivar, \'Dulce\' received the highest overall quality score but the panelists found no significant difference among the cultivars, (2)the correlation between overall quality score and flavor score was very high (r=0.94). The result showed that flavor is very important factor in consumer food choice, (3) Honeydew type melon had a higher rating on texture, flavor and overall eating quality, compared with cantaloupe type melon, (4) Although there was no significant difference between cultivars, the cultivars \'Athena\' and \'Sivan\' from two locations each had significant between location differences for overall quality. Objective 2C:Field trials were conducted at CMREC looking at alternative controls for striped cucumber beetle (STCB) on cantaloupe (Athena). There were 8 treatments: 1. Control-no treatment for STCB, 2. kaolin clay (Surround), 3. Pyganic (pyrethrins) alone, 4. Entrust (spinosad) alone, 5. Surround + Pyganic, 6. Surround + Entrust, 7. endophyte - Beauveria bassiana strain GHA and 8. endophyte-Acremonium spp. Striped cucumber beetle populations were considered moderate in these treatments. All treatments significantly (p\<0.05, orthogonal contrasts) reduced the level of feeding by striped cucumber beetle compared with the control. The two best treatments to reduce STCB feeding were the endophyte B. bassiana and Entrust + Surround. All treatments had significantly (p\<0.05) fewer plants killed by bacterial wilt than the control, with the two best treatments being the two endophytes-B. bassiana and Acremonium. Combining Entrust or Pyganic with Surround increased the effectiveness of the control vs each alone and reduced the number of plants killed by bacterial wilt. Cantaloupe plants infected with Acremonium had

2.2 times the yield of fruit compared with the control (p\<0.001) while plants infected with the other endophyte B. bassiana had increased yields of 80% compared with the control. Plants treated with Entrust alone or with Entrust + Surround had the next highest yields (an average of a 55% increase) compared with the control. Endophytes appeared to work in different ways; B. bassiana reduced STCB feeding resulting in less bacterial wilt and greater yields while Acremonium did not reduce STCB feeding as much, but decreased the number of plants developing bacterial wilt, significantly increasing yields. PUBLICATIONS (not previously reported): 2014/09 TO 2015/08 1\. Type: Conference Papers and Presentations Status: Accepted Year Published: 2015 Citation: ? Reed-Jones, N.L., Marine, S.C., Everts, K. and Micallef, S., 2015. Evaluating the effect on the survival and growth dynamic of food borne Bacterial indicators in the soil and on cantaloupes grown organically. Developing Scientist Finalist for Oral Presentation. International Association of Food Protection National Conference, 2015, 25-28 July, Portland Oregon. 2\. Type: Other Status: Published Year Published: 2015 Citation: Marine, S. and K. Everts. 2015. Cantaloupe (muskmelon) in Maryland. Fact Sheet. University of Maryland Extension: Organic Vegetable Production webpage. 3\. Type: Other Status: Awaiting Publication Year Published: 2015 Citation: Marine, S.C., R. Korir and K.L. Everts. 2015. Field evaluation of muskmelon cultivars for anthracnose, powdery mildew and downy mildew in organic production in Maryland. Plant Disease Management Report

↑ Return to Index

Improving the Competitiveness of Ltd. Resource Farmers & Ranchers (lrfr) in Southern New Mexico Thru the Adoption of Organic Practices Proj.

Accession No.	1003803
Subfile	CRIS
Project No.	NMGutierrez-14G
Agency	NIFA NM.
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22082
Proposal No.	2014-03378
Start Date	01 SEP 2014
Term Date	31 AUG 2017
Grant Amount	$499,191
Grant Year	2014
Investigator(s)	Gutierrez, P.; Uchanski, MA.
Performing Institution	Extension Economics, NEW MEXICO STATE UNIVERSITY, 1620 STANDLEY DR ACADEMIC RESH A RM 110

NON-TECHNICAL SUMMARY

The diversity, traditions, and determination of limited resource farmers and ranchers in Southwestern New Mexico reflect both the physical and cultural landscapes of the region and make for a productive and rich agricultural system. Yet, these strengths are often not rewarded in the marketplace which makes it difficult for small-scale farmers and ranchers to stay in business. Not only are these producers disadvantaged in conventional marketing systems by their size being very small in many cases, but many are producing alternative or unconventional products, and a great many are traditionally underserved farmers and ranchers, especially Hispanic. In New Mexico, for example, according to the 2007 Census of Agriculture, more than 30% of principal farm and ranch operators are Hispanic. Further, 94% of New Mexico farms run by Hispanic operators generate less than \$50,000 in annual sales. Many small farms and ranches struggle to increase productivity and profitability. While entrepreneurial spirit is prevalent in many areas as evidenced by roadside stands, farmers\' markets, and other informal marketing, these efforts often lack the knowledge, resources and markets opportunities needed to make them as profitable as they could be. In addition, those with entrepreneurial leadership skills are not being networked with other farmers who could benefit from their expertise and experience. The goal of this project, Improving the Competitiveness of Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico Through the Adoption of Organic Practices Project (LRFR ORG), is to assist the Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico to build knowledge, skills, resources, and relationships that will improve their competiveness through the successful adoption of organic farming and ranching practices. This will be accomplished through the following five interrelated research and extension objectives:The Research and Extension components of the project will have the intended impact on the organic agricultural industry in southern New Mexico because the innovative research and programs developed will respect the knowledge and life experiences of each participant. Producer and community stakeholders who have cited the need for research and educational resources and tools to help transition to organic agricultural practices will be engaged as partners in the planning process through implementation.

OBJECTIVES

The goal of this project,Improving the Competitiveness of Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico Through the Adoption of Organic Practices Project (LRFR ORG), is to assist the Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico to build knowledge, skills, resources, and relationships that will improve their competiveness through the successful adoption of organic farming and ranching practices. This will be accomplished through the following five interrelated research and extension objectives: Objective 1: Value Chain Development: Determine present markets and potential future markets for selected organic crops and livestock products (research and extension);Objective 2: Organic Agriculture/Enterprise Development: Using the StratSense™ framework, LRFR ORG project staff will systematically help producers define and analyze the markets for organic agricultural products, and then, configure their farm or ranch operation to meet that market demand. (research and extension).Objective 3: Participatory Research and Peer Learning: Assist producers during the critical transition period when adopting organic practices through participatory involvement in applied and adaptive research of documenting and understanding the certification guidelines and regulations and required record keeping (research and extension).Objective 4: ORG Transition Tool Kit and Popular Education. Drawing on the pedagogical approach of the educational philosophy known as Popular Education, develop a bi-lingual ORG Transition Tool Kit and provide trainings and workshops on evaluating the social, biological and economic impacts of transitioning to organic agricultural practices (extension).Objective 5: Dissemination of Models: Through existing relationships with regional and national organization, ensure that project methodology, curriculum, research and attainments are shared with producers, agricultural service providers, and other food system stakeholders throughout the country.The Research and Extension components of the project will have the intended impact on the organic agricultural industry in southern New Mexico because the innovative research and programs developed will respect the knowledge and life experiences of each participant. Producer and community stakeholders who have cited the need for research and educational resources and tools to help transition to organic agricultural practices will be engaged as partners in the planning process through implementation.

APPROACH

The LRFR ORG project proposed here acknowledges that creating a truly integrated research and extension project that supports LRFR transition to organic agriculture will require a collective impact, the commitment of a group of important actors from different sectors of local agriculture/food system with a common agenda for solving specific organic production, management and marketing problems. Successful collective impact initiatives typically have five conditions that together produce true alignment and lead to powerful results: a common agenda, shared measurement systems, mutually reinforcing activities, continuous communication, and backbone support organizations. The following proposed activities to support the LRFR ORG project objectives were developed with this in mind.Activity 1: Coordination of project partners and stakeholder participants:Continuous communication by the LRFR ORG Project Director will be imperative to the success of this project. The LRFR ORG Project Director and staff, in collaboration with partner organizations, will plan, manage, and support project objectives through ongoing facilitation, and communications, data collection and reporting, and handling the myriad logistical details needed for the project to function smoothly. Additionally, a principal objective of Activity1 is to provide un-interrupted support to cooperating LRFR as they transition to organic agriculture. This includes referral to existing service providers and introductions to well-networked community members\--Objective 2.Activity 2: Needs Assessment-USDA ORG Priorities 1 and 4:To insure that research findings will have their intended impact on the organic agricultural industry in southern New Mexico, transitioning organic and/or potential transitioning organic producers and partner organization will be directly involved in developing an aggressive integrated research and extension effort. Activity 2 will involve the development of common integrated research and extension agenda that aligns with USDA NIFA ORG Priorities 1 and 4. This research/extension agenda will be fundamentally grounded in a common understanding of challenges and opportunities to transitioning to organic agriculture and agreed upon integrated research and extension approach that will help address these challenges and opportunities in southern New Mexico, and beyond.Activity 3: Initiate Value Chain, Organic Agriculture/Enterprise Development and Participatory Research and Peer Leaning\--Project Objectives 1, 2 & 3.Objective 1: Value Chain DevelopmentAs a complement to organic agriculture/enterprise development, this LRFR ORG project will include information, education about and development of value chains for local organic agricultural products as a key project activity. This will include:Incorporating value chain methodology into all project activities, such as providing training on value chain methodology as part of peer learning/networking sessions and organic curriculum development.Offering hands-on workshops, strategy sessions and annual conference aimed at developing specific regional organic agricultural product value chains.Collaborate with La Semilla, Mountain View Market and NMSU Small Farm initiative to provide train-the-trainer workshops to school districts, health care institutions, agricultural service providers and producer groups on value chain

methodology.On the groundwork to develop specific value chains as identified through the StartSense framework/producer participants and other food system stakeholders. Project director will meet on a bi-monthly basis with partners and stakeholders throughout the duration of the grant period.Objective 2: Organic Agriculture/Enterprise DevelopmentThe Organic Agriculture/Enterprise Development methodologies to be employed in this project will be informed by the StratSense™ framework. StratSense™ will be used to conduct a local and regional organic market study, identify the value-added chain elements, analyze producer abilities, and form a Strategic Business Plan for the LRFR to access and meet market demands. StratSense™ is an established methodology of analyzing market conditions and defining and/or detecting market opportunities, threats, trends and strategic questions for existing, new, and value-added organic products/commodities produced in southern New Mexico. It is a procedure under which existing and alternative crops and or livestock or organic crop and livestock may be analyzed for probable profitability and successful production. Objective 3: Participatory Research and Peer Learning/NetworkingFeedbacks from producers who attend the New Mexico Organic Farming Conference consistently report the need for more opportunities to network with and learn from other producers in their region. NMSU LRFR ORG project staff and partners will coordinate both formal and informal peer learning/networking opportunities, at each of three LRFR ORG project farm sites. Each project farm site will be conducting on going producer identified integrated research and demonstration projects, identified in Activity 2.All three-farm sites will be host sites for organic practices, demonstrations and peer networking activities. The NMSU Student Centered Field Lab will be host sites for identified organic research projects. Examples of research/demonstration projects might include: On site locally adapted/alternative food and medicinal crops (prickly pear, mesquite, therapy).Reduced till, killed cover crop rotations with cash (vegetable) crops. Low cost drip irrigation technologies.-Novel, organic weed control technologies, especially focused on the transition period. Optimal tillage, cover crop and rotation practices to reduce erosion and increase carbon sequestration during the transition to organic agricultural systems. Practices assessing the environmental, conservational, greenhouse gas emission reduction, and/or climate change mitigation potential of pasture-based organic dairy systems;Examining soil dynamics in fields under long-term organic soil management compared to that during the transition.Generating data set on nitrous oxide emissions from organic systems using various sources of nitrogen, rotation practices, and tillage levels.Evaluating the effect of transitioning to organic production on biodiversity, including pollinators.All three-project farm sites will provide peer learning/networking opportunities to producers, students, or their information providers, such as extension agents/educators, agricultural consultants, or college teaching faculty. Educational opportunities will include workshops, internships and technical assistance.Activity 4: ORG Transition Tool Kit and Popular EducationDrawing on the pedagogical approach of the educational philosophy known as Popular Education, the LRFR ORG project proposes to develop an bi-lingual ORG Transition Tool to support producer trainings and workshops on evaluating the social, biological and economic effect of transitioning to organic production.The ORG Transition Tool Kit would consist of several learning modules that are aligned with the USDA Organic Program Handbook (USDA, September 2010) and the New Mexico Department of Agriculture Organic Certification requirements. The goal of the ORG Transition Tool Kit is to provide LRFR, or those who own, manage, or certify organic operations with guidance and instructions that can assist them in complying with the National Organic Program (NOP) regulations.The project outreach goal is to engage more than 50 farmers, ranchers, processors and food purveyors each year in the Organic Agriculture Transition Popular Education model by sharing the skills, the knowledge and the experience of organic practices.

PROGRESS

2014/09 TO 2017/08 Target Audience:The proposed outreach area for this proposal included the New Mexico counties of Doña Ana County (789 Hispanic principal operators), Luna (40 Hispanic principal operators), and Otero (123 Hispanic principal operators), based on the 2007 Census of Agriculture. Although the three counties were designated the target program area, and limited resource farmers and ranchers were the designated target audience, farmers and ranchers from all over New Mexico have been welcome to participate in any of the programs and activities resulting from this proposal. And in fact, that has been the case. Many growers from northern New Mexico have learned about this USDA NIFA Organic Transition project and have reached out to us for information, workshops and technical support. Over trhe course of the three year the reproting period (September 1, 2014 through August 31, 2017), the Organic Transition (OT) project has reached: 800 producers, non-profits members, master gardeners, local municipality employees, local and state government agency staff and elected officials through numerous one-on-one meeting, farm visits, field days, workshops and conferences, with information and education matierial pertaining to Organic Farming and Ranching best practices and certification requirements and process. Sing in sheets and participation records show that approximately 43% of participants were Hispanic, 8% Native American and 49% were non-Hispanic and non-Native American. Additionally, and important to the goals and objectives of the project, the OT project Team has worked closely with severalproducers/growers\--farmer/rancher participants to transitionto organic agriculture production. At the

end of the second year the OT project had approximately 53 producrs/growers that had made some level of commitment. However, at the beinning of the the calendar year 2017, state budget support for New Mexico Department of Agriculture Organic Certification Program was cut significantly. Several producers, concerned about the level of commitment from the state to support organic cetification, decied to hold off on the OT certification process.At the end of the three year OT project, and currently: 15 producers are OT committed and have formally initiated the 3-year citification process. 10 of the 15 producers are Hispanic growers. 23 producers are committed to organic farming best practices, but have not yet committed to certification process. These producers are still apprehensive about \"the burden\" of the record keeping process to become certified organic. 12 of these producers are Hispanic growers. 15 producers are \"on the fence, \" thinking about it.\" These individuals are not convinced that the \"extra effort\" will make a difference to the bottom line.5 of these producers are Hispanic. We continue to work with all these producers. Working with small (mostly) vegetable producers in southern NM over the past three years, it was apparent that a lot of farmers\' information about \"organic\" is mostly word of mouth, assumptions and/or myths. As a direct result from working closely with the target audience, the development of the \"Organic Toolkit\" proposed as part of this project was developed with the intent to assist farmers, industry specialists, extension, non-profits and other stakeholders in navigating vast amount of organic resources for small producers. There is noshortage of information and literature related organic transition/farming, but their is significant shortage of Organic framing/transitioningexperts who can mentor limited resource farmers and ranchers. At the end of the day, our target audience wanted to know what USDA wanted and or expected from them to be able to display the USDA Organic Certified Label.Therefore, the OT Toolkit highlights the work of the USDA AMS so that the reader becomes familiar with the mission and vision of United States Department of Agriculture (USDA) Agricultural Marketing Service (AMS), that houses the National Organic Program (NOP). Changes/Problems:The New Mexico State University Cooperative Extension Organic Transition Team is very thankful for USDA NIFA support for the Organic Transition Funding the past three years. We are better researchers and educators as a result, but more importantly we have developed a sustainable relationship with a previously unknown group of farmers and ranchers that are passionate and committed to sustainable agriculture. The only limitation is time and resources, but with a new level of commitment from all involved in this project we are confident that we can over come both and stay focused on the work. The above \"results focus\" is actually a very exciting outcome from the three-year project that we, the university are on a pathway that will benefit limited resource growers. Going forward beyond the grant, in a effort to have a continued focus on the OT project deliverables made possible by this grant, we plan to engage more with our project partners and cooperators and set up structured demonstrations related to one or more of the topics identified previously on each of partner farms and on cooperators farms. Structured demonstrations mean that there would be a protocol for monitoring, measuring, evaluating and documenting demonstration. Simply starting with goals and objective of demonstrations and methods. Short of calling these demonstrations research plots, needs to be structure in the process. This will help individual growers overcome the some of their record keeping challenges and provide valuable information on best practices for the region. This is not a change from the original proposal, but developing the relationships and local vision for this took a significant investment in time in moving producers to a level where their were comfortable with participating. To help sustain producers interest in OT and the education and community building efforts, producers participants have identified areas that they would like to collaborate with NMSU on: Small Farmers Cooperative, to support producer education, regional market development and processing. USDA Small Farms Center of Excellence. Provide a university focus on the need of small farmers in Southwestern NM/US and define the role and relationship with community partners to insure sustainability What opportunities for training and professional development has the project provided?Fiscal year 2014-2015 Workshop and Conferences\-- Sept 19, 2014\--Orientation Tours. In effort to do a little Ogranic Transition Team (OTT) building, we spent a couple of days touring each OT grant cooperators farm: NMSU Student Resarch Farm (Ogranic Certified), La Semilla Community Farm (Organic Transition farm), MVM Farm (Organic Transition farm) Anthony Water District Community Farm (Organic Transition farm). Dec, 10, 2014\--Ogranic Pest Management Workshop, Anthony Soil and Water District Jan 2015\--Interpreation of Soil Analysis Results\--La Semilla Community farm February 21 and 22, 2015; New Mexico Organic Conference, Abq NM. (500 plus participants) May 27th, 2015 Organic Transition Workshop, Abiqu New Mexico\--OT workshop Table 1 below reports a Timeline of completed and proposed workshop for calendar year 2015 Table 1: OT Workshop Time Lines Organic Transition Team Workshop Timeline OTT members present: Mike P., Mark U., Joanie Q., David K. Fiscal Year 2015-2016 Farm Site visit Activities included; Soil test and follow up interpretation Salt Management/irrigation management • Insect pest management Weed control -including vinegar burning and hoeing technique • Rain water harvesting Tours\--7 Irrigation system set up and management and best practices Field preparation, leveling Cover crop, cover crop management\--crimping and termination • Manure analysis Numerous Email correspondence and telephone calls OT Grower Events/Activities\-- • Master Gardeners\--weed management • Santa Fe Farmers Market • NMDA, City of Las Cruces • New Mexico State Fair • Eastern NM State Fair • Southern NM State Fair Organized Workshops: Chronological sequence of workshop and events resulting from NMSU NIFA OT Project: January, 2015. Anthony, NM: La Semilla-Soil Interpretation April 15,

2015. Anthony, NM: 2015 Seed Blessing Event with partner La Semilla April 2016, Anthony, NM: La Semilla Seed Blessing Ceremony and Farm May 27, 2015. Abiquiu\', NM: Certification and Marketing Workshop. Based upon the overwhelming success of this workshop, four more workshop were planned, organized and executed during the reminder of 2015. September 29, 2015. Las Cruces, NM: NMSU NIFA Organic Transition Project Food Safety Workshop. October 1, 2015. Las Cruces, NM: NMSU Organic Transition Project Food Safety Workshop. October 10, 2015. Anthony, NM: Cover Cropping, Certification, and NRCS Funding Opportunities. Done in partnership with La Semilla. November 18, 2015. Espanola, NM: Certification and Marketing Workshop. Farming Conference. At the conference, NMSU OT team set up a booth as prearranged to display our before and after work with Mountain View Market/Coop. We distributed the NMSU OTT information packet we developed to explain the USDA grant and seek participants. 50 packets were distributed and numerous potential participants were engaged during the conference. Fiscal Year 2016-2017 April, 2016. Self Guided Farm Tour, La Semilla Farm. Cover Crops, Crop Rotation, Compost, Chickens, Perennial Vegetables, Pollinators, and more. April 9, 2016 Seed Blessing and Planting. June 6-9, 2016. Discovery Camp, 1st-6th grade. Hands on learning activities about what is living in the soil, soil composition, vermicomposting, bugs, etc. June 20-23, 2016, 1st-6th grade. Culinary ARTS Camp. Learn various culinary skills as well as ways that food can be used to make art. 2017 Agroecology Workshop Series: February 9th, 2017. Food Safety-NMFMA April 8th, 2017 Seasonality workshop, transplanting and direct seeding of summer crops April 11th, 2017. Crop Extension and Early Production in High Tunnels; Farm walk and farmer to farmer learning. April 22, 2017. Splitting a Bee Hive and Beekeeping 101. Auburn University and the Bee Biodiversity Initiative. May 9, 2017. Native Bee Wrokshop, Bashira Chowduhury, Auburn University and the Bee Biodiversity Initiative. May 11th, Bee Anthony. Native bees potluck with Bashira Chowdury, Auburn University and Bee Biodiversity Initiative May 30th, 2017. IMP with Dr Carol Sutherland. 2017 Meetings/sequence of events undergone with OT farmers: Review NMDA application and provide OSP resources Coordinate meeting with Mike Peterson: reviewed NMSU Organic Farm\'s NMDA Re-newal Application & Recordkeeping notebook(s) Answer questions, liason with NMDA, look-up/clarify forms needed Review application a second or third time until complete Submit to inspector (Submitted 3 Farm Crop applications & 1 Processor/Handler Provide inspector\'s feedback to farmer Conduct mock inspection How have the results been disseminated to communities of interest?Possibly the most important, and also the most challenging performance expectation of this project, it disseminating results to communities of interest-contract performance deliverables. The past three years have provided us with a number of learning opportunities as research and educators, as a project like this should do. It was clear early on in this project that the \"proposed\" deliverables and the areas of interest and related results that are the most important to the communities and individuals of interest, would need to be adjusted to needs and interest of audience. The perceived and actual challenges of limited resource growers was only understood after working one-on-one with individual growers. This was important understanding as we disseminated results in \"real time.\" Dissemination of USDA-NMSU OT Team Results; By the end of year two, it was clear what primary educational needs and interest of growers was. Participating growers as needed areas of training and education identified the following lists of topics. Pollinators and beneficial insects\--Hedgerows and \"Farm Scaping\" Cover Crops\--need to set up several demonstrations, monitor and report results Soil Fertility\--best practices for building soil fertility in the valley and with brackish water Integrated Pest Management\--what works, what is doable Composting, including using worms to help with the heavy lifting Food Safety-Food Modernization and Safety Act (FSMA) Improved pastures and rotational grazing on small farm plots. What grasses and or forage mix. \"Ally\" cropping Native trees and fruit production. What works in the valley? Effectively managing invasive grasses\--what role can animals play. Farm Walks\-- visit successful farm operations and walk around with the \"expert\" farmer and \"expert\" faculty and have a conversation about best practices. All the aforementioned topics could be covered, in part in a Farm Walk. Demonstrations and or documentation of best practices, continues today as an on going effort with all of the above topics. In many cases, the \"results\" are still being assessed through on farm demonstration and research. It is clear after three years of support from the USDA OT funding, that growers need more information/documentation on what works in their \"backyard.\" There are volumes of literature of agronomic practice across the country, but very little or none for limited resource growers in southern New Mexico, particularly those adopting organic practices. This USDA OT project has allowed for us, in partnership with the targeted community start to develop and document this need information. Ongoing OT work. Soil Health Farmers have historically overlooked/underestimated the need for soil testing OTT offered farmer opportunity for soil testing. Conducted Soil test in 201. Uchanski conducted workshops Follow-up 2017\--farmers still not conducting periodic testing of soil health, lack of fertilization programs in place; conducted another round of analysis in collaboration with NIFI, Working closely with Dr. Robert Flynn to develop Soil Health Workbook for small farmers; Dr. Flynn will be presenting workbook at NM Organic Conference Food Safety Training / FSMA Identified as another area of \"need\" amongst small farmers; especially those aggregating and distributing to school districts/other wholesale buyers Increased number of farmers participating in aggregation due to networking at workshops etc\... More farmers are actively engaged in continued workshops and discussions involving becoming

members of cooperative/aggregating Trained member of SyTGC in PSA On-campus staff support for FSMA (food safety grant) What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2015/09 TO 2016/08 Target Audience:The proposed outreach area for this proposal included the New Mexico counties of Doña Ana County (789 Hispanic principal operators), Luna (40 Hispanic principal operators), and Otero (123 Hispanic principal operators), based on the 2007 Census of Agriculture. Although the three counties were designated the target program area, and limited resource farmers and ranchers were the designated target audience, farmers and ranchers from all over New Mexico have been welcome to participate in any of the programs and activities resulting from this proposal. And, in fact, that has been the case. Many growers from northern New Mexico have learned about this USDA NIFA Organic Transition project and have reached out to us for information, workshops and technical support. During this reporting period, the Organic Transition (OT) project reached: 500 producers, non-profits members, master gardeners, local municipality employees, local and state government agency staff and elected officials through numerous one-on-one meeting, farm visits, field days, workshops and conferences, with information and education material pertaining to Organic Farming and Ranching best practices and certification requirements and process. Sign in sheets and participation records show that approximately 50% of participants were Hispanic, 10% Native American and 50% were non-Hispanic and non-Native American. Additionally, and important to the goals and objectives of the project, the OT project Team has worked closely with 53 producers/growers\--farmer/rancher participants that have made a level of commitment to transitioning to organic agriculture production. Specifically: 15 producers are OT committed and have formally initiated the 3-year citification process. 10 of the 15 producers are Hispanic growers. 23 producers are committed to organic farming best practices, but have not yet committed to certification process. These producers are still apprehensive about \"the burden\" of the record keeping process to become certified organic. 12 of these producers are Hispanic growers. 15 producers are \"on the fence, \" thinking about it. These individuals are not convinced that the \"extra effort\" will make a difference to the bottom line.5 of these producers are Hispanic. We continue to work with all these producers Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?OT Producers The OT project Team has worked closely with 53 producers/growers\--farmer/rancher participants that have made a level of commitment to transitioning to organic agriculture production. Specifically: 15 producers are OT committed and have formally initiated the 3-year citification process. 10 of the 15 producers are Hispanic growers. 23 producers are committed to organic farming best practices, but have not yet committed to certification process. These producers are still apprehensive about \"the burden\" of the record keeping process to become certified organic. 12 of these producers are Hispanic growers. 15 producers are \"on the fence,\" thinking about it. These individuals are not convinced that the \"extra effort\" will make a difference to the bottom line.5 of these producers are Hispanic. We continue to work with all these producers At least one member of the OT team visits at least one farm per week, on average. Those farms that have comitted to the 3-year transition process recive more frequent visits, typically.Log of each vist is made. Site visit Activities included; Soil test and follow up interpretation Salt Management/irrigation management Insect pest management Weed control -including vinegar burning and hoeing technique Rain water harvesting Tours\--7 Irrigation system set up and management and best practices Field preparation, leveling Cover crop, cover crop management\--crimping and termination Manure analysis Numerous Email correspondence and telephone calls OT Grower Events/Activities\-- There were 6 events. Master Gardeners\--weed management Santa Fe Farmers Market NMDA, City of Las Cruces New Mexico State Fair Eastern NM State Fair Southern NM State Fair March, Albuquerque,NM: 245thAnnual NM Organic Farming Conference. At the conference, NMSU OT team set up a booth as prearranged to display our before and after work with Mountain View Market/Coop. We distributed the NMSU OTT information packet we developed to explain the USDA grant and seek participants. 50 packets were distributed and numerous potential participants were engaged during the conference. How have the results been disseminated to communities of interest?Organized Workshops: Chronological sequence of workshop and events resulting from NMSU NIFA OTProject: January, 2015. Anthony, NM: La Semilla-Soil Interpretation April 15, 2015. Anthony, NM: 2015 Seed Blessing Event with partner La Semilla May 27, 2015. Abiquiu\', NM: Certification and Marketing Workshop. Based upon the overwhelming success of this workshop, four more workshop were planned, organized and executed during the reminder of 2015. September 29, 2015. Las Cruces, NM: NMSU NIFA Organic Transition Project Food Safety Workshop. October 1, 2015. Las Cruces, NM: NMSU Organic Transition Project Food Safety Workshop. October 10, 2015. Anthony, NM: Cover Cropping, Certification, and NRCS Funding Opportunities. Done in partnership with La Semilla. November 18, 2015. Espanola, NM: Certification and Marketing Workshop. April 2016, Anthony, NM: La Semilla Seed Blessing Ceremony and Farm June 2015. OTT offered La Semilla further assistance in pursuing and obtaining a Customized irrigation system able to meet the variety of needs Other Accomplishments: Santa Fe Farmer\'s Market Institute- A key working relationship was established with The Santa Fe Farmer\'s Market Institute Executive Director, staff and members, as well as, the dedicated NM Cooperative Extension Agents in the immediately surrounding counties of Santa Fe, Rio Arriba, Sandoval, Bernalillo, Valencia, Los Alamos and Taos. These agents teamed up with the NMSU OT team to plan and

implement the May 23, 2015 Organic Certification Workshop held in Abiquiu\' (32) attendees) and the November 18, 2015 \"Converting Your Operation to Organic Certified & Cover Cropping/Crop Rotation Methods\" (workshop held in Espanola (39 attendees). Speakers were recruited from the Agricultural Industry, NMDepartment of Agriculture, NMSU, NMSU Cooperative Extension Service, Santa Fe Farmer\'s Market Institute, American Friends Service Committee (AFSC) and Northern New Mexico College. (Please see attached flyers). Community Based Activities and Support for Organic Agriculture:The Organic Transition Team actively participated in numerous meetings working to support La Semilla in their effort to obtain the Las Cruces City Council (LCCC) approval of the Urban Agriculture and Food Policy Plan (UAFPP) developed by the Local Food Policy Council (LFPC). At the June 6, 2016 Las Cruces City Council meeting, NMSU OT Project Coordinator, Dr. David Kraenzel testified as a New Mexico Cooperative Extension representative in favor of adopting the proposed Urban Agricultural Plan. On Monday, June 6, 2016 the Las Cruces City Council passed a resolution adopting the Las Cruces Urban Agriculture and Food Policy Plan. The urban agricultural plan is the first of its kind in New Mexico. Las Cruces is now poised to be an innovator in urban agriculture initiatives in the state, making good use of the rich agricultural, culinary, and cultural heritage of the area. The plan is driven by the three following goals: A healthy & food-secure community: All residents should have enough to eat and access to affordable, local, healthy, sustainable, and culturally appropriate food. A stronger, more vibrant local economy with more food growing and processing opportunities: Businesses and entrepreneurs that produce, process, distribute, and sell local and healthy food are a key component of a vibrant local economy. Healthier ecosystems and smart environmental resources stewardship: Food related waste should be prevented, reused, or recycled, and natural resources should be used wisely. The NMSU Organic Transition team believe this to be a significant step forward in the support and sustainability of Organic Agriculture production and practices Example Specific Farm Visit/Results DissiminationActivities: Mike Petersen: Mike is the NMSU Student Farm Manager and Organic Technician. Mike\'s visits our collaborators on the average of once per week and makes special notations. (a minimum of 40 times from October 2015 through July 2016) with the following special notations of assistance. He is available to La Semilla (and all other collaborators) to offer advice. One good example of Mike\'s dedication will be his rapid response to the insect invasion (migration) La Semilla experienced awhile back.Mike immediately went down, got samples, got Carol Sutherland to identify them and then informed Cristina that the insects were migrating. So, basically, realizing that \"this too shall pass\" Cristina and her workers did what they could\.....while their minds were put a little more at ease. He keeps an accurate log of activities, assistance and advice. In the past year he has attended all of the La Semilla Farm workshops and was involved in the follow-up. Mike Petersen also accomplished the following: La Semilla\...soil sample 10/7/15 Crop Rotation Seminar 10/10/15 14/Oct 2015\....MVM farm and diagnosed sunscald and roll cover Oct 13/15 2015 Visited La Semilla, Anthony Youth and Water Works, Oscar Gutierrez 17 Nov. 2015 Soil Sample test results to La Semilla 17percent saline\.....sodic (over 15%) gave advice on amendment program. 26 Nov.2015 Visited all farms. MVM planting sunflowers 14 Dec. 2015visited all farms\....Anthony W&S answered questions 21 Dec. 2015visited all farms\.....broccoli at LS\....vertical cracks on broccoli. Took sample to NMSU 4 Jan. 2016 Observed LS\'s use clay powder (organic) insecticide applications, MVM in process of moving and visited new site. to share with others. 5 Jan 2016\.....Broccoli to Professor French for testing 13 Jan 2016sent broccoli results to Cristina\...no pathogens found. 31 March 2016\....gave soil test interpretations to all farms. greatly appreciated by audience. 1 April 2016\.....La Mesa farm (delivered susbanea seed and soil interpretations to farmer. 14 April\...2016\...\...talked with Joseph, Alma and Cristina and suggested covering tomatoes with sun shade (row cover) to minimize leaf hopper damage and later sun scald. 2 May\...2016 Cristina called about false chinch bugs For the rest of May and early June. 2 June\...2016 .met with Villalobos family about irrigation on the susbanea.Suggested industrial sprinklers 7 June 2016\.....all farms\...\...\...\...talked to Alma about their needs and she furnished following request: 7 July 2016 Mike Petersen and David Kraenzel made a round-trip tour of DYGUP/Sustain Farm, Anthony Youth Farm and Anthony Waterworks Farm. The following request came from the Anthony Youth Farm. Chicken pellets fertilizer (donated two bags) compost \$300/truck fish emulsion pyrethrin insecticide Insecticidal soap mycorrhiza 24 June\...observation (all farms)\...\...La Semilla had rabbit issues \....suggested fencing and other methods such as repellants. Significant events Mike recertified the NMSU Students farms until October 2017. No small task. Mike Petersen also designed and executed a three hour extension service demonstration with the Anthony Youth Farm staff regarding \"Documentation and the Use of Records and Record Keeping for the Organic Operation\". What do you plan to do during the next reporting period to accomplish the goals? Complete task of developing \"Tool Kit for Organic Producers\" int Spanish to better serve the Spanish speaking clients. Make it known that this Spanish Tool Kit would be available and disseminated to anyone interested to include the 33 NM Cooperative Extension Service County Agents Continue educational venues focusing on the Value Chain for producers. Finalize the \"StratSense\" marketing framework in a teachable, down to earth, format that makes application by producers straightforward and financially rewarding. Emphasize Organic Agriculture/Enterprise Development by finalizing the proper documentation, budgeting and managerial decision-making skills of our producers. Continue Participatory Research and Peer Learning. Sponsor 6 more producer farm walks where we bring in horticultural, pest management and soil experts to analyze producers fields on the

spot. Set up a rain water harvesting research and demonstration at the NMSU cooperating farm. Have cover crop research and demonstrations with our two cooperating farms, La Semilla and DYGUP Farm. The hands on demonstrations are by far the most powerful educational tool. All the right questions get asked at these demonstrations. Established irrigation system set up, management and best practices demonstration project at La Semilla Farm. Cooperating OT farms all have the opportunity to visit these research and demonstration projects. Increase Community Awareness of Organic Best Practices and Markets. We will continue and conduct 4 seminars for groups such as the Master Gardeners of Dona Ana County and the Anthony Water and Sewer Economic Development Department Entity to increase community awareness of such things as: the health benefits of organically grown produce. Continue to maintain existing and build new working relationships with ancillary organizations such as theNew Mexico Department of Agriculture

IMPACT

2014/09 TO 2017/08 What was accomplished under these goals? Over the course of the three year project, the Organic Transition Team (OTT) and project reached an estimate 850 producers, non-profits members, master gardeners, local municipality employees, local and state government agency staff and elected officials through numerous one-on-one meeting, farm visits, field days, workshops and conferences, with information and education material pertaining to Organic Farming and Ranching best practices, and certification requirements and transition process. Our recruitment efforts will continue beyond the grant performance period. All activities are geared to the development of an individual grower Organic Transition Plan. Over the past three years, each of the following five (5) project objectives is intentionally addressed as part of the work we do with small growers. 1\. Value Chain Development. As a direct result of the OT project research and extension work, many more producers, vendors, and consumers have greater knowledge of organic agriculture production and \"value added\" agriculture, and role and opportunity in development of the local food/value chain. Many producers now see themselves as a member of the local value chain and recognize their strength in collaborating with other small growers. 2\. Organic Agriculture/Enterprise Development. During the past three years we have focused on teaching a market-oriented approach to production. Developing Organic Enterprise budgets for our cooperating producers has been a challenge. Unlike commodity agriculture and commodity producers, small Organic Farms and farmers are each unique. Currently, many of our participants do not have the knowledge and skill to develop and maintain enterprise budget analysis. The organic certification application forms require enterprise related information, data and activities, but does not necessarily lend it self well to enterprise cost and returns record keeping. Much of the OT Teams efforts focused on mentoring producers through agronomic issues and organic certification applications. 3. Participatory Research and Peer Learning. Clearly one of the most successful aspects of the project has been the \"learn by doing\" producer farm walk where we bring in horticultural, pest management and soil experts to analyze producers fields on the spot. Set up rainwater harvesting research and demonstration at the NMSU cooperating farm. Have cover crop research and demonstration projects established at our other two cooperating farms: La Semilla and DYGUP Farm. The hands on demonstrations were by far the most powerful educational tools for our target audience. All the right questions get asked at these demonstrations. Established irrigation system set up, management and best practices demonstration project at La Semilla Farm. Cooperating OT farms all have the opportunity to visit these research and demonstration projects. Most of the educational needs and opportunities are were identified at the producer farm walks, including the 2017 Agro ecology Workshop Series and series of FSMA workshops. 4\. Increase Community Awareness of Organic Best Practices and Markets. Over the past three years we have organized and conducted seminars for groups such as the Master Gardeners of Dona Ana County and the Anthony Water and Sewer Economic Development Department Entity to increase community awareness of such things as: the health benefits of importance of food hubs and local food systems; and the various market outlets for the individual organic producer. We also sponsored a table at the 25th and 26th Annual NM Organic Conference in Albuquerque NM, attended by over 500 Organic Agriculture enthusiasts from around the country and world. The community in southern New Mexico and around the state are much better informed of Organic Agriculture, the challenges, myths and truths and the opportunities for local growers, large and small. 5\. Dissemination of Models: The challenge of reaching limited resource growers is well documented in extension work. It proved to be no less a challenge with this OT project. Providing selected information on agronomic, horticultural, food system and distribution systems as well as a tool kit of financial, production and marketing resources for producers to choose from continues to evolve as we have come to better understand the various \"pathways\" that limited resource and Hispanic growers, become, or choose to become Organically Certified farmers. This understanding of growers, sometimes complex and diversified was a direct result of multiple farm visits and farm walks. With a fundamental focus of this project to\--\"to assist the Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico to build knowledge, skills, resources, and relationships that will improve their competiveness through

the successful adoption of organic farming and ranching practices,\" the NMSU OT team spent the majority of it time working with individual growers to help insure their success in transitioning to organic agriculture. Primary Partners and Collaborators: Our non-profit partners have been critical to the success of this OT project. Not only are all leading by example, OT farms, but also because of their location and focus on local food development in underserved communities, they have helped open doors and recruit our target audience. Their mostly modest farm operations provide demonstration sites that are in the community\--and look much like other low-input and limited resource farms in the area look like. This is important. La Semilla\-- La Semilla Food Center is a collaborative partner of the OT. La Semilla leads the Las Cruces Food Council initiative and that effort resulted in passage and adoption of the Las Cruces Urban Agricultural Plan by the Las Cruces City Council. In addition, La Semilla provides a \"true\" on farm experience for its regular labor force, students and volunteers. It is important to note that La Semilla is a growing employer of the local, available labor force. La Semilla has also created \"A Mobile Mini Market\" on wheels that attends various farmers markets and local food deserts in the Paso del Norte Region. La Semilla has been instrumental in hosting a number of USDA OT workshops over the past three years. Anthony Farm\--AFSC, Tierra y Sol and Anthony Water District-. Over the past three years the OT team has had an established working relationship with the American Friends Service Committee (AFSC). AFSC NM, up until recently, provided comprehensive hands-on farmer-to-farmer training. All trainings and workshops are free of charge. The NMSU NIFIA OT project directly supported this project, and still does today. NMSU Student Gardens-The OT Farm Manager attends to project on a daily basis. Over the past 3-years there have been 4 part-time interns. One of those interns is continuing her career in the Midland-Odessa Texas area. One intern graduated and is starting up her own organic farm operation. She has installed a new well and drip irrigation system for approximately 2 acres and plans on developing the remaining 34 acres on the family farm south of Las Cruces. DYGUP (Formerly MVM Farm)\--DYUP is located in Las Cruces, NM near Historic Old Mesilla. DYGUP practices Regenerative Organic Agriculture, and operate as a demonstration farm. Their mission is to demonstrate sustainable agricultural practices, and encourage the growth and support of small-scale local food production. They offer tours, volunteer opportunities, classes, and a weekly farm share. **PUBLICATIONS (not previously reported):** 2014/09 TO 2017/08 1. Type: Journal Articles Status: Other Year Published: 2018 Citation: Defining Pathways to Organic Certification for Limited Resource Farmers, Ivon Diaz, Gutierrez, Paul and Vela, Margie. Intend to submit to Journal of Extension. In progress 2. Type: Conference Papers and Presentations Status: Accepted Year Published: 2018 Citation: Organic Transition Tool Kit, 26th Annual Organic Conference, Abq NM. Ivon Diaz and Gutierrez, Paul 3. Type: Other Status: Under Review Year Published: 2017 Citation: Organic Transition Resource Kit: OT Mentors. AxEd MS Creative Component Project. Ivon Diaz.

2015/09 TO 2016/08 What was accomplished under these goals? During this reporting period, the Organic Transition Team(OTT) and project reached 500 + producers, non-profits members, master gardeners, local municipality employees, local and state government agency staff and elected officials through numerous one-on-one meeting, farm visits, field days, workshops and conferences, with information and education material pertaining to Organic Farming and Ranching best practices, and certification requirements and transition process. Our recruitment efforts continue, and will continue throughout the life of the grant, and beyond. However, with a number of producers currently committed to OT, our team has focused on building knowledge, skills, resources, and relationships with our cooperating OT producer that will improve their competiveness through the successful adoption of organic farming and ranching practices. Included efforts to support cooperating OT producers are educational materials, custom workshops, an average of 14 farm visits per farm, soil/water testing, and follow up interpretation. All activities are geared to the development of an individual growers Organic Transition Plan. Each of the following five (5) project objectives is intentionally served in each and every encounter. Value Chain Development. The teaching and learning of the food supply chain is kept in the forefront in each educational endeavor. In addition, the notion of \"value-added\" in the organic food chain is introduced. This results in an increased producer awareness of alternate profit opportunities by differentiating their organic products. This has proven to be of particular importance to many producers who see real opportunity in value added organic produce. Organic Agriculture/Enterprise Development. We are assembling, analyzing and teaching a market-oriented approach to production. Developing Organic Enteprise budgets for our cooperating producers has been a challenge. Unlike commodity agriculture and commodity producers, Organic Farms and farmers are each unique. There are standards for organic production, but not standards for \"managing\" those standards. Participatory Research and Peer Learning. For example, we are sponsoring \"learn by doing\" producer farm walks where we bring in horticultural, pest management and soil experts to analyze producers fields on the spot. Set up a rain water harvesting research and demonstration at the NMSU cooperating farm. Have cover crop research and demonstrationprojects established at our other two cooperating farms: La Semilla and DYGUP Farm. The hands on demonstrations are by far the most powerful educational tool. All the right questions get asked at these demonstrations. Established irrigation system set up, management and best practices demonstration project at La Semilla Farm. Cooperating OT farms all have the opportunity to visit these research and demonstration projects. Increase Community Awareness of Organic Best Practices and Markets. We have

organized and conducted seminars for groups such as the Master Gardeners of Dona Ana County and the Anthony Water and Sewer Economic Development Department Entity to increase community awareness of such things as: the health benefits ofimportance of food hubs and local food systems; and the various market outlets for the individual organic producer. We also sponsored a table at the 25th Annual NM Organic Conference in Albuquerque NM, attended by over 500 Organic Agriculture enthusiasts from around the country and world. Dissemination of Models: Providing selected information on benchmarking food system and distribution systems as well as a tool kit of financial, production and marketing models for producers to choose from. Individual Farm Visits:With a fundamental focus of this project to\--\"to assist the Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico to build knowledge, skills, resources, and relationships that will improve their competiveness through the successful adoption of organic farming and ranching practices,\" the NMSU OT team spent the majority of it time working with individual growers to help insure their success in transitioning to organic agriculture. Primary Partners and Collaborators: These non-profit partners have been critical to the success of this OT project. Not only are all OT farms, but because of their location and focus local food development in underserved communities, they have helped open doors and recruit our target audience. Their mostly modest farm operations provide demonstration sites that are in the community\--and look much like other low-input and limited resource farms in the area look like. This is important. La Semilla\--site visits = 17. La Semilla Food Center is a collaborative partner of the OT. The OT provides a yearly stipend to contribute to the support of this organization as well as providing managerial and technical assistance. La Semilla leads the Las Cruces Food Council initiative and that effort resulted in passage and adoption of the Las Cruces Urban Agricultural Plan by the Las Cruces City Council. In addition, La Semilla provides a \"true\" on farm experience for both its regular labor force, students and volunteers. It is important to note that La Semilla is a growing employer of the local, available labor force. La Semilla has also created \"A Mobile Mini Market\" on wheels that attends various farmers markets andlocal food deserts in the Paso del Norte Region. Anthony Farm\--AFSC, Tierra y Sol and Anthony Water District-site visits = 21.The OT has an established working relationship the American Friends Service Committee (AFSC). AFSC NM provides comprehensive hands-on farmer-to-farmer training led by Don Bustos, AFSC NM director, who has been recognized by the state as an Organic Farmer of the Year as well as by New Mexico State University as an agriculturist of distinction. Beginning farmers are mentored on all aspects of sustainable farming including crop selection, soil health, irrigation methods, harvesting and post harvest handling techniques, business planning, aggregation and marketing. Training is a one year commitment. All trainings and workshops are free of charge. The NMSU NIFIA OT project supports this ongoing effort. NMSU Student Gardens-site visits. The OT Farm Manager attends to project on a daily basis. Over the past year there have been 3 part-time interns. One of those interns is continuing her career in the Midland-Odessa Texas area. One intern graduated and is starting up her own organic farm operation. This first year she has installed a new well and drip irrigation system for approximately 2 acres and plans on developing the remaining 34 acres on the family farm south of Las Cruces. DYGUP (Formerly MVM Farm)\--site visits =16. DYUP is located in Las Cruces, NM near Historic Old Mesilla. DYGUP practices Regenerative Organic Agriculture, and operate as a demonstration farm. Their mission is to demonstrate sustainable agricultural practices, and encourage the growth and support of small scale local food production. We offer tours, volunteer opportunities, classes, and a weekly farm share. DYGUP is an acronym for Developing Youth from the Ground Up and is available to youth ages 14 through 17. The DYGUP program is a 12 week 72 hour program which integrates intensive farmer training with the Roots of Success Environmental Literacy Curriculum. Roots of Success is an empowering environmental literacy and job readiness curriculum that helps young people increase their academic and professional skills, prepare for college and careers, and become leaders who can improve conditions in their communities. **PUBLICATIONS (not previously reported):** 2015/09 TO 2016/08 1. Type: Other Status: Under Review Year Published: 2015 Citation: New Mexico Organic Transition Record Keeping Binder. D. Kraenzel, P. Gutierrez, M. Uchanski, and M. Peterson. 2015 2. Type: Other Status: Under Review Year Published: 2015 Citation: 2015 Solicitud de Cetificacion (2015 Application for Organic Certification) New Mexico Department of Agriculture. L. Urquijo-Hawkes, P. Gutierrez, M. Uchanski and D. Kraenzel. 2015 3. Type: Other Status: Under Review Year Published: 2016 Citation: Kit de herramientas org?nica para los productores de habla hispana. (Organic Tool Kit for Spanish Speaking Producers) A. Maquitico, I. Diaz, D. Kraenzel and P. Gutierrez (in progress) Progress 09/01/14 to 08/31/15 Outputs Target Audience:The proposed outreach area for this proposal includes the New Mexico counties of Doña Ana County (789 Hispanic principal operators), Luna (40 Hispanic principal operators), and Otero (123 Hispanic principal operators), based on the 2007 Census of Agriculture. Although the three county area is designated the target program area, and limited resource farmers and ranchers are the designated target audience, farmers and ranchers from all over New Mexico have been welcome to participate in any of the programs and activities resulting from this proposal. During this reporting period, the Organic Transition (OT) project reached: 285 producer, non-profits members, gardners, local municipality employees and others individuls through field days, workshops and conferences, with informaiton and education pertainig to Organic Farming and Raching best practices and certification requirements and process. Sing in sheets and participation records show that approximately 40% of participants were Hispanic, and 60% were non-hispanic. Additionally, and important to

the goals and objectives of the project, the OT project Team has worked closely with 36 producers/growers\--farmer/rancher participants that have made a level of commitment to transitioning to organic agriculture production. Spcifically: 15 producers are OT committed and have formaly initiated the 3 year cetification process. 10 of the 15 producers are Hispanic growers. 14 producers are committed to organic farming best pracitices, but have not yet committed to certification process. These producers are still apprehensive about \"the burden\" of the record keeping process to become certified organic. 8 of these producers are Hispanic growers. 7 producers are \"on the fence, \" thinking about it. These individuals are not convinced that the \"extra effort\" will make a difference to the bottom line. 5 of these producers are Hispanic. We continue to work with all thise producers Changes/Problems:No major changes to report. The NMSU OT is enthusiastically excited about the progress and success of the first year. As previously mentioned, we feel that the goals and objectives of this project have served us well and that we have an outstanding OT team of community partners and university faculty and staff. And most importantly we have a great group of OT farmers and ranchers that are committed to the project. The only real challenge/problem is the limitation of resources that many of our cooperating producers have. We have been able to this point to be innovative and creative in helping these producers gain access to machinery and equipment and water resources to help them prepare their fields, etc. We will continue to work with these growers and USDA to put them on a pathway to organic agricultural sustainability. What opportunities for training and professional development has the project provided?Workshop and Conferences\--10-150 participant per worshop Sept 19, 2014\--Orientation Tours. In effort to do a little Ogranic Transition Team (OTT) building, we spent a couple of days touring each OT grant cooperators farm: NMSU Student Resarch Farm (Ogranic Certified), La Semilla Community Farm (Organic Transition farm), MVM Farm (Organic Transition farm) Anthony Water District Community Farm (Organic Transition farm). Dec, 10, 2014\--Ogranic Pest Management Workshop, Anthony Soil and Water District Jan 2015\--Interpreation of Soil Analysis Results\--La Semilla Community farm February 21 and 22, 2015; New Mexico Organic Conference, Abq NM. (500 plus participants) May 27th, 2015 Organic Transition Workshop, Abiqu New Mexico\--OT workshop Table 1 below reports a Timeline of completed and proposed workshop for calendar year 2015 Table 1: OT Workshop Time Lines Organic Transition Team Workshop Timeline OTT members present: Mike P., Mark U., Joanie Q., David K. 1st Quarter 2014 2nd Quarter 2014 3rd Quarter 2014 4th Quarter 2014 Jan Feb March April May June July August Sept Oct Nov Dec 1st Quarter 2015 2nd Quarter 2015 3rd Quarter 2015 4th Quarter 2015 Jan Feb March April May June July August Sept Oct Nov Dec Orientation Certification-Joanie Livestock Test Informal Demo Certification-Joan Abiquiu May 27 Food Safety NRCS(funding/Equip IPM Scouting 101-Tess+ Soil Fertility-Iwou Cover Cropping Soils 101-Uchanski Composting-Allen ***Marketing/Sales in 30 minute segments in each workshop 1st Quarter 2016 2nd Quarter 2016 3rd Quarter 2016 4th Quarter 2016 Jan Feb March April May June July August Sept Oct Nov Dec Wholistic Weed Con Farm Walks Farm Walks Integrated Livestock Systems Pollinators Farmscaping Farmscaping Certifying Livestock Soils 101-Uchanski ***Marketing/Sales in 30 minute segments in each workshop 1st Quarter 2017 2nd Quarter 2017 3rd Quarter 2017 4th Quarter 2017 Jan Feb March April May June July August Sept Oct Nov Dec Honeybees Vermicomposting Hedge rows, windbreaks Soils 101-Uchanski Farm Walks Farm Walks Agriponics Poultry, herbs,Irrig, Farmscaping Farmscaping Selected topics evidenced Cultivation Vermiculture ***Marketing/Sales in 30 minute segments in each workshop In-depth Soils includes amendments, health, disease and fertility ***Innovative approaches include the Farm or Ranch Walks, Garden Walks(on site discussions) in combination with a follow-on round table luncheon. Farmer history, Amplification Equipment How have the results been disseminated to communities of interest?With our OT producers, farm visits and on going email and phone correspondence are imperative to keep information and activity moving forward. With the general farm population, our OT Program Coordinator follows up on a number of referrals and make short/infomerical presnetations at various agricultural venues. What do you plan to do during the next reporting period to accomplish the goals?Simply put, more of the same. Thus far we have been extremely sucessful in recruiting OT farmers and ranchers, but we will need to focus on theier sucess and the 5 underling goals and objectives of this project. Thus far, the 5 objectives for this project have served us well. The challege is that each individual OT farm or ranch has a unique set of challenges and goals and objectives for transitioning to ogranic production, their sucess will be, in part, determined by how well we can support their individual goals and the goals of this USDA OT project. Impacts What was accomplished under these goals? With a strong focus on the principal goal of this project,Improving the Competitiveness of Limited Resource Farmers and Ranchers (LRFR) in Southern New Mexico Through the Adoption of Organic Practices Project (LRFR ORG), initial project efforts focused on the recruitment of Limited Resource Farmers and Ranchers (LRFR) to participate in the OT project. Recruitment efforts included numerous one-on-one farm visits, small group meetings, subject matter workshops and field days. To would be recruits we provided a packet of information that included OT Terms of Agreement form, signed by both parties, that clearly laid out what support the OT project team would provide cooperating producers and what was expected of cooperating producers. One of our most successful recruitment efforts was the New Mexico Organic Conference, February 20th and 21st in Abuqurque NM. The USDA NIFA OT grant supported the participation of 23 producers in the conference, this was a game changer for many of are now cooperating OT producers. Many of our limited resource growers had never had the opportunity to attend an

conference of this type and scale\--over 500 participants from across the county and several international countries in attendance\--nor did they have any idea of the potential for organic agriculture, we will be going back. As previously mentioned, we ended the first year with 36 producers/growers\--farmer/rancher participants that have made a level of commitment to transitioning to organic agriculture production. Specifically: 15 producers are OT committed and have formaly initiated the 3 year cetification process. 10 of the 15 producers are Hispanic growers. 14 producers are committed to organic farming best pracitices, but have not yet committed to certification process. These producers are still apprehensive about \"the burden\" of the record keeping process to become certified organic. 8 of these producers are Hispanic growers. 7 producers are \"on the fence, \"thinking about it. These individuals are not convienced that the \"extra effort\" will make a difference to the bottom line. 5 of these producers are Hispanic. We continue to work with all these producers Our recruitment efforts continue, and will continue throughout the life of the grant, and beyond. However, with a number of producers currently committed to OT, our team has focused on building knowledge, skills, resources, and relationships with our cooperating OT producer that will improve their competiveness through the successful adoption of organic farming and ranching practices. Included efforts to support cooperating OT producers are educational materials, custom workshops, an average of 10 farm visits per farm, soil/water testing, and follow up interpretation. All activities are geared to the development of an individual growers Organic Transition Plan. Each of the following five (5) project objectives is intentionally served in each and every encounter. Value Chain Development. The teaching and learning of the food supply chain is kept in the forefront in each educational endeavor. In addition, the notion of \"value-added\" in the organic food chain is introduced. This results in an increased producer awareness of alternate profit opportunities by differentiating their organic products. Organic Agriculture/Enterprise Development. We are assembling, analyzing and teaching a market-oriented approach to production or more simply stated: we have these seeds we are going to plant so where are we going to go with the product they produce before we plant them. Participatory Research and Peer Learning. For example, we are sponsoring \"learn by doing\" producer farm walks where we bring in horticultural, pest management and soil experts to analyze producers fields on the spot. Set up a rain water harvesting research and demonstration at the NMSU cooperating farm. Have cover crop research and demonstration project on established at our other two cooperating farms, La Semilla and MVM Farm. Established irrigation system set up, management and best practices demonstration project at La Semilla Farm. Cooperating OT farms all have the opportunity to visit these research and demonstration projects. Increase Community Awareness of Organic Best Practices and Markets. We have organized and conducted seminars for groups such as the Master Gardener\'s of Dona Ana County and the Anthony Water and Sewer Economic Development Department Entity to increase community awareness of such things as: the health benefits of organically grown produce; the importance of food hubs and local food systems; and the various market outlets for the individual organic producer. Dissemination of Models: Providing selected information on benchmarking food system and distribution systems as well as a tool kit of financial, production and marketing models for producers to choose from. And the support to assist in learning these approaches. For example: the Ag Squared financial tool. In the comming year, the NMSU OT team has developed a workshop/field day calendar that will address a number of the seasonal issues realated to ogranic production, marketing and management. Some of this workshops will be held across the state in regions outside the initial project area, as the interest in this USDA OT project has statwide and regional interest. Publications Type: Other Status: Under Review Year Published: 2014 Citation: 2014 Solicitud de Certificacion (2014 Application for Organic Certification) New Mexico Department of Agriculture. Translated into Spanish for use and support of this OT project. Type: Other Status: Other Year Published: 2014 Citation: Kraenzel, David etl. Organic Transition Team (OTT) Needs Assessment Type: Other Status: Under Review Year Published: 2015 Citation: Kraenzel, David, etl. NM Organic Transition Handbook

↑ Return to Index

Agroecological Strategies for Balancing Tradeoffs in Organic Corn and Soybean Production.

Accession No.	1004097
Subfile	CRIS
Project No.	NYC-125532
Agency	NIFA NY.C
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22080
Proposal No.	2014-03385
Start Date	15 SEP 2014
Term Date	31 AUG 2017
Grant Amount	$499,932
Grant Year	2014
Investigator(s)	Ryan, M. R.; Curran, WI, S..; Mirsky, ST.
Performing Institution	Crop and Soil Sciences, CORNELL UNIVERSITY, ITHACA, NEW YORK 14853

NON-TECHNICAL SUMMARY

Cover crops have potential to replace external inputs, improve cropping system performance, and facilitate the transition to certified organic crop production. Using insights from long-term organic cropping systems experiments, we will establish a new transition-to-organic field experiment at research stations in New York, Pennsylvania, and Maryland to test advanced cover crop-based management systems. We will compare cover crop interseeding and rotational no-till strategies to standard organic crop production practices to quantify differences in profitability and ecosystem services including crop performance, soil health, greenhouse gas emissions, weed seed predation, and nectar provisioning for pollinator conservation. Our previous and on-going research suggests that interseeding grass-legume cover crop mixtures into corn and soybean can improve soil health. Moreover, grass-legume cover crop mixtures can self-regulate based on soil nitrogen levels and have potential to reduce nitrous oxide emissions compared to standard cover cropping practices. While it has broader implications for addressing problems with greenhouse gas (GHG) emissions and water quality, this project is organic farmer-focused and builds on stakeholder interest in diverse cover crop mixtures and interseeding cover crops using aerial applicators and spinner spreaders at layby cultivation. We will work together with organic farmers to develop advanced cover crop management recommendations. In addition to working directly with leaders in the organic farming community, we will transform agriculture through hands-on educational programming. Students will interview organic farmers about their cover crop utilization practices and collect on-farm data to assess relationships between management strategies and indicators of cropping system performance.

OBJECTIVES

Goal: Improve organic crop production by developing practical cover cropping and crop rotation strategies that overcome tradeoffs between short-term profitability and long-term sustainability.Objectives:Initiate a new 3-year cropping systems experiment in New York, Pennsylvania, and Maryland to test cover crop-based strategies for transitioning to certified organic corn and soybean production.Conduct a component experiment within the long-term USDA Farming Systems Project (FSP) to quantify the effect of cover crops and cover crop establishment

practices on soil health and greenhouse gas (GHG) emissions. Develop and offer an undergraduate organic cropping systems course that engages students in experiential learning by integrating field research with coursework. Disseminate new information through a project newsletter, research bulletins, cover crop interseeding demonstrations, on-farm soil weed seed bank characterizations, experiential learning activities, and presentations at farmer meetings.

APPROACH

Sampling and Data Collection in the Cover Crop Systems Experiment (CCSE) and the Farming Systems Project (FSP):Cover Crops. Cover crop ground cover in late-fall and during spring \"green-up\" will be determined using a NDVI (naturalized differential vegetation index), which is measured using a Crop Circle Model ACS-430 from Holland Scientific. All sites currently have this instrument. This will provide cover crop performance data that will be used to evaluate variation within and among treatments. Cover crop flower density and duration of nectar provisioning will be quantified each spring to determine the effect of each treatment on pollinator conservation. Cover crop flower density (number of flowers/0.5 m2 quadrat) will be measured weekly starting at the onset of flowering. Aboveground cover crop biomass will be measured in each plot in the fall after the first frost and just prior to termination in the spring by clipping all plant material \>1 cm in height from two 0.5 m2 quadrats. Cover crop biomass samples for each plot will be separated by species and oven dried, weighed, and ground. Total tissue carbon and nitrogen content will be determined on the samples using dry combustion.Crop Performance. Grain yield will be determined by harvesting the center two rows of each plot using a plot combine with a calibrated yield monitor. All research stations have plot combines on-site. Final crop population density will be quantified by counting plants in the center two rows the entire length of the plot at harvest.Soil Health. Soil samples will be collected in the spring in the CCSE and the FSP each year and sent to the Cornell Soil Health Lab for a standard analysis including aggregate stability, organic matter, active carbon, soil pH, extractable phosphorus, potassium, and micronutrients, in addition to and total nitrogen and potentially mineralizable N. In order to characterize baseline fertility at each site, a composite soil sample (10 cores from 0-15 cm) will be collected from plots prior to establishing treatments and analyzed for pH and soil nutrient levels.Weed Suppression. Weed biomass will be quantified in late August by clipping all weed biomass at the soil surface from an area 0.76 × 1 m centered on a crop row in a representative portion of each plot when corn and soybean reaches maturity. Weed samples will be hand-separated to quantify biomass of individual species, dried, and weighed. Weed density will be recorded at the same time.Soil Weed Seed Banks. Weed seed banks will be measured with soil cores collected from every plot using soil augers (5.7 cm diameter) and sampled to a depth of 20 cm. Soil samples will be weighed upon arrival from the field to determine soil bulk density. Samples will then be homogenized by stirring soil in a bucket and passing the soil through a 1.25 cm sieve. Each sample will then be spread over a plastic flat (25 × 50 cm) containing 2.5 cm layer of vermiculite. Flats will be watered daily and the greenhouse will be maintained at roughly 25/15 C (day/night) for the duration of the assay. Cover crop and weed seedlings will be allowed to grow until positive identification can be made, and then counted and removed by clipping. Six weeks after initiation of the assay, the soil will be allowed to air dry for two weeks, after which the soil and vermiculite will be mixed and placed back into the flat. This sequence will be repeated several times until the germinable weed seed bank is exhausted. This germination bioassay will allow us to quantify the density and diversity of weed and cover crop seeds in the soil. All soil seed bank germination bioassays will be conducted at Cornell University.Weed Seed Predation. Weed seed predation will be quantified using two types of arenas (e.g., seed cards) to distinguish between vertebrate and invertebrate seed removal. Exclosure arenas consisting of galvanized metal hardware cloth (3.5 x 3.5 cm openings) will prevent access by small mammals and birds, but will allow most invertebrates. Exclosure arenas (14 cm diameter, 9 cm tall) will be capped with a clear lid to repel rain. Open arenas will allow both vertebrate and invertebrate seed predators to access seeds. Within each arena a 10-cm Petri dish will be placed bottom side up and buried so that the dish is flush with the soil surface. The surface of the Petri dish will be covered with double-sided indoor/outdoor carpet tape, and 100 giant foxtail (S. faberi Herrm.) seeds placed on the surface. Approximately 1 to 2 g of field soil will be applied to the tape to reduce adhesiveness and better mimic the soil surface. Weed seed predation rate will be based on the removal of giant foxtail seed over a 14-d period and repeated five times during the summer beginning in late May and ending in early September. During the course of the summer, arenas will be removed then returned to their original position when agronomic management practices (tillage, sowing, etc.) are performed. Directly quantifying seed predation instead granivorous insects will provide more useful information for evaluating the effect of tillage and cover crop treatments in the CCSE.Standard and appropriate statistical analyses will be used to analyze data and test hypotheses. We will seek out expert advice and consult with other researchers and professionals such as statisticians, economists, and seed or equipment dealers if needed.On-Farm Interseeding and Soil Weed Seed Banks:Students at Cornell University will interview organic farmers about their interseeding practices, experiences, and research priorities, and collect soil samples for seed bank germination assays. Organic farmers in New York, Pennsylvania, and Maryland will participate in this project by providing soil samples from their farms

that will be analyzed to determine the quantity of seeds of each plant species present, including weeds and cover crops. We will conduct in-depth interviews about weed management practices, equipment, crop rotations, soil nutrient management, and use of cover crops using the \"Mental Models\" approach outlined in Jabbour et al. (2014). Quotes and other qualitative information will be collected during this time, including perceptions about cover crop interseeding. We will select three fields with histories of cover crop use and where volunteer cover crops often emerge at each site. Each spring, soil will be sampled using a grid sampling approach with coordinates of each sample recorded with a GPS. We will use the same protocol for analyzing seed banks as described above. We will use multivariate statistical analyses to assess relationships between cover crop utilization practices and soil weed seed bank density and diversity. Results from the seed bank analysis will be shared with participating organic farmers during outreach and project advisor activities.Monitoring and Evaluation:Project team members will meet quarterly in person and an evaluation of our activities will occur annually. Project evaluation will focus on the impact of activities and resources on: 1) increasing awareness of cover crop-based systems that increase profitability during the transition to organic, 2) increasing the ability of extension educators to deliver high-quality technical information to organic growers, and 3) increasing the quality of organic agriculture curriculum. Quality of educational activities including course modules will be evaluated with i-clickers in class and with end-of-semester course evaluations. We will administer end-of-session questionnaires after extension and educational activities to assess the overall quality and then use the information to improve future training activities. Evaluation data from all sources will be statistically analyzed and included in project reports and distributed to project collaborators and participants.

PROGRESS

2014/09 TO 2017/08 Target Audience:Target audiences reached during this period were • Organic farmers via articles, meetings, and field days, • Northeast US agronomists and weed scientists via presentations, and • Cornell University and other students via classroom instruction, internships, and through their work as research assistants Changes/Problems:In order to accomplish the project\'s goals more effectively, the proposed field experiment was split into two experiments: one to study ecosystem services of interseeded cover crops under differing corn densities; and the other to look at soil health and yield impacts of four approaches to the management of an overwintered cereal rye cover crop before soybeans. In addition poor weather and field conditions resulted in cover crop failures in the USDA Farming Systems Project where Objective 2 was to take place. What opportunities for training and professional development has the project provided?Two graduate students and one undergraduate student were trained as part of this project. Their thesis are listed under the products section. How have the results been disseminated to communities of interest?Yes, as reported earlier, we disseminated our findings to farmers and students through presentations, articles, trainings. Results from this project were also shared and discussed at the first annual Northeast Cover Crop Council Meeting on November 8 and 9th 2017, hosted at Cornell University. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

2015/09 TO 2016/09 Target Audience:Target audiences reached during this period were Organic farmers via articles, meetings, and field days, Northeast US agronomists and weed scientists via presentations, and Cornell University and other students via classroom instruction, internships, and through their work as research assistants Changes/Problems:In order to accomplish the project\'s goals more effectively, the proposed field experiment was split into two experiments: one to study ecosystem services of interseeded cover crops under differing corn densities; and the other to look at soil health and yield impacts of four approaches to the management of an overwintered cereal rye cover crop before soybeans. In addition poor weather and field conditions resulted in cover crop failures in the USDA Farming Systems Project where additional sampling was to take place. Theseminor changes will not affect our ability to reach our goal. What opportunities for training and professional development has the project provided? Nothing Reported How have the results been disseminated to communities of interest? Nothing Reported What do you plan to do during the next reporting period to accomplish the goals?Over the next 12 months, we will continue our research and outreach programs. This includes continuing the four experiments, collecting and analyzing data. With more site-years of results, we will begin writing research bulletins on cover crops and interseeding, as well as What\'s Cropping Up extension articles. We will also host field days and present information at winter farmer conferences.

2014/09 TO 2015/09 Target Audience:The target audience for this project is conventional farmers in NY, PA, and MD interested in transitioning to organic corn and soybean production without using a transition crop such as alfalfa. The target audience also includes organic farmers who want to learn more about growing corn and soybeans organically, using novel cover cropping methods to increase their success. Changes/Problems:The MD site experienced unexpected and insurmountable amounts of rainfall so that equipment could not get into the field

in any reasonable amount of time and the experiment had to be abandoned at that site for this year. Research will continue at these sites in 2016. What opportunities for training and professional development has the project provided?Technicians, graduate students, and research assistants learned weed species identification for the soil weed seed bank bioassay. New graduate students learned how to write effective protocols and maintain field logs. How have the results been disseminated to communities of interest?As the experiment is still in its first year, results are not yet available to share. However, farmers have been made aware that we are conducting this experiment, and their interest is primed for when results are available. Among other venues, the experiment was mentioned at the NYCO (New York Certified Organic) winter meetings and at the Organic Work Team annual meeting at Cornell University. What do you plan to do during the next reporting period to accomplish the goals?For the next period we will continue all experiment management activities and data collection as planned. Information and preliminary results on the project will be posted to the Cornell University Sustainable Cropping Lab\'s website. Field days at all sites will be hosted in summer 2016 to feature the experiments and preliminary results

IMPACT

2014/09 TO 2017/08 What was accomplished under these goals? \(1\) This project worked to address improving organic production through utilizing cover crops, in order to make organic production more profitable and sustainable. This project built on organic farmers\' keen interest in cover crops, including diverse mixtures and interseeding. Cover crops have potential to replace external inputs such as nitrogen fertilizer, improve cropping system performance, and facilitate the transition to certified organic crop production. \(2\) We established new transition-to-organic field experiments at research stations in New York, Pennsylvania, and Maryland to test advanced cover crop-based management systems. We quantified profitability and ecosystem services including crop performance, soil health, and weed seed predation. Our teams in NY and PA presented these results to farmers, researchers, and extension educators both locally and at national conferences. \(3\) Our research helped develop recommendations that enhance environmental benefits from cover crops. Our outreach helped farmers make the transition to organic production while remaining profitable and productive. Objective 1. Initiated a new 3-year cropping systems experiment in New York, Pennsylvania, and Maryland to test cover crop-based strategies for transitioning to certified organic corn and soybean production. Major activities completed / experiments conducted: In order to accomplish the project\'s goals more effectively, the proposed field experiment was split into two experiments: one to study ecosystem services of interseeded cover crops under differing corn densities (\"PHOENIX\"); and the other to look at soil health and yield impacts of four approaches to the management of an overwintered cereal rye cover crop before soybeans (\"MOSS\"). PHOENIX had the following treatments: No corn crop + interseeded cover crop Low corn density (15K seeds/acre) + interseeded cover crop Medium corn density (30K seeds/acre) + interseeded cover crop High corn density (45K seeds/acre) + interseeded cover crop Medium corn density (30K seeds/acre) + no interseeded cover crop MOSS included 4 cereal rye management treatments: No-till, in which rye is terminated with a roller-crimper at anthesis; Ryelage, in which rye is removed at the boot stage; Plow down, in which rye is moldboard plowed at jointing; and No cover, which has no rye cover crop. Soybeans were grown in all treatments, and interseeded in July with hairy vetch. Bottom of Form The first experiment was redesigned and implemented at three locations in NY, MD, and PA. The second experiment was repeated in NY. 2. Data collected: PHOENIX: Data was taken on soil characteristics, cover crop biomass, weed biomass, crop yield, and weed seed predation at all 3 sites. MOSS: Data was taken on soil characteristics, cover crop biomass, weed biomass, and crop yield. Spring cover crop biomass was collected in 2017 in both experiments in NY. 3. Summary statistics and discussion of results MOSS: In 2015 yield and profitability in \"No-till\" and \"No cover\" treatments were similar; in 2016 the \"No-till\" treatment was lower The \'Ryelage\' treatment soybean yields were among the highest; this treatment also included a forage harvest Weed biomass was greater in the \'No-till\' treatment, but still relatively low for organic production Cover crop growth in 2016 was enough to interfere with mechanical harvest, but not in 2015. Greater infiltration and soil respiration in the \'No-till\' treatment compared with the \"No cover\" treatment Compared to the \'No cover\' treatment, greater soil respiration in the \'No-till\' and greater PMN in the \'Plow down\' in 2016 only. PHOENIX: Light transmittance and cover crop biomass decreased with greater crop density Weed seed predation was similar over crop densities Invertebrates did not feed on cover crop and weed seeds equally An increase in cover crop biomass did not increase weed seed predation Corn planting density had a negative effect on weed biomass in NY and MD Path analysis showed that corn planting density and light transmission each had a direct effect on cover crop biomass and that the indirect effect of corn planting density was mediated by light transmission. 4. Key outcomes or other accomplishments realized: Researchers, graduate students and farmers gained knowledge about experimental design, cover crop management, and results from this study. Objective 2. Conduct a component experiment within the long-term USDA Farming Systems Project (FSP) to quantify the effect of cover crops and

cover crop establishment practices on soil health and greenhouse gas (GHG) emissions. 1. Major activities completed / experiments conducted: This was not implemented due to failure of cover crop establishment in both 2015 and 2016 at the Beltsville, MD Long Term USDA Farming Systems Project experiment, where the data was to be collected. Data collected: NA Summary statistics and discussion of results: NA Key outcomes or other accomplishments realized: NA Objective 3. Develop and offer an undergraduate organic cropping systems course that engages students in experiential learning by integrating field research with coursework. 1. Major activities completed / experiments conducted; A new course at Cornell University entitled Principles and Practices in Certified Organic Agriculture was developed. It utilizes findings from this and related research as well as broader agro-ecological theory to engage students in exploring the concepts and approaches to organic farming and sustainability. 2. Data collected; NA 3. Summary statistics and discussion of results: NA 4. Key outcomes or other accomplishments realized: There were 11 students in this class in the Spring 2017 semester of the class \'Principles and Practices in Organic Agriculture\' at Cornell University. Students learned about the history of organic agriculture, the USDA National Organic Program, management practices used in organic crop and livestock production, and current scientific research in organic agriculture. Laboratory sessions complemented lecture discussions with fieldwork and field trips to a variety of organic farms. Students worked through the certification process and grew organic vegetable, grain, and forage crops on campus. Objective 4. Disseminate new information through a project newsletter, research bulletins, cover crop interseeding demonstrations, on-farm soil weed seed bank characterizations, experiential learning activities, and presentations at farmer meetings. 1. Major activities completed / experiments conducted; Reported earlier. 2. Data collected; NA 3. Summary statistics and discussion of results: NA 4. Key outcomes or other accomplishments realized: Sharing concepts and preliminary information from this project and related ongoing work has stimulated strong interest among leading regional organic farmers. They see the value of cover crops and are looking for the best ways to incorporate them into their farming systems. These farmers are early adopters and serve as learning examples for other local farmers, serving to these demonstrate novel and helpful ideas. They will take findings and elements from this project and use them in ways that will increase their productivity and viability. Interseeding has already visibly increased in Aurora, NY area farm fields. Years 2015 (very wet) and 2016 (wet and then very dry) were notable in their extreme weather conditions, and having this project conducted over these two field seasons offered an important opportunity to study the effects of extreme weather on these systems. **PUBLICATIONS (not previously reported):** 2014/09 TO 2017/08 1. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Caswell, K, WS Curran, SB Mirsky, GW Roth, MR Ryan, JM Wallace. 2015. Evaluation of different cover crops in interseeded corn. ASA, CSSA, and SSSA International Annual Meeting. ASA Section: Agronomic Production Systems. 66-112-11. 2. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Champagne, R., W.S. Curran, C. Keene, J. Wallace, and T. Mazzone. 2016. Alternatives for reducing tillage in organic annual grain systems: implications for weed management. Proceedings The Northeastern Plant, Pest, and Soils Conference 1:56. 3. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Mazzone, T.R., W.S. Curran, and J.M. Wallace. 2016. No-till organic cover crop performance and weed suppression in Pennsylvania small grains. Proceedings The Northeastern Plant, Pest, and Soils Conference 1:137. 4. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Caswell, KE, WS Curran, SB Mirsky, G Roth, MR Ryan, and JM Wallace. 2016. Evaluation of different cover crops in interseeded corn. Proceedings of the Northeastern Weed Science Society. 69:136. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Curran, W., K. Caswell, S. Mirsky, G. Roth, M. Ryan, and J. Wallace. 2016. Opportunities and Challenges to Interseeding Cover Crops in Corn (Zea mays L.). Proceedings of 7th International Weed Science Congress. Prague, Czech Republic. 6. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Youngerman, CZ, W Curran, S Wayman, and MR Ryan. 2016. Crop density effects on interseeded cover crop productivity and weed seed predation. Proceedings of the Northeastern Weed Science Society. 69:54. 7. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Roth, GW, WS Curran, MR Ryan, SB Mirsky. 2015. Interseeding cover crops in corn: Impacts on corn yield and cover crop biomass production in the Mid Atlantic. ASA, CSSA, and SSSA International Annual Meeting. ASA Section: Agronomic Production Systems. 66-138-12 8. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Crowley, K., Ryan, M. 2017 Cereal Rye Management Prior to Organic Soybean: Effects on Soil Health, Weed Suppression, and Yield. ASA, CSSA, and SSSA International Annual Meeting. ASA Section: Agronomic Production Systems. 67-203-4 9. Type: Theses/Dissertations Status: Published Year Published: 2017 Citation: Crowley, Kiera A. 2017. Tradeoffs in cereal rye management strategies prior to organic soybean. Master of Science. Thesis. Cornell University, Ithaca NY. 10. Type: Theses/Dissertations Status: Published Year Published: 2017 Citation: Youngerman, Connor Z. 2017. Terms of service: enhancing establishment and growth of interseeded cover crops. Master of Science. Thesis. Cornell University, Ithaca NY. 11. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Youngerman, C. Z., A. DiTommaso, J. Losey, W. Curran, S. Mirsky, M. Ryan. 2017. Effects of interseeded cover crops on weed seed predation in corn. Proceedings of the Weed Science Society of America.

57: 137. 12. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Youngerman, C.Z., A. DiTommaso, J. Losey, W. Curran, S.B. Mirsky, M.R. Ryan. 2017. Effects of corn planting density on interseeded cover crops and weed seed predation. Proceedings of the Northeastern Weed Science Society. Proceedings ? The Northeastern Plant, Pest, and Soils Conference. 2:52 13. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Crowley, K and M Ryan. 2017. Effects of cover crop management and tillage on weed suppression, soil health, and profitability in organic soybean. Proceedings ? The Northeastern Plant, Pest, and Soils Conference. 2:51. 14. Type: Journal Articles Status: Published Year Published: 2017 Citation: 2. Jernigan, AB, BA Caldwell, S Cordeau, A DiTommaso, LE Drinkwater, CL Mohler, and MR Ryan. 2017. Weed abundance and community composition following a long-term organic vegetable cropping systems experiment. Weed Science 65:639?649. 15. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Crowley, K, HM van Es, M Gomez, MR Ryan*. 2017. Trade-offs in cereal rye management strategies prior to organically managed soybean. Agronomy Journal. (submitted). 16. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Youngerman, CZ, A DiTommaso, JE Losey, MR Ryan*. 2017. Cover crop and weed seed preference of four common weed seed predators. Weed Science 17. Type: Theses/Dissertations Status: Published Year Published: 2017 Citation: Peters, K. 2017. Soil seed banks on four organic grain crop farms in central new York. Undergraduate Honors. Thesis. Cornell University, Ithaca NY.

2015/09 TO 2016/09 What was accomplished under these goals? This project builds on organic farmers\' keen interest in cover crops, including diverse mixtures and interseeding. Cover crops have potential to replace external inputs such as nitrogen fertilizer, improve cropping system performance, and facilitate the transition to certified organic crop production. We have established new transition-to-organic field experiments at research stations in New York, Pennsylvania, and Maryland to test advanced cover crop-based management systems. We are quantifying profitability and ecosystem services including crop performance, soil health, and weed seed predation. Our research will be used to develop recommendations that enhance these environmental benefits. Our outreach will help farmers make the transition to organic production while remaining profitable and productive. In order to accomplish the project\'s goals more effectively, the proposed field experiment was split into two experiments: one to study ecosystem services of interseeded cover crops under differing corn densities (\"PHOENIX\"); and the other to look at soil health and yield impacts of four approaches to the management of an overwintered cereal rye cover crop before soybeans (\"MOSS\"). PHOENIX has the following treatments: No corn crop + interseeded cover crop Low corn density (15K seeds/acre) + interseeded cover crop Medium corn density (30K seeds/acre) + interseeded cover crop High corn density (45K seeds/acre) + interseeded cover crop Medium corn density (30K seeds/acre) + no interseeded cover crop MOSS includes 4 cereal rye management treatments: No-till, in which rye is terminated with a roller-crimper at anthesis; Ryelage, in which rye is removed at the boot stage; Plow down, in which rye is moldboard plowed at jointing; and No cover, which has no rye cover crop. Soybeans are grown in all treatments, and interseeded in July with hairy vetch. The first experiment was redesigned and implemented at three locations in NY, MD, and PA. The second experiment was repeated in NY. PHOENIX: Data was taken on soil characteristics, cover crop biomass, weed biomass, crop yield, and weed seed predation at all 3 sites. MOSS: Data was taken on soil characteristics, cover crop biomass, weed biomass, and crop yield. MOSS: Yield was lower in the second year of the \'No-till\' treatment \'Ryelage\' treatment soybean yields were among the highest; this treatment also includes a forage harvest Weed biomass was greater in the \'No-till\' treatment, but still relatively low for organic production Cover crop growth in 2016, but not 2015, was enough to interfere with mechanical harvest Greater infiltration in the \'No-till \'treatment Compared to the \'No cover\' treatment, greater soil respiration in the \'No-till\' and greater PMN in the \'Plow down\' in 2016 only. PHOENIX: Light transmittance and cover crop biomass decreased with greater crop density Weed seed predation was similar over crop densities Invertebrates did not feed on cover crop and weed seeds equally Researchers, students and farmers gained knowledge of its goals and preliminary results. This was not implemented due to failure of cover crop establishment in both 2015 and 2016 at the Beltsville, MD Long Term USDA Farming Systems Project experiment, where the data was to be collected. A new course at Cornell University entitled Principles and Practices in Certified Organic Agriculture was developed. It utilizes findings from this and related research as well as broader agro-ecological theory to engage students in exploring the concepts and approaches to organic farming and sustainability. We sampled three fields each at four organic farms and performed greenhouse weed seedbank bioassays. We reported the results back to the farmers along with soil test information. Results from the first year of this project were reported at the 2016 Northeast Organic Farming Association Winter Conference, Saratoga Springs, NY on January 22, 2016, and at At an organic farmer/Extension advisory group meeting on January 11, 2016, Dr. Ryan presented preliminary 2015 results from the PHOENIX study. 25 farmers, researcher and Extension educators were present. At the New York State Certified Organic Farmers (NYCO) meeting on February 9, 2016, Brian Caldwell shared the research goals and results from organic cash grain experiments at Cornell\'s Musgrave Research Farm, including the organic cropping systems experiment, an organic transitions experiment under Dr. Bill Cox, MOSS, and PHOENIX. NYS

research plots were shown to, and discussed by, an advisory group of organic farmers on July 19, 2016. Brian Caldwell spoke at a regional organic dairy meeting on July 13, 2016 on all Ryan lab organic projects including cover crops and interseeding in MOSS and PHOENIX. Dr. Matt Ryan spoke on Cover crop interseeding into corn and soybean at the Empire Farm Days on August 9, 2016. He presented preliminary results from cover crop interseeding in this project as well as results from related Ryan lab experiments. Articles on cover crop interseeding and the weed seedbank research in this project were written for Cornell\'s What\'s Cropping Up, the Soil and Crop Sciences Section\'s Extension print and on-line newsletter. These focused on the practical implications and results of the research. The What\'s Cropping Up newsletter will be used for a series of articles detailing the future results of this research as they are analyzed, to share important practical results with the farm community in advance of journal publications Sharing concepts and preliminary information from this project and related ongoing work has stimulated strong interest among leading regional organic farmers. They see the value of cover crops and are looking for the best ways to incorporate them into their farming systems. They will take findings and elements from this project and use them in ways that will increase their productivity and viability. Interseeding has already visibly increased in Aurora, NY area farm fields. **PUBLICATIONS (not previously reported):** 2015/09 TO 2016/09 1. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Youngerman, C.Z., W. Curran, S. Wayman, and M.R. Ryan. 2016. Crop density effects on interseeded cover crop productivity and weed seed predation. Proceedings The Northeastern Plant, Pest, and Soils Conference 1:54. 2. Type: Other Status: Published Year Published: 2016 Citation: Wayman, S., B. Caldwell, C. Pelzer, and M.R. Ryan. Weed Seedbanks on Local Organic Farms. What?s Cropping Up. 26:2. http://blogs.cornell.edu/whatscroppingup/2016/05/26/weed-seedbanks-on-local-org anic-farms/ 3. Type: Other Status: Published Year Published: 2016 Citation: Caldwell, B., C. Pelzer, and M.R. Ryan. 2016. Cover crop interseeding research in New York. What?s Cropping Up. 26:2. http://blogs.cornell.edu/whatscroppingup/2016/03/15/cover-crop-interseeding-res earch-in-new-york/ 4. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Jernigan, AB, MR Ryan, B Caldwell, A DiTommaso, L Drinkwater, C Marschner, and C Mohler. 2016. Weed abundance and community composition in a long-term organic cropping systems trial. Proceedings of the Northeastern Weed Science Society. 69:67. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Ryan, MR, M Ball, B Caldwell, A DiTommaso, L Drinkwater, C Marschner, and CL Mohler. 2016. Effects of tillage and nutrient management during the transition to organic grain production. Proceedings of the Northeastern Weed Science Society. 69:181. 6. Type: Book Chapters Status: Awaiting Publication Year Published: 2017 Citation: Ryan, MR and J Peign?. 2017. Chapter 4. Applying Agroecological Principles for Regenerating Soils. In Agroecological practices for Sustainable Agriculture: Principles, Applications, and Making the Transition. Editor A Wezel. In-review.

2014/09 TO 2015/09 What was accomplished under these goals? 1. This reporting period is the first year of the experiments replicated in NY, MD, and PA to assess an organic transition system using corn and soybean rotations with cover crops. The main goal of the experiment is to explore the effect of light on cover crop establishment and performance by creating a gradient of different crop populations in corn and soybean. Within the experiment there is also a treatment to control for additional fertilizer application at interseeding time. Organically managed field sites were prepared and planted with seven crop density treatments in NY, MD, and PA in spring of 2015 to organic corn and soybeans. Preparatory activities included fertilizing fields, plowing and cultipacking plots, planting corn and soybeans, and fertilizing the fertility treatments. Soil samples were collected in the spring at all three sites to characterize baseline soil health and soil weed seed bank levels. Soil samples were also collected from four organic farms in New York. Three fields were samples at the Martens, Oechsner, Myer, and Potenza farms. Greenhouse soil weed seed bank bioassays with soil collected from all experiment locations were conducted to determine weed seed bank density and diversity. Maryland The experiment in MD was successfully initiated but due to the wettest June in recorded history at this site and a very wet July, we could not perform adequate weed control or get into the field for timely cover crop interseeding. Thus the MD experiment had to be canceled. New York In NY, an impossibly wet spring delayed planting of corn and soybeans. However, the experiment was established and data collection is underway. An additional field experiment in NY was planted with a cereal rye cover crop in fall 2014 and planted to soybeans in spring. The focus of this single site experiment is to evaluate the transition to organic using cover crop based no-till practices. Water infiltration, soil moisture sampling, and soil sampling for potentially mineralizable nitrogen occurred in the additional NY experiment. We will use this site to conduct a multi-criteria assessment of four organic management systems during the transition to organic in a corn silage-soybean rotation. Pennsylvania Because of wet weather in June and the concern that we might impact crop populations, blind tillage for weed control was not performed, but the plots were cultivated three times with the last time just prior to interseeding the prescribed cover crop mix. Activities in PA and NY Sites in PA and NY were successfully cultivated at least three times and interseeded with legume cover crops in mid-summer. Weed seed predation arenas and pitfall traps to assess insect seed predation and activity density were designed, constructed, and deployed at the PA and NY sites.

Light penetration into the crop canopy was measured, corn and soybean planting success assessed, and weed and cover crop biomass will be collected in the near future. Grain yield will be collected and measured at the appropriate time this fall. 2. An experiment on the role of cover crop establishment on the greenhouse gas Nitrous Oxide was successfully launched within the Farming Systems Project but due to the extremely wet June and July had to be cancelled. 3. Plans were made to develop the organic cropping systems course, which should be available to students in the near future. 4. Extension activities: May 28 - Conducted a tour of organic and sustainable cropping systems projects at Penn State for approximately 20 undergraduate students who worked on the various projects during the summer of 2015. The tour stopped at multiple projects and explained the objectives and goals for each one. June 18 - Hosted a field tour for about eight Argentinean farmers/scientists led by Jeff Moyer from the Rodale Institute at the Penn State facility. The focus was on organic crop management including management of cover crops and interseeding. June 18 - A \"twilight tour\" about no-tillage roller-crimped organic cover cropping for soybean production was held at Cornell University\'s research farm. A handout introduced our research goal of exploring soil impacts in organic tillage systems for growing soybeans and corn. July 7 - Conducted an inservice at Rock Springs for County-based extension educators on our organic and sustainable research projects. We discussed organic crop management including management of cover crops and interseeding. Fifteen people attended. September 2 - A field day at Dueppengiesser Farm highlighted cover crop interseeding in corn and an informational handout about interseeding equipment and research results was distributed. **PUBLICATIONS (not previously reported):** 2014/09 TO 2015/09 No publications reported this period.

↑ Return to Index

Implementation of Non-antibiotic Programs for Fire Blight Control in Organic Apple and Pear in the Western United States

Accession No.	1003609
Subfile	CRIS
Project No.	ORE00117
Agency	NIFA ORE
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22079
Proposal No.	2014-03386
Start Date	01 SEP 2014
Term Date	31 AUG 2017
Grant Amount	$496,557
Grant Year	2014
Investigator(s)	Johnson, K. B.
Performing Institution	Botany / Plant Path, OREGON STATE UNIVERSITY, CORVALLIS, OREGON 97331

NON-TECHNICAL SUMMARY

Recently, the National Organic Program established a sunset date of October 2014 for antibiotics for fire blight suppression in organic pome fruit, requiring a transition to non-antibiotic methods in 2015. Several years ago, at stakeholder request, we initiated research and subsequently developed non-antibiotic programs for fire blight control based on combinations of NOP-approved materials. With the sunset approaching, these alternative programs have not been evaluated fully in commercial orchards in western states where organic pome fruit has an annual farm gate value of \~\$200M. Moreover, these programs have not been optimized for specific cultivars (e.g., fruit russet sensitivity) or adapted to disease risk models. This project will build on our previous efforts by moving non-antibiotic fire blight control from \'development\' to \'implementation\'. We will: a) refine non-antibiotic control programs to maximize fruit finish quality; b) continue evaluation of other non-antibiotic materials with potential for adoption in organic pome fruit; c) adapt non-antibiotic control recommendations to disease risk models; d) monitor commercial organic orchards for establishment of a biocontrol agent, for presence of the pathogen, and for disease severity; and e) teach and extend information on non-antibiotic control to the organic tree fruit community. We will work closely with organic producers, and disseminate the data regionally and nationally via webinars and traditional methods. Stakeholders will be involved continuously in the research, data review, and program evaluation. This project addresses Priority 3 of the 2014 Organic Transitions Program: Develop other allowable alternatives to antibiotics used to control fire blight in organic crops.

OBJECTIVES

The project goal is to implement, within the context of organic production practices, effective non-antibiotic programs for fire blight suppression in apple and pear.

APPROACH

Non-antibiotic strategies and materials for fire blight control will be evaluated in experimental pear and apple orchards. In these orchards, pear and apple trees will be treated with non-antibiotic materials during the flowering period, inoculated with the fire blight pathogen and then assessed for levels of infection. Additional trials to evaluate safety of non-antibiotic materials to developing fruit will be conducted in commercial organic orchards. Growth chamber experiments will determine the effect of temperature on the ability of a yeast biocontrol agent to colonize pear and apple flowers; this data will be used to develop weather-based recommendations for the timing of yeast treatments. The colonization success of a yeast biocontrol agent in commercial orchards will be measured by plating floral washes and by PCR assay of these washes. Project success will be measured through case studies of cooperating growers, and through surveys of grower audiences at webinars and in-person presentations.

PROGRESS

2014/09 TO 2018/08 Target Audience:The primary audience is organic pome fruit growers and the consultants who advise on growing this crop. Since 2015, these individuals have transitioned to non-antibiotic methods of fire blight control In NOP-compliant pear and apple orchards. A secondary audience is policymakers and consumers who have been concerned about the use of antibiotics for suppression of fire blight disease in organic orchards. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?An undergraduate microbiology major at Oregon State University, Evan Thompson, worked in the Johnson lab for three years on the objective of understanding how the yeast biocontrol agent, Aureobasidium pullulans, protects apple and pear from fire blight infection. In summer 2016, he gave a paper at the western region meeting of the American Phytopathological Society titled: \"Dynamics of colonization of pome flowers by biocontrol strains of Aureobasidium pullulans, a yeast that effectively suppresses fire blight. In August 2018, we submitted his research for publication in the journal Plant Disease. Also in 2018, Mr. Thomson completed addional coursework in clinical microbiology and is currently working as a clinical microbiologist in the VA hospital in Boise, ID. How have the results been disseminated to communities of interest?Outreach Presentations by Ken Johnson: (only presentations since 2017 progress report shown - see previous progress report for list of presentations and webinars by year): - Ken Johnson, Oregon State University Upcoming: \"Organic Controls that Work\", Fire Blight Session,Washington Hort Association Annual Conference, Yakimak, WA, December, 2018. \"Fire blight management in organic and conventional orchards\". Two workshops presented to Wilbur-Ellis crop consultants, Zillah, WA, and to Broetje Orchards fieldmen, Pasco, WA, March 2018. \"Fire Blight Management\", IPM in Montana Apple Orchards Conf., MSU Western Ag Res Center, Corvallis, MT March 2018. \"Fire Blight: A rare disease in the Willamette Valley - Should we worry? Willamette Valley Tree Fruit Growers Assoc. Annual Meeting, Salem, OR February 2018. \"Fire Blight Management in Pear\", OSU SOREC Pear day, Medford, OR, February 2018. \"Open forum on fire blight management\", OSU MCAREC Winter Grower\'s Meeting, Hood River, OR, February 2018. \"Managing fire blight as a system\", Wilber-Ellis Einter Grower\'s Meeting, Hood River, OR, January 2018. \"Materials and Most Effective Use Strategies for Fire Blight Control\" and \"Panel Discussion: Fire blight Strategies\", Wilbur Ellis Yakima Valley Organic Grower\'s Meeting, Benton City, WA, January 2018. \"Managing fire blight in young trees\", N. Central Washington Apple Day, Wenatchee, WA, January 2018. \"Fire blight trends, future predictions, common question, new products\", N. Central Washington Pear Day, Wenatchee, January 2018. \"Fire blight management\", Washington Hort Association Annual Conference, Kennewick, WA, December, 2017. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2014/09 TO 2018/08 What was accomplished under these goals? Fire blight-susceptible, organic pome fruit orchards occupy \~20,000 acres in the Pacific Northwest region of the United States. In response to the NOP\'s 2014 antibiotic phased-out, we developed and implemented non-antibiotic programs for fire blight control that integrate cultural and copper-based sanitation, crop load-thinning, biological control and non-antibiotic chemical protection. Parsing the pathogen\'s biology into stages - prebloom activity, epiphytic increase on floral stigmas, and infection via the floral cup - has been key in timing and maximizing the effectiveness of individual materials. Non-antibiotic programs have now been used commercially for four seasons with a high level success. To date, important materials for non-antibiotic fire blight control include lime sulfur, a filamentous yeast (Aureobasidium pullulans), and fixed and soluble copper bactericides, with limited contributions from biological products comprised of gram-positive (Bacillus spp.) or gramnegative (Pseudomonas and Pantoea spp.) bacteria. Ongoing research is investigating i) the mechanism(s) by which the A. pullulans-based product, Blossom Protect, suppresses fire blight, ii) the environmental conditions that trigger fruit russeting by non-antibiotic materials, and iii) the relative ability of individual materials to impact/eradicate epiphytic pathogen populations. Moreover,

because both A. pullulans and copper increase the risk of fruit russeting (undesirable marking of smooth-skinned apple and pear fruit), we have continued to evaluate additional materials for the ability to control fire blight with greater safety to the crop. In 2018, in particular, numerous trials were completed to be better understand how specific cultivar influences the risk of fruit russeting from non-antibiotic fire blight control materials. We continued to work closely with organic producers and their advisers, and have disseminated the data regionally and nationally via webinars and traditional methods. The 2018 season was very favorable for fire blight across the region. Consequently, numerous organic pear and apple orchards suffered damage from fire blight, but this damage did not appear to be beyond that observed in comparable conventional orchards. **PUBLICATIONS (not previously reported):** 2014/09 TO 2018/08 1. Type: Journal Articles Status: Under Review Year Published: 2018 Citation: Thompson, E. C., Temple, T. N., Uppala, S., Granatstein, D., and Johnson, K. B. 2019. Floral colonization dynamics of Aureobasidium pullulans strains used to suppress fire blight of pome fruit. Plant Dis. (in review). 2. Type: Journal Articles Status: Other Year Published: 2019 Citation: Johnson, K. B., and Temple, T. N. 2019. Refinement of integrated, non-antibiotic spray programs for fire blight control in organic pome fruit. Plant Dis.(in preparation). 3. Type: Websites Status: Published Year Published: 2017 Citation: DuPont, T., Johnson, K., Elkins, R., Smith, T., and Granatstein, D. 2017. Organic fire blight management in the western U.S. eOrganic http://articles.extension.org/pages/74505/organic-fire-blight-management-in-the -western-us 4. Type: Conference Papers and Presentations Status: Published Year Published: 2106 Citation: Johnson, K., Temple, T., Elkins, R., Granatstein, D., and Smith, T. Non-antibiotic strategies for fire blight control in the U.S.A. 1st International Symposium on Fire Blight of Rosaceous Plants, Girona, Spain, July 2016. Progress 09/01/16 to 08/31/17 Outputs Target Audience:The primary audience is organic pome fruit growers and the consultants who advise on growing this crop. Since 2015, these individuals have transitioned to non-antibiotic methods of fire blight control In NOP-compliant pear and apple orchards. A secondary audience is policymakers and consumers who have been concerned about the use of antibiotics for suppression of fire blight disease in organic orchards. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?An undergraduate microbiology major at Oregon State University, Evan Thompson, has worked in the Johnson lab for three years on the objective of understanding how the yeast biocontrol agent, Aureobasidium pullulans, protects apple and pear from fire blight infection. In summer 2016, he gave a paper at the western region meeting of the American Phytopathological Society titled: \"Dynamics of colonization of pome flowers by biocontrol strains of Aureobasidium pullulans, a yeast that effectively suppresses fire blight.\" How have the results been disseminated to communities of interest?Extension and/or education activities completed or upcoming: Webinars: \"Alternatives for fire blight control\", CCOF monthly webinar, California Certified Organic Farmers, November, 2014. \"Non-antibiotic fire blight control: What works as we head into a new era\", eOrganic webinar, March, 2015. Traditional Outreach Presentations: (only 2017 presentations shown - previous years were similar): Johnson, K.: \"Fire blight biology and cultural controls\" and panel discussion \"In Season Fire Blight Management Programs that Work\", Washington State University Tree Fruit School: Organic Pest and Disease Management, Wenatchee, WA, March 2017. \"Effective material use strategies in non-antibiotic fire blight management\", Wilbur Ellis Yakima Valley Organic Grower\'s Meeting, Benton City, WA, January 2017. \"Fire blight management after a disease year\", talk given at Chamberlin Hood River Valley Grower\'s Meeting, Hood River, OR; GS Long Hood River Valley Grower\'s Meeting, Hood River, OR; Wilber Ellis Conventional Grower\'s Meeting, Yakima and Pasco,WA; OSU MCAREC Winter Grower\'s Meeting, Hood River, OR; and OSU SOREC Pest Management Forum, Medford, OR. January to March 2017. \"Non-antibiotic fire blight control\", \"Progress on understanding Aureobasidium (Blossom Protect yeast)\", and \"Measuring the effect of biopesticides on eradication of epiphytic Erwinia populations under high risk conditions\", Western Orchard Pest and Disease Management Conference, Portland, January 2017. DuPont, T.: \"Prevencion y control de Fire Blight\", GS Long, Yakima (500 participants), G.S. Long, Wenatchee (250 particpants), Manejo de Frutales, WSU Fruit School (80 participants). Wenatchee, WA, January, 2017. \"Fire Blight Management\", North Central Washington Pear Day (235 participants) and North Central Washington Apple Day. (180 participants), Wenatchee, WA. January 2017. \"Managing Fire Blight in your orchard after a problem year\", Northwest Wholesale, Orroville. (50) partipants), Manejo de Frutales (80 participants), Oroville, Othello and Manson, WA, February 2017. Scientific presentations: Johnson, K. B., Temple, T. N., Elkins, R. B., Granatstein, D. M., and Smith, T. J. Non-antibiotic strategies for fire blight control in the U.S.A. 1st International Symposium on Fire Blight of Rosaceous Plants, Girona, Spain, July 2016. Thompson, E. C., Temple, T. N., Elkins, R. B., and Johnson, K. B. Dynamics of colonization of pome flowers by biocontrol strains of Aureobasidium pullulans, a yeast that effectively suppresses fire blight. American Phytopathological Soc. Pacific Div. Annual Conf., LaConner, WA, June 2016. Phytopathology 106:S4.206. Websites, patents, inventions, or other community resources created: Websites: http://treefruit.wsu.edu/crop-protection/disease-management/fire-blight/ http://www.tfrec.wsu.edu/pages/organic/fireblight http://articles.extension.org/pages/74505/organic-fire-blight-management-in-the-western-us What do you plan to do during the next reporting period to accomplish the goals?We are currently in a one-year no-cost extension of this project. We have sufficent funding to continue the outreach effort over winter/spring 2018 and partial funding to conduct research trials in spring 2018. The trials will attempt to confirm previous research results, which is a

requirement for peer-reviewed publication. Impacts What was accomplished under these goals? Fire blight-susceptible, organic pome fruit orchards occupy \~20,000 acres in the Pacific Northwest region of the United States. In response to the NOP\'s 2014 antibiotic phased-out, we developed and implemented non-antibiotic programs for fire blight control that integrate cultural and copper-based sanitation, crop load-thinning, biological control and non-antibiotic chemical protection. Parsing the pathogen\'s biology into stages - prebloom activity, epiphytic increase on floral stigmas, and infection via the floral cup - has been key in timing and maximizing the effectiveness of individual materials. Non-antibiotic programs have now been used commercially for three seasons with a high level success. To date, important materials for non-antibiotic fire blight control include lime sulfur, a filamentous yeast (Aureobasidium pullulans), and fixed and soluble copper bactericides, with limited contributions from biological products comprised of gram-positive (Bacillus spp.) or gram-negative (Pseudomonas and Pantoea spp.) bacteria. Ongoing research is investigating i) the mechanism(s) by which the A. pullulans-based product, Blossom Protect, suppresses fire blight, ii) the environmental conditions that trigger fruit russeting by non-antibiotic materials, and iii) the relative ability of individual materials to impact/eradicate epiphytic pathogen populations. Moreover, because both A. pullulans and copper increase the risk of fruit russeting (undesirable marking of smooth-skinned apple and pear fruit), we have continued to evaluate additional materials for the ability to control fire blight with greater safety to the crop. We have worked closely with organic producers and their advisers, and have disseminated the data regionally and nationally via webinars and traditional methods. Publications Type: Websites Status: Published Year Published: 2017 Citation: DuPont, T., Johnson, K., Elkins, R., Smith, T., and Granatstein, D. 2017. Organic fire blight management in the western U.S. eOrganic http://articles.extension.org/pages/74505/organic-fire-blight-management-in-the-western-us Progress 09/01/15 to 08/31/16 Outputs Target Audience:Project goals are to implement in organic apple and pear orchards effective non-antibiotic spray programs to control fire blight based on combinations of registered biological materials. In general, recommendations to make spray treatments for disease control in commercial orchards are done by state-licensed pest control advisors (PCAs). Consequently, our largest audience is PCAs who for their business model need to deliver effective fire blight control programs to their clients (growers). Through our outreach activities, we have communicated with regional and national audiences of pome fruit producers, advisors, farm supply distributors, and consumer advocates interested in growing, marketing and eating organic pome fruit. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?An undergraduate microbiology major at Oregon State University, Evan Thompson, has worked in the Johnson lab for two years on the objective of understanding how the yeast biocontrol agent, Aureobasidium pullulans, protects apple and pear from fire blight infection. In summer 2015, he gave a paper at the western region meeting of the American Phytopathological Society titled: \"Dynamics of colonization of pome flowers by biocontrol strains of Aureobasidium pullulans, a yeast that effectively suppresses fire blight.\" How have the results been disseminated to communities of interest?Presentations by Ken Johnson: (audience size given as \'n =\') 2015 \"Progress in Organic Fire blight Control\", Organic Tree Fruit - Gone Global Session, Washington Hort Association Annual Conference, Kennewick, WA. n = 200 \"Fire blight Management: Progress & Perils\", Pest and Disease Session, Washington Hort Association Annual Conference, Kennewick, WA. n = 250 2016 \"Organic and post bloom programs for fire blight control\", Certis USA 2nd annual fire blight workshop, Portland, OR. n = 25 \"Update on non-antibiotic fire blight control\", Western Orchard Pest and Disease Management Conference, Portland, OR. n = 60 \"Organic and conventional programs for fire blight control\", Wilbur-Ellis Northwest Operations Winter Meeting, Sun River, OR. \"Progress in fire blight control\", GS Hood River Valley Grower\'s Meeting, Hood River, OR. n = 40 \"Non-antibiotic fire blight control\", Wilbur Ellis Yakima Valley Organic Grower\'s Meeting, Benton City, WA. n = 60 \"New (and old) technologies for fire blight control\", OSU Extension, Hood River Winter Horticulture Meeting, Hood River, OR. n = 45 \"Update on fire blight control\", S. OR pear grower\'s lunchtime workshop, OSU-SOREC, Medford, OR. n = 20 Presentations by David Granatstein: 2016 \"Fire blight update\", Green Bluff Growers, Spokane, WA, May. n = 27. Presentations by Tim Smith: 2016 \"Key management steps to reduce the risk of fire blight in organic systems\", Northwest Wholesale organic grower meeting, Chelan, WA Feb. n = 70 Presentations by Rachel Elkins 2015 \"Fire blight control tactics for use in California North Coast pear orchards\", Western Orchard Pest and Disease Management Conference, Portland, OR, Jan. n = 60 \"Managing fire blight without antibiotics\", EcoFarm Conference, Pacific Grove, CA Jan. n = 50 \"Evaluation of potential components of a fire blight IPM program\", Grower meetings, Walnut Grove and Hopland, CA, Feb. n = 62 \"Copper formulations - why all the new products\", Grower meetings, Ukiah and Lakeport, CA Dec. n = 89 2016 \"Fire blight research update from California\", 2nd Annual Certis USA Fire Blight Workshop, Portland, OR, Jan. n = 25 \"Update of North Coast fire blight and scab field trials\", Western Orchard Pest and Disease Management Conference, Portland, OR. Jan. n = 60 \"North Coast and Oregon research: evaluation of components of a fire blight IPM program\", Grower meetings, Walnut Grove and Lucerne, CA, Feb. n = 55 \"Alternative fire blight control programs\", Ag Unlimited Sonoma County Apple Grower Meeting, Sebastopol, CA, Feb. n = 33 \"Regular updates on fire blight research\", Monthly PCA breakfasts, Kelseyville, CA. n = 8 to 10 What do you plan to do during the next reporting period to accomplish the goals?We will continue to address each of the objectives. To publish our field studies, we generally need a minimum of two years of data;

we are now beginning the process of writing manuscripts. Project empahsis will shift slightly away from examining the microbial ecology of Aureobasidium pullulans on pome flowers and towards experiments to evaluate late- and post-bloom sanitation of the fire blight pathogen. These later bloom sanitation treatments will emphasize the low pH materials mentioned above and two products that contain phage viruses that specifically attack and kill the fire blight pathogen. Refinement of the disease risk model, outreach to stakeholders and documentation of project impact will continue. The 2016 season reinforced to us (and our stakholders) that non-antibiotic control of fire blight requires change in practice. Stakholder implementation of developed methods is occurring, but control program refinement and full program adoption across the industry is still incomplete. Impacts What was accomplished under these goals? Under the objectives listed above, in addition to five orchard trials to measure efficacy of non-antibiotic materials for fire blight control, experiments were conducted to specifically evaluate the safety of materials with regard to fruit finish (russeting). These trials were done on both pear and apple, and in different environments (arid, semi-arid and moist spring weather). We also furthered our study to determine if Aureobasidium pullulans isolates recovered from pear and apple flowers are strains specific to the biocontrol product, Blossom Protect, or strains that originated in the orchard. The result of this effort will improve our understanding on how the Blossom Protect product achieves fire blight control, and how frequently and intensely the product should be used to obtain outstanding disease suppression. With regard to new materials for fire blight suppression, research emphasis has shifted to chemicals that reduce the pH of pear and apple tree surfaces (aluminum potassium sulfate and citric acid), which could potentially be used inexpensively as full-, late- and post-bloom sanitizing agents to prevent infections in flowers and new shoots. Weather conditions in spring of 2016 were outstanding for the purpose of observing the sanitizing potential of non-antibiotic materials. Outreach presentations in 2016 emphasized to growers/advisers the need to adopt lower action thresholds in the CougarBlight disease risk model for organic orchards and to utilize non-antibiotic materials within an integrated program. We documented project impact through stakeholder \'clicker\' surveys, which to date have shown that as a result of the research and outreach associated with this project, growers and PCAs are optimistic about the future of organic apple and pear production. Publications Type: Websites Status: Published Year Published: 2015 Citation: Granatstein, D. 2015. Organic & Integrated Tree Fruit Production: Fire Blight Control in Organic Apples and Pears. WSU Tree Fruit Management website. Tree Fruit Research and Extension Center, Washington State University, Wenatchee, WA. 4446 visits in last 10 months. http://www.tfrec.wsu.edu/pages/organic/fireblight Type: Websites Status: Published Year Published: 2016 Citation: Smith, T., Johnson, K. and DuPont, T. 2016. Fire blight. WSU Tree Fruit Management website. Tree Fruit Research and Extension Center, Washington State University, Wenatchee, WA. http://treefruit.wsu.edu/fire-blight/ Type: Other Status: Published Year Published: 2016 Citation: Smith, T. 2015. Improving the management of two critical pome fruit diseases. Final report, WA Tree Fruit Research Commission. www.treefruitresearch.com Type: Other Status: Published Year Published: 2016 Citation: Johnson, K. 2014. Fire blight management in organic and conventional apple. Final report, WA Tree Fruit Research Commission. www.treefruitresearch.com Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2016 Citation: Granatstein, D. Status of organic production of temperate fruits in the USA. 17th International Conference on Ecological Fruit Production, Hohenheim, Germany, Feb., 2016. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2016 Citation: Thompson, E., Temple, T., Elkins, R., and Johnson, K. Dynamics of colonization of pome flowers by biocontrol strains of Aureobasidium pullulans, a yeast that effectively suppresses fire blight. American Phytopathological Soc. Pacific Div. Annual Conf., LaConner, WA, June 2016. Phytopathology 116: (in press). Type: Conference Papers and Presentations Status: Other Year Published: 2016 Citation: Johnson, K., Temple, T., Elkins, R., Granatstein, D., and Smith, T. Non-antibiotic strategies for fire blight control in the U.S.A. 1st International Symposium on Fire Blight of Rosaceous Plants, Girona, Spain, July 2016. Type: Conference Papers and Presentations Status: Awaiting Publication Year Published: 2016 Citation: Granatstein, D. Current Trends for Temperate Organic Tree Fruits in North America. 2nd Canadian Organic Science Conference, Montreal, Quebec, Sept., 2016. Progress 09/01/14 to 08/31/15 Outputs Target Audience:Project goals are to implement in organic apple and pears orchards effective non-antibiotic spray programs to control fire blight based on combinations of registered biological materials. In general, recommendations to make spray treatments for disease control in commercial orchards are done by state-licensed pest control advisors (PCAs). Consequently, our largest audience is PCAs who for their business model need to deliver effective fire blight control programs to their clients (growers). Through our eOrganic webinar, we reached a national audience of pomefruit producers, advisors, distributors, consumer advocates interested in growing, marketing and eating organic pome fruit. 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?Presentations by Ken Johnson: (audience size given as \'n =\') 2014 Oct to Dec \"Development of non-antibiotic programs for fire blight control in organic apple and pear\", USDA NIFA OREI project director\'s meeting, Washington, D.C. n =25. \"New developments in Fire blight control\", Workshop presented to Wilbur-Ellis N. central pest control advisors, Chelan, WA. n =18 Updates for fire blight control programs for organic orchards\", WA Hort Association, Kennewick, WA, December, 2014. 2015 Jan/Feb \"Materials and strategies for

non-antibiotic fire blight control\", Wilbur Ellis Organic Growers, Benton City, WA, n =60. \"New developments in fire blight control\", Treasure Valley Tree Fruit Growers, Nampa, Idaho. n =30 \"Non-antibiotic control of fire blight\", Western Disease Conference, Portland. OR. \"Fire blight control without antibiotics\"\' GS Long Organic Growers, n =60. \"Biocontrol of fire blight: Why a yeast is a new paradigm in disease suppression\", Organic Research Symposium, Lacrosse, WI. n =20 \"Managing fire blight without antibiotics\", MOSES conference, Lacrosse, WI. n = 175 March \"Fire blight management in organic orchards\". Workshops to Wilbur-Ellis fieldmen, Sunnyside, WA, and to Broetje Orchards fieldmen, Pasco, WA, N = 25 and 20. \"Fire blight management\", S. OR pear grower\'s workshop, OSU-SOREC, Medford, OR. n = 20 Presentations by Tim Smith: 2014 Oct/Nov/Dec Certis Fire blight research review, \"Fire Blight of apples and pears, promising management practices and choices of materials for control.\" n =40. Washington Tree Fruit Association, Kennewick, WA, \"Fire Blight, more progress towards promising alternative materials for control.\" n =400. 2015 Jan/Feb Western DiseaseConference, Portland, OR, \"Fire Blight of Pears, promising management practices and choices of materials for control.\" n =40. Lake Chelan Hort Day, Chelan, WA, \"Fire Blight, more progress benefitting management practices and choices of non-antibiotic materials for control.\" n =160. Pear Day, Wenatchee, WA, \"Modern fire blight control materials- product choices and timing. n =190. Apple Day, Wenatchee, WA, \"Fire Blight of apples, promising management practices and more new choices of non-antibiotic spray materials for control.\" n =180. NW Wholesale Growers Meeting, Oroville, WA, \"Fire Blight of apples and pears, promising management practices and choices of non-antibiotic materials for spray control.\" \" n =55. February, Okanogan Co. Hort. Assoc., Omak, WA \"Fire Blight of apples and pears, promising management practices and non-antibiotic choices of spray materials for control.\" n =110. NW Wholesale Organic Growers, Chelan, WA, \"Alternatives for the control of fire blight using OMRI approved materials.\" n =70. Manson Fruit Growers, \"Fire Blight of apples and pears, promising management practices and choices of materials for control.\" n =38. G.S. Long Fieldmen, Yakima, WA. \"Fire Blight of apples and pears, promising management practices and choices of materials for control.\"n = 10. Presentations by David Granatstein 2014 Oct/Nov/Dec \"Fire Blight - Current Products, Research Grants and Regulatory Status\". CertisUSA fire blight summit, Asheville, NC. Oct. 8, 2014. 2015 Jan/Feb \"Organic tree fruit grower survey.\" GS Long organic meeting, Yakima, WA.. \"Fire Blight Control without Antibiotics\". Ecofarm Conference, Asilomar, CA.. \"Recent trends in organic tree fruit production.\" Wilbur-Ellis organic meeting, Benton City, WA, Feb. 4, 2015. \"Recent trends in organic tree fruit production.\" Northwest Wholesale organic meeting, Chelan, WA,. \"Fire Blight Control without Antibiotics\". MOSES Conference, Lacrosse, WI. Oct/Nov/Dec \"Implementation of non-antibiotic programs for fire blight control in organic apple and pear in the western United States\". D. Granatstein, K. Johnson, T. Smith, R. Elkins. Poster presentation at USDA-OREI project directors meeting, Washington, DC. Oct. 23, 2015. What do you plan to do during the next reporting period to accomplish the goals?We will continue to address each of the objectives. To publish our field studies, we generally need a minimum of two years of data. Project empahsis will shift slightly away from examining the microbial ecology of Aureobasidium pullulans on pome flowers and towards experiments to evaluate late- and post-bloom sanitation of the fire blight pathogen. These later bloom sanitation treatments will emphasize the low pH materials mentioned above and two products that contain phage viruses that specifically attack and kill the fire blight pathogen. Refinement of the disease risk model, outreach to stakeholders and documentation of project impact will continue. Impacts What was accomplished under these goals? Under the objectives listed above, in addition to four orchard trials to measure efficacy of materials for blight control, in 2015 we conducted four additional trials to specifically evaluate the safety of non-antibiotic materials with regard to fruit russetting. These trials were done on different hosts (two apple, two pear) and in different environments (semi-arid desert and Pacific maritime). We also developed PCR-based molecular methods to determine if Aureobasidium pullulans isolates recovered frompear and apple flowers are a strain specific to the biocontrol product, Blossom Protect, or strains that reside in the orchard. With regard to new materials, we are placing research emphasis on those that reduce the pH of pear and apple tree surfaces, which could potentially be used inexpensively as full-, late- and post-bloom sanitizing agents to prevent infections in flowers and new shoots. We are also developing new risk thresholds for the CougarBlight model that will result in enhanced protection of 1- to 10-year-old trees, which are especially sensitive to damage from fire blight infections. We are documenting project impact through stakeholder \'clicker\' surveys, which to date have shown that as a result of the research and outreach associated with this project, growers and PCAs are feeling more optimistic about the future of organic apple and pear production. They are taking a systems approach to fire blight control, using integrated programs of non-antibiotic materials as well as adjusting nitrogen rates, irrigation timing, insect vector control, canopy shape and other factors known to influence the disease. Publications Type: Websites Status: Published Year Published: 2014 Citation: Fire blight control in organic apples and pears. Managed by D. Granatstein. http://www.tfrec.wsu.edu/pages/organic/fireblight .

↑ Return to Index

A Natural Approach to Human-pathogen Suppression: Can Biodiversity Fill the Gaps?

Accession No.	1003771
Subfile	CRIS
Project No.	WNP04419
Agency	NIFA WN.P
Project Type	OTHER GRANTS
Project Status	NEW
Contract / Grant No.	2014-51106-22547
Proposal No.	2014-03354
Start Date	01 SEP 2014
Term Date	31 AUG 2015
Grant Amount	$298,706
Grant Year	2014
Investigator(s)	Snyder, W. E.
Performing Institution	Entomology, WASHINGTON STATE UNIVERSITY, 240 FRENCH ADMINISTRATION BLDG

NON-TECHNICAL SUMMARY

Restoring livestock to organic farms allows on-farm fertilizer production and the sale of high-value meat products. Likewise, diversifying farms with native plants provides habitat for pest-killing birds and predatory insects. Unfortunately, both practices carry the risk of unintentional contamination of produce by human pathogens (e.g., E. coli O157:H7), transmitted through livestock feces or those of wildlife drawn to native plantings. Currently, the only way to manage this risk is to remove all natural vegetation from the farm, which disrupts natural pest control, or to install deer-fencing around the entire farm perimeter, which is expensive and cannot exclude all vertebrate carriers of human pathogens. Arthropods and microbes that eat feces likely reduce this risk, but little is known about coprophage biodiversity, impacts, or conservation. Working on mixed-vegetable farms varying in their levels of livestock integration, we propose to: (1) Quantify biodiversity of feces-feeding arthropods (e.g., dung beetles, flies) through intensive field sampling; (2) Assess functional-genetic diversity of soil microbes, focusing on genes likely to be active in feces digestion; and (3) Relate biodiversity among coprophagous arthropods and microbes to rates of feces removal and E. coli suppression. Our ultimate goal is to provide organic growers with practical ways to reduce the risk of harboring human pathogens on their farms, by conserving and augmenting beneficial coprophagous insects and microbes. We address ORG program goals by exploring and understanding the role of biodiversity in organic agriculture systems, to reveal the importance of biodiversity as a benefit of organic agriculture, production, and sustainability.

OBJECTIVES

We will focus on three tightly-interrelated research and outreach objectives. First, working on farms varying in their level of livestock integration, we will quantify the biodiversity of feces-feeding arthropods (e.g., dung beetles, flies) and measure their feces-consumption rates. Second, on these same farms we will use next-generation DNA sequencing to assess the functional diversity of soil microbes, while also searching for resident E. coli and assessing soil quality. Third, we will directly measure the ability of coprophagous insects and microbes to kill

pathogenic E. coli O157:H7 bacteria. All that we learn will be relayed to growers through a vigorous outreach program, focusing on hands-on learning, web, and video components.

APPROACH

OBJECTIVE 1. Document farming practices; measure biodiversity of coprophagous insects and their rate of feces consumption. The lynchpin of our project is a rigorously detailed study of coprophage biodiversity on each of a large group of cooperating organic mixed-vegetable farms located across WA, OR, and CA. Half of these farms have integrated livestock into their produce operations (Table 1); the farms are arranged in pairs, such that each integrated-livestock-vegetable farm is matched with a nearby vegetable-only farm (Fig. 1). While we are focusing on ecological differences between \"integrated\" and \"vegetable-only\" farms, these growers also differ in a wide variety of other management practices (e.g., fertility management regimes, use of flowering hedgerows, etc). Therefore, during the first year of the project we will interview growers to gain insight into livestock management and other aspects of their farming philosophy, while also mapping surrounding unfarmed habitats to document the farm\'s landscape context. The Integrated Extension Component will focus on a \"Dirty jobs: nature\'s pooper scoopers and how they can help save your farm\" series of field days, which will be piloted through a series of farm-walk field days featuring hands-on learning in basic ID and sampling of coprophagous insects. These field days will be recorded on video, allowing us to develop the field days into eOrganic web content available to anyone. Thus, we will provide practical tools and know-how for growers to monitor coprophages on their own farms.OBJECTIVE 2: Measure microbial functional diversity and feces degradation. It is likely that coprophagous insects work in concert with soil-dwelling microbes to consume feces (reviewed above). Because microbial coprophages live in the soil, it is important to determine what soil-management practices and characteristics are associated with microbial pathogen suppression. Here, through a series of tightly inter-related sub-objectives, on each farm we will (1) quantify soil quality, (2) measure densities of resident pathogenic and non-pathogenic E. coli, (3) quantify microbial functional diversity using next-generation DNA sequencing, and (4) measure rates of feces consumption by microbes. Our ultimate goal is to establish links among farm management practices (recorded under Objective 1), soil characteristics, functional microbial genetic diversity, and E. coli persistence/degradation. In turn, this information will inform our experimental measures of pathogenic E. coli degradation as described under Obj. 3.OBJECTIVE 3: Suppression of pathogenic E. coli O157:H7 by insects and microbes. Our first two objectives will allow us to draw correlations between management practices, coprophage biodiversity, and resulting E. coli densities. While we anticipate often finding harmless E. coli in farm soils, providing robust data, pathogenic E. coli are (thankfully) rare and may not be detected at all within our sampling regime. This raises the risk that we remain uncertain whether the coprophages that we are collecting truly are effective at suppressing the most harmful strains of the bacteria. Therefore, we propose a final objective where we directly measure survival of human-pathogenic E. coli O157:H7 bacteria in the presence versus absence of (1) key coprophagous insect species, (2) farm soils differing in functional diversity, and (3) the combination of coprophagous insects and putative \"suppressive\" soils. Of course, we cannot intentionally bring E. coli O157:H7 onto the farms of our cooperating growers. Therefore, we will conduct these experiments in \"microcosms\" that include soil, B. oleracea (broccoli) plants, and the focal coprophages, with the microcosms housed within co-PI Besser\'s biosafety level-2 microbiology laboratory space at Washington State University. PROGRESS: 2014/09 TO 2018/08 Target Audience:The central goal of our project is to provide new, transitioning growers with a roadmap for how to build naturally-pathogen-resistant farms. However, our project may also suggest to long-time organic vegetable growers that they could benefit from a second transition, moving towards livestock integration or the adoption of other practices found to build coprophage biodiversity. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project partially supported the training of graduate student Matthew Jones and postdoctoral scholar Zhen \"Daisy\" Fu. In addition, undergraduate students Ashley Huhn (WSU), Andrea Watts (WSU), Colton Crawford (WSU), and Andrew MacDonald-Urango (CalPoly) participated in the project and gained valuable research experience. How have the results been disseminated to communities of interest?We were heartened by the constant support of our grower cooperators: over the life of the project we had \>40 growers join our grower-collaborator team. Team members gave the following invited presentations about the work: We were heartened by the constant support of our grower cooperators: over the life of the project we had \>40 growers join our grower-collaborator team. Team members gave the following invited presentations about the work: The National Meeting of the Entomological Society of America in Minneapolis, MN (where project PhD student Jones co-organized a symposium on decomposer ecology). The National Meeting of the Entomological Society of America in Portland, OR. The Center for Produce Safety annual research symposium in Los Angeles, CA. Cal State Chico, UC Berkeley, UC Merced, University of Minnesota, Michigan State University, and University of Georgia The Annual Meeting of the Lower Mainland Horticultural Improvement Association in Abbotsford, BC. The Hoes Down Harvest Festival at Full Belly Farm, Capay, CA. The National Meeting of the Entomological Society of America in Denver, CO (2 talks) Semiannual BioAg meeting, Pullman, WA WA Tilth annual meeting, Spokane, WA What do you plan to do

during the next reporting period to accomplish the goals? Nothing Reported IMPACT: 2014/09 TO 2018/08 What was accomplished under these goals? Objective 1. Document farming practices; measure biodiversity of coprophagous insects and their rate of feces consumption. Over two field seasons, we sampled dung beetles, flies and isopods on over 40 farms from central California to northern Washington using feces-baited pitfall traps. Interestingly, we found that the invasive dung beetle species Onthophagus nuchicornis dominated beetle communities from mid-Oregon to northern Washington, while more-diverse communities of native coprophagous beetles were found from mid-Oregon into California. Feces-feeding flies were captured on every farm in high densities, with dominant taxa including house flies (Diptera: Muscidae) and blow flies (Diptera: Calliphoridae). Isopods were captured inconsistently on a smaller number of farms. We have identified these specimens to the lowest-possible taxonomic level. In addition to identifying insects on each farm, we directly measured rates of feces removal by the coprophage community. Briefly, we placed 20g frozen pig feces \"cubes\" on the soil surface in the same location as the pitfall traps from the previous week. Arthropods fed on these feces for 7 days, after which remaining feces were removed. Finally, we conducted a GIS analysis, taking advantage of USDA cropland data layers, to better understand how landscape variables (e.g., % grassland in proximity to vegetable farms) contribute to coprophage abundance and biodiversity, and rates of feces removal. As a final step with these data, we used structural equation modeling to (1) construct a web of possible interactions and (2) test for statistical support for these putative interactions. Across all of this on-farm and experimental work, we found evidence that the emerging consensus that there is a necessary tradeoff between on-farm diversification and food safety is incorrect. We were able to demonstrate that biodiverse assemblages of feces-feeding (coprophagous) dung beetles and soil bacteria formed an important natural barrier against human pathogen persistence. Indeed, we demonstrated that organic farming practices are particularly adept at conserving the dung beetle and soil-bacteria species most antagonistic to human pathogenic E. coli O157:H7. In contrast, on conventionally managed farms surrounded by grazed grassland, we found that an invasive dung beetle is significantly reducing dung beetle diversity and reducing pathogen-suppression services on fresh produce farms. Overall, our project strongly suggested that coprophage conservation could be a key to reducing food safety risk, and that organic farming provides a roadmap for how to successfully conserve these beneficial insects and microbes. More broadly, we suggest that coprophages are providing a key, although perhaps underappreciated, ecosystem service by preserving food safety. This would form an important addition to the growing list of biodiversity-associated ecosystem services that must be considered when farm managers, policy-makers, and regulators move to simplify farm landscapes. Our work is especially timely given the E. coli O157:H7 outbreak\-- attributed to contaminated romaine lettuce \-- that is currently affecting both the United States and Canada, with \>50 illnesses and multiple deaths. This highlights the continuing need to better understand the ecology of food safety threats on working farms. Objective 2: Measure soil quality, microbial functional diversity and feces degradation. In both years of field sampling, we measured a broad suite of biotic and abiotic soil characteristics. These include pH, % organic matter, particle size/soil texture, ammonium, and nitrate. We collected soil DNA immediately after each soil sample arrived on campus. Microbial DNA was extracted from a 0.25-gram aliquot of homogenized soil, processed following procedures of the PowerSoil DNA Isolation Kit (Mo Bio Laboratories, Inc.).DNA samples were processed and sent to BGI Americas, who generated DNA libraries targeting bacterial 16S ribosomal RNA v3/v6 hypervariable regions on the Illumia HiSeq 2000 platform. We are currently processing these high-throughput sequencing data, and we plan to analyze bacterial diversity and the abundance of key taxa. We are well into the analysis of these complex data and will submit a manuscript describing what we find by the summer of 2019. We tested each soil sample for both generic Escherichia coli (meaning, typical E. coli strains that are not harmful to humans) and pathogenic (O157:H7) E. coli. No pathogenic E. coli were found on any farm, but low levels of generic E. coli were found on some farms. Initially, we thought we might be getting poor E. coli recovery due to sample degradation during handling; our initial sampling protocol involved overnight-shipping soils back to our lab on the WSU main campus, in well-ventilated containers and packed on ice packs, before testing for the presence of E. coli. To explore this possibility, during the final field season we tried various adjustments to our protocol to focus on conserving any E. coli in the soil samples. For example, we explored adding media nutrients and antibiotics to subsets of our soil samples before shipment to campus. Through these efforts we found that our original technique provided the best survival of the E. coli in our farm soils, without plates becoming overgrown with fungi and undesirable bacteria. It appears, then, that our initial measures of low E. coli abundance were accurate, indicating that these bacteria simply do not often persist for long in the agricultural soils on our farms. We are preparing these data for publication and will make our findings available to growers through an eOrganic article. Objective 3: Suppression of pathogenic E. coli O157:H7 by insects and microbes. As described above, in our broad-scale on-farm work we found that organic farming promotes dung beetles capable of suppressing human pathogenic E. coli. Additionally, it is well known that calliphorid flies can transmit pathogens and compete for resources with dung beetles. However, very little is known about how these organisms interact, and in turn contribute to pathogen transmission or suppression. Additionally, nothing is known about the effects of farm management on these underlying processes. Our ORG-funded project filled this knowledge gap by demonstrating that resident dung beetles form an important natural barrier against fly-mediated human pathogen

transmission. Working in 49 mixed-vegetable farm fields across Oregon and California, we found differences in coprophagous fly community composition under organic versus conventional management practices. While dung beetle (Coleoptera: Scarabaeidae) community assemblages did not differ significantly based on farm management systems, organic farms fostered populations of Onthophagus taurus, a dung beetle species that is a known antagonist of human-pathogenic E. coli. We examined the possible implications of differing coprophage communities in microcosms containing pig (Sus scrofa) feces inoculated with human pathogenic E. coli O157:H7 and placed near broccoli (Brassica oleracea) plants. In the absence of dung beetles, the fly Calliphora vomitora readily acquired the bacteria and transmitted them to broccoli foliage. In the presence of the dung beetle O. taurus, however, E. coli in the soil and fly survivorship were reduced, and the pathogen was rarely recovered from foliage. Altogether, our results suggest the potential for dung beetles to both directly suppress enteric pathogens in vertebrate feces and to indirectly reduce the spread of these bacteria by co-occurring flies. The beneficial beetle O. taurus commonly occurred only on organic farms, suggesting the benefits of beetle-fly interference for food safety might be particularly likely under this farming regime. PUBLICATIONS (not previously reported): 2014/09 TO 2018/08 1\. Type: Journal Articles Status: Submitted Year Published: 2019 Citation: Jones, MS, SA Wright, OM Smith, TE Besser, DH Headrick, DW Crowder, and WE Snyder. In review. Organic farms conserve dung beetles capable of disrupting fly vectors of foodborne pathogens. Biological Control. 2\. Type: Journal Articles Status: Accepted Year Published: 2019 Citation: Jones, MS, TE Besser, LA Carpenter-Boggs, JP Reganold, JL Tylianakis and WE Snyder. 2019. Organic farming promotes biotic resistance to foodborne human pathogens. Journal of Applied Ecology, 56:1117--1127. 3\. Type: Journal Articles Status: Published Year Published: 2018 Citation: Blubaugh, CK, L Carpenter-Boggs, JP Reganold, RN Schaeffer, and WE Snyder. 2018. Tri-trophic interactions over microbial and nutritional gradients. Invited contribution to special feature \"the ecology of plant chemistry and how it drives multi-species interactions\", Frontiers in Plant Science: https://www.frontiersin.org/articles/10.3389/fpls.2018.01239/full. 4\. Type: Journal Articles Status: Published Year Published: 2018 Citation: Jones, MS, JL Tylianakis, JP Reganold, and WE Snyder. 2018. Dung beetle-mediated soil modification: a data set for analyzing the effects of a recent introduction on soil quality. Ecology: https://doi.org/10.1002/ecy.2374. 5\. Type: Journal Articles Status: Published Year Published: 2018 Citation: Blubaugh, CK, JS Asplund, H Atthowe, SD Eigenbrode, MJ Morra, CR Philips, I Popova, JP Reganold, and WE Snyder. 2018. Dual-guild herbivory disrupts predator-prey interactions. Ecology 99:1089-1098. 6\. Type: Journal Articles Status: Published Year Published: 2016 Citation: Karp, DS, R Moses, S Gennet, M Jones, S Joseph, LK M&#65533;Gonigle, LC Ponisio, WE Snyder, and C Kremen. 2016. Farming practices for food safety threaten pest-control services to fresh produce. Journal of Applied Ecology 53:1402-1412. 7\. Type: Book Chapters Status: Published Year Published: 2018 Citation: Jones, MS and WE Snyder. 2018. Beneficial insect biodiversity in agriculture. In: Insect Biodiversity: Current Trends and Future Prospects (Eds. P Adler and R Foottit). Wiley Blackwell. 8\. Type: Websites Status: Published Year Published: 2017 Citation: Jones, MS and WE Snyder. 2017. Dung Beetles: How to identify and benefit from nature\'s pooper scoopers. eXtension/eOrganic Publication 74557. <http://articles.extension.org/pages/74557/dung-beetles:-how-to-identify-and-benefit-from-natures-pooper-scoopers>.

PROGRESS

2016/09 TO 2017/08 Target Audience:The central goal of our project is to provide new, transitioning growers with a roadmap for how to build naturally-pathogen-resistant farms. However, our project may also suggest to long-time organic vegetable growers that they could benefit from a second transition, moving towards livestock integration or the adoption of other practices found to build coprophage biodiversity. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?This project has entirely supported the PhD work of graduate student Matthew Jones, and partially supported the training of postdoctoral scholar Zhen \"Daisy\" Fu. In addition, undergraduate students Ashley Huhn (WSU), Andrea Watts (WSU), Colton Crawford (WSU), and Andrew MacDonald-Urango (CalPoly) have participated in the project and gained valuable research experience. How have the results been disseminated to communities of interest?We have been heartened by the continuing, and growing, support of our grower cooperators: since the inception of the project we have had \>40 growers join our grower-collaborator team. Team members have given the following invited talks during the 2017 reporting period: The National Meeting of the Entomological Society of America in Denver, CO (2 talks) The National Meeting of the Ecological Society of America National Meeting, Portland, OR Semiannual BioAg meeting, Pullman, WA WA Tilth annual meeting, Spokane, WA The Biology Department Seminar Series at California State University at Chico, CA The Center for Produce Safety annual research symposium in Los Angeles, CA UC Berkeley The Annual Meeting of the Lower Mainland Horticultural Improvement Association in Abbotsford, BC The Hoes Down Harvest Festival at Full Belly Farm, Capay, CA What do you plan to do during the next reporting period to accomplish the goals? We will continue our work in pursuit of 3 objectives. First, working on farms varying in their level of livestock integration, we will continue to de-couple the biodiversity of coprophagous dung beetles & flies by more deeply exploring the biodiversity data

collected over the past years. Second, on these same farms we will continue our analyses of how soil quality and farm management drive the diversity of soil microbes (next-generation DNA sequencing). Third, we will continue to analyze the results of our lab studies to better understand the ability of coprophagous insects and microbes to kill pathogenic E. coli O157:H7.. Each research objective includes an \"Integrated Extension Component\", tightly linked to research outputs in the form of online extension content through eOrganic. While we have published one online bulletin (see products) with eOrganic, we aim to complete an additional webinar. Our ultimate goal is to provide both new and long-time organic growers with the tools to efficiently transition their farms to be naturally suppressive of human pathogens. Furthermore, we hope to inform the ongoing debate about food safety GAPs, by providing scientifically-rigorous research conducted (as much as possible) on the farms of innovative organic growers.

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reporting period to accomplish the goals?Our project is exploring inter-relations among farm management practices, feces-feeding insects and microbes, and the natural suppression of human-pathogenic E. coli. Nearly all of our work is being conducted on the farms of our cooperating growers, half of whom have integrated livestock into their vegetable-farming operations (Table 1). For our coprophage sampling efforts we focus on working within Brassica oleracea crops (broccoli, cabbage, etc.) because of (1) the near-ubiquity of these crops on mixed-vegetable farms, (2) their importance in providing season-long produce for sale, and, critically, (3) because these are the sort of low-growing, fresh-marketed vegetable crops often linked to outbreaks of pathogenic E. coli in humans (OMAFRA 2001). As an additional reason, a focus on brassicas complements our currently-funded USDA-ORG project, \"BAN-PestS: Biodiversity and Natural Pest Suppression\", which is examining how on-farm biodiversity influences natural control of herbivorous pest insects. Drs. Snyder and Reganold are co-PIs on both projects, and are hoping to find commonalities among farming practices that suppress pest insects, and those that suppress human pathogens. We will continue our work in pursuit of 3 objectives. First, working on farms varying in their level of livestock integration, we will continue to quantify the biodiversity of coprophagous dung beetles & flies, and measure their feces-consumption rates. Second, on these same farms we will continue to assess soil quality, quantify resident E. coli, while beginning to use next-generation DNA sequencing to assess the functional diversity of soil microbes. Third, we next will directly measure the ability of coprophagous insects and microbes to kill pathogenic E. coli O157:H7 bacteria. Each research objective includes an \"Integrated Extension Component\", tightly linked to research outputs, which together use hands-on-learning \"farm walks\" to create new, video-based online extension content through eOrganic. Our ultimate goal is to provide both new and long-time organic growers with the tools to efficiently transition their farms to be naturally suppressive of human pathogens. Furthermore, we hope to inform the ongoing debate about food safety GAPs, by providing scientifically-rigorous research conducted (as much as possible) on the farms of innovative organic growers.

IMPACT

2016/09 TO 2017/08 What was accomplished under these goals? Objective 1. Document farming practices; measure biodiversity of coprophagous insects and their rate of feces consumption. Over two field seasons, we sampled dung beetles, flies and isopods on over 40 farms from central California to northern Washington (Figure 1) using feces-baited pitfall traps. Dung beetles (Coleoptera: Scarabaeidae) were captured on farms across the entire study range. Interestingly, we have found that the invasive dung beetle species Onthophagus nuchicornis dominates beetle communities from Oregon north to northern Washington, while a more- diverse community of native coprophagous beetles is found south from mid-Oregon into California. Feces-feeding flies were captured on every farm in high densities, with dominant taxa including house flies (Diptera: Muscidae) and blow flies (Diptera: Calliphoridae). Isopods were captured inconsistently on a smaller number of farms. We have identified these specimens to the lowest-possible taxonomic level. In addition to identifying insects on each farm, we directly measured rates of feces removal by the coprophage community. Briefly, we placed 20g frozen pig feces \"cubes\" on the soil surface in the same location as the pitfall traps from the previous week. Arthropods were allowed to feed on these feces for 7 days, after which remaining feces were removed. We then calculated removal weights using dry mass. Feces-removal rates differed dramatically among farms, ranging from 4%-97% removal over our 7-day period of feces exposure to coprophages. Finally, we have completed a GIS analysis, using USDA cropland data, to better understand how landscape variables (namely % grassland in proximity to vegetable farms) contribute to coprophage abundance and biodiversity, and rates of feces removal. To better understand the relationships between on-farm coprophage biodiversity measured during our insect sampling and the rates of feces removal observed on each farm, we used structural equation modeling to (1) construct a web of possible interactions and (2) test for statistical support for these putative interactions. We found that organic farming encouraged relatively bio-diverse and effective coprophage communities. Above-ground, organic farms fostered dung beetle species that removed livestock feces particularly effectively, although this benefit was weakened in simplified landscapes dominated by pasture and an invasive dung beetle; livestock integration did not significantly impact dung beetle communities or rates of feces removal. Objective 2: Measure soil quality, microbial functional diversity and feces degradation. In both years of field sampling, we measured a broad suite of biotic and abiotic soil characteristics. These include pH, % organic matter, particle size/soil texture, ammonium, and nitrate. We did this by taking 10-cm-deep soil cores at the exact site where pitfall trapping and above/belowground manure degradation measurements had occurred. Soil cores (3 per farm) were homogenized/pooled in a sterile bucket and then mailed overnight (on ice packs) back to our laboratory. Pooled soil samples were divided up and sent to the various collaborating labs responsible for different sub-components of our rigorous soil testing. For example, we have measured soil microbial activity using dehydrogenase testing, in collaboration with Lynne Carpenter-Boggs at Washington State University. Briefly, this biochemical assay

measured a soil enzyme that reflected the potential net metabolism of the soil\'s microbial community. In essence, this is a broad measure of microbial life that spans the entire community. Initial results indicate dramatic differences between farms in soil microbial activity (0.56-7.32 ug TPF per g dry soil per h). We collected soil DNA immediately after each soil sample arrived on campus. Microbial DNA was extracted from a 0.25-gram aliquot of homogenized soil, processed following procedures of the PowerSoil DNA Isolation Kit (Mo Bio Laboratories, Inc.). DNA concentration was quantified using a Qubit Fluorometer (Life Technologies). DNA samples from were processed and sent to BGI Americas, who generated DNA libraries targeting bacterial 16S ribosomal RNA v3/v6 hypervariable regions (Chakravorty et al. 2007, J Microbiol Methods), using high-throughput sequencing on the Illumia HiSeq 2000 platform. We obtained raw data in FASTQ format from BGI America. We are currently processing these high-throughput sequencing data, and we plan to analyze bacterial diversity and the abundance of key taxa. We will focus these analyses on microbial genera known to have both positive and negative effects on the persistence of pathogenic E. coli. In turn, this will allow us to understand how microbial diversity (species richness and species evenness) correlates with the soil biological activity and manure degradation rates we are measuring in other components of our project (described above and next). We tested each soil sample for both generic Escherichia coli (meaning, typical E. coli strains that are not harmful to humans) and pathogenic (O157:H7) E. coli. No pathogenic E. coli were found on any farm, but low levels of generic E. coli were found on some farms. As for the above-ground coprophage community, we used structural equation modeling to understand the direct and indirect effects of farm management on the soil community. We found that organic farming encouraged significantly more-diverse bacterial communities. Objective 3: Suppression of pathogenic E. coli O157:H7 by insects and microbes. We completed 4 experiments aimed at connecting biodiversity among coprophagous dung beetles and soil microbes and the suppression of pathogenic E. coli. In the first experiment we compared each of the 3 most common dung beetle species in their ability to kill pathogenic E. coli in pig feces. We found species on resident dung beetle species was relatively effective in removing the pathogens, while an invasive dung beetle was relatively less effective. The second experiment compared how soil communities with naturally-differing levels of microbial biodiversity differed in their ability to suppress E. coli. This experiment used soils collected from our different study farms, fresh transported back to the laboratory with microbial communities intact. We found that soils with greater bacterial biodiversity were more effective in suppressing pathogenic E. coli than soils with lower bacterial biodiversity. The third experiment examined the interaction between soil diversity and the presence absence of dung beetles, to better understand how these above- and below-ground communities might work in synchrony to suppress pathogenic E. coli. This experiment was completed during the summer of 2017, and is in the process of being analyzed. Lastly, a fourth experiment examined how dung beetle-mediated suppression of E. coli might adversely affect the ability of flies to vector pathogenic E. coli in pig feces. This final experiment has been completed and is in the process of being analyzed. **PUBLICATIONS (not previously reported):** 2016/09 TO 2017/08 1. Type: Websites Status: Published Year Published: 2017 Citation: Jones, MS and WE Snyder. 2017. Dung Beetles: How to identify and benefit from nature\'s pooper scoopers. eXtension/eOrganic Publication 74557. http://articles.extension.org/pages/74557/dung-beetles:-how-to-identify-and-ben efit-from-natures-pooper-scoopers 2. Type: Journal Articles Status: Published Year Published: 2016 Citation: Karp, DS, R Moses, S Gennet, M Jones, S Joseph, LK M?Gonigle, LC Ponisio, WE Snyder, and C Kremen. 2016. Farming practices for food safety threaten pest-control services to fresh produce. Journal of Applied Ecology 53:1402-1412.

2015/09 TO 2016/08 What was accomplished under these goals? Objective 1. Document farming practices; measure biodiversity of coprophagous insects and their rate of feces consumption. In the 2014-2015 field seasons, PhD student Matt Jones was able to sample dung beetles, flies and isopods on over 40 farms from central California to northern Washington (Figure 1) using feces-baited pitfall traps. Dung beetles (Coleoptera: Scarabaeidae) were captured on the vast majority of farms across the entire study range. Interestingly, we have found that the invasive dung beetle species Onthophagus nuchicornis dominates beetle communities from Oregon north, while a more-diverse community of native coprophagous beetles is found in California. Feces-feeding flies were captured on every farm in high densities, with dominant taxa including house flies (Diptera: Muscidae) and blow flies (Diptera: Calliphoridae). Isopods were captured inconsistently on a smaller number of farms. We have sorted and cleaned pitfall-trap catches, and have identified these species to the lowest-possible taxonomic level (our fly identifications are being led by co-PD Headrick, and are a work in progress). Once identifications are complete, we will be able to calculate coprophage richness and evenness for each of our cooperating farms. In addition to trapping insects on each farm, we directly measured rates of feces removal by the coprophage community. Detailed methodology is provided below, but briefly, we place 20g frozen pig feces \"cubes\" on the soil surface in the same location as the pitfall traps from the previous week. Arthropods are allowed to feed on presented feces for 7 days, after which feces is removed. We then calculate removal weights using dry mass. Feces removal rates differed dramatically among farms, ranging from 4%-97% removal over our 7 day period of feces exposure to the coprophages. We currently are in the process of modelling the relationships between on-farm coprophage biodiversity measured during our insect sampling, and the rates of feces removal

observed on each farm, using structural equation modelling (a form of path analysis). Furthermore, we have initiated a GIS analysis, using USDA cropland data, to better understand how landscape variables (namely % grassland in proximity to vegetable farms) contributes to coprophage abundance and biodiversity, and rates of feces removal. Objective 2: Measure soil quality, microbial functional diversity and feces degradation. In 2014 and 2015, we measured a broad suite of biotic and abiotic soil characteristics. These include pH, % organic matter, particle size/soil texture, ammonium, and nitrate. We did this by taking 10-cm-deep soil cores at the exact site where pitfall trapping and above/belowground manure degradation experiments will occur. Soil cores (3 per farm) were homogenized/pooled in a sterile bucket and then mailed overnight (on ice packs) back to our laboratory. Approximately 2 liters of soil were needed from each farm to complete all of the soil work. Pooled soil samples were divided up and sent to the various collaborating labs responsible for different sub-components of our rigorous soil testing. For example, we have been measuring soil microbial activity using dehydrogenase testing, in collaboration with Lynne Carpenter-Boggs at WSU. Briefly, this biochemical assay measures a soil enzyme that reflects the potential net metabolism of the soil\'s microbial community. In essence, this is a broad measure of microbial life that spans the entire community. Initial results indicate dramatic differences between farms in soil microbial activity (0.56-7.32 ug TPF per g dry soil per h). We collected soil DNA immediately after each soil sample arrives on campus. Microbial DNA was extracted from a 0.25-gram aliquot of homogenized soil, processed following procedures of the PowerSoil DNA Isolation Kit (Mo Bio Laboratories, Inc.). DNA concentration was quantified using a Qubit Fluorometer (Life Technologies). DNA samples from the 2014-2015 field seasons were processed and sent to BGI Americas, who generated DNA libraries targetingbacterial 16S ribosomal RNAv3/v6 hypervariable regions (Chakravorty et al. 2007, J Microbiol Methods), following high-throughput sequencing on the Illumia HiSeq 2000 Platform. We obtained raw data in the FASTQ format from BGI America in June 2015. We are currently processing these high-throughput sequencing data, and we plan to analyze bacterial diversity and the abundance of key taxa. We will focus these analyses on microbial genera known to have both positive and negative effects on the persistence of pathogenic E. coli. In turn, this will allow us to understand how microbial diversity (species richness and species evenness) correlates with the soil biological activity and manure degradation rates we are measuring in other components of our project (described above and next). Lastly, we tested each soil sample for both generic Escherichia coli (meaning, typical E. coli strains that are not harmful to humans) and pathogenic (O157:H7) E. coli. No pathogenic E. coli were found on any farm, and very low levels of generic E. coli were found across all of the farms in our sampling network. Initially, we thought we might be getting poor E. coli recovery due to sample degradation during handling; our initial sampling protocol involved overnight-shipping soils back to our lab on the WSU main campus, in well-ventilated containers and packed on ice packs, before testing for the presence of E. coli. To explore this possibility, during the 2015 field season we tried various adjustments to our protocol to focus on conserving any E. coli in the soil samples. For example, we explored adding media nutrients and antibiotics to subsets of our soil samples before shipment to campus. Through these efforts we found that our original technique provided the best survival of the E. coli in our farm soils, without plates becoming overgrown with fungi and undesirable bacteria. It appears, then, that our initial measures of low E. coli abundance were accurate, indicating that these bacteria simply do not often persist for long in the agricultural soils on our farms. Ultimately, across all sub-components under Objective 2, we have the data to continue the modelling of soil health, biodiversity among soil-dwelling organisms, microbe-mediated feces degradation, and densities of E. coli bacteria. Objective 3: Suppression of pathogenic E. coli O157:H7 by insects and microbes. Using the data collected from the field in 2014 and 2015, we are in the midst of completing 3 experiments aimed at connecting the dots between on-farm biodiversity and the suppression of pathogenic E. coli. Experiment 1 compared single-species treatments of the 3 most common dung beetle species. We found species to differ in their abilities to suppress pathogenic E. coli. This experiment was completed by PhD student Jones during the fall of 2015. Experiment 2 is comparing how soil communities with different levels of biodiversity differentially suppress E. coli. This experiment uses soils from across our field study sites and represents a broad range of soil types and management practices. This experiment was completed by PhD student Jones in the spring of 2016, however, we are waiting on genomic sequences in order to compare pathogen suppression levels with biodiversity data from the specific soils used in this experiment. When these sequences arrive, we will proceed with the community analysis. Lastly, we are using the results from the dung beetle field data as well as the first experiment to test dung-beetle biodiversity effects on pathogen survival. In this experiment, we are testing 1 sp, 2 spp., and 3spp. mixtures of dung beetles to better understand what role species richness might have in pathogen suppression. This experiment was completed by PhD student Jones during the summer of 2016; analysis of biodiversity effects is in progress. **PUBLICATIONS (not previously reported):** 2015/09 TO 2016/08 No publications reported this period.

2014/09 TO 2015/08 What was accomplished under these goals? Objective 1. Document farming practices; measure biodiversity of coprophagous insects and their rate of feces consumption. In the 2014 field season, PhD student Matt Jones was able to sample dung beetles, flies and isopods on over 30 farms from central California to northern Washington using feces-baited pitfall traps. Dung beetles (Coleoptera: Scarabaeidae) (\>800

collected in total) were captured on the vast majority of farms across the entire study range. Interestingly, we have found that the invasive dung beetle species Onthophagus nuchicornis dominates beetle communities from Oregon north, while a more-diverse community of native coprophagous beetles is found in California. Feces-feeding flies (\>43,000 collected in total) were captured on every farm in high densities, with dominant taxa including house flies (Diptera: Muscidae) and blow flies (Diptera: Calliphoridae). Isopods (\>700 collected in total) were captured inconsistently on a smaller number of farms. We have sorted and cleaned pitfall-trap catches, and we now are working to identify these species to the lowest-possible taxonomic level (our fly identifications are being led by co-PD Headrick). Once identifications are complete, we will be able to calculate coprophage richness and evenness for each of our cooperating farms. In addition to trapping insects on each farm, we have been directly measuring rates of feces removal by the coprophage community. Detailed methodology is provided below, but briefly, we place 20g frozen pig feces \"cubes\" on the soil surface in the same location as the pitfall traps from the previous week. Arthropods are allowed to feed on presented feces for 7 days, after which feces is removed. We then calculate removal weights using dry mass. Feces removal rates differed dramatically among farms, ranging from 4%-97% removal over our 7 day period of feces exposure to the coprophages. We currently are in the process of searching for correlations between on-farm coprophage biodiversity measured during our insect sampling, and the rates of feces removal observed on each farm. Furthermore, we are working to create GIS maps of each farm, which will eventually allow us to search for landscape features associated with coprophage abundance and biodiversity, as well as rates of feces removal. Objective 2: Measure soil quality, microbial functional diversity and feces degradation. First in 2014, and now again in 2015, we are measuring a broad suite of biotic and abiotic soil characteristics. These include pH, % organic matter, particle size/soil texture, ammonium, and nitrate. We do this by taking 10-cm-deep soil cores at the exact site where pitfall trapping and above/belowground manure degradation experiments will occur. Soil cores (3 per farm) are homogenized/pooled in a sterile bucket and then mailed overnight (on ice packs) back to our laboratory at Washington State University (\"WSU\") in Pullman, WA. Approximately 2 liters of soil are needed from each farm to complete all of the soil work. Once at the university, pooled soil samples are divided up and sent to the various collaborating labs responsible for different sub-components of our rigorous soil testing. For example, we have been measuring soil microbial activity using dehydrogenase testing, in collaboration with Lynne Carpenter-Boggs at WSU. Briefly, this biochemical assay measures a soil enzyme that reflects the potential net metabolism of the soil\'s microbial community. In essence, this is a broad measure of microbial life that spans the entire community. Initial results indicate dramatic differences between farms in soil microbial activity (0.56-7.32 ug TPF per g dry soil per h). We have been collecting soil DNA soon after each soil sample arrives on campus. Microbial DNA is being extracted from a 0.25-gram aliquot of homogenized soil, processed following procedures of the PowerSoil DNA Isolation Kit (Mo Bio Laboratories, Inc.). DNA concentration is quantified using a Qubit Fluorometer (Life Technologies). DNA samples from the 2014 field season were processed and sent to BGI Americas, who generated DNA libraries targetingbacterial 16S ribosomal RNAv3/v6 hypervariable regions (Chakravorty et al. 2007, J Microbiol Methods) following high-throughput sequencing on the Illumia HiSeq 2000 Platform. We obtained raw data in the FASTQ format from BGI America in June 2015. We are currently processing these high-throughput sequencing data, and we plan to analyze bacterial diversity and taxa abundance. In turn, this will allow us to understand how microbial diversity (species richness and species evenness) correlates with the soil biological activity and manure degradation rates we are measuring in other components of our project (described above and next). We are monitoring below-ground feces degradation by microbes with a methodology similar to that described above for our measurements of feces consumption by coprophagous insects. Our detailed methodology is described below, but briefly, we bury 20g cubes of frozen pig feces enclosed in mesh bags (fine mesh on bottom, course mesh on top) 10cm below the soil surface. Mesh caging of this type prevents coprophagous insects from reaching the feces, while allowing contact with the soil and thus feeding by soil-dwelling microbiota. We allow soil organisms to feed on these feces for 2 weeks before recovering the mesh bags and remaining feces. Similar to above-ground feces removal calculations, we use dry mass removal to determine amounts being consumed by soil microorganisms. Lastly, we are testing each soil sample for both generic Escherichia coli (meaning, typical E. coli strains that are not harmful to humans) and pathogenic (O157:H7) E. coli. For the first year of data, no pathogenic E. coli were found on any farm, and very low levels of generic E. coli were found across all of the farms in our sampling network. Initially, we thought we might be getting poor E. coli recovery due to sample degradation during handling; our initial sampling protocol involved overnight-shipping soils back to our lab on the WSU main campus, in well-ventilated containers and packed on ice packs, before testing for the presence of E. coli. To explore this possibility, during the 2015 field season we tried various adjustments to our protocol to focus on conserving any E. coli in the soil samples. For example, we explored adding media nutrients and antibiotics to subsets of our soil samples before shipment to campus. Through these efforts we found that our original technique provided the best survival of the E. coli in our farm soils, without plates becoming overgrown with fungi and undesirable bacteria. It appears, then, that our initial measures of low E. coli abundance were accurate, indicating that these bacteria simply do not often persist for long in the agricultural soils on our farms. Ultimately, across all sub-components under Objective 2, we will have the data to search for correlations among soil health,

biodiversity among soil-dwelling organisms, microbe-mediated feces degradation, and densities of E. coli bacteria. Objective 3: Suppression of pathogenic E. coli O157:H7 by insects and microbes. As described in the \"Ongoing Objectives\" and \"Ongoing Methods\" sections below, this Objective is designed to build upon the field work pursued in the first field season of our project under Objectives 1 and 2. Now that we have initial data from these aspects of the project as described above, fulfillment of the components of this Objective will form a key focus of our work in the next 2 years of this project. **PUBLICATIONS (not previously reported):** 2014/09 TO 2015/08 1. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Jones, M. 2014. Invited talk at the national meeting of the Entomological Society of America. Portland, OR 2. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Jones, M. 2014. Invited talk at the Center for Produce Safety annual research symposium in Los Angeles, CA 3. Type: Conference Papers and Presentations Status: Other Year Published: 2014 Citation: Jones, M. 2014. Invited talk at the Annual Meeting of the Lower Mainland Horticultural Improvement Association in Abbotsford, BC. 4. Type: Other Status: Other Year Published: 2014 Citation: Jones, M. Invited talk at UC Berkeley. 2014

↑ Return to Index

Promoting Native Bee Health and Pollination Services on Diversified Organic Produce Farms

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NON-TECHNICAL SUMMARY

We propose an integrated approach to evaluating the effects of transitioning to organic farming on native bee community health and pollination services. While organic farming has many advantages, we have a poor understanding of the distinct characteristics of long-term organic farms that provide the greatest benefits for biodiversity and ecosystem services. Understanding which aspects of organic farming create robust systems would ease future farmer\'s transitions. Our project was developed in cooperation with an engaged group of farmers to understand native bee community health and pollination services on long-term organic and transitioning produce farms. Diversified organic produce farms are dependent on healthy native bee communities for sustainability, and farmers have expressed their desire for innovative research and education on native bee conservation. Our project addresses these needs with three integrated research and extension components. The First Component will evaluate farm characteristics that promote healthy native bee communities on long-term organic and transitioning produce farms. The Second Component will determine if habitat augmentation expedites the development of healthy native bee communities on long-term organic and transitioning farms. The Third Component will develop an extension program to provide farmers with the tools to maintain native bee communities in their farming systems and ensure the project\'s influence endures. To achieve these objectives our project team includes farmers, entomologists, pollination biologists, and extension educators. The project directly addresses ORG program goals to (1) evaluate how organic practices influence biodiversity and ecosystem services; (2) develop new models for determining suites of practices to promote environmental services on organic crops; and (3) conduct outreach to producers.

OBJECTIVES

This proposal will evaluate the effects of transitioning to organic farming on native bee community health and pollination services. It is well established that organic farming promotes greater biodiversity and ecosystem services compared to conventional farming. However, we have a poor understanding of the distinct characteristics of long-term organic farms that provide the greatest benefits for biodiversity and ecosystem

services. Understanding which aspects of organic farming create robust and resilient systems would ease future farmer\'s transitions. The long-term goals of our project are to (1) evaluate farm characteristics that promote healthy native bee communities on long-term organic and transitioning farms; (2) determine if habitat augmentation expedites the development of healthy native bee communities on long-term organic and transitioning farms; and (3) provide farmers with the educational tools to maintain healthy native bee communities on their farms. Specifically, out project will achieve the following objectives:Objective 1: Evaluate farm characteristics that promote healthy native bee communities on long-term organic and transitioning farms(i) Sub-objective 1a: Sample native bee communities on a network of farms(ii) Sub-objective 1b: Evaluate pollination services on each farm(iii) Sub-objective 1c: Measure characteristics of each farm and surrounding landscapes(iv) Sub-objective 1d: Determine effects of farm characteristics and landscape intensity on native bee community health and pollination services(v) Sub-objective 1e: Develop content for eOrganic related to native bee community health and pollination services in organic farming systemsObjective 2: Determine if habitat augmentation expedites the development of healthy native bee communities on long-term organic and transitioning farms(i) Sub-objective 2a: Establish habitat augmentation treatments on farms(ii) Sub-objective 2b: Evaluate if habitat augmentation promotes native bee community health and pollination services on farms(iii) Sub-objective 2c: Develop content for eOrganic related to habitat augmentation strategiesObjective 3: Conduct extension and outreach to educate farmers on practices to promote native bee community health and pollination services in organic farming systems(i) Sub-objective 3a: Conduct field-days with farm walks and presentations to train farmers on practices that promote native bees(ii) Sub-objective 3b: Produce public lectures on native bee conservation(iii) Sub-objective 3c: Develop a webinar series on native bees in organic farming systems(iv) Sub-objective 3d: Develop a website to link the project team, farmer cooperators, and the broader public

APPROACH

Creation of Stakeholder Advisory CommitteeOur project was developed in consultation with an engaged group of long-term organic and transitioning farmers and educators interested in native bee conservation. Members of these groups were invited to form a stakeholder advisory committee (SAC) that represents the interests of farmers and educators who are involved in promoting organic farming, conserving native bees, and community outreach. Input from the SAC is essential to: (1) achieve our objectives; (2) evaluate the effectiveness of the project in meeting the needs of organic farmers; and (3) ensuring that the project\'s influence endures. The SAC will meet annually.Farm Site Selection The core o of of our project is to develop a network of farms that have been certified organic for more than five years (long-term organic) or have recently begun the transition to organic production (transitioning). Farm-selection will focus on locating pairs of farms. Each farm in a pair will be similar in size, production practices, age (transitioning or long-term organic), and landscape intensity (farms in a pair will be separated by no more than 10 km).Objective 1 Methods:Native bees will be sampled three times per year at each farm using traps and netting. From these data we will evaluate the diversity, stability, and abundance of native bee communities. At each farm we will also assess pollination services provided by native bees. We will use fruit set and pollination stability as two metrics of pollination services. On each farm fruit set will be measured using summer and winter squashAt each farm site, we will collect annual data on farm characteristics that influence native bees. Landscape variables and farm characteristics have varying predicted impacts on native bee community health (abundance, richness, evenness) and pollination services. Measuring these farm characteristics and landscape-level variables is necessary to include them as covariates in statistical analyses testing our main hypotheses. This will also allow us to determine the characteristics of both transitioning and long-term organic farms that provide the greatest benefits for native bee community health and pollination services. Many of these data will be collected directly from farmers, while remaining data will be collected from on-farm sampling and landscape analyses.Using these data we will develop statistical models to determine the suite of practices in long-term organic and transitioning farms that promote native bee community health and pollination services. Our analysis will allow us to explore how other farm characteristics interact with landscape intensity to influence native bee community health and pollination services. This will provide essential information for organic farmers about the best practices to implement depending on their farm characteristics and landscape context. Methods for Objective 2: In 2016 we will augment habitat on one randomly selected farm in each farm pair (nine farms total). The second farm in each pair will be a control (nine farms total). Augmentation treatments will consist of two 25×2m linear rows of flowering plants, two nesting structures, and eight 5×2m bare ground strips. We will then evaluate the effects of habitat augmentation on native bee communities and pollination services through the same sampling methods used in Objective 1. Statistical analyses will allow us to determine the types of farms that benefit most from habitat augmentation.Developing Content for eOrganic We will develop two 15-minute \"short-course\" videos related to native bees and pollination services in organic farming systems in partnership with eOrganic. The first video will cover techniques to sample native bees on the farm. This video will describe how farmers can make their own \"bee collection\", and simple tips to identify major native bee families. The second video will focus on measuring pollination services. The video will describe how to observe

bee visitation to flowers and mark them. We will show how these flowers can be observed through fruit set to determine pollination services. Both videos will be shot on production farms and will feature several of our cooperating farmers. The third video will describe how to make a bee box or nesting structure to promote native bees. The video will also describe techniques to establish flowering strips, bare ground, and other habitats to promote native bees. We will focus in particular on flowering plant species that benefit organic produce growers in the Pacific Northwestern United States, although the techniques will be applicable to many farmers. Field Days: At each field day we will present a standardized curriculum to help growers identify the native bee communities on their farm, assess the communities, modify their farms to conserve native bees, and develop networks with other growers. Each field day will have a four hour curriculum followed by a lunch to promote peer-to-peer communication

PROGRESS

2014/09 TO 2018/08 Target Audience:Our project has several main target audiences. First, the results we are generating have direct relevance for diversified organic farmers in Washington State and nationally, and individuals who wish to transition to organic production practices. For these individuals we have produced vast amounts of information on bee communities in diversified farming systems, and the impact of landscape intensity on these bee communities. We have also conducted over 50 field days, workshops, and other public events to devliver information to this audience, and we have published two pollination identification guides. Our second target audience is the general public community, particularly individuals interested in the health and conservation of wild bee species. We have offered multiple classes for the public on pollinator conservation and identification, and we have initiated a citizen science program for bees calles CSI:Bees (Citizen Science Initiative for Bees). This program has attracted master gardeners, members of 4-H, and farmers in addition to interested community members. Finally, our project will produce results of immediate relevance for academic audiences who are interested in the ecology and conservation of native bee communities. To reach this audience we have published multiple scientific papers, and delivered talks at national and international conferences. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?We trainedtwo graduate students during the course of the project, Elias Bloom and Rachel Olsson. They have gotten the chance to develop professionally as scientists by taking the lead on data collection and execution of the grant objectives. They have also taken the lead in the outreach components of the grant, and have received training from the PI on scientific presentation. We have also supported over eightundergraduates with this project, including three co-funded through an internship at Washington State University. These undergrads receiviedtraining on native bee identification and general scientific inquiry. Moreover, we have used the project to train members of the community on bee identification. We have reached over 1,000 individuals this past year through our field days, public lectures, webinars, and website. Many of these individuals are now engaged in our citizen science program. Eli Bloom will graduate in spring 2019 with his PhD, and Rachel Olsson will graduate with her PhD in 2020. Six of our undergraduates have received their BS from Washington State University over the course of the project. How have the results been disseminated to communities of interest?Overthe course of the project we presented results from our study at 20citizen science events, 4webinars, 15 field days, 4 \'Town Hall\' events, and over 30 public presentations.These events were located throughout the Seattle, Tacoma, and Olympia metropolitan areas, as well as at conferences in Portland, Denver, and Vancouver BC. We targeted the general public as well as diversified organic farmers. In total we had over 5,000 individuals attend our outreach events, including over 2,000 that viewed our webinars and 1,000 users of our website. Second, we developed twoextension guides focused on pollinator identification and wild cavity nesting bees that havebeen disseminated toindividuals in the community. These guide can help individuals characterize the bees on their farm or home garden, and both were published through WSU Extension. Finally, we have published or submitted one book chapter and six scientific publications to disseminate our reseach to academic audiences. What do you plan to do during the next reporting period to accomplish the goals? Nothing Reported

IMPACT

2014/09 TO 2018/08 What was accomplished under these goals? \(i\) Objective 1a: Sample native bee communities on a network of farms During the project we sampled bees on 36 diversified organic farms over four years. Each site was sampled three times per year, for a total of over 300 site visits (not all sites were sampled in each year). From these surveys we collected and identified over 15,000 bees to morphospecies. We found that over 100 morphospecies of bees visit diversified organic farms in the Puget Sound region. \(ii\) Objective 1b: Evaluate pollination services At each of site visit, we measured pollination services provided by observining visits by bees to flowers for 2 hours at each visit, to determine which species of plants were being pollinated by which bees. We also collected pollen from bees to determine what they were collecting, an indirect measure of

pollination services. These data are currently being analyzed to construct plant-pollinator networks. \(iii\) Objective 1c: Measure characterists of each farm and surrounding landscapes We collected data on farming practices at each site, such as the time in organic production, the diversity of crops, tillage practices, use of honeybees, and livestock integration. We also calculated metrics to characterize landscapes surrounding crop fields, including the percent of crop production and urbanization, and the overall landscape diversity. \(iv\) Objective 1d: Determine effects of farm characteristics and landscape intensity on native bee community health and pollination services Our work shows that plant diversity on farms is the single most important factor that affect bee communities. Factors such as the length of time in organic production had little effect; this suggests that farmers may see relatively immediate gains from transitioning to organic farming. Increased floral diversity on farms promoted bee diversity by decreasing competition among bee species and by promoting niche partitioning. Interestingly, increasing diversity of crop landscapes around farms mitigated losses of diversity on farms. This suggests that organic farms embedded in diverse landscapes are likely to see the greatest benefits from wild pollinators. Our work detailing these phenomena have been submitted to Proceedings of the National Academy of Sciences and Ecology Letters. We have also dissiminetated these results through the publication of two extension bulletins and over 50 public events. \(v\) Objective 1e: Develop content for eOrganic related to native bee community health and pollination services in organic farming systems Working with eorganic, we produced four webinars about bees in diversified organic farming systems. These webinars were viewed by over 2,000 individuals in total. \(vi\) Objective 2a: Establish habitat augmentation treatments on farms In 2016 we established a habitat augmentation experiment involving 22 farms in 11 pairs; farms in each pair used similar practices and were similar in size. One farm in each pair received a diverse suite of habitat augmentation, including a large floral strip of native annual and perennial flowering plants, a large patch of bare ground (to support ground-nesting bees), and two nesting structures (to support cavity-nesting bees). Working with producers, we maintained these treatments throughout 2018. Interestingly, we observed that the floral strips, despite having the same seeding mixture, had variable establishment, and the dominant plant species varied considerably among sites. Maintaining bare ground involved solarization (to kill weeds) and regular maintenance. Maintaining the nesting structures involved checking the structures each fall and replacing tubes used by bees. Overall, this was a collaborative effort that proved successful. \(vii\) Objective 2b: Evaluate if habitat augmentation promotes native bee community health and pollination services on farms Our habitat augmentation treatments were fully established by 2017 (it takes a year for plants to establish), and we collected bees on each farm in each pair. We also collected pollination service data on each farm with sentinel plants. While these data are still being analyzed, we can make several preliminary conclusions. First, the habitat augmentation treatments did not promote greater abundance of bees. Despite our best efforts, our habitat augmentation treatments were too \'small\' to make a marketable difference on bee community abundance. It is likely that floral strips need to be considerably larger than 3 x 6m to produce measurable impacts. Moreover, our nesting structures only recieved about 10% occupancy, or about 25bees per site. However, the habitat augmentation did seem to promote niche partiotioning and pollination services. By providing habitat, more rare species in the broader landscape are attracted to farms. These bees may provide unique pollination services. Further work is being conducted on these questions, and we expect to publish several papers in 2019. Our habitat augmentation experiments were complemented by a large-scale citizen science project examining habitat augmentation for cavity-nesting bees. This \"Pollinator Post Project\", provided individuals with small \'pollinator mailboxes\' that contained nesting habitat for up to 40 solitary bees. We had over 70 volunteers place these mailboxes throughout the Puget Sound region, and report data on our website. \(viii\) Objective 2c: Develop content for eOrganic related to habitat augmentation strategies We produced two webinars for eOrganic about habitat augmentation. These webinars were viewed by over 1,000 individuals. \(ix\) Objective 3a: Conduct field-days with farm walks and presentations to train farmers on practices that promote native bees With our partners, we produced 15 field days over the course of the project. Each involved active demonstrations on participating farms regarding strategies to identify bees and promote habitat. We also provided growers with simple tools to sample and monitor bees. By working on farms, we were able to directly demonstrate the impacts of simple practices on bee conservation, and spur the public to adopt these approaches. In total we had over 200 individuals attend our field days. \(x\) Objective 3b: Produce public lectures on native bee conservation Each year we had a large \'capstone\' event at Seattle Town Hall. These events typically involved a major speaker, or a diverse panel of speakers, who could speak on their own work regarding pollinator conservation. We also invited members of the broader community to attend these events, including local groups focused on sustainability. In total we had over 500 individuals attend our Town Hall lectures. \(xi\) Objective 3c: Develop a webinar series on native bees in organic farming systems As mentioned earlier, we produced 4 webinars for eOrganic that were viewed by over 2,000 individuals. \(xii\) Objective 3d: Develop a website to link the project team, farmer cooperators, and the broader public Our project website, nwpollinators.org, was developed to link the project team, cooperators, and the broader public. We listed events on this site, and maintained a blog. This site was also used as the hub for our citizen science project. We have over 100 registered users on the site who have published observations of pollinators. This site should provide a nice scaffold for future development of future projects. **PUBLICATIONS (not previously reported):** 2014/09 TO

2018/08 1. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Bloom EH, Northfield TD, Crowder DW (2018) Landscape effects on pollinator beta diversity mediated by niche processes. Ecology Letters, submitted. 2. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Bloom EH, Northfield TD, Crowder DW (2018) Landscape diversity enhances response of wild and managed bees to floral complementarity. Proceedings of the National Academy of Sciences USA, submitted 3. Type: Journal Articles Status: Submitted Year Published: 2018 Citation: Bloom EH, Crowder DW (2018) Educational courses and passive methods attract citizen scientists and promote data collection. Citizen Science: Theory and Practice (submitted) 4. Type: Other Status: Published Year Published: 2018 Citation: Bloom EH, Olsson RL, Wine EH, Schaeffer RN, Crowder DW (2018) Managing cavity-nesting wild bees in Western Washington. Washington State University Extension, FS293E, 8 pp. 5. Type: Conference Papers and Presentations Status: Published Year Published: 2018 Citation: Bloom EH, Olsson R, Crowder DW (2018) Beacon Food Forest Field Day 6. Type: Conference Papers and Presentations Status: Published Year Published: 2018 Citation: Bloom EH, Olsson R, Crowder DW (2018) An introduction to cavity-nesting bees. Koppel Community Garden (Pullman, WA) 7. Type: Conference Papers and Presentations Status: Published Year Published: 2018 Citation: Bloom EH, Crowder DW (2018) Build pollinator habitat in 1 year or less: Augmenting pollinator habitat in the Puget Sound Region of Washington State, USA. Pollinator Week (Seattle, WA) 8. Type: Conference Papers and Presentations Status: Published Year Published: 2018 Citation: Bloom EH, Crowder DW (2018) Introduced pollinators mediate breakdown in wild plant pollination. Centre for Tropical Environmental and Sustainability Science (Cairns, QLD, AU) Progress 09/01/16 to 08/31/17 Outputs Target Audience:Our project has several target audiences. First, the results were are generating have direct relevance for diversified organic farmers in Washington State and nationally, and individuals who wish to transition to organic production. For these individuals we are producing vast amounts of information on bee communities in diversified farming systems, and the impact of landscape intensity on these bee communities. We have conducted multiple field days to deliver information to this audience, as well as a pollinator identification guide. Our second target audience is the general public community, particularly individuals interested in the health and conservation of wild bee species, We have offered multiple classes for the public on pollinator conservation and identification, and we have initiated a citizen science program for bees. This program has attracted master gardeners, members of 4-H, and farmers in addition to interested community members. Finally, our project will produce results of immediate relevance for academic audiences who are interested in the ecology and conservation of native bee communities. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?We have two graduate students working on the project, Elias Bloom and Rachel Olsson. They have gotten the chance to develop professionally as scientists by taking the lead on data collection and execution of the grant objectives. They have also taken the lead in the outreach components of the grant, and have received training from the PI on scientific presentation. We have also supported two undergraduates with this project, including one funded through an internship at Washington State University. These undergrads are receiving training on native bee identification and general scientific inquiry. Moreover, we have used the project to train members of the community on bee identification. We have reached over 1,000 individuals this past year through our field days, public lectures, webinars, and website. Many of these individuals are now engaged in our citizen science project on native bee conservation. How have the results been disseminated to communities of interest?As mentioned above, during the reporting period we presented results from our study at 13 citizen science events, 1 webinar, and 5 public presentations.These events were located throughout the Seattle, Tacoma, and Olympia metropolitan areas, as well as at conferences in Portland and Denver. We targeted the general public as well as diversified organic farmers. In total we had over 1000 individuals attend our outreach events, including over 750 that viewed our webinar and 700 users of our website.Second, we developed a extension guide focused on wild cavity nesting bees that has been dissemination to individuals in the community. This guide can help individuals characterize the bees on their farm or home garden. This guide has been published through WSU Extension. We also delivered the third webinar in our series through our partnership with eOrganic. What do you plan to do during the next reporting period to accomplish the goals?For Objective 1, our major goal in the coming year is to complete our identification of bees and non-bees on each of ourfarms. We expect this to be done in early 2018. With these data we will complete our analysis of the effects of farming practices and landscape conditions on bee populations. We expect to have an extremely rich dataset to examine how bee communities are influenced by farming practices once the identifications are complete. We hope to publish this paper in 2018. For Objective 2, in 2018 we will collect the second year of data on the effects of habitat augmentation on our bee communities and pollination services. Once these data are collected we hope to prepare manuscripts detailing the impacts of habitat augmentation on our bee communities. We are also preparing a manuscript on the impact of nesting structures in promoting cavity nesting bees, which we expect to submit in the summer of 2018. For Objective 3, we are planning to offer a capstone extension event to correspond with National Pollinator Week. We plan to invite a series of speakers who will come to Seattle Town Hall and present seminars, and participate in a panel, on native bee conservation. We hope to attract between 300-500 individuals to these events. We also plan to continue our courses, and offer 10+ citizen science classes in 2018.We are also continuing to develop content for

our website, nwpollinators.org, which will serve as the major clearinghouse of information for our project. Impacts What was accomplished under these goals? Objective 1: Evaluate farm characteristics that promote healthy native bee communities on long-term organic and transitioning farms (i) Sub-objective 1a: Sample native bee communities on a network of farms In 2017 we sampled native bee biodiversity on 22 small-holder diversified farms, representing over 3,000 bee specimens. These bees are in the process of being identified. We also continued to identify bees from prior years of the study, and have completed our analysis of all bees collected in 2014 to 2016 by identifying bees to morphospecies. These data will be incorporated into statistical models in our last year of the project to explore the effects of farming practices influencing bee populations. We also published an extension bulletin on cavity-nesting bees (in a previous year we published a bulletin on wild bee diversity) to aid growers in identifying bees on their own forms and gardens. We also held over 10 citizen science classes to train members of the community in conducting bee biodiversity research. (ii) Sub-objective 1b: Evaluate pollination services on each farm On each of the 22 farms where bees were sampled in 2017 we also measured pollination services using sentinel squash and strawberry plants. We measured fruit set as a proxy for pollination services, and two data points were taken for each crop. Our results show that farms that are transitioning to organic production generally have lower pollination services than long-term organic. This indicates that pollination services may stabilize given enough time in organic production. ?(iii) Sub-objective 1c: Measure characteristics of each farm and surrounding landscapes We have obtained data on the landscape surrounding each of our farms from 2014 to 2016. Data from 2017 will be collected in early 2018 when the National Agricultural Statistics Service Cropland Datalayer maps are produced in January. We collected landscape data using 20concentric 250 meter buffers surrounding each field (representing the landscape within 5 km of each field). We will use these data, along with information on the farming practices for each farm, to determine how the combined effects of farm management and landscape context affected bee communities. Secondly, we developed a survey for our participating growers to gather information on their management practices over the past 3 years. This survey has been deployed, and we expect results back in early 2018. (iv) Sub-objective 1d: Determine effects of farm characteristics and landscape intensity on native bee community health and pollination services As mentioned above, we have a 4-year dataset on bee communities across 20-30 farms per year. We have also collected landscape data for each site, and we are in the process of gathering farm management data for each site. In 2018 these data will be analyzed fully and we will develop a manuscript on our results. (v) Sub-objective 1e: Develop content for eOrganic related to native bee community health and pollination services in organic farming systems We gave 1 webinar on wild bee communities in organic farms through eXtension in 2017. We reached 300 participants, and increase of over 50% from our webinar in 2016. Moreover, the recorded webinar is available online and has 466 views to date. Objective 2: Determine if habitat augmentation expedites the development of healthy native bee communities on long-term organic and transitioning farms (i) Sub-objective 2a: Establish habitat augmentation treatments on farms In 2016 we established habitat augmentation (cavity-nests, ground nesting sites, and floral buffer strips) on half of the 22 farms sampled in our monitoring network. Each of these 11 farms was paired with a farm of similar characteristics that did not have habitat augmentation treatments. We measured the response of the bee communities to our habitat augmentation (or lack of it) on every farm, as well as variation in pollination services for farms with and without augmentation. We need to identify the bees to species to complete our analysis, and this will be done in early 2018. (ii) Sub-objective 2b: Evaluate if habitat augmentation promotes native bee community health and pollination services on farms We measured pollination services on the 22 farms we sampled, 11 with habitat augmentation and 11 without.Preliminary results indicate that habitat strips increase pollination services with 20m of the installation. This means that we observed strong edge effects of augmentation treatment that may also depend on farm size. For example, smaller farms might get greater benefits from habitat augmentation because the ratio of farm area to edge area is lower, whereas large farms might get lower benefits because the ratio of farm area to edge area is greater. Moreover, data indicate that efficacy of habitat strips may be landscape dependent, with peri-urban farms receiving the greatest boost in pollination over rural and urban counterparts. A second year of data will be collected in 2018 to finalize these analyses and determine if these trends hold across multiple years. (iii) Sub-objective 2c: Develop content for eOrganic related to habitat augmentation strategies We delivered a webinar in 2017 on habitat augmentation through eOrganic. This webinar had over 300 views live, and over 450 have watched it on the archived site. We plan to release an extension bulletin in 2017 through eOrganic. Objective 3: Conduct extension and outreach to educate farmers on practices to promote native bee community health and pollination services in organic farming systems (i) Sub-objective 3a: Conduct field-days with farm walks and presentations to train farmers on practices that promote native bees In 2017 we delivered 13 field days and/or citizen science events in 2017. These events, which were 1-2 hour classes, largely replaced the field days we had delivered in 2014 to 2016, as we have found that individuals in our region are extremely excited not only to learn about wild bees but to put their knowledge into action. As a result of our efforts we leveraged grower citizen scientists to measure bee communities, pollination, and plant diversity on an additional 10 farms. We also used community members to measurecavity-nesting bees at 50 urban gardens and farms in the Seattle area. (ii) Sub-objective 3b: Produce public lectures on native bee conservation We delivered 3 public lectures in 2017 by

graduate student Bloom, and 2 presentations by PD Crowder. Through these presentations we reached over 250 individuals. (iii) Sub-objective 3c: Develop a webinar series on native bees in organic farming systems We delivered one webinar in 2017 on habitat augmentation and effects on bee communities (iv) Sub-objective 3d: Develop a website to link the project team, farmer cooperators, and the broader public We have developed a fully functional website: nwpollinators.org. This website has general information on our study and is our site for hosting our citizen scientists. It also is used by our team to network with collaborators. The site also has blog posts from the project team on native bee projects. In total we have over700 website users, which is approximately 7x the number of users from 2016. Publications Type: Journal Articles Status: Accepted Year Published: 2017 Citation: Bloom EH, Olsson RL, Wine EH, Schaeffer RN, and Crowder DW (2017) An Introduction to Cavity-Nesting Bees in the Puget Sound Region. Washington State University Press. Pullman, Washington. In press Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Bloom EH, Crowder DW (2017) The global value of ecosystem services on organic and conventional farms. Entomology Society of America (Denver, Colorado) Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Bloom EH, Crowder DW (2017) Pollinators in Organic Farms and Urban Areas. WSU Urban IPM and Pesticide Safety Education (Tacoma, WA) Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Crowder DW (2016) Pollinators in Organic Farms and Urban Areas. WSU Urban IPM and Pesticide Safety Education (Tacoma, WA) Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Crowder DW (2016) Providing Habitat for Wild Bees on Organic Farms. eXtension/eOrganic, Oregon State University (Corvallis, OR) Type: Journal Articles Status: Published Year Published: 2017 Citation: Lichtenberg EM, Kennedy CM, Kremen C, Batary P, Berendse F, Bommarco R, Bosque-P&#65533;rez NA, Carvalheiro LG, Snyder WE, Williams NM, Winfree R, Klatt B, Astrom S, Faye B, Brittain C, Chaplin-Kramer R, Clough Y, Connelly H, Danforth B, Diekotter T, Eigenbrode SD, Ekroos J, Elle E, Freitas BM, Fukuda Y, Gaines-Day HR, Gratton C, Holzschuh A, Isaacs R, Isaia M, Jha S, Jonason D, Jones VP, Klein A-M, Krauss J, Letourneau DK, Macfadyen S, Mallinger RE, Martin EA, Martinex E, Memmott J, Morandin L, Neame L, Otieno M, Park MG, Pfiffner L, Pocock M, Ponce C, Potts SG, Poveda K, Ramos M, Rosenheim JA, Rundlof M, Sardinas H, Saunders ME, Schon NL, Sciligo AR, Sidhu CS, Steffan-Dewenter I, Tscharntke T, Vesely M, Weisser WW, Wilson JK, Crowder DW (2017) A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes. Global Change Biology 11, 4946-4957. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Crowder DW (2017) Conserving pollinator communities in diversified organic farms along an urbanization gradient. Pacific Branch of the Entomological Society of America, Portland, OR. Type: Conference Papers and Presentations Status: Published Year Published: 2017 Citation: Crowder DW (2017) The global value of ecosystem services on organic and conventional farms. Annual Meeting of the Entomological Society of America, Portland, OR. Progress 09/01/15 to 08/31/16 Outputs Target Audience:Our project has several target audiences. First, the results were are generating have direct relevance for diversified organic farmers in Washington State and nationally, and individuals who wish to transition to organic production. For these individuals we are producing vast amounts of information on bee communities in diversified farming systems, and the impact of landscape intensity on these bee communities. We have conducted multiple field days to deliver information to this audience, as well as a pollinator identification guide. Our second target audience is the general public community, particularly individuals interested in the health and conservation of wild bee species, We have offered multiple classes for the public on pollinator conservation and identification, and we have initiated a citizen science program for bees. This program has attracted master gardeners, members of 4-H, and farmers in addition to interested community members. Finally, our project will produce results of immediate relevance for academic audiences who are interested in the ecology and conservation of native bee communities. Changes/Problems:Due to some logistical challenges, we established our suite of augmentation treatments one year later than expected in the original submission. We plan to take a no-cost extension year for the grant to allow us an additional year for data collection, and thus this delay will not affect the overall outputs of the project. The other major changes described earlier are extensions of the original proposal. Major additions we have completed include: (1) evaluating non-bee communities on our farms (not just bees), (2) evaluating individual bee health on our farms, and (3) developing a citizen science initiative for native bees. We believe these extensions of our original proposal will provide significant value added. What opportunities for training and professional development has the project provided?We have two graduate students funded by the project, Elias Bloom and Rachel Olsson. They have gotten the change to develop professionally as scientists by taking the lead on data collection and execution of the grant objectives. They have also taken the lead in the outreach components of the grant, and have received training from the PI on scientific presentation. We have also supported two undergraduates with this project, including one funded through an internship at Washington State University. These undergrads are receiving training on native bee identification and general scientific inquiry. Moreover, we have used the project to train members of the community on bee identification. We have reached over 1,000 individuals this past year through our field days, public lectures, webinars, and website. Many of these individuals are now engaged in our citizen science project on native bee conservation. How have the results been

disseminated to communities of interest?As mentioned above, during the reporting period we presented results from our study at 3 field days, 8 citizen science events, and 11 public workshops. These events were located throughout the Seattle, Tacoma, and Olympia metropolitan areas. We targeted the general public as well as diversified organic farmers. In total we had over 1000 individuals attend our outreach events, including over 100 that attended our large public lecture by Gary Nabhan and over 300 that viewed our webinar. Second, we developed a pollinator extension guide that has been dissemination to individuals in the community. This guide can help individuals characterize the bees on their farm or home garden. This guide has been published through WSU Extension. We also delivered the second webinar in a series of 4 through our partnership with eOrganic. We have a third webinar planned in 2017. Finally, we created a website that will be a clearinghouse for all of our information collected on pollinators (nwpollinators.org). This website also serves as the clearinghouse for our citizen science project What do you plan to do during the next reporting period to accomplish the goals?For Objective 1, our major goal in the coming year is to complete our identification of bees and non-bees on each of our farms. Without these complete data we cannot determine the overall impacts of the farming systems on bee communities. We are in the process of finalizing our identifications from 2015, and have the full 2014 data completed as well. To identify bees in 2016 we are using a combination of molecular methods (genetic barcoding) and visual identifications. In total, we have a dataset containing over 10,000 bee and non-bee specimens across our 35 farms from 2014 to 2016. We have also collected data from each farm on their organic status (long-term or transitioning) and a suite of other factors we hypothesize may impact bee communities. Thus, we have an extremely rich dataset to examine how bee communities are influenced by farming practices once the identifications are complete. This is our major goal in 2016-2017. For Objective 2, in the coming reporting period we will sample each of our farms again for wild bees and other floral visitors. As half of our farms have received an augmentation treatment, and half serve as controls, these data will allow us to determine the effects of habitat augmentation on bee communities and the services they provide. For Objective 3, we are planning to again offer 3 field days, a webinar through eOrganic, a major public lecture on pollinators at Seattle Town Hall, and 10+ workshops associted with our citizen science classes. We hope to reach another 500-1000 individuals through these means in the coming year. We are also continuing to develop content for our website, nwpollinators.org, which will serve as the major clearinghouse of information for our project. Impacts What was accomplished under these goals? To make progress on Objective 1a, we sampled native bee communities on a network of 35 farms in 2016, with each farm sampled three times (May, July, September). Farms were either long-term certified organic farms or diversified farms. Bees were sampled on sunny days with wind speeds below 10 mi/hr using traps, netting, and visual observations. With each method, collected bees are in the process of being identified to species. From these data we will calculate native bee abundance, richness, and evenness at each of our farms. These data, once the bees are identified, will be combined with similar samples conducted in 2014 and 2015 to provide a baseline of bee communities at each site. In addition, we expanded the scope of this objective by sampling non-bee floral visitors (flies, butterflies, moths, etc) on each of our 35 farms three times per year in 2015 and 2016. This provided an additional 2,600 insects that are in the process of being identified These data, when combined with the bee data, provide a comprehensive baseline of bee communities on our participating farms. We also assessed a variety of other factors on our farms, including (1) characterizing the structure of the plant-pollinator network (by making observations of bees visiting flowers and from pollen collected from bees) and (2) measuring individual bee health (body size and condition). To make progress on Objective 1b, at each farm we assessed pollination services provided by native bees. We used fruit set as a metric of pollination services. On each farm fruit set was measured using summer (Cucurbita pepo \'Raven\') squash and strawberry. Data on fruit set was collected twice at each farm, once in June (summer squash) and again in Sep (strawberry). These data are in the process of being analyzed for effects of farming systems on bees. We have also collected extensive data from individual bees on pollen transport to a variety of crop species. We are investigating if these data can be used as a measure of pollination services in the future. To make progress on Objective 1c, at each farm we also collected data on crop diversity, farm size, farm age, presence of honey bees, pesticide use, tillage, presence of livestock, landscape factors, and habitat management. We have also mapped out the landscape surrounding each farm using Geographical Information Systems technology. These variables will be used to assess how different farming practices influenced bees, once all our data is collected. This will be part of Objective 1d, which is currently underway and will be finalized when we have finished identification of all the bees and non-bee floral visitors. To make progress on Objective 1e, in 2016 we delivered one Webinar through eOrganic. This was viewed by over 300 individuals in Feburary 2016. We are in the process of making informational videos related to pollinators for eOrganic. To make progress on Objective 2a, in the past year we established habitat augmentation treatments on half of our participating farms. These consisted of nesting structures (which provide habitat for cavity-nesting bees), bare ground (which provide habitat for ground-nesting bees), and floral strips (which provide pollen and nectar resources). These treatments will be fully effective in 2017, as the floral strips will establish over the winter months. We will then measure the impacts of these augmentation treatments in 2017 and 2018 (Objectives 2b and 2c). Additionally, since 2014 we have measured the impacts of a single form of habitat augmentation, nesting structures, on native bee communities. We have

found that three genera of wild bees readily use the nesting structures, and upwards of 100 bees per site used the structures to make their nests. We are in the process of determining if this relates to an increase in pollination services, but the preliminary data is promising. To make progress on Objective 3, in 2016 members of our term organized and deliver 3 field days on Native Bees, 8 citizen science outreach talks, and an additional 11 pollinator workshops designed to inform the public and farmers about native bee conservation. We also had a major public lecture with Gary Nabhan at Seattle Town hall. We produced the second of our webinar series through eOrganic in February, and have developed a website for our project (nwpollinators.org). We exceeded our outreach from our original grant in every of these categories, and reached over 1,000 individuals through these events. We have also developed a citizen science project, CSI: Bees (Citizen Science Iniatiative for Bees) in 2016. We offered two classes, one on monitoring wild bee diversity and the other on establishing nesting structures in the home garden/farm. Our classes attracted over 100 individuals, many of which are now contributing data to our project as citizen scientists. This form of outreach has helped us attract more public support and engagement for our project. We have used surveys to continue to refine our content for future years. Publications Type: Other Status: Awaiting Publication Year Published: 2016 Citation: Bloom EH, Crowder DW (2016) A Field Guide to Western Washington Wild Bees and Floral Visitors. Washington State University Press, Pullman, Washington, in revision. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH (2016) Can Pollinator Monitoring Inform Wild Bee Conservation. Seattle Parks and Recreation, Seattle, WA (invited talk) Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Crowder DW (2016) Advances in Organic Farming. International Congress of Entomology, Orlando, FL (invited talk) Type: Journal Articles Status: Awaiting Publication Year Published: 2016 Citation: Lichtenberg et al (Crowder last author, 59 authors total)(2016) A global synthesis of the effects of diversified farming systems on arthropod diversity in fields and across regions. Global Change Biology, in revision. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH (2016) Wild Bees in the Wild. Scarabs - University of Washington (UW) Insect Society (Seattle, WA) (invited talk) Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH (2016) Challenging Assumptions with Bee Monitoring in the Puget Sound Region. Kiwanis Club of America, Olympia, WA (invited talk) Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Bloom EH (2015) Bee Monitoring and Restoration in the Puget Sound Region. Seattle Parks and Recreation, Seattle, WA (invited talk) Type: Other Status: Published Year Published: 2016 Citation: Bloom EH, Redmond B, Olsson R (2016) Wild Bee Monitoring, Identification, and Outreach. eXtension/eOrganic webinar, Corvallis, OR. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Bloom EH, Crowder DW (2015) Diverse nest substrate may be essential for bee conservation. Entomology Society of America, Minneapolis, MN. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Olsson R (2016). Organic Farming & Pollinators: A practical field course. 3 separate field days were offered with this title throughout western Washington. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Olsson R (2016). CSI Bees: WildBeeSense Biodiversity Project. 5 separate citizen science classes were offered with this title throughout western Washington. Type: Conference Papers and Presentations Status: Published Year Published: 2016 Citation: Bloom EH, Olsson R (2016). CSI Bees: Pollinator Post Project. 5 separate citizen science classes were offered with this title throughout western Washington. Type: Websites Status: Published Year Published: 2015 Citation: http://nwpollinators.org/ Type: Book Chapters Status: Published Year Published: 2016 Citation: Bloom EH, Crowder DW (2016) Biological Control and Pollination Services on Organic Farms. In: Advances in Insect Control and Resistance Management (eds Horowitz AR, Ishaaya I). Springer International Publishing AG, Cham, Gewerbestrasse, Switzerland. Progress 09/01/14 to 08/31/15 Outputs Target Audience:Our project has several target audiences. First, the results were are generating have direct relevance fordiversified organic farmers in Washington State and nationally, and individuals who wish to transition to organic production. For these individuals we are producing vast amounts of information on bee communities in diversified farming systems, and the impact of landscape intensity on these bee communities. We have conducted multiple field days to deliver information to this audience, and are also creating extension bulletins.Our second target audience is the general public community, particularly individuals interested in the health and conservation of wild bee species, We have offered multiple classes for the public on pollinator conservation and identification, and are in the process of starting a citizen science program for bees. Finally, our project will produce results of immediate relevance for academic audiences who are interested in the ecology and conservation of native bee communities in agricultural systems. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided?We have two graduate students funded by the project. They have gotten the chance to develop professionally as scientists by taking the lead on data collection and execution of the grant objectives. They have also taken the lead in the outreach components of the grant, and have received training from the PI on scientific presentation. We have also supported two undergraduates with this project, including one funded through an internship at Washington State University. These undergrads are receiving training on native bee identification and general scientific inquiry. How have the results been disseminated to communities of

interest?As mentioned above, to date we presented results from our study at 3 field days, 8 citizen science events, and 6 public workshops. These events were located throughout the Seattle, Tacoma, and Olympia metropolitan areas. We targeted the general public as well as diversified organic farmers. In total we had over 300 individuals attend our outreach events in the first year, and over 100 attended our large public lecture by Eric Mader. Second, we developed a pollinator extension guide that has been dissemination to individuals in the community. This guide can help individuals characterize the bees on their farm or home garden. We also delivered the first Webinar in a series of 4 through our partnership with eOrganic. We have a second webinar planned in 2016. Finally, we created a website that will be a clearinghouse for all of our information collected on pollinators. What do you plan to do during the next reporting period to accomplish the goals?We plan to resample all of our farms for diversity and stability of wild bees in 2016, as well as the pollination services they provide. This will provide three years of baseline data (2014-2016) on bee communities before habitat augmentation was implemented. Using data collected on the farm-management and landscape intensity variables, at the end of 2016 we plan to analyze which factors influence the diversity of bee communities and their pollination services. This will allow us to complete Objective 1 in early 2017. To complete Objective 2, in 2016 we plan to establish habitat augmentation on half of our study farms. One of our goals is to evaluate if habitat augmenation can improve bee community health on long-term and transitioning organic farms. In the fall of 2016 we will establish nesting structures, bare ground, and flowering strips on our study farms. Data will be collected in 2017 and 2018 to determine if these habitat augmentation treatments improved bee community health (Objective 2). For Objective 3, we are expanding our outreach in the next year. We have over 20 field days, citizen science events or workshops lined up at various locations in 2016. These will offer us an opportunity to directly deliver information to our stakeholders. We also plan to more completely develop our website and work with eOrganic to produce content in the next year. Impacts What was accomplished under these goals? To make progress on Objective 1a, we sampled native bee communities on a network of 35 farms in 2015, with each farm sampled three times (May, July, September). Farms were either long-term certified organic farms or diversified farms.Bees were sampled on sunny days with wind speeds below 10 mi/hr using traps, netting, and visual observations.With each method, collected bees were identified to species. From these data we calculated native bee abundance, richness, and evenness at each of our farms. These data will be combined with similar samples conducted in 2014 and 2016 to provide a baseline of bee communities at each site. To make progress onObjective 1b, at each farm we assessed pollination services provided by native bees. We usedfruit set as ametricof pollination services. On each farm fruit set wasmeasured using summer (Cucurbita pepo \'Raven\') and winter squash (Cububirta maxima \'Hubbard\'). Data on fruit set was collected twice at each farm, once in June (summer squash) and again in Aug (winter squash). These data are in the process of being analyzed for effects of farming systems on bees. To make progress onObjective 1c, at each farm we also collected data on crop diversity, farm size, farm age, presence of honey bees, pesticide use, tillage, presence of livestock, landscape factors, and habitat management. These variables will be used to assess how different farming practices influenced bees, once all our data is collected. This will be part ofObjective 1d, which will begin in 2016 To make progress onObjective 1e, in 2015 we delivered one Webinar through eOrganic. This was viewed by over 300 individuals in March 2015. We are in the process of making informational videos related to pollinators for eOrganic. Objective 2 was not slated to begin until 2016, and we are on target for this objective. To make progress onObjective 3, in 2015 members of our term organized and deliver 3 field days on Native Bees, 8 citizen science outreach talks, and an additional 6 pollinator workshops designed to inform the public and farmers about native bee conservation. We also had a major public lecture with Eric Mader of the Xerces Society at Seattle Town hall. We produced the first of our webinar series through eOrganic in March, and have developed a website for our project (nwpollinators.org). We exceeded our outreach from our original grant in every of these categories. Publications Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Redmond B, Crowder D (2015) Bee community ecology and urban fruit production. City Fruit, Seattle, WA. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Redmond B, Crowder D (2015) Bee community ecology: Introduction and field study. Seattle Tilth, Seattle, WA. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Crowder D (2015) The diversity, abundance, and stability of bees and pollination services. Snow Valley Tilth Grower Meeting, Carnation, WA. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Crowder D (2015) Bee community ecology, the importance of pollinator health to pollination services. Sustainable South Sound, Olympia, WA. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Crowder D (2015) Science, insects, bees and society. University of Washington, Seattle, WA. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Crowder D (2015) Science, insects, bees and society. Seattle University, Seattle, WA. Type: Conference Papers and Presentations Status: Published Year Published: 2015 Citation: Bloom E, Crowder D (2015) The community ecology of bees in urban and rural diversified farming systems. Entomological Society of America Annual Meeting, Minneapolis, MN. Type: Other Status: Published Year Published: 2015 Citation: Bloom E, Redmond B, Crowder D (2015) Citizen Science for bees (offered at 8 different locations in 2015)

↑ Return to Index