OREI Project Details

Award Year 2006

6 Research Projects

PROJECT INDEX

Crop Diversification Complexity and Pest Beneficial Organism Communities in Humid Tropical and Sub-tropical Climatic Regimes

Accession No.	0206897
Subfile	CRIS
Project No.	FLA-HOS-04512
Agency	NIFA FLA
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2006-51300-03481
Proposal No.	2006-02047
Start Date	01 JUN 2006
Term Date	31 MAY 2007
Fiscal Year	2006
Grant Amount	$226,139
Grant Year	2006
Investigator(s)	Chase, C. A.; Swisher, M. E.; McSorley, R.; Liburd, O. E.; Datnoff, L. E.; Treadwell, D. D.; Unruh Snyder, L.; Weiss, S. A.; Arancibia, R. A.; Robles, C.
Performing Institution	HORTICULTURAL SCIENCE, UNIVERSITY OF FLORIDA, BOX 100494, JHMHC

NON-TECHNICAL SUMMARY

The warm, humid climate in Florida and the US Virgin Islands is both an advantage and a disadvantage for vegetable producers. The tropical/sub-tropical climate permits year-round cropping. However, lack of a winter or mild winters allow pests to persist from season to season. In addition, pest species occur that do not persist outside tropical and sub-tropical habitats. Although relatively high rainfall may reduce dependence on irrigation, year-round persistence of many pests and pathogens are encouraged. Therefore, we propose an integrated research project that will examine the effects of crop rotation, intercropping, and cover crop management on insects, weeds, nematodes, and plant pathogens in organic vegetable cropping systems. We will conduct this research under humid tropical conditions in the Virgin Islands and humid sub-tropical conditions in north-central Florida. Our research will compare crop rotation systems that include cover crops and cash crops grown in monoculture or intercropped with a control system with cash crops grown in monoculture, but without cover crops.

OBJECTIVES

1. Evaluate the impact of selected crop rotation, cover crops, and intercrop systems on growth and yield of organically produced vegetables. 2. Evaluate the effects of the selected systems on the population dynamics of weeds, insect pests and beneficial insects, and plant pathogenic nematodes; on microbiological activity and soilborne pathogens; and on the dynamics of associated diseases or disease complexes. 3. Assess soil and crop nutrient status in order to minimize the occurrence of crop macronutrient deficiencies and to correlate pest density and diversity with changes in crop and soil nutrient status.

APPROACH

The effects of crop diversification complexity on pest populations and community dynamics will be evaluated in organic vegetable cropping systems under humid sub-tropical conditions in north central Florida and humid tropical conditions in the Virgin Islands. Mild or no winter results in the year round persistence of many pests, so alternative ways of breaking pest cycles and preventing species from achieving pest status are critically needed. Summer cover crops in monoculture or mixtures will be grown in sequence with several vegetable crops in monoculture or intercropped in a biannual rotation system. The impact of increasing plant biodiversity on growth and yield of organically produced vegetables, on the population dynamics of key insect pests and beneficial insects, weeds, plant pathogenic nematodes, and soil borne plant pathogens will be assessed. Three rotations of cover crops and vegetable cash crops designed to promote plant diversity along with a control treatment that consists of cash crops and weed fallows comprise the four cropping system treatments to be evaluated. Because the research is conducted in subtropical and tropical locations, year-round cropping is possible. Systems employing leguminous cover crops during the summer fallow will be compared with systems utilizing graminaceous cover crops and grass/legume mixtures. Legume cover crops that are well-adapted to hot, humid conditions and have been characterized as nematode suppressive, sunn hemp (Crotalaria juncea) and velvet bean (Mucuna deeringiana) will be planted at densities selected to optimize weed suppression. Graminaceous cover crops will be sorghum-sudan grass (Sorghum bicolor x S. sudanense) and pearl millet (Pennisetum glaucum). The leguminous and graminaceous cover crops in monoculture and their mixtures will be used in rotation with vegetable cash crops in monoculture or intercropped in order to promote plant diversity. Cover crops and cash crops will be evaluated for weed, insect, pathogen, nematode infestation and soil borne plant pathogens. Plant vigor, biomass, total yield and marketable yield of the cash crops will be assessed also. Biotic diversity of pest and beneficial species will be quantified through the use of species richness, species diversity, and evenness. Ordination techniques will be used to characterize how pest communities are affected by the treatments. The project is aimed at developing strategies that address pest and pest-related problems using an integrated or systems approach and at finding correlations between crop nutritional status and pest incidence. Improved control of pests in organic vegetable production will result in economic benefits to organic growers by improving marketable yields and reducing the need for labor-intensive pest management or the purchase of approved organic pesticides.

PROGRESS

2006/06 TO 2007/05 OUTPUTS: To close project, last report should have been marked final. PARTICIPANTS: Not relevant to this project. TARGET AUDIENCES: Not relevant to this project. PROJECT MODIFICATIONS: Not relevant to this project.

2006/06/01 TO 2007/05/31 Prior to initiation of the study in Florida and the US Virgin Islands (USVI) in 2006 the fields were sampled to assess the type and frequency of weed species in the soil seedbank. Rotations were initiated with grass cover crops (pearl millet and sorghum-sudangrass) and legume cover crops (sunn hemp and velvetbean) and their mixtures (pearl millet-sunn hemp and sorghum-sudan grass-velvetbean). Weeds were identified and counted and cover crop growth and biomass yields were assessed. A variety of traps were used to monitor pest and beneficial insect incidence in cover crops. In Florida, weed infestation was also assessed during fall cash crops of summer squash and broccoli and spring cash crops of sweet corn and bell peppers. In fall, in the most complex systems, broccoli was interplanted with a crimson clover living mulch and squash with a hairy vetch/rye living mulch. In the most complex systems in spring both cash crops were intercropped with green beans. In USVI the first cycle of cash crops were tomatoes and tatsoi. In the most complex systems, these were intercropped with green beans. The second cycle of cash crops was cucumbers and sweet corn, which were intercropped with Iron-Clay cowpeas in the most complex systems. Pest insects in cash crops were assessed by using yellow and white sticky traps. Leaf disc counts were also performed. Aphids, whiteflies (eggs, immatures and adults), thrips, and lepidopteran insects were counted. Other insects that were observed were also recorded. In Florida, cover crop and cash crops were sampled to detect and identify pathogenic organisms. Pyricularia leaf spot caused by *Pyricularia grisea* was identified and found to be infecting pearl millet throughout the experiment. Southern blight caused by *Bipolaris maydis* was observed in sorghum-sudangrass. Soil samples were assessed to enumerate colonies of fluorescent pseudomonas, filamentous actinomycetes, total fungi, total aerobic heterotrophic bacteria, and endospore-forming bacteria. Background nematode samples were obtained prior to cover crop establishment. Initial population levels in Florida averaged 54 ring nematodes and 2.2 lesion nematodes/100 cc soil, with trace levels (\<1.0/100 cc) of stubby-root, spiral, and sheath nematodes. At USVI, initial levels were 372 reniform and 121 spiral nematodes/100 cc soil, with trace levels of stubby-root nematodes. Nematode samples were collected from all plots at the end of each crop. Following the cover crops, high numbers of reniform nematodes were detected in USVI, while in Florida, levels of ring and lesion nematodes

increased, and populations of root-knot nematodes are evident in some plots. The nutrient content of soil and plant samples was monitored throughout the year. Soil was sampled prior to planting the cover crops and immediately following cover crop and cash crop harvests. The results have been used to recommend permitted fertilizers and amendments to minimize crop macronutrient deficiencies and to modify soil pH, and will be used to evaluate treatment effects on soil quality.

IMPACT

2006/06 TO 2007/05 To close project, last report should have been marked final. **PUBLICATIONS (not previously reported):** 2006/06 TO 2007/05 1. Bhan, M., C.A. Chase, R. McSorley, O.E. Liburd, D.D. Treadwell, and W.P. Cropper. 2007. Weed population response to summer cover crops in fall squash and broccoli production. Proc. Florida Weed Science Society, p. 5. (abstract) 2. Bhan, M., C.A. Chase, R. McSorley, O.E. Liburd, D.D. Treadwell, and W.P. Cropper. 2007. Weed population response to crop diversification complexity in organic vegetable production. Proc. Southern Weed Science Society 60: 144. (abstract) 3. Scott, C.A. and O.E. Liburd. 2007. Tracking insect populations within organic vegetable systems to determine how residual populations from cover crops affect vegetable production. Florida Entomological Society 2007 annual meeting abstracts, p. 6. http://www.flaentsoc.org/2007annmeetabstracts.pdf 4. No publications reported this period

2006/06/01 TO 2007/05/31 A workshop and field day on organic production was held in September 2006 in Citra, FL. More than 200 conventional and organic growers, administrators, faculty, students, and industry representatives participated. Principal investigators and collaborators gave presentations or moderated panel discussions on: ecological management of insects, nematodes, and weeds; organic certification; organic vegetable and fruit production; and water and nutrient management for organic production systems.

PUBLICATIONS

2006/06/01 TO 2007/05/31 1. Bhan, M., C.A. Chase, R. McSorley, O.E. Liburd, D.D. Treadwell, and W.P. Cropper. 2007. Weed population response to summer cover crops in fall squash and broccoli production. Proc. Florida Weed Science Society, p. 5. (abstract) 2. Bhan, M., C.A. Chase, R. McSorley, O.E. Liburd, D.D. Treadwell, and W.P. Cropper. 2007. Weed population response to crop diversification complexity in organic vegetable production. Proc. Southern Weed Science Society 60: 144. (abstract) 3. Scott, C.A. and O.E. Liburd. 2007. Tracking insect populations within organic vegetable systems to determine how residual populations from cover crops affect vegetable production. Florida Entomological Society 2007 annual meeting abstracts, p. 6. http://www.flaentsoc.org/2007annmeetabstracts.pdf

↑ Return to Index

Organic Production of Blueberries in the Southeastern United States: Development of Best Management Practices

Accession No.	0206795
Subfile	CRIS
Project No.	FLA-QUN-04507
Agency	NIFA FLA
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2006-51300-03475
Proposal No.	2006-04971
Start Date	01 SEP 2006
Term Date	31 AUG 2010
Fiscal Year	2009
Grant Amount	$364,156
Grant Year	2006
Investigator(s)	Andersen, P. C.; Scherm, H.; Krewer, G. W.; Liburd, O. E.; Fonsah, E. G.
Performing Institution	NORTH FLA RESEARCH & EDUCATION CENTER, QUINCY, UNIVERSITY OF FLORIDA, BOX 100494, JHMHC

NON-TECHNICAL SUMMARY

The demand for organic production of fruits and vegetables is increasing by about 20er year. Organic blueberries can be grown sucessfully in the southeastern United States after best management practices are developed. The purpose of this project is to research materials and cultural practices that will facilitate the organic production of blueberries in the southeastern United States.

OBJECTIVES

The goal of this project is to develop best management practices and economic budgets for organic blueberry production in the southeastern United States. Specific objectives are: 1) evaluate establish methods for organic blueberry plantings using organic mulches or plasticulture for weed control; 2) develop fertilizer regimes using fertilizer materials that are approved by the Organic Materials Review Institute (OMRI); 3) formulate strategies for organic management of key pests in blueberry plantings; 4) conduct economic analyses and develop risk rated enterprise budgets for organic blueberries. We will utilize various outreach mechanism to reach clientele

APPROACH

Non-idegenous crops such as peaches, apples and strawberries have limited potential for commercial production in the southeastern United States due to high pest pressure and a long hot humid growing season. By comparison, rabbiteye blueberries are native to the region and are well adapted to the climate, soils and extensive pest complexes. The acreage of organic blueberries is expanding. There is increased consumer demand associated with the widely publicized health benefits of blueberry fruit. There is also a need for alternative source of income for small to moderate sized farms in a region where more traditional crops are no

longer profitable. If some important production limitations can be solved, organic blueberry will become a significant industry in south Georgia and north Florida.

PROGRESS

2006/09 TO 2010/08 OUTPUTS: The rabbiteye blueberry (Vaccinium virgatum) is native to southern Georgia and northern Florida and can be grown organically in the southeastern United States. They are well adapted to the climate, soils and pest complexes. In the last 5 years the acreage of organic blueberries has expanded from 10 to 400 acres in Georgia alone. There is increased consumer demand associated with the widely publicized health benefits of blueberry fruit. There is also a need for alternative source of income for small- to moderate-sized farms in a region where many traditional crops are no longer profitable. Organic rabbiteye blueberries are poised to become a large industry in southern Georgia and northern Florida. The purpose of this project was to research management practices that will facilitate the organic production of blueberries in the southeastern United States. The goals of this project were to develop best management practices for organic blueberry production in the southeastern United States. Specific objectives are to: 1) evaluate establish methods for organic blueberry plantings using organic mulches or plasticulture for weed control; 2) develop fertilizer regimes using fertilizer materials that are approved by the Organic Materials Review Institute (OMRI); 3) formulate strategies for organic management of key blueberry pests; 4) conduct economic analyses and develop enterprise budgets for organic blueberries. Research on organic blueberries involved: organic mulches, organic fertilizers, mummy berry, Septoria leaf spot, leaf beetle and blueberry gall midge. For more detailed information please consult the publications listed below. Each year the Co-Principal Investigators have attended the Southeastern Fruit and Vegetable Convention in Savannah, GA. Information was also disseminated at the Southern Association of Agricultural Scientists Conference, the Ozeki Nursery Blueberry Growers Conference, the Ninth International Blueberry Grower\'s Association meeting, and the Entomological Society of America. Grower outreach, Field days and In-Service training of County Extension Agents have also been conducted from 2006-2010. Our stakeholders have included Dave and Debbie Hardage (Organic Producers, Vero Beach, FL), Alan Miles, (Organic Producer, Baxley, GA), Connie Horner (Organic Producer, Alma GA), Stanley Scarborough (Production Manager, Sunny Ridge Inc. Winter Haven, FL), Dave Trinka (MBG Marketing, Traverse City, MI) and Relinda Walker (Georgia Organics). Many of these individuals were integrally involved in this Organic Blueberry Grant by donating land and plant material for experimentation. In addition, many of these individuals have made significant contributions and appear as authors on publications pertaining to various aspects of culture and management and integrated pest management of rabbiteye blueberries(see publication list). Our target audience includes organic blueberry growers, prospective organic blueberry growers, Georgia Organics (www.georgiaorganics.org), County Extension Agents, and the interested public. Refereed and non-refereed publications are being generated for the scientific community. PARTICIPANTS: The individuals that have worked on this project include: 1) P. C. Andersen, Prof. Horticulture, Univ. FL; 2) E. G. Fonsah, Asst. Prof. Agricultural Economics, Univ. GA; 3) G. Krewer, Prof. Horticulture, Univ. GA; 4) O. E. Liburd, Assoc. Prof. Entomology, Univ. FL; 5) B. Mullinix. Prof. Statistics, Texas A and M Univ.; 6) M. Tertuliano, Post-doctoral Associate, Univ. FL; 7) H. Scherm, Prof. Plant Pathology, Univ. GA; 8) K. Plattner, MS student Agricultural Economics, Univ. GA. Collaborators and stakeholders include Jerald Larsen (County Agent, Ft. Valley State College), Dave and Debbie Hardage (Organic Producers, Vero Beach, FL), Alan Miles, (Organic Producer, Baxley, GA), Connie Horner (Organic Producer, Alma GA), Stanley Scarborough (Production Manager, Sunny Ridge Inc. Winter Haven, FL), Danny Stanaland (County Extension Coordinator, Alma, GA), Dave Trinka (MBG Marketing, Traverse City, MI) and Relinda Walker (Georgia Organics. Many of these individuals were integrally involved in this Organic Blueberry Grant by donating land and plant material for experimentation. In addition, many of these individuals have made significant contributions and appear as authors on publications pertaining to various aspects of culture and management and integrated pest management of rabbiteye blueberries(please see publication list). TARGET AUDIENCES: Each year the Co-Principal Investigators attend the Southeastern Fruit and Vegetable Convention in Savannah, GA. Presentations are given concerning the organic culture of rabbiteye blueberries in the southeastern United States (see publications below). Information was also disseminated at the Southern Association of Agricultural Scientists Conference (Atlanta, GA), the Ozeki Nursery Blueberry Growers Conference (Japan), the Ninth International Blueberry Grower\'s Association meeting (Corvallis, OR), and the Entomological Society of America. Grower outreach, Field days and In-Service training of County Extension Agents have also been conducted from 2006 to 2009. Target audience includes organic blueberry growers, prospective organic blueberry growers, Georgia Organics (www.georgiaorganics.org), County Extension Agents, and the interested public. Refereed and non-refereed publications have been and still are being generated for the scientific community. We have also utilized the Southern Region Small Fruit Consortium (SRSFC) website (www.smallfruits.org), a regional project consisting of VA, NC, SC, GA, TN, to enhance the dissemination of issues pertaining to the culture of organic blueberries in the southeastern United States. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2008/09/01 TO 2009/08/31 OUTPUTS: Each year the Co-Principal Investigators attend the Southeastern Fruit and Vegetable Convention in Savannah, GA. Presentations are given concerning the organic culture of rabbiteye blueberries in the southeastern United States (see publications below). Information was also disseminated at the Southern Association of Agricultural Scientists Conference (Atlanta, GA), the Ozeki Nursery Blueberry Growers Conference (Japan), the Ninth International Blueberry Grower\'s Association meeting (Corvallis, OR), and the 2008 Entomological Society of America (Reno, NV). Grower outreach, Field days and In-Service training of County Extension Agents have also been conducted in 2008. PARTICIPANTS: The individuals that have worked on this project include: 1) P. C. Andersen, Prof. Horticulture, Univ. FL; 2) E. G. Fonsah, Asst. Prof. Agricultural Economics, Univ. GA; 3) G. Krewer, Prof. Horticulture, Univ. GA; 4) O. E. Liburd, Assoc. Prof. Entomology, Univ. FL; 5) B. Mullinix. Prof. Statistics, Texas A and M Univ.; 6) M. Tertuliano, Post-doctoral Associate, Univ. FL; 7) H. Scherm, Prof. Plant Pathology, Univ. GA; 8) K. Plattner, MS student Agricultural Economics, Univ. GA. Collaborators and stakeholders include Jerald Larsen (County Agent, Ft. Valley State College), Dave and Debbie Hardage (Organic Producers, Vero Beach, FL), Alan Miles, (Organic Producer, Baxley, GA), Connie Horner (Organic Producer, Alma GA), Stanley Scarborough (Production Manager, Sunny Ridge Inc. Winter Haven, FL), Danny Stanaland (County Extension Coordinator, Alma, GA), Dave Trinka (MBG Marketing, Traverse City, MI) and Relinda Walker (Georgia Organics. Many of these individuals were integrally involved in this Organic Blueberry Grant by donating land and plant material for experimentation. In addition, many of these individuals have made significant contributions and appear as authors on publications pertaining to various aspects of culture and management and integrated pest management of rabbiteye blueberries(see publication list). TARGET AUDIENCES: Target audience includes organic blueberry growers, prospective organic blueberry growers, Georgia Organics (www.georgiaorganics.org), County Extension Agents, and the interested public. Refereed and non-refereed publications are being generated for the scientific community. We also plan to utilize the Southern Region Small Fruit Consortium (SRSFC) website (www.smallfruits.org), a regional project consisting of VA, NC, SC, GA, TN, to enhance the dissemination of issues pertaining to the culture of organic blueberries in the southeastern United States. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2007/09/01 TO 2008/08/31 OUTPUTS: Classroom presentations: G. Krewer. Results of organic blueberry mulching trials. Southeastern Fruit and Vegetable Convention, Organic Blueberry section. Savannah, GA 12 Jan. 2008. Scientific meetings: G. Krewer. Effect of mulches on the establishment of organically-grown blueberries in Georgia. 9th International Symposium on Vaccinium culture. Corvallis, OR 16 June 2008. G. Fonsah. Discussion on emerging organic and natural markets. Southern Outlook Conference Atlanta, Georgia 24-26 September 2007. Plattner, K., E.G. Fonsag, C. Escalante, G. Krewer, H. Scherm, P.C. Andersen and M. Tertuliano. Economics of Organic Blueberry Establishment in Georgia. Food Distribution Research Society, New Orleans 3-7 Nov. 2007. Field days: University of Georgia Blueberry Field Day. Alapaha, GA 1 May 2008. County Agent Training: Tour of Alma Research Plots for County Agents. Alma GA. 25 June 2008. Organic Small Fruit Production. Georgia Organics Dalton, GA 29 Feb. 2008 Organic blueberry and small fruit production. Statesboro, GA 7 Feb. 2008. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2006/09/01 TO 2007/08/31 The most important limitation to successful organic blueberry production is weed control. Several experiments have been initiated since September 2006. Experiment 1 was established 30 Nov. 2006 and is a mulch study incoporating pine bark, pine straw, wheat straw, peanut shells, landsacpe fabric, white on black plastic and a control. The experiment is a randomized complete block with 4 replications per treatment and 7 plants per replication. The cultivar is Brightwell. We are collecting leaf analysis data and plant growth data in 2007 and yield data in 2007. Native soils for rabbiteye blueberries are typically low in phosphate. Experiment 2, also initiated 30 Nov. 2006, is a phospate requirement study on Powderblue. UGA recommendations are to till in 300 pounds per acre of superphosphate if P is less than 20 pounds per acre. This relates to 2.87 grams per square foot. Phosphate sources include triple superphosphate (0-46-0), bone meal (1-13-0), Lonfonsco colloidal phospate (0-2-0) and Florida rock phosphate (0-3-0). Phosphate was applied in the planting hole at establishment. The experimental design is a randomized complete block with four replications of 5 plants per replication. Experiment 3 is a organic nitrogen study of mature Brightwell, Premier and Powderblue rabbiteye blueberries at the Miles farm. All treatments received 30 pounds of nitrogen (190 pounds of Nature Safe (8-5-5))in late winter and again just after harvest. Treatments are suplemented with 45, 60 and 75 pounds of feather meal (13-0-0) in the spring and again just after harvest. Yield data was compromised by a late spring frost. The experiment will be repeated for 2008. Experiment 4 involves mummy berry control in organic blueberries. This was a test on a mature planting of Brightwell and Tifblue near Alma Georgia. The following materials were

evaluated: 1) Actinovate; 2)Micro Sulf; 3) Organocide; 4) PlantShield HC; 5) Prev-Am; 6) Serenade Max; 7) Indar 75WSP (non-organic treatment) and an untreated control. Experiment 5 involves leaf spot management conducted this summer in Bacon County. The treatments include: 1) Pristine (non-organic industry standard); 2) Koicide 2000; 3) Actinovate; 4) Milstop; 5) Serenade Max plus Biotune surfactant; 6) Proud, and; 7) untreated control. The gall midge and leaf beetle were investigated in Gainesville FL and Alma Georgia, respectively. Three trap designs (adhesive coated petri dish, inverted funnel glass jar and oil coated plastic lid) were placed on the soil and tested for the gall midge. The petri dish caught 7 times the number of insects as the plastic lid traps and 3 times as many as the jar trap. The seasonal distribution of the gall midge was also assessed in flower buds collected from different locations of a blueberry planting. The efficacy of organic isceticides was tested on the leaf beetle (Colaspsi pseudofavosa). The insecticides were Entrust, PayGanic, Diatomaceous Earth (DE) and a control. The highest efficacy was for Entrust followed by DE and PayGanic. When insects were allowed to feed on leaves of different cultivars of blueberry for 48 hours Oneal sustained the most damage followed by Austin, Climax, Emerald and Star.

IMPACT

2006/09 TO 2010/08 There is ample justification for research on organic production of blueberry. The consumer demand and the price paid to the grower for organically-grown blueberries are high. Research on conventionally-grown blueberries has shifted toward intensification, and does not necessarily emphasize alternative methods of pest control and environmental sustainability. Economic forecasts indicate that there will be an increasing demand for organically-grown produce. There are several key limitations to organic blueberry production in the deep South. Significant issues of weed, insect and disease control and optimal cultural practices remain. Perhaps the most critical limitation in the Southeastern United States is weed control; organic herbicides and mulches are expensive. One unique aspect of organic blueberry production is the low soil pH that is not amenable to cover cropping for weed control or fertility management. Prior to this project there were blanket recommendations from other crops and other states. Available information was not based on rabbiteye blueberries (Vaccinium virgatum) and unique pest complexes in the deep South. We now have researched-based information on best management practices for organic rabbiteye blueberries including issues of establishment, fertility, mulches, pest management and economics. Hence, the acreage of organic blueberries in Georgia alone has increased from 10 to over 400 during the last 5 years. The expansion of the acreage of organic blueberries has contributed to economic development in the economically-depressed deep South. Some of our organic research is also amenable to conventional producers. Three examples are the evaluation of blueberry cultivars, the efficacy and economics of 7 different mulching systems and the monitoring and trapping of the blueberry gall midge. Partnerships and other forms of stakeholder input contributed to the design and management of the project. There was significant stakeholder input from organic growers both during project development and project execution. Much of the research has been conducted on farm with organic growers. We partnered with Georgia Organics, a major organic farming umbrella and interest group in Georgia. Many challenges still remain for future organic research. Probably the two greatest impediments to organic blueberry production in the deep South are weed control and fertility management. The organic production of the Southern highbush blueberries (largely developed by the University of Florida) has not been adequately researched and remains more problematic because they are more sensitive to soil conditions and pest pressures. Lastly, the predictability or the future economics of organic blueberries is an important research area, particularly as it relates to the early season market. **PUBLICATIONS (not previously reported):** 2006/09 TO 2010/08 1. 1. Liburd, O.E., A.J. Arevalo, E. Andrews and G. Krewer. 2007. Control of flea beetles in southern highbush and rabbiteye blueberries. Proc. 13th Biennial Southeast Blueberry Conf. 3 pp. 2. 2. Liburd, O.E., E.M. Sarzynki, B.J. Sampson and G. Krewer. 2007. Blueberry gall midge:A major insect pest of blueberries in the southeastern United States. UF/IFAS University of Florida IN458. 3. 3. Krewer G., M. Tertuliano, P. Andersen, O. Liburd, G. Fonsah, H. Serri, and B. Mullinix. 2009. Effect of mulches on the establishment of organically grown blueberries in Georgia. Acta horticulturae Vol. 2, 810: 483-488. 4. 4. Scherm H., Savalle A.T., G. Krewer, M. Tertuliano, and J.R. Clark. 2008. Control of Septoria leaf spot, Septoria albopunctata of blueberry, Vaccinium virgatum with biofungicides, 2008. Plant Disease Management Reports 2: STF037. 5. 5. Roubos, C.R. and O.E. Liburd. 2009. Evaluation of emergence traps for monitoring blueberry gall midge (Diptera: Cecidomyiidae) adults and within field distribution of midge infestation. J. Econ. Entomol. 103:1258-1267. 6. 6. Krewer, G., R. Walker, H. Scherm, and M. Tertuliano. 2008. Organic blueberry production. 2008 Proceedings of the First Annual Ozeki Nursery Japanese Blueberry Growers Conference pp. 1-63. 7. 7. Tertuliano M., G. Krewer, P. Andersen, H. Scherm, O. Liburd, E.G. Fonsah. 2009. Update on organic blueberry mulching research at Alma and comparison of organic vs conventional blueberry production at Alapaha, Ga. Georgia Fruits and Vegetables meeting. Savannah, Jan. 8-11, 2009. Proceeding of Blueberry Section, pp. 23-25. 8. 8. Krewer, G., M. Tertuliano, J.E. Smith, H. Scherm, K. Plattner, J. Clark, J. Jacobs, E.

Andrews, D. Stanaland, T. Varnadore, P. Andersen, O. Liburd, E.G. Fonsah and Ben Mullinix. 2009. Evaluation of seven mulching treatments for organic rabbiteye blueberry production. The Southern Assoc. of Agric. Scient. Conf., Atlanta, GA, Feb. 3-6, 2009. 9. 9. Tertuliano M., G. Krewer, H. Scherm, J.E. Smith, J. Clark, K. Plattner, P. Andersen, O. Liburd, E.G. Fonsah, D. Stanaland, J. Jacobs, T. Varnedore, and E. Andrews. 2009. Update on leaf beetle control and organic mulching experiment. Georgia Fruits and Vegetables meeting. Jan. 8-11, 2009. Proceeding of Blueberry Section; pp. 23-25. 10. 10. Krewer G., C. Horner, R. Horner, E. Andrews, M. van Iersel, A. Ogden, M. Rieger, M. Tertuliano and B. Mullinix 2009. Evaluation of high tunnels for organic southern highbush production in South Georgia. Georgia Fruits and Vegetables meeting. Jan 08-11, 2009. Proceeding of Blueberry Section; pp. 26-31. 11. 11. Tertuliano, M., G. Krewer, P. Andersen, O. E. Liburd and E. G. Fonsah 2008. Blueberry leaf beetle, Colaspis pseudofavosa Riley, IPM In: Organic blueberry systems. The 2008 Entomological Society of America Annual Meeting Abstract. Reno NV, Nov. 16-19, 2008. 12. 12. Krewer G., M. Tertuliano, P. Andersen, O. Liburd, G. Fonsah, H. Serri, and B. Mullinix. 2008. Effect of Mulches on the Establishment of Organically Grown Blueberries in Georgia. Proceeding of 9th International Vaccinium Symposium. Corvallis, Oregon, USA, Jul. 13-16, 2008). 13. 13. Roubos, C.R. and O.E. Liburd. 2010. Pupation and emergence of blueberry gall midge, Dasineura oxycoccana (Piptera: Cecidomyiidae), under varying temperature consitions. Florida Entomologist 93:283-290. 14. 14. Tertuliano, M., G. Krewer, J.E. Smith, K. Plattner, J. Clark, J. Jacobs, E. Andrews, D. Stanaland, T. Varnadore, P. Andersen, O. Liburd, G. Fonsah and H. Scherm. 2011. Growing organic blueberries in Georgia, USA: Results of two field experiments. International Journal of Fruit Production (in press).

2008/09/01 TO 2009/08/31 Research on organic blueberries involve: organic mulches, fertilization, mummy berry, leaf spot, leaf beetle and blueberry gall midges. Data generated from these studies will be invaluable toward establishing best management practices of organic blueberries in the southeastern U.S. A six year study was conducted to evaluate the effect of mulches on the performance of organically-grown Brightwell rabbiteye blueberry (Vaccinium virgatum Aiton). Treatments were plastic woven ground cover, pine straw, pine bark, and an unmulched control. It was necessary to reapply pine straw in years three and six, and reapply pine bark in year five. Weeds were suppressed with organic burn down compounds and by hand hoeing. Only limited additional weed control was required with the mulch treatments in the first two years. Over time the amount of supplemental weed control increased, especially for the ground cover treatment. By years five and six pine straw and pine bark produced the largest plants and the highest yields (7,500 kg per hectare). Powderblue and Brightwell blueberries were grown in 20 liter containers in loamy sand soil amended with composted pine bark (pH 4.5 to 5.0). Plants were subjected to the following OMRI-approved organic nitrogen treatments at low (2 g N) and high (4 g N): Cotton seed meal 6-2-1, Nature Safe 8-5-5, Blood Meal 12-0-0, Feather Meal 13-0-0 and Fish Meal 10-0-0. Fertilizer was applied ever six weeks at low (2 g N) and (4 g N) per container. Plant growth, yield berry size, berry soluble solids were recorded and are now being statistically analyzed. A subset of plants will be destructively sampled for leaf and stem dry weight. Leaf anaylses will also be performed. The following treatments were initiated for mummy berry (Monilinia vaccinii-corymbosi) control for Brightwell and Tifblue blueberries: 1) Actinovate; 2) Micro Sulf; 3) Oranocide; 4) PlantShield HC; 5) Prev-Am; 6) Serenade Max; 7) Indar WSP (non organic treatment) and an untreated control. The incidence of mummy berry was very low and the results will be discussed after statistical analyses. The management of foliar diseases (Phyllosticta vaccinii and Septoria albopunctata) is sometimes required to prevent premature defoliation and reductions in subsequent yield. Omega Grow (2%), SeaCide (1%) + Therm X70 (2 fl oz/A), Organic Gem (2%), Organocide (2%), Sporan EC (2.5 pt/Acre, Serenade (1.5 lbs/A) and an untreated control. These organic fungicides were applied four times during late summer. Treatments effect on disease severity were limited; only Organocide was significantly better than the control. None of the treatments affected percent defoliation or return bloom. Effective leaf beetle (Colaspis pseudofavosa) control was accomplished with Entrust (80W), PyGanic EC 5.0 and Diatomaceous Earth for two studies conducted in 2007 and 2008. Four emergence traps were tested for monitoring the blueberry gall midge (Dasineura oxycoccana) including a jar trap, a wheat blosson midge trap, petri dish trap, and a bucket trap. The latter two traps captured the highest number of adults in 2007 and 2008. Blueberry gall midge infestation was not uniform throughout the grove.

2007/09/01 TO 2008/08/31 Research on organic blueberry is underway. Experiments involve mulches, fertilization, mummy berry, leaf spot and leaf beetles. Data generated from these studies will be invaluable toward determing best management practices of organic blueberries in the southeastern United States.

2006/09/01 TO 2007/08/31 Experiments involving mulches, fertility, mummy berry, leaf spot leaf beetle are underway. Data generated from these studies will be invaluable toward determining best management practices of organic rabbiteye blueberries in the southeastern United States.

PUBLICATIONS

2008/09/01 TO 2009/08/31 1. Krewer G., M. Tertuliano, P. Andersen, O. Liburd, G. Fonsah, H. Serri, and B. Mullinix. 2009. Effect of mulches on the establishment of organically grown blueberries in Georgia. Acta horticulturae Vol. 2, 810: 483-488. 2. Scherm H., Savalle A.T., G. Krewer, M. Tertuliano, and J.R. Clark. 2008. Control of Septoria leaf spot, Septoria albopunctata of blueberry, Vaccinium virgatum with biofungicides, 2008. Plant Disease Management Reports 2: STF037. 3. Roubos, C.R. and O.E. Liburd. 2009. Evaluation of emergence traps for monitoring blueberry gall midge (Diptera: Cecidomyiidae) adults and within field distribution of midge infestation. J. Econ. Entomol. (submitted). 4. Krewer, G., R. Walker, H. Scherm, and M. Tertuliano. 2008. Organic blueberry production. 2008 Proceedings of the First Annual Ozeki Nursery Japanese Blueberry Growers Conference pp. 1-63 5. Tertuliano M., G. Krewer, P. Andersen, H. Scherm, O. Liburd, E.G. Fonsah. 2009. Update on organic blueberry mulching research at Alma and comparison of organic vs conventional blueberry production at Alapaha, Ga. Georgia Fruits and Vegetables meeting. Savannah, Jan. 8-11, 2009. Proceeding of Blueberry Section, pp. 23-25. 6. Krewer, G., M. Tertuliano, J.E. Smith, H. Scherm, K. Plattner, J. Clark, J. Jacobs, E. Andrews, D. Stanaland, T. Varnadore, P. Andersen, O. Liburd, E.G. Fonsah and Ben Mullinix. 2009. Evaluation of seven mulching treatments for organic rabbiteye blueberry production. The Southern Assoc. of Agric. Scient. Conf., Atlanta, GA, Feb. 3-6, 2009. 7. Tertuliano M., G. Krewer, H. Scherm, J.E. Smith, J. Clark, K. Plattner, P. Andersen, O. Liburd, E.G. Fonsah, D. Stanaland, J. Jacobs, T. Varnedore, and E. Andrews. 2009. Update on leaf beetle control and organic mulching experiment. Georgia Fruits and Vegetables meeting. Jan. 8-11, 2009. Proceeding of Blueberry Section; pp. 23-25. 8. Krewer G., C. Horner, R. Horner, E. Andrews, M. van Iersel, A. Ogden, M. Rieger, M. Tertuliano and B. Mullinix 2009. Evaluation of high tunnels for organic southern highbush production in South Georgia. Georgia Fruits and Vegetables meeting. Jan 08-11, 2009. Proceeding of Blueberry Section; pp. 26-31. 9. Tertuliano, M., G. Krewer, P. Andersen, O. E. Liburd and E. G. Fonsah 2008. Blueberry leaf beetle, Colaspis pseudofavosa Riley, IPM In: Organic blueberry systems. The 2008 Entomological Society of America Annual Meeting Abstract. Reno NV, Nov. 16-19, 2008. 10. Krewer G., M. Tertuliano, P. Andersen, O. Liburd, G. Fonsah, H. Serri, and B. Mullinix. 2008. Effect of Mulches on the Establishment of Organically Grown Blueberries in Georgia. Proceeding of 9th International Vaccinium Symposium. Corvallis, Oregon, USA, Jul. 13-16, 2008).

2007/09/01 TO 2008/08/31 1. Krewer, G., M. Tertuliano, H. Scherm, J.E. Smith, J. Clark, J. Jacobs, T. Varnedore, E. Andrews, K. Plattner, P.C. Andersen, O. Liburd, G. Fonsah, and H. Serri. 2008. Results of organic mulching trials at UGA Alapaha and UGA Bacon Co. blueberry stations-2007 update In; G. Krewer (ed.) Proc. of the Georgia Blueberry Conference (S.E. Regional Fruit and Vegetable Convention). Savannah, GA, pp. 18-19. 2. Tertuliano, M., G. Krewer, O. Liburd, P. Andersen, G. Fonsah, S. NeSmith, and J.E. Smith. 2008. Blueberry leaf beetle, Colaspis pseduofavosa, control in organic systems. In: G. Krewer (ed.) Proc. of the Georgia Blueberry Conference (S.E. Regional Fruit and Vegetable Convention). Savannah, GA, pp. 20-21. 3. Krewer, G., M. Tertuliano, P. Andersen, O. Liburd, G. Fonsah, H. Serri, and B. Mullinix. 2008. Effect of mulches on the establishment or organically grown blueberries in Georgia. In: Book of Abstracts for the 9th International Symposium on Vaccinium Culture. Acta Horticulturae (accepted for publication).

2006/09/01 TO 2007/08/31 1. Liburd, O.E., A.J. Arevalo, E. Andrews and G. Krewer. 2007. Control of flea beetles in southern highbush and rabbiteye blueberries. Proc. of 13th Biennial Southeast Blueberry Conference. 5-7 January 2007. 3pp. 2. Liburd, O.E., E.M. Sarzynki, B.J. Sampson and G. Krewer. 2006. Blueberry gall midge: A major insect pest of blueberries in the southeastern United States. EDIS UF/IFAS University of Florida IN458. 3. Plattner,K., E.G. Fonsah, C. Escalante, G. Krewer, H. Scherm, P.C. Andersen and M. Tertuliana. 2007. Economics of Organic Blueberry Establishment in Georgia. Food Distrubtion Research Society New Orleans LA 3-7 Nov. 2007. 4. Fonsah, E.G. 2007. Discussion on Emerging Organic and Natural Markets. Southern Outlook Conference Atlanta 24-26 September

↑ Return to Index

Beyond Corn and Soybean: Alternative Organic Crops for the Upper Midwest

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Investigator(s)	Sheaffer, C. C.; Harbur, M.; Allan, D.; Hathaway, M.; Wyse, D.
Performing Institution	AGRONOMY & PLANT GENETICS, UNIV OF MINNESOTA, ST PAUL, MINNESOTA 55108

NON-TECHNICAL SUMMARY

The expansion of organic farming has been driven by a high demand for organic products. Corn and soybean are the major organic crops and alternative crops are needed. Our goal is to diversify organic grain production systems. Crop diversification will improve weed and soil management and provide increased feed options for organic livestock producers.

OBJECTIVES

Compare the performance and nutritive value of alternative crops grown following corn or soybean. Compare the nutritive value or millet, barley, and buckwheat varieties and plant introductions. Determine the methionine bioavailability of millets, amaranth, and buckwheat. Deliver research findings to stakeholders using learning groups and other outreach activities.

APPROACH

Field experiments will be conducted at multiple locations to evaluate millet, barley, and buckwheat in rotations with corn and soybean. Swine feeding trials will be conducted to measure the methionine availability from organically grown millet, amaranth, and buckwheat

PROGRESS

2006/07 TO 2011/06 OUTPUTS: Objective 1 - Compare performances of alternative crops grown in sequence with organic corn and soybean. Oat, barley, wheat, field pea, pearl millet, flax, buckwheat, sorghum, and

amaranth were grown following corn, soybean, and alfalfa. In all 3 years, highest yielding alternative crops at 3 sites after corn and soybean were sunflower and small grains. Weed populations and biomass were greatest for field pea and flax indicating lack of competitiveness. We determined that fall-seeded oilseed radish was effective in reducing weeds in field pea and flax that were spring-seeded in the radish residue, but yields were reduced. Sweet sorghum was evaluated to determine adaptation to organic rotations as a corn alternative. At Staples, Simon and Della were the top performers in syrup production. At Lamberton, Sugar Drip and Dale yielded the highest. Umbrella and M81E performed best at Rosemount. At Lamberton in 2009, field pea varieties were tested in organic rotations. Admiral, Yellow and Miami yielded 51, 63, and 43 bu/ac. In 2010 at Lamberton, alternative crops were examined in rotation after alfalfa in addition to corn and soybean. Small grains yielded well, but other alternative crops performed poorly. Similar results were found after corn. Objective 2 - Evaluate methionine content of alternative crops. We grew alternative crops to determine potential to identify crops with increased grain methionine. In 2008, methionine content of dry bean, field pea, and flax were about 0.21% compared to 0.38% for soybean. Amaranth contained 0.16%. Foxtail millet, proso millet, barley, oat, and sorghum contained about 0.10%. In 2009, highest methionine concentrations occurred in sunflower, millets, and amaranth. Objective 3 - Determine methionine bioavailability to swine from alternative crops. Results showed low consumption by the piglets, due to the fine grind. The trial was conducted again with feed of a coarser grind and piglets grew well on the organic feed from the alternative crops. Objective 4 - Deliver research findings to stakeholders. Outreach efforts included field days, conferences, workshops, learning groups, and a manual. Plot tours of our experiments were conducted every July at the Organic Field Day in Lamberton with 125+ people. An on-farm field day on organic alternative crops was held in Staples in 2009. A 3rd on-farm field day was held in Pipestone in 2009. Results of this project were also presented at the Buckwheat Growers Association in 2008; the Minnesota Organic Conference in 2009 in St. Cloud; and at the Annual Southern Minnesota Organics Crops Day in 2009 in Owatonna. Workshops on growing alternative organic crops were held in St. Charles in 2008, Staples in 2009, Litchfield in 2009, and Lamberton in 2009. Learning group meetings with organic farmers were held regularly to discuss their experiences with alternative crops. We published the 300-page \"Risk Management Guide for Organic Producers\" manual. PARTICIPANTS: Individuals involved in this project - Dr. Craig Sheaffer is the Principal Investigator for \"Beyond Corn and Soybean: Alternative Organic Crops for the Upper Midwest\". He coordinated project activities that included overseeing the field research (alternative crops is rotation), the lab analysis (nutrient content, piglet study, and soil analysis), and outreach education (field days, plot tours, winter workshops, and learning group meetings). Dr. Deborah Allan conducted the soil quality testing for the alternative crops in rotation experiment. Dr. Marsha Hathaway was responsible for assessing the nutrient availability of alternative crops by testing the methionine availability to piglets. Dr. Don Wyse was involved with the research planning and interpreting the research results and will assist in manuscript preparation. Joshua Larson coordinated all the field research activities for this project at Rosemount, Lamberton, and Waseca. In the laboratory, Joshua analyzed grain samples for methionine and other nutrients. Kristine Moncada is conducting data analysis of the alternative crops in rotation study and the methionine content study. She assisted in event coordination such as the winter workshops, field days and learning group meetings. Pauline Nickel is the Southwest Research and Outreach Center Head. She plans the Organic Field Days held in Lamberton and oversees the organic research projects at the center. Mel Wiens is an organic producer in northwest Minnesota who has assisted with field days and plot tours in Staples, MN. Tom and DeEtta Bileks are organic producers who are involved in alternative crops marketing and have assisted with field days and plot tours. Carmen Fernholz, the organic research coordinator at the Southwest Research and Outreach Center, has helped coordinate organic research including the alternative crops in a corn-soybean rotation experiment. Carmen also assisted with learning group meetings, field days, and presentation of research results at regional conferences. TARGET AUDIENCES: The target audience for this research is organic producers from the Midwest. Efforts to convey project information to our target audience included winter workshops, conferences field days, plot tours, learning group meetings, and presentations at regional organic meetings. Another effort to reach our target audience is the \"Risk Management Guide for Organic Producers\" publication, a 300-page manual intended as a guide for organic and transitioning producers in the Upper Midwest to lower risk in their operations. The fourteen chapters of this manual cover a wide range of production topics that are relevant to organic farmers, including the importance of rotation, soil health and fertility, weed management, cover crops, and alternative crops. The website (http://www.organicriskmanagement.umn.edu/) has received almost 1000 visitors. PROJECT MODIFICATIONS: Not relevant to this project.

2009/07/01 TO 2010/06/30 OUTPUTS: Objective 1 - Compare performance of alternative crops grown in sequence with organic corn and soybean. Soybean, oat, spring barley, spring wheat, field pea, pearl millet, flax, buckwheat and amaranth were grown following corn, and following soybean with corn substituted for soybean at three locations over four years. Data analysis of these field experiments is being conducted. Objective 2 - Evaluate variation in nutritional value of alternative crops. We are evaluating the concentration of essential amino acids in organically grown soybean, oat, spring barley, spring wheat, field pea, pearl millet, flax, buckwheat and

amaranth. Objective 3 - Methionine bioavailability to swine from millets, amaranth, and buckwheat. One trial of the piglet feeding has been conducted. The trial will be conducted a second time with feed of a coarser grind to increase piglet consumption. Objective 4 - Deliver research findings to stakeholders. Plot tours of the organic alternative crop research were conducted at the Organic Field day in Lamberton, MN on July 9, 2009. Over 100 people attended this event where they could observe organic alternative crops such as peas, lentils, flax, and sunflowers in field research plots. An on-farm field day dedicated to organic alternative crops was held in Staples, MN on July 11, 2009 with 15 people attending. A third field day was held on-farm in Pipestone, MN on August 31, 2009 with 12 people in attendance. PARTICIPANTS: Individuals involved in this project - Craig Sheaffer is the Principal Investigator for \"Beyond Corn and Soybean: Alternative Organic Crops for the Upper Midwest\". He coordinates all activities relating to this project. Activities include overseeing the field research (alternative crops is rotation), the lab analysis (nutrient content, piglet study, and soil analysis), and outreach education (field days, plot tours, winter workshops, and learning group meetings). Deborah Allan conducts the soil quality testing for the alternative crops in rotation experiment. She will be doing the soil data analysis. Marsha Hathaway is responsible for assessing the nutrient availability of alternative crops. She has tested the methionine availability to piglets. Don Wyse is involved with the research planning. He will be interpreting the research results and assisting in manuscript preparation. Joshua Larson coordinates all the field research activities for this project at Rosemount, Lamberton, and Waseca. He plants, cultivates and harvests the alternative crops in rotation study. He oversees undergraduate students who collect and process samples. In the laboratory, Joshua has analyzed grain samples for methionine and other nutrients. Kristine Moncada conducts data analysis of the alternative crops in rotation study and the methionine content study. She assists in event coordination such as the winter workshops and field days. She conducts the learning group meetings. Kristine also prepares presentations with research results. She will be preparing manuscripts with the final research results. Pauline Nickel is the Southwest Research and Outreach Center Head. She plans the organic field day held in Lamberton and oversees the organic research projects at the center. Mel Wiens is an organic producer in northwest Minnesota. He has assisted with field days and plot tours in Staples, MN. Tom and DeEtta Bileks are organic producers who are involved in alternative crops marketing. The Bileks have assisted with field days and plot tours. Carmen Fernholz is the organic research coordinator at the Southwest Research and Outreach Center. He helps coordinate organic research including the alternative crops in a corn-soybean rotation experiment. Carmen also assists with learning group meetings, organizes field days, and presents research results at regional conferences. TARGET AUDIENCES: The target audience for this research is organic producers from the Midwest. Efforts to convey project information to our target audience include workshops, field days, plot tours, learning group meetings, and presentations at regional organic meetings. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2008/07/01 TO 2009/06/30 OUTPUTS: Objective 1 - Compare performance of alternative crops grown in sequence with organic corn and soybean. Soybean, oat, spring barley, spring wheat, field pea, pearl millet, flax, buckwheat and amaranth were grown following corn, and these same crops were grown following soybean with corn substituted for soybean at three locations over several years. Data analysis of these field experiments is being conducted. Objective 2 - Evaluate variation in nutritional value of alternative crops. We are evaluating the content of the essential amino acids in soybean, oat, spring barley, spring wheat, field pea, pearl millet, flax, buckwheat and amaranth. Objective 3 - Methionine bioavailability to swine from millets, amaranth, and buckwheat. We are growing and testing quantities of feed to conduct the feeding trial. Objective 4 - Deliver research findings to stakeholders. Plot tours of the organic alternative crop research were conducted at the Organic Field day in Lamberton, MN on July 10, 2008. Over 125 people attended this event. At the end of 2008, learning group meetings were held around the state. Three learning group meetings were held averaging an attendance of 6 producers per meeting. We discussed alternative crops and their production and other organic topics such as weed control and crop fertilization. Another learning group meeting was held in Lamberton, MN on March 17, 2009. 20 producers attended this meeting. A winter workshop on alternative crops was held in Litchfield, MN on March 24, 2009. 24 producers attended this meeting. On January 6, 2009, Craig Sheaffer gave a presentation on alternative crops and research results at a winter workshop in Staples, MN. Results of this project and other organic University research were also given at the Minnesota Organic Conference on January 16, 2009 in St. Cloud, MN and at the Annual Southern Minnesota Organics Crops Day on March 24, 2009 in Owatonna, MN. PARTICIPANTS: Individuals involved in this project - Craig Sheaffer is the Principal Investigator for \"Beyond Corn and Soybean: Alternative Organic Crops for the Upper Midwest\". He coordinates all activities relating to this project. Activities include overseeing the field research (alternative crops is rotation), the lab analysis (nutrient content, piglet study, and soil analysis), and outreach education (field days, plot tours, winter workshops, and learning group meetings). Matt Harbur is no longer employed by the University of Minnesota and not involved in this project. Deborah Allan conducts the soil quality testing for the alternative crops in rotation experiment. She will be doing the soil data analysis. Marsha Hathaway is responsible for the nutrient availability aspect of this project. She is preparing to test the methionine availability of the alternative crop in piglets. Don Wyse is involved with the research planning. He will be interpreting the research results and assisting in

manuscript preparation. Joshua Larson coordinates all the field research activities for this project at Rosemount, Lamberton, and Waseca. He plants, cultivates and harvests the crops in the alternative crops in rotation study. He oversees undergraduate students who collect and process samples. In the laboratory, Joshua has analyzed grain samples for methionine and other nutrients. Kristine Moncada conducts data analysis of the alternative crops in rotation study and the methionine content study. She assists in event coordination such as the winter workshops and field days. She conducts the learning group meetings. Kristine also prepares presentations with research results. She will be preparing manuscripts with the final research results. Collaborators on this project - Nathan Winter is an extension educator who helped organize a winter school on organic alternative crops in Litchfield, MN. Pauline Nickel is the Southwest Research and Outreach Center Head. She plans the organic field day held in Lamberton. She oversees the organic research projects at the center. Mel Wiens is an organic producer in northwest Minnesota. He has assisted with field days and plot tours in Staples, MN. Tom and DeEtta Bileks are organic producers who are involved in alternative crops marketing. The Bileks have assisted with field days and plot tours. Carmen Fernholz is the organic research coordinator at the Southwest Research and Outreach Center. He helps coordinate organic research including the alternative crops in a corn-soybean rotation experiment. Carmen also assists with learning group meetings, organizes field days, and presents research results at regional conferences. TARGET AUDIENCES: The target audience for this research is organic producers from the Midwest. Efforts to convey project information to our target audience include workshops, field days, plot tours, learning group meetings, and presentations at regional organic meetings. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2007/07/01 TO 2008/06/30 OUTPUTS: Objective 1 - Compare performances of alternative crops grown in sequence with organic corn and soybean. Soybean, oat, spring barley, spring wheat, field pea, pearl millet, flax, buckwheat and amaranth were grown following corn, and these same crops were grown following soybean with corn substituted for soybean at three locations. Weed management was a challenge especially following corn. Weed competition reduced the yield of peas and flax. We will be examining the agroecological and economical values of these alternative crops. Objective 2 - Evaluate variation in nutritive value of millets, barley, buckwheat, and other species. This experiment focuses on methionine, an essential amino acid that is limiting in most grains. We grew multiple varieties and plant introductions of pearl and proso millet, amaranth, buckwheat, and other species to determine the potential to develop varieties with increased methionine content. Samples are being analyzed for methionine and other essential amino acids. Preliminary results show that flax, sunflower, and amaranth were highest in methionine, while foxtail millet, proso millet, and dry bean were next highest. Spring wheat, chenopodium, field pea, buckwheat, spring oat, spring barley, and sorghum had methionine contents similar to or lower than corn. Flax had high crude protein content, comparable to the legumes like dry bean and field pea. This field experiment is on-going and further data analysis will be conducted. Objective 3 - Determine methionine bioavailability to swine from millets, amaranth, and buckwheat. Preparations are being made for the piglet feeding trials to begin in 2008. This experiment will be ongoing. Objective 4 - Deliver research findings to stakeholders. Plot tours of the experiments were conducted at the Organic Field Day in Lamberton, MN in July 2007. Preliminary research results were presented to the Buckwheat Growers Association in January 2008. We met with three organic farmers\' learning groups across the state in the winter and spring of 2008; topics of discussion included growing alternative crops. We held a winter school focused on organic feed crops in St. Charles, MN. The agenda included: Producing Organic Feed Crops and Accessing Organic Markets, Minimizing Risk in Organic Feed Crop Production, and a producer panel. We have several more educational activities planned including more learning group meetings and field plot tours. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2006/07/01 TO 2007/06/30 Organic experiments were established to compare the agroecological and economical value of alternative crops grown in rotation with corn and soybean. Soybean, oat, spring barley, spring wheat, field pea, pearl millet, proso millet, flax, buckwheat and amaranth were grown following corn, and these same crops were grown following soybean with corn substituted for soybean. Weeds were controlled following planting using mechanical tillage. Grain yields and grain quality (amino acid profile, protein, and fatty acid composition) will be measured. Weed population and soil quality effects of alternative crops will be determined. Another experiment involves methionine, an essential amino acid that is limiting in most grains. We grew multiple varieties and plant introductions of pearl and proso millet, amaranth, and buckwheat to determine the potential to select varieties with increased methionine content. Samples will be analyzed for methionine and other essential amino acids. Other research is examining peas and flax, which can be high value alternative crops but weed control is challenging. We evaluated the use of winter mulches of oilseed radish and oat to suppress weeds in flax and peas. A preliminary result is that oilseed radish effectively controlled weeds without reducing flax or pea yield

compared to the control. All field experiments are on-going and further data analysis will be conducted. The research results will be distributed to producers through various educational programs.

IMPACT

2006/07 TO 2011/06 Corn and soybean are commonly grown organic crops for processing into human foods or for livestock feeding. Diversification of crop rotations to include crops beyond corn and soybean is critical to provide economic insurance as well as ecosystem services. Improved production practices for commonly grown, alternative organic crops will decrease their costs to consumers and make healthy foods available to more consumers in our society. Crops like field bean, peas, and lentils that are high in protein and amino acids have great potential to be grown by organic farmers and to be used locally to provide healthy foods for the general public. In addition, these grains can be used as a protein replacement for soybean in livestock rations. Increased diversification of the number of crops that can be grown provides great reduction in the production and economic risks to producers. Yield and nutritional information on alternative crops like flax, millet, amaranth, buckwheat, and peas is important to determine their economic value to producers. The results of this project will provide options for rotation diversification, improve methods for growing alternative crops, and develop crops with richer sources of methionine for livestock. We explored the effect of crop rotation and found that weed control was more challenging after corn. We also found that organic sunflower and small grains were among the most successful alternative crops over the different locations and years. Laboratory analysis showed that sunflower, millets, and amaranth have potential for livestock feed with higher methionine content when compared to corn. Organic producers learned the latest results of our research through several field days and plot tours, while we learned about producers\' experiences with alternative crops through our semi-annual learning group meetings. Organic agriculture intrinsically has greater risk than conventional agriculture because of the greater complexity in crop management issues such as fertility, weed control and pest control. Consequently, we found a need for information directed to organic producers on managing risk. One of the outcomes of this project was the development of our \"Risk Management Guide for Organic Producers\" publication, a 300-page manual intended as a guide for organic and transitioning producers in the Upper Midwest to lower risk in their operations. The fourteen chapters of this manual cover a wide range of production topics that are relevant to organic farmers, including the importance of rotation, soil health and fertility, weed management, cover crops, and alternative crops. Learning group discussions with organic producers provided us with their experiences, which were incorporated in the manual. Research results from this project were used to support our discussion, particularly for Chapter 14 Alternative Crops and Chapter 2 Rotation. The website with the manual (http://www.organicriskmanagement.umn.edu/) has received almost 1000 visitors. We have received excellent feedback from numerous organic producers on the publication. **PUBLICATIONS (not previously reported):** 2006/07 TO 2011/06 1. Moncada, K. M. and Sheaffer, C. C. (editors). 2010. Risk Management Guide for Organic Producers. University of Minnesota. This 300-page PDF manual is available at: www.organicriskmanagement.umn.edu . 2. Coulter, J.A., Sheaffer, C.C., Haar, M.J., Wyse, D.L., and J.H. Orf. 2011. Agronomic performance of cropping systems with contrasting crop rotations and external inputs. Agronomy Journal 103(4):1223-1229.

2009/07/01 TO 2010/06/30 Objective 1 - Compare performance of alternative crops grown in sequence with organic corn and soybean. The Rosemount site was extremely dry in 2009 and alternative crops such as buckwheat, foxtail millet, Japanese millet, and proso millet had poor yields. The yield of corn, grain sorghum and sunflower were 66, 22, and 32 bushels/acre, respectively. The addition of compost equivalent to 80 lbs of nitrogen/acre increased yields of the crops to 99, 22, and 51 bushels/acre, respectively. At Lamberton, amaranth, grain sorghum, and Japanese millet had poor yields. Yields of buckwheat, corn, foxtail millet, proso millet, and sunflower were 37, 60, 28, 26, 118 bushels/acre. The addition of compost equivalent to 80 lbs of nitrogen to buckwheat, corn, foxtail millet, proso millet, and sunflower resulted in yields of 30, 88, 33, 14, and 129 bushels/acre. Sweet sorghum varieties were evaluated to determine their adaptation to organic rotations as an alternative to corn. In Staples, which has a short season, \'Simon\' and \'Della\' were the top performers in syrup production with 2258 and 2237 gallons of syrup/acre. At Lamberton, \'Sugar Drip\' and \'Dale\' yielded 1514 and 1195 gallons/acre. Improved varieties, \'Umbrella\' and \'M81E\', performed best at Rosemount with 2634 and 2526 gallons/acre. At Lamberton in 2009, the field pea varieties, \'Admiral\', \'Yellow\' and \'Miami\' yielded 51, 63, and 43 bushels/acre, respectively, in organic rotations. Objective 2 - Evaluate variation in nutritional value of alternative crops. Methionine content of recently harvested alternative crops is being analyzed. Objective 3 - Methionine bioavailability to swine from millets, amaranth, and buckwheat. Preliminary results demonstrated low consumption of alternative crop feed by the piglets, most likely due to the feed being ground too fine. Another feeding trial will be conducted with organic alternative feeds that are more coarsely ground with a longer

adjustment period for the piglets. Objective 4 - Deliver research findings to stakeholders. Organic producers learned the latest results of our research through several field days and plot tours. We learned about producers\' experiences with alternative crops. Overall impacts: Improved production practices for commonly grown and alternative organic crops will decrease their costs to consumers and make healthy foods available to more consumers in our society. In addition, these grains can be used as a protein replacement for soybean in livestock rations. Increased diversification of the crops that can be grown provides great reduction in the production and economic risks to producers.

2008/07/01 TO 2009/06/30 Objective 1 - Compare performance of alternative crops grown in sequence with organic corn and soybean. A significant location by alternative grain crop effect occurred for grain yields. At Waseca sunflower and milo had the greatest grain yield following corn while flax had the least yield. Field pea, amaranth, and buckwheat yields were intermediate and similar. At Rosemount, yields of all grain crops following corn were less that at Waseca due to the lack of soil moisture but grain yields were again greatest for milo and least for flax and buckwheat. At each location, weed populations and biomass were greatest for field pea and flax indicating the relative lack of competitiveness of these crops. At Waseca, barley, foxtail millet, and sunflower had the greatest yield following soybean, while at Rosemount yields following soybean were greatest for wheat and barley. At both locations, flax was the lowest yielding crop. Weed yields were greatest for flax and wheat at Rosemount and Waseca, respectively. We also determined that fall seeded oilseed radish was effective in reducing weeds in field pea and flax that were spring seeded into the radish residue but oilseed radish reduced flax and pea yields. Objective 2 - Evaluate variation in nutritional value of alternative crops. Methionine content of dry bean, field pea, and flax averaged 20.9 % (crude protein basis) compared to 37.8% for soybean. Amaranth grain contained 16% methionine (crude protein basis). Foxtail millet, proso, millet barley, oat, and sorghum contained about 10% methionine (crude protein basis). The legumes, dry bean, soybean, and field pea were also high in lysine while grass crops (millets, barley oat and sorghum) were very low in methionine. Plant introduction of millets and amaranth did not differ in methionine content. Objective 4 - Deliver research findings to stakeholders. Organic producers learned the latest results of our research through learning groups and plot tours. We learned about producers\' individuals experiences with alternative crops. Overall impacts: Improved production practices for commonly grown and alternative organic crops will decrease their costs to consumers and make healthy foods available to more consumers in our society. Crops like field bean, peas, and lentils that are high in protein and amino acids have great potential to be grown by organic farmers and to be used locally to provide healthy foods for the general public. In addition, these grains can be used as a protein replacement for soybean in livestock rations. Increased diversification of the number of crops that can be grown provides great reduction in the production and economic risks to producers.

2007/07/01 TO 2008/06/30 Corn and soybean are commonly grown organic crops for processing into human foods or for livestock feeding. Diversification of crop rotations is critical to provide economic insurance as well as ecosystem services. Yield and nutritional information on alternative crops like flax, millet, amaranth, buckwheat, and peas is important to determine their economic value to producers. The results of this project will provide options for rotation diversification, improve methods for growing alternative crops, and for development of crops with richer sources of methionine for livestock.

2006/07/01 TO 2007/06/30 Corn and soybean are commonly grown organic crops for processing into human foods or for livestock feeding. Diversification of crop rotations is critical to provide economic insurance as well as ecosystem services. Yield and nutritional information on alternative crops like flax, millet, amaranth, buckwheat, and peas is important to determine their economic value to producers. The results of this project will provide options for rotation diversification, improve methods for growing alternative crops, and develop crops with richer sources of methionine for livestock.

PUBLICATIONS

2009/07/01 TO 2010/06/30 No publications reported this period

2008/07/01 TO 2009/06/30 No publications reported this period

2007/07/01 TO 2008/06/30 No publications reported this period

2006/07/01 TO 2007/06/30 No publications reported this period

↑ Return to Index

Transition Strategies That Control Perennial Weeds and Build Soil

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Investigator(s)	Cardina, J.; Felix, J.; Doohan, D.; Stinner, D.; Batte, M.
Performing Institution	HORTICULTURE AND CROP SCIENCE, OHIO STATE UNIVERSITY, 1680 MADISON AVENUE

NON-TECHNICAL SUMMARY

Perennial weeds are one of the most important problems for adoption, expansion, and sustainability of organic farming. Perennials are a challenge because they produce long-lived underground structures that survive cultivation other control tactics. A survey of organic growers in Ohio showed that perennial weed control was the major limitation to successful transition; some growers were ready to abandon organic methods because of problems with perennial weeds. Perennial weeds require years of persistent effort for effective control, especially in vegetable crops that are not competitive against weeds. Current control methods disturb the soil so much that soil-building goals of organic management are ineffective. Organic farmers need to know how to design transition strategies that allow them to control perennial weeds while building the soil and gaining a financial return during and after transition. We will develop and evaluate transition strategies and outreach information for management of perennial weeds while enhancing soil quality for organic vegetable crop production. Biologically-based and properly timed control efforts, integrated with soil building measures, will provide effective and economical transition strategies that can be readily adopted by organic and transitioning farmers. The research is a response to feedback we have received from organic farmers during our on-farm weed survey as well as during workshops and presentations and telephone conferences.

OBJECTIVES

1) Evaluate the biological and economic impacts of strategies for transitioning to organic vegetable production in fields with perennial weeds. 2) Evaluate the impact of on-farm management strategies on perennial weeds and soil quality. 3) Facilitate development of a learning community to share, evaluate, and generate information on problems with perennial weeds during transition.

APPROACH

There will be four basic cropping systems: clean fallow + smother crops, a standard one-crop/year with cultivation, a fabric-culture system designed by a local organic grower, and short-season crops that allow frequent cultivation. Within each system will be three nutrient management options: an untreated control, annual compost applications, and annual compost plus high-calcium lime and other OMRI-approved nutrient additions to achieve nutrient ratios recommended by biodynamic farmers. These treatments will be imposed in an alfalfa/grass hay field, which represents a typical starting point for transition to organic vegetables. This will allow us to evaluate a wide range of strategies that incorporate different mechanical, cultural, and natural-product weed management options together with different nutrient management levels. Performance of these strategies will be evaluated using biological indicators (soil quality, weed suppression) and economic returns during transition, and during the first vegetable crop season after transition. The combination of weed management with nutrient management options will allow us to explore weed/soil interactions that are of great interest to organic farmers. We will work with cooperating farmers to study how perennial weed patches respond to grower management practices. Our rationale is that understanding the behavior of perennial weed populations in response to variations in farm field conditions, soil quality indicators, and farmer management decisions will help us design farm-relevant transition strategies that are more effective in perennial weed suppression. We will focus on the most important perennial weeds identified by farmer cooperators; these are Canada thistle, quackgrass, yellow nutsedge, and field bindweed. In fields that have been managed as pasture or reduced-tillage corn/soybean rotations, it is fairly easy to discern discrete patches of these perennials, due to their interconnected underground vegetative connections. These species also occur in patchy distributions along field edges, from which they spread into otherwise well managed crop fields. Farmers will choose fields that have known perennial weed infestations and patches will be selected to monitor and map changes in these patches and in soil quality indicators; data will also be collected on all inputs and management operations in the fields of interest. Outreach activities will be developed through informal learning communities that have self-organized among organic farmers in Ohio. We will integrate relevant foundational biology and ecology into this network and to bring to it increased scientific rigor to evaluate results from participatory experiments that will be conducted under the domain of this proposal.

PROGRESS

2006/07 TO 2011/06 OUTPUTS: Studies were conducted to evaluate the effects of five organic transition strategies on soil quality, weed suppression, and yield of tomato and potato in the first year of organic production. The transition strategies included a tilled fallow, non-treated weedy, high diversity prairie mixture, smother crops, and vegetable rotation. Subplots with and without compost application were also included. Another study was conducted to determine optimal tef and sorghum-sudangrass mixtures for biomass production and weed suppression. Tef and sorghum-sudangrass were planted in monoculture and in mixture with soybean and sunflower. The percentage cover of crops and weeds and height of crops were measured weekly, and final biomass was measured for component crops and weeds. Biomass was used to calculate the land equivalent ratio (LER) and aggressivity indices of crops in mixture. Another study was conducted to evaluate tef as a smother crop for management of weeds during transition to organic production. Greenhouse and field trials were conducted to evaluate the growth of eight tef varieties and their effect on Canada thistle and annual weeds. A major cropping system study was conducted to evaluate smother crop mixtures seeded, at different times, for Canada thistle control. Field trials were established to evaluate the ability of smother crop mixtures to suppress Canada thistle growth and development. Results were shared with organic farming audiences at annual field days and at the Ohio Ecological Food and Farming Association annual meeting. Presentations were made and posters displayed at regional and national scientific meetings. In-field presentations were made at urban garden sites to adult and youth groups. One doctoral graduate student completed a dissertation based on this work, and three peer-reviewed publications about this work are in print. Annual field days were held for the public to tour our field plots and learn about the organic research. Workshops were presented at an upscale organic foods market (two locations) to provide practical information to the consumer, gardener, and farmer about organic food production, food safety and to bridge the gap between local organic food producers and consumers. Investigators on this project conducted lectures in an undergraduate course, Organic Farming and Gardening offered at the Agricultural Technical Institute for associate degree students. PARTICIPANTS: Stephanie Wedryk, Catherine Herms, Peter McDonough, Joel Felix, Douglas Doohan, Ohio Ecological Food and Farming Association, Ohio State University Agricultural Technical Institute, Ohio Agricultural Research and Development Center Organic Food and Farming Education and Research program. TARGET AUDIENCES: Organic farmers, transitioning farmers, extension educators, and researchers are the main audience for this project. Efforts to change knowledge in this audience included annual field days and presentations at various meetings. Presentations were made and posters displayed at regional and national scientific meetings. In-field presentations were made at urban garden sites to adult and youth groups. Annual field days were held for the public to tour the field plots and

share results. Workshops were presented at grocery stores, and lectures were presented in an undergraduate course. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2008/07/01 TO 2009/06/30 OUTPUTS: Soil samples were taken to study the impact of transition strategies and compost addition on soil quality. Transition strategies implemented were: Nontreated - allow weeds to grow and mow once per year; Fallow - disk field when weeds grow to be 5-6 cm; Biomass - a mix of sixteen native prairie species was planted in year one; Vegetable -four varieties of edamame soybeans were planted in year one, mixed vegetables (lettuce, cabbage, kale, brussel sprouts) in year two; and edamame soybeans in year three; Smother crop -a commercial blend of Royal oats and Packer peas was planted in year one; a mix of soybean and sorghum-sudangrass in subsequent years. The crop mixes provided a dense cover of the plots to control Canada thistle and annual weed growth by preventing light from reaching the soil surface. Additional smother crop studies included work on the interaction of three planting dates and three smother crop mixes on Canada thistle and other weed control. The three mixes are: Royal oats, Packer peas, and Florida Broadleaf India mustard; VA-T1 tef, Santiago burr medic, and buckwheat; Special Effort sorghum-sudangrass, Stonewall forage soybeans, and S678 sunflower. Additional work compares the smothering ability of eight tef varieties as well as a comparison between sorghum-sudangrass smother crop mixes and tef crop mixes. Combinations of grass, legume, and forb species were used as smother crop mixes, but crimson clover and kenaf did not perform well against Canada thistle. Different planting times of smother crop mixes were tested for smothering ability against Canada thistle. We evaluated mixtures of smother cropping species for suppression of Canada thistle in field and greenhouse experiments. Eight varieties of Tef were evaluated as a smother crop against early emerging Canada thistle. We hosted The Organic Food and Farming Education and Research (OFFER) Field Day as part of their annual tour, along with visitors from around Ohio and neighboring sttes. PARTICIPANTS: J. Cardina D. Doohan C. P. Herms S. Walker D. Stinner Z. Hussain E. Duarte TARGET AUDIENCES: Organic Food and Farming Extension and Research (OFFER) Ohio Ecological Food and Farming Association PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2007/07/01 TO 2008/06/30 OUTPUTS: Five management strategies for transitioning from conventional to organic vegetable production were evaluated for weed suppression and soil quality. This was the final year of the transition period, to be followed by a year with a uniform crop in all plots. The biomass crop consisted of a diverse mix of prairie species, which was dominated by Rudbekia triloba. The vegetable treatment plots were planted to two varieties of edamame soybeans, both of which emerged poorly and did not compete effectively with weeds. A clean fallow was difficult to achieve, due to heavy infestation with Canada thistle, which was often more dense than in the non-treated control plots. Combinations of grass, legume, and forb species were used as smother crop mixes. Two species, crimson clover and kenaf did not perform well against Canada thistle. The crimson clover did not grow tall enough to be competitive. Other mixes that included any combination of sorghum-sudangrass, tef, soybean, and sunflower were competitive against Canada thistle and effectively smothered it. Canada thistle affected by these mixes had weak stems and fewer and weaker thistles. The most competitive mix was sorghum-sudangrass, soybean, and sunflower. In the next year, only sorghum-sudangrass, soybean, tef, and sunflower will be tested in smother crop mixes. Different planting times of smother crop mixes were tested for smothering ability against Canada thistle. Of the mixes planted on May 1, the oat, pea, mustard mix smothered Canada thistle most effectively. The second planting date was May 22 and the mix seeded on this date that suppressed Canada thistle most effectively was sorghum-sudangrass, soybean, and sunflower. Of the mixes planted on June 15, the tef, burr medic, and buckwheat mix was the most competitive against Canada thistle. The experiment will be repeated in the next growing season.We evaluated mixtures of smother cropping species for suppression of Canada thistle in field and greenhouse experiments. Eight varieties of Tef were evaluated as a smother crop against early emerging Canada thistle. The variety \"Pharaoh\" was most effective in weed suppression. The differences in smothering ability of tef varieties will be further explored in the next year. Germination and competitiveness of seedlings against Canada thistle will be investigated to see if differences at these stages help to confer a competitive advantage of varieties. PARTICIPANTS: Individuals who worked on the project: Stephanie Wedryk, graduate research associate, Lourdes Arreuta, visiting scholar, Eileen Duarte, visiting scholar Zahid Hussain, visiting scholar. Partner organizations include the following: Organic Food and Farming Education and Research (OFFER), interdisciplinary team Ohio Ecological Food and Farming Association (OEFFA) TARGET AUDIENCES: The target audience is farmers transitioning from conventional to organic production. This might be an entire farm, or in most cases, one field at a time on an existing organic farm. To help facilitate this, we have participated in two courses called \"Organic 101\" and \"Organic 201\" which were presented in two locations to new and transitioning farmers. The data we collect from this project are summarized and put into a form for presentation to this audience. Our eventual goal is to contribute to a book on transition of agricultural systems. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2006/07/01 TO 2007/06/30 OUTPUTS: Different smother cropping strategies were tested against Canada thistle. Tef was tested as a smother crop and effectively outcompeted Canada thistle. Eight different varieties were tested and \"Pharaoh\" variety showed the best ability to smother Canada thistle. The differences in smothering ability of tef varieties will be further explored in the next year. Germination and competitiveness of seedlings against Canada thistle will be investigated to see if differences at these stages help to confer a competitive advantage of varieties. Combinations of grass, legume, and forb species were used as smother crop mixes. Two species, crimson clover and kenaf did not perform well against Canada thistle. The crimson clover did not grow tall enough to be competitive. Japanese beetles damaged the kenaf shortly after planting. Other mixes that included any combination of sorghum-sudangrass, tef, soybean, and sunflower were competitive against Canada thistle and effectively smothered it. Canada thistle affected by these mixes had weak stems and fewer and weaker thistles. The most competitive mix was sorghum-sudangrass, soybean, and sunflower. In the next year, only sorghum-sudangrass, soybean, tef, and sunflower will be tested in smother crop mixes. Different planting times of smother crop mixes were tested for smothering ability against Canada thistle. Of the mixes planted on May 1, the oat, pea, mustard mix smothered Canada thistle most effectively. The second planting date was May 22 and the mix seeded on this date that suppressed Canada thistle most effectively was sorghum-sudangrass, soybean, and sunflower. Of the mixes planted on June 15, the tef, burr medic, and buckwheat mix was the most competitive against Canada thistle. The experiment will be repeated in the next growing season. PARTICIPANTS: Individuals who worked on the project: Stephanie Wedryk, graduate student Eileen Duarte, visiting scholar Zahid Hussain, visiting scholar Partner organizations include the following: Organic Food and Farming Education and Research (OFFER), interdisciplinary team Ohio Ecological Food and Farming Association (OEFFA) TARGET AUDIENCES: The target audience is farmers transitioning from conventional to organic production. This might be an entire farm, or in most cases, one field at a time on an existing organic farm. To help facilitate this, we have participated in a course called \"Organic 101\" which was presented in two locations in 2008 to new and transitioning farmers. The data we collect from this project is summarized and put into a form for presentation to this audience. Our eventual goal is to contribute to a book on transition of agricultural systems. PROJECT MODIFICATIONS: No major changes.

IMPACT

2006/07 TO 2011/06 Transition strategies affected weed density and biomass in the first organic year with the prairie strategy being the most suppressive. Compost application increased plant available nutrients and soil organic matter. The fallow transition strategy improved the quantity of plant available P and K 33 and 15 percent, respectively, while the prairie strategy improved soil organic matter by 10 percent or more. Compost application increased yields of potato 50 percent and tomato 17 percent, with transition strategy affecting the number and weight of cull potato tubers. Canonical correlation analysis showed that plant available nutrients strongly influenced potato yield while organic matter affected tomato yield. Biomass production was affected by the species of grass in monoculture or mixture, but land-equivalent-ration was greater in 3-species mixtures than monoculture. Aggressivity of grass crops was linearly related to total land-equivalent-ratio in 2- and 3-species mixtures. Percent cover of crops was greater in multi-species mixtures and weed cover was suppressed 70 and 45 percent in 2008 and 2009 by multi-species mixtures. The biomass and percent cover of the grass crop in mixture or monoculture was related to total biomass production and percent cover. Canada thistle biomass was suppressed 50 percent in 2009 and 87 percent in 2010 by the sorghum-sudangrass mixture. The oat mixture suppressed annual weed biomass more than 58 percent. Canada thistle shoot density and percent cover were affected by the crop mixture in 2009 and 2010, with sorghum-sudangrass being the most suppressive. Tef decreased the biomass of Canada thistle shoots and rhizomes 44 to 74 percent depending on variety. In field studies, tef varieties suppressed annual weeds 35 to 54 percent, but there were no differences among varieties. Canada thistle growth was suppressed 73 percent by tef in 2008 and 37 percent in 2009, a year of cooler temperatures and unseasonal rainfall. All tef varieties except Pharaoh were competitive with Canada thistle in the field experiment. The transition strategy implemented during the 3 years prior to organic farming can affect the weed density and biomass in the first year of organic production. The use of native, perennial prairie species can suppress Canada thistle, monocot, and broadleaf weeds. Prairie species are also a potential source of biofuel feedstocks for ligno-cellulosic fuel markets that may provide economic return during transition. Smother crops were effective at reducing populations of Canada thistle and weed biomass. Compost applications and transition strategies during organic transition improved soil fertility and quality. During the first year of organic production, compost application strongly affected potato and tomato yield and quality. In potato production, plant available nutrients had the strongest influence on yield. Transition strategies that increase soil nutrients were most effective in improving yields in the first year of organic potato production. However, in tomato production, improving OM in the soil may have the strongest influence on first-year organic yields. **PUBLICATIONS (not previously

reported):** 2006/07 TO 2011/06 1. Wedryk, S., J. Felix, D. Doohan, and J. Cardina. 2012. Strategies for weed suppression and improving soil fertility during transition to organic vegetable production. Hort Technology 22:207-214. 2. Wedryk, S. and J. Cardina. 2012. Smother crop mixtures for Canada thistle suppression in organic transition. Weed Science. In Press. 3. Wedryk, S. and J. Cardina. 2012. Evaluation of tef as a smother crop during transition to organic management. Weed Technology 26:102-109.

2008/07/01 TO 2009/06/30 The crimson clover did not grow tall enough to be competitive. Other mixes that included any combination of sorghum-sudangrass, tef, soybean, and sunflower were competitive against Canada thistle and effectively smothered it. Canada thistle affected by these mixes had weak stems and fewer and weaker thistles. The most competitive mix was sorghum-sudangrass, soybean, and sunflower. In the next year, only sorghum-sudangrass, soybean, tef, and sunflower will be tested in smother crop mixes. Of the mixes planted on May 1, the oat, pea, mustard mix smothered Canada thistle most effectively. The second planting date was May 22 and the mix seeded on this date that suppressed Canada thistle most effectively was sorghum-sudangrass, soybean, and sunflower. Of the mixes planted on June 15, the tef, burr medic, and buckwheat mix was the most competitive against Canada thistle. The variety Pharaoh was most effective in weed suppression. The differences in smothering ability of tef varieties will be further explored in the next year. Germination and competitiveness of seedlings against Canada thistle will be investigated to see if differences at these stages help to confer a competitive advantage of varieties. Smother crops suppressed some of the worst weeds of vegetable production while building soil carbon and providing economic return during the transition from conventional to organic production. Perennial weeds, such as Canada thistle, are most difficult to control since certification measures require that no herbicides be used for three years prior to harvest of the first organic crop. Establishment of the smother crops was difficult, and in a cool growing season, thistle can out-grew smother crops that are adapted to warmer conditions.

2007/07/01 TO 2008/06/30 OARDC research is pointing to smother crops like sorghum, tef, and forage-type soybeans to help farmers suppress tough weeds like Canada thistle during the three-year transition period from conventional to organic crops. Also effective are diverse mixes of native prairie plants that could be harvested as a biofuel crop. Results show that these smother crops can suppress some of the worst weeds of vegetable production while building soil carbon and providing economic return during the transition from conventional to organic production. Worst are perennial weeds, like Canada thistle, since certification measures require that no herbicides be used for three years prior to harvest of the first organic crop. However, researchers caution that establishment of the smother crops can be difficult, and in a cool growing season, such as early 2009, thistle can out-grow smother crops that are adapted to warmer conditions. Combinations of early season tillage followed by vigorous crops like sorghum-sudangrass can keep Canada thistle from spreading and deplete the energy reserves in the thistle rhizomes.

2006/07/01 TO 2007/06/30 OARDC researchers are finding ways to transition from conventional to organic vegetable production in the worst of circumstances: a field infested with Canada thistle. Troublesome perennial weeds, like Canada thistle, are one of the main impediments to the adoption of organic farming, since certification measures require that no herbicides be used for three years prior to harvest of the first organic crop. OARDC scientists are finding that smother crops like sorghum, tef, and forage-type soybeans can help farmers suppress thistle during the three-year transition period. Also effective are diverse mixes of native prairie plants that can be harvested as a biofuel crop. Research at OARDC is providing farmers with novel management strategies that suppress the worst weeds of vegetable production while building soil carbon and providing economic return during the transition from conventional to organic production.

PUBLICATIONS

2008/07/01 TO 2009/06/30 No publications reported this period

2007/07/01 TO 2008/06/30 No publications reported this period

2006/07/01 TO 2007/06/30 No publications reported this period

↑ Return to Index

Organic Farming of Marine Shrimp: a Holistic Approach to Management of Feeds & Microbial Dynamics

Accession No.	0206743
Subfile	CRIS
Project No.	SCW-2006-02028
Agency	NIFA SC.W
Project Type	OTHER GRANTS
Project Status	TERMINATED
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Proposal No.	2006-02028
Start Date	01 SEP 2006
Term Date	30 NOV 2009
Fiscal Year	2008
Grant Amount	$431,203
Grant Year	2006
Investigator(s)	Browdy, C. L.
Performing Institution	MARINE RESOURCES DIVISION, SC DEPT OF NATURAL RESOURCES, 217 FT. JOHNSON ROAD, P.O. BOX 12559

NON-TECHNICAL SUMMARY

The US imports increasing quantities of shrimp of variable quality. Some imported products have been associated with contamination and/or environmentally unsustainable production practices. Holistic organic approaches for farming of shrimp will be developed. New organic certifiable plant-based diets will be applied in an integrated farming system designed to maximize natural productivity while minimizing waste.

OBJECTIVES

1. Explore the inter-relationships between organically certifiable diet formulations & characteristics of water column microbial floc communities in terms of shrimp growth, system productivity & edible tissue nutritional profiles. 2. By controlling inputs of organic certifiable fertilizer & organic certifiable shrimp feed, C/N ratios will be modified to explore effects on the functional dynamics of system microbial floc communties. 3. Model the funtional role of microbial floc communities in determining system water quality stability, efficiency of nitrogen & carbon assimilation into shrimp & production of dissolved & particulate waste. 4. Deliver applied production information producers through commercial scale on-farm demonstration, seminars & publications.

APPROACH

Organic certifiable cultured shrimp can command competitive prices & can be raised in a sustainable manner that ensures high nutritional quality safety from chemical contamination,& minimal environmental impact from wastes. The proposed work builds on our recent success in raising shrimp on an organic certifiable, plant-based diet, as well as many years of experience developing high density, zero exchange production systems. The goal is to produce organic certifiable shrimp with all the nutritional quality of wild shrimp while managing the water quality & nutrient wastes in an environmentally sustainable, economically viable manner. The proposed project will

develop, disseminate, & demonstrate protocols for a holistic approach to driving the functional dynamics of microbial floc communities in zero exchange shrimp aquaculture ponds by managing feed formulations & nutrient inputs. Using this ecosystem based approach, increasing shrimp growth, productivity & product quality can be achieved through food formulation integrated with naturally derived nutritional supplemention. It will also reduce export of wastes to the environment through enhanced nutrient cycling, as well as reduce both economic rish & livestock stress by stabilizing water chemistry. The goals will be achieved by a stewise process. First, feed composition will be varied in a microcosm system to explore the integrated effects of distinct microbial floc communities & diet formulation on shrimp growth, production & fatty acid composition. Second, carbon & nitrogen budgets will be modeled for a series of replicated mesocosm tanks in which shrimp stocking density & system nutrient inputs are varied in a controlled fashion. This will provide data for optimizing the timing & composition of organic fertilizer & organic shrimp feed for different production intensities. With the assistance of extension professionals, the results will be synthesized & disseminated through scientific publications presentation & extension fact sheets as well as by commercial scale farm demonstration trials in cooperation with two commercial producers. With the pending establishment of USDA standards for organic aquaculture, the timing of dissemination of practicl results of this research will be opportune to yeild verfiable increases in organic shrimp production.

PROGRESS

2006/09 TO 2009/11 OUTPUTS: Experiments to manipulate composition of biofloc communities including alteration of nutrients (P, Si), C/N ratio (molasses, dextrose, urea), light penetration (total exclusion, solids cropping), and solids control. Experiments were conducted in greenhouse raceways, outdoor tanks, and a pond. To evaluate how organic feeds can be integrated with the biofloc community, raceways were managed to produce predominantly heterotrophic or photoautotrophic communities. Two trials tested how organic diets produced by extrusion would impact shrimp production in these different environments. Seven diet experiments in small flow through tanks evaluated contribution of microbial biofloc integrated with an organic feed to impact shrimp growth. Waters from heterotrophic and the photoautotrophic raceways were each pumped through 16 tanks. The remaining 16 tanks received recirculated clear water. Experiments evaluated organic feeds vs fishmeal feeds in different microbial communities. Using deficiency diets we identified the nutrition (protein, HUFAs, or vitamins) that shrimp might extract from different microbial communities. The organic diet was tested under pond conditions as an extension demonstration project. Juvenile shrimp were stocked at low density in a privately owned pond and fed an extruded organic diet. Shrimp growth, water quality, and microbial community structure were monitored. The farmer sold to the public through partial harvests and a large final harvest. 32 outdoor tanks evaluated organic feeds in 8 biofloc communities. Treatments included high and low protein diets, high and low stocking densities, and high and low solids levels. Shrimp were grown in the 8 resulting communities. Parameters were measured to correlate biological and chemical dynamics with shrimp productivity within the different communities. A nitrogen mass balance model and a dynamic systems nitrogen model were developed. A study using outdoor tanks evaluated an organic extruded plant based feed vs a commercial fishmeal feed. Suspended solids were controlled by settling chambers or tilapia. Water quality, shrimp production, nutritional (fatty acid) and sensory (taste) attributes were measured. Studies evaluated whether specific biofloc algae and cyanobacteria could supply nutrition and whether shrimp could ingest and digest these microbes. Pure cultures were grown and incorporated into shrimp feeds or made available directly to shrimp. Results were disseminated through meetings of the SC Aquaculture Assoc., World Aquaculture Society, US Aquaculture Society, National Shellfisheries Assoc., 7th International Conference on Recirculating Aquaculture, Ferrum College Symposium, Grice Marine Lab Seminars, and SC Aquarium Public Forum. Testimony prepared for the Organic Aquaculture Symposium in conjunction with Fall 2007 NOSB meeting; Browdy served on expert panel. Talks for SCDNR Open House (2000 visitors), Waddell Mariculture Center Public Tours (1200 visitors). Local newspaper story on cooperative organic shrimp farming demonstration with private farmer. Research/training for 2 scientists, 1 postdoctoral fellow, 1 PhD and 2 MS students, and 9 college student internships. PARTICIPANTS: Individuals: John Leffler, PI, assisted former PI in design of project, now directing all aspects of project and supervising staff; Craig Browdy, former PI, designed, formerly directed, supervised all aspects of project; Jesus Venero, scientist, supervised on-site operations, nutritional studies; Jason Haveman, husbandry manager, supervised animal care and facilities management; Heidi Atwood, former shrimp program manager, supervised analytical and field measurements; Brad McAbee, former husbandry manager, supervised animal care and facilities management; Beth Lewis, lab manager, supervised analytical and field measurements; Andrew Ray, biologist, managed tank studies; Alisha Lawson, biologist, daily animal care and sample collection/analysis; Andrew Shuler, biologist, microbial community analysis; Jacob Richardson, biologist, daily animal care and sample collection/analysis; Stacy Stefan, lab technician, sample collection/analysis; David Brune, professor, modeling; Kendall Kirk, graduate student, modeling; Andrew Ray, graduate student, microbial community analysis; Megan Kent, graduate student, algal culture and nutrition studies; Amy Dickson, student intern, daily

animal care and sample collection/analysis; Traci Holstein, student intern, daily animal care and sample collection/analysis; Elyse Walker, student intern, daily animal care and sample collection/analysis; Kristin Hoke, student intern, daily animal care and sample collection/analysis; Asher Dale, student intern, daily animal care and sample collection/analysis; Christopher Miner, student intern, daily animal care and sample collection/analysis; Emma Landherr, student intern, daily animal care and sample collection/analysis; Luis Vinatea, visiting Brazilian professor; Alfredo O. Galvez, visiting Brazilian professor; Mariane Pallaoro da Fontoura, Brazilian university student; Mauricio Emerciano, Brazilian university student. Partner organizations: Hollings Marine Laboratory, NOAA-NCCOS; Center for Coastal Environmental Health and Biomolecular Research, NOAA-NCCOS; Grice Marine Laboratory, College of Charleston; Agricultural Engineering Department, Clemson University; Collaborators: David Brune, Clemson University; MaryAnne Drake, North Carolina State University; Don Smith, Smith Shrimp Farm; Jon Ravenel, Yonges Island Mariculture Farm; Allen Davis, Auburn University; Robert Bullis, Advanced BioNutrition, Inc.; Tony Ostrowski, Oceanic Institute; Tzachi Samocha, Texas Agricultural Experiment Station; Gloria Seaborn, CCEHBR, NOAA-NCCOS; Jack Whetstone, Clemson University Agricultural Extension Service; Tim Markey, Zeigler Brothers, Inc., Susan Wilde, MRRI-SCDNR & USC. Provided research/training for two visiting Brazilian scientists, one post-doctoral fellow, one PhD student, two MS students. Internships provided for two undergraduate students and two visiting Brazilian university students. Training: Research/training for post-doctoral fellow; Research/training for PhD student; Thesis research/training for two MS students; Internships provided for 7 undergraduates, one graduate student; Volunteer assistance from one high school student. TARGET AUDIENCES: Provided educational talks for the South Carolina Aquaculture Association, World Aquaculture Society, U.S. Aquaculture Society, National Shellfisheries Association, 7th International Conference on Recirculating Aquaculture, the Ferrum College Environmental Symposium, Grice Marine Laboratory Seminars, and the South Carolina Aquarium public forum series. Testimony was prepared for the Organic Aquaculture Symposium in conjunction with the Fall 2007 NOSB meeting and C.L. Browdy served on the expert panel. Provided educational talks for SCDNR Marine Resources Division Open House (over 2000 visitors), SCDNR Waddell Mariculture Center Public Tours (over 1200 visitors), and a College of Charleston Aquaculture course. Interviewed by local newspaper for story on cooperative organic shrimp farming demonstration with private shrimp farmer. Provided research/training for two visiting Brazilian scientists, one post-doctoral fellow, one PhD student, two MS students, and summer internships for 7 undergraduate students and two visiting Brazilian university students. PROJECT MODIFICATIONS: Most of this project\'s goals and objectives were met following general procedures originally proposed. In order to improve transference of results to the private sector, shrimp densities for all experiments were increased to between 100 - 450 per cubic meter rather than the lower levels originally proposed. We also concentrated on greenhouse raceway systems since economically viable commercialization in the US will only be feasible in such superintensive systems rather than ponds. The dynamic systems modeling did not provide the anticipated insights, although the mass balance modeling demonstrated the apparent reduction of polluting nutrients through denitrification or volatilization. Two commercial producers with whom we were to interact closely went out of business and another private sector advisor left the industry. These individuals were no longer available for consultations.

2007/09/01 TO 2008/08/31 OUTPUTS: During Year 2, in order to evaluate how organic feeds can be integrated with microbial community composition, two raceways were managed to produce a no-light, totally heterotrophic community and a photoautotrophic/mixed community. Two trials were run testing how organic certifiable diets produced by different manufacturing processes that make possible a fully organic formulation would impact shrimp production in these microbially structured environments. Four diet experiments designed to improve on 2007 studies and aimed at better understanding the contribution of microbial biofloc to shrimp nutrition were conducted in 48 continuous flow-through tanks. Waters from the heterotrophic and the photoautotrophic raceways were each pumped through 16 tanks. The remaining 16 tanks were on a clear water, UV-filtered recirculating system. Experiments evaluated the effectiveness of organic feeds versus traditional fishmeal-based feeds in the different microbial communities. Through the use of deficiency diets we sought to identify the type of nutrition (protein, HUFAs, or vitamins) that shrimp might extract from the different microbial communities. The organic certifiable diet was tested under pond conditions as an extension demonstration project. Juvenile shrimp were stocked at low density in a privately owned shrimp pond and fed an extruded organic diet similar to the one fed in the raceway studies. Shrimp growth, water quality, and microbial community structure were monitored every two weeks. The farmer sold to the public through partial harvests and a large final harvest. Data from the 2007 tank study were analyzed and used to develop mass balance and dynamic system models based on the nitrogen cycle within these systems. Another study using 24 large outdoor tanks was conducted in 2008. Half of the tanks received a fishmeal-based feed and half received organically certifiable extruded feed. Suspended solids were reduced in one third of the tanks through settling chambers, one third used tilapia used as a filtering mechanism, and the remaining third had no filtration applied to them. In addition to a range of water quality and shrimp production parameters, sensory (taste) analysis of shrimp produced on typical fishmeal diets versus shrimp grown on organic plant-based diets will be conducted. Nitrogen and phosphorus mass balance budgets

are being calculated. Provided educational talks for SCDNR Marine Resources Division Open House (over 2000 visitors), SCDNR Waddell Mariculture Center Public Tours (over 600 visitors); Aquaculture America Convention, World Aquaculture Society, 7th International Conference on Recirculating Aquaculture, Grice Marine Laboratory Graduate Student Seminar, College of Charleston Aquaculture course, local newspaper story on cooperative organic shrimp farming demonstration with private shrimp farmer. Provided research/training for two visiting Brazilian scientists, one post-doctoral fellow, one PhD student, two MS students. Internships provided for two undergraduate students and two visiting Brazilian university students. PARTICIPANTS: Individuals: John Leffler, PI, assisted former PI in design of project, now directing all aspects of project and supervising staff; Craig Browdy, former PI, designed, formerly directed, supervised all aspects of project; Jesus Venero, scientist, supervised on-site operations, nutritional studies; Jason Haveman, husbandry manager, supervised animal care and facilities management; Beth Thomas, lab manager, supervised analytical and field measurements; Andrew Ray, biologist, manager of tank pad studies; Alisha Lawson, biologist, daily animal care and sample collection/analysis; Andrew Shuler, microbial community analysis; Jacob Richardson, biologist, daily animal care and sample collection/analysis; Kristin Hoke, student intern, daily animal care and sample collection/analysis; Asher Dale, student intern, daily animal care and sample collection/analysis; Megan Kent, graduate student, algal culture and nutrition studies; David Brune, professor, modeling; Kendall Kirk, graduate student, modeling; Luis Vinatea, visiting Brazilian professor; Alfredo O. Galvez, visiting Brazilian professor; Mariane Pallaoro da Fontoura, Brazilian university student; Mauricio Emerciano, Brazilian university student. Partner organizations: Hollings Marine Laboratory, NOAA-NCCOS; Center for Coastal Environmental Health and Biomolecular Research, NOAA-NCCOS; Grice Marine Laboratory, College of Charleston; Agricultural Engineering Department, Clemson University; Collaborators: David Brune, Clemson University; MaryAnne Drake, North Carolina State University; Don Smith, Smith Shrimp Farm; Allen Davis, Auburn University; Tony Ostrowski, Oceanic Institute; Gloria Seaborn, CCEHBR, NOAA-NCCOS; Jack Whetstone, Clemson University Agricultural Extension Service; Tim Markey, Zeigler Brothers, Inc. Provided research/training for two visiting Brazilian scientists, one post-doctoral fellow, one PhD student, two MS students. Internships provided for two undergraduate students and two visiting Brazilian university students. TARGET AUDIENCES: Provided educational talks for SCDNR Marine Resources Division Open House (over 2000 visitors), SCDNR Waddell Mariculture Center Public Tours (over 600 visitors); Aquaculture America Convention, World Aquaculture Society, 7th International Conference on Recirculating Aquaculture, Grice Marine Laboratory Graduate Student Seminar, College of Charleston Aquaculture course, local newspaper story on cooperative organic shrimp farming demonstration with private shrimp farmer. Provided research/training for two visiting Brazilian scientists, one post-doctoral fellow, one PhD student, two MS students. Internships provided for two undergraduate students and two visiting Brazilian university students. PROJECT MODIFICATIONS: We conducted a low density pond demonstration grow out with a local private shrimp farmer as specified in the proposal. However economically viable commercialization of shrimp farming in the US will probably only be feasible in superintensive greenhouse raceways rather than ponds. As a result we continued to focus on raceway and tank studies with stocking densities of 300 animals per square meter rather than the lower levels originally proposed. We continued experiments to modify and manage different microbial biofloc communities using simple management protocols while improving the formulation of organically certifiable feeds designed to integrate with these communities. This led to another summer tank study not envisioned in the original proposal, but which has provided some of the best results to date demonstrating how properly formulated organic diets can be integrated with supplemental nutrition from the microbial community if the biofloc is well managed through a cropping regime.

2006/09/01 TO 2007/08/31 OUTPUTS: During Year 1 we conducted four diet experiments designed to better understand the contribution of microbial biofloc to shrimp nutrition. In one experiment shrimp were grown in photoautotrophic-dominated, heterotrophic-dominated, and clear water communities under several levels of conventional feed. A second study repeated this experiment with the inclusion of a plant-based diet made entirely from organically certifiable ingredients. The third diet study grew shrimp in the three types of microbial communities but modified the organic diet to evaluate whether shrimp could obtain supplemental protein or fatty acids from biofloc. In the fourth experiment biofloc from a heterotrophic-dominated community was incorporated directly into the organic diet formulation without supplemental fatty acids and fed to shrimp in clear water to evaluate its nutritional or growth promoting properties. A large experiment utilizing 32 outdoor tanks evaluated the efficacy of organic feeds in eight different microbial communities. Two diets manufactured with organic certified ingredients provided high and low protein levels. These provided two distinct carbon-nitrogen ratios as inputs to the systems. Two levels of target stocking densities provided two distinct nutrient loading rates. Clarifiers on half of the tanks also altered microbial community structure by controlling suspended solids. Shrimp were grown in the 8 resulting communities for 13 weeks. All inputs, exports and shrimp harvest biomass were measured and analyzed. Shrimp growth and health were monitored weekly. Approximately 35 parameters were measured throughout the study to correlate biological and chemical dynamics with shrimp productivity within different microbial biofloc communities. One graduate student is using fluorescent microscopy, HPLC, and bacterial lipid

analyses to describe the dynamics of the microbial communities in the outdoor tank experiment. His Masters thesis will relate shrimp productivity to microbial community structure. Two undergraduate students (Florida, South Carolina) and a graduate student (Arizona) received internships to work on the tank study for 10 weeks during Summer 2007. Collaborating with David Brune at Clemson University, a PhD student is working with us on modeling the carbon and nitrogen fluxes in the biofloc systems from the outdoor tank experiment. The goal is to better understand the inputs, exports, and nutrient recycling dynamics in these systems in order to minimize or eliminate nutrient impacts on the external environment. We have developed and tested low energy airlift, gravity flow clarifiers to remove suspended solids from the biofloc systems as a means of guiding the microbial communities into configurations that increase shrimp productivity using organic diets. Preliminary results have been disseminated through talks to the Ferrum College Environmental Symposium, South Carolina Aquaculture Association, World Aquaculture Society annual meeting, and the South Carolina Aquarium public forum series. Testimony was prepared for the Organic Aquaculture Symposium in conjunction with the Fall 2007 NOSB meeting and project PI will serve on the expert panel. PARTICIPANTS: Individuals: Craig Browdy, PI, designed, directed, supervised all aspects of project; John Leffler, PD, assisted PI in design and implementation of project on daily basis, supervised staff; Jesus Venero, scientist, supervised on-site operations, nutritional studies; Heidi Atwood, lab manager, supervised analytical and field measurements; Brad McAbee, husbandry manager, supervised animal care and facilities management; Beth Thomas, biologist, daily animal care and sample collection/analysis; Jacob Richardson, biologist, daily animal care and sample collection/analysis; Alisha Lawson, technician, daily animal care and sample collection; Stacy Stefan, lab technician, sample collection/analysis; Andrew Ray, graduate student, microbial community analysis; Amy Dickson, student intern, daily animal care and sample collection/analysis; Traci Holstein, student intern, daily animal care and sample collection/analysis; Elyse Walker, student intern, daily animal care and sample collection/analysis; David Brune, professor, modeling; Kendall Kirk, graduate student, modeling; Partner organizations: Hollings Marine Laboratory, NOAA-NCCOS; Center for Coastal Environmental Health and Biomolecular Research, NOAA-NCCOS; Agricultural Engineering Department, Clemson University; Collaborators: Robert Bullis, Advanced BioNutrition, Inc.; Allen Davis, Auburn University; OceanBoy Farms Inc; Tony Ostrowski, Oceanic Institute; Jon Ravenel, Yonges Island Mariculture Farm; Tzachi Samocha, Texas Agricultural Experiment Station; Gloria Seaborn, CCEHBR, NOAA-NCCOS; Andrew Shuler, MRRI-SCDNR; Jack Whetstone, Clemson University Agricultural Extension Service; Susan Wilde, MRRI-SCDNR Training: Research/training for post-doctoral fellow; Research/training for PhD student; Thesis research/training for MS student; Internships provided for two undergraduates, one graduate student; Volunteer assistance from one high school student. TARGET AUDIENCES: Provided educational talks for SCDNR Marine Resources Division Open House, Ferrum College Environmental Symposium, South Carolina Aquaculture Association, World Aquaculture Society, South Carolina Aquarium Public Forum Series, Grice Marine Laboratory Graduate Student Seminar. Provided research/training for post-doctoral fellow, research/training for PhD student, thesis research/training for MS student, internships for two undergraduates and one graduate student, and volunteer opportunity for one high school student. PROJECT MODIFICATIONS: In order to increase the ease of transferring the results of these studies directly to commercial operations, shrimp were stocked in the outdoor tank study at 100 and 300 per square meter rather than the lower levels originally proposed. We also sought to produce eight different microbial biofloc communities using simple management protocols rather than only the two communities originally proposed. Economically viable commercialization in the US will probably only be feasible in superintensive greenhouse raceways rather than ponds. We are seeking complementary funding beyond this grant to repeat and expand on this summer\'s tank studies to better achieve the goals of producing organic certifiable shrimp in greenhouse systems that are totally independent of coastal locations and that will require no discharge permits.

IMPACT

2006/09 TO 2009/11 We found it very difficult to impose reliable, repeatable control over biofloc taxonomic composition. All communities were mixtures of heterotrophic and photoautotrophic organisms unless light was totally excluded, creating a heterotrophic system. Solids removal increased light penetration, increasing photoautotrophic structure, but did not control taxonomic composition. Nutrient loading from feed was the most significant factor altering this balance, driving systems into predominantly heterotrophic conditions. Within an established, stable system, biofloc composition can change dramatically and unpredictably without apparent effect on shrimp growth or water quality. Raceway experiments show that shrimp can grow in both heterotrophic and photoautotrophic communities using an organic plant based feed. No significant difference in shrimp growth or survival due to different biofloc communities. Feed produced by an extrusion vs pelleting permitted a higher growth rate while eliminating the need for chemical binders. Synthesis of diet experiments demonstrated that biofloc cannot replace or reduce prepared feeds, but will often improve growth when complete feeds are used.

Neither heterotrophic nor photoautotrophic biofloc provides superior supplemental nutrition. Biofloc provides vitamins, but does not consistently provide DHA. Harmful flora may bloom in biofloc resulting in negative impacts on shrimp growth. Organic plant based diets can perform as well as fishmeal diets as long as a biofloc community is present. Shrimp in the pond demonstration project grew well and received considerable attention when local media ran a story that referred to the product as Green Shrimp and discussed the ecological and economic benefits. The first tank study demonstrated that biofloc community structure is resistant to management efforts. Potentially harmful algae appear and disappear, but their impact on shrimp growth and survival is unclear. Shrimp production was affected by stocking densities and solids removal improved shrimp performance. Mass balance nitrogen budgets showed a loss due to denitrification or volatilization when solids were controlled, reducing polluting effluents. The second tank study found no difference in shrimp production between the fishmeal and the organic plant diet. Solids removal resulted in greater shrimp production and lower nitrate and phosphate accumulation. Shrimp fed the plant diet were lower in EPA and DHA, but higher in LA; hence slightly lower quality. The n6:n3 fatty acid ratios for both were below 2. There were no flavor differences between shrimp fed the two diets, but the plant diet shrimp were more moist and fibrous. Experiments with pure cultures of important biofloc algal and cyanobacteria species incorporated into feeds displayed little nutritional benefit or inhibition from any of the organisms tested. Shrimp consumed and digested diatom species, but were unable to ingest or digest significant amounts of microbes less than 10 um. Nutritional benefit derived from biofloc is species specific or results from the aggregation of cells into larger particles. **PUBLICATIONS (not previously reported):** 2006/09 TO 2009/11 1. Browdy C.L., Atwood, H., McAbee, B., Leffler, J., Stokes, A.D., Samocha, T., Losordo, T., Hanson, T.R., and Posadas, B.C. 2007. Research and development of sustainable super-intensive shrimp production systems: Perspectives on commercialization potential for US growers. World Aquaculture Society Annual Meeting Abstract Book, San Antonio, Texas. February, 2007. 2. Browdy C.L., Seaborn, G., Atwood, H., Davis, D.A., Bullis, R.A., Samocha, T.M., Wirth, E., and Leffler, J.W. 2007. Comparison of pond production efficiency, fatty acid profiles and contaminants in Litopenaeus vannamei fed organic plant-based and fishmeal based diets. World Aquaculture Society Annual Meeting Abstract Book, San Antonio, Texas. February, 2007. 3. Browdy, C.L, Venero, J. 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2007/09/01 TO 2008/08/31 2007/09 - 2008/08. Results of the two raceway experiments show the economic potential of the organically certifiable, all plant-ingredient diet to grow shrimp under super-intensive conditions in greenhouse raceways. Both experiments were successful in producing market size shrimp under both sunlight photoautotrophic and completely dark heterotrophic conditions. Feed produced by an extrusion rather than a pelleting process permitted a growth rate of 1.2 vs. 0.9 g/wk respectively and makes feasible a truly organic feed. The small tank diet experiments demonstrated that with poor or deficient diets shrimp are able to benefit from both heterotrophic and photoautotrophic/mixed floc communities. However it is difficult to compensate for the benefits of a complete diet. Organically certifiable, plant-based diets performed as well as fishmeal diets as long as some form of biofloc community was present. Vitamin deficiencies are easily compensated when shrimp are grown in either type of biofloc community. Shrimp in the pond demonstration project had a growth rate of 1.1 g/wk and averaged \>17 g. The project received considerable attention in the local general and aquaculture communities when the local media ran a story that referred to the product as \"Green Shrimp\" and discussed the ecological benefits and economic potential to the area of raising \"organic\" shrimp produced with feed prepared primarily with plant ingredients. Results from the 2007 large tank study demonstrated that microbial community structure is remarkably resistant to management efforts evaluated. Shrimp production was affected mainly by stocking densities, but solids removal through settling tanks tended to improve shrimp performance. Mass balance nitrogen budgets suggested a significant loss due to denitrification or volatilization, an important result for reducing nutrient effluents. The 2008 tank study demonstrated no significant difference in shrimp production between the fishmeal diet and the plant-based, organically certifiable diet. Suspended solids removal by settling chambers resulted in lower nitrate accumulation and significantly greater shrimp production. Tilapia did not cause noticeable changes in microbial community structure and did not impact shrimp production over the control systems.

2006/09/01 TO 2007/08/31 The first diet experiment demonstrated that at 100% and 50% ration shrimp grew significantly better in both the photoautotrophic-dominated and the heterotrophic-dominated biofloc communities compared to the clear water community. This suggests that natural productivity contributed to their nutrition. In the second experiment shrimp raised on the organic diet grew just as well as those on the conventional diet when raised in the photoautotrophic community. However, in the heterotrophic and the clear water systems shrimp fed the organic diet had a significantly lower final weight than shrimp fed the conventional diet. The photoautotrophic microbial community, dominated by chlorophytes and diatoms, apparently supplements the nutritional value of the organic feed allowing it to produce results equivalent to conventional diets. Further analyses of the diets suggests that the photoautotrophic biofloc may supply the shrimp with long chain omega 3 fatty acids present in low quantities in the organic feed. In diet study 3 shrimp fed the low protein diet gained significantly less weight than shrimp fed the other diets, either in the photoautotrophic or the heterotrophic water system demonstrating that the biofloc did not provide supplemental protein. For the other three diets (fish meal, organic, and low fatty acids) shrimp raised in the heterotrophic water system gained significantly less weight than those in either the photoautotrophic or in the clear water systems. Analyses of the microbial communities showed an abundance of a cyanobacterium, Synechococcus, in the heterotrophic community. This suggests that some microbial floc communities might retard shrimp productivity as well and promote it. Results from diet experiment 4 demonstrated that biofloc incorporated directly into fatty acid deficient feed permitted growth rates equivalent to the full formulation organic diet. Samples from the large outdoor tank experiment are still being processed and the results analyzed. Preliminary evaluation of the nutrient dynamic model based on the tank data is planned for

early December. In terms of new applied knowledge at this stage, we observed that the microbial communities are remarkably resistant to management efforts to alter their structure. However species compositions do change over time and these may have significant impacts on shrimp productivity. Potentially harmful algae, HABs, appear and disappear occasionally, but do not seem to adversely affect the shrimp. Development of a protocol that temporarily turned off aeration in order for in-situ dissolved oxygen probes to measure total system respiration (oxygen demand) and gross primary production proved to be an effective tool. The clarifier system designed and tested in the tank study proved to be very successful as a means to reduce organic solids rapidly and to maintain suspended solids levels within defined levels. This finding will have significant implications in reducing cost for systems commercialization, thereby improving competitiveness.

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Meeting Abstract Book, San Antonio, Texas. February, 2007. 7. Holstein,T.E., Atwood, H.L., Venero, J.A., Browdy, C.L. and Leffler, J.L. 2008. Ecosystem energetics of a microbial biofloc community used to culture Pacific white shrimp Litopenaeus vannamei. Aquaculture America 2008 Annual Meeting Abstract Book, Orlando, Florida, February, 2008 (in press). 8. Ray, A., Shuler, A., McAbee, B., Seaborn, G., Wilde, S., Browdy, C.L. and Leffler, J.W. 2008. Influence of microbial community dynamics on the production of shrimp Litopenaeus vannamei in zero exchange biofloc systems. Aquaculture America 2008 Annual Meeting Abstract Book, Orlando, Florida, February, 2008 (in press). 9. Venero, J.A., McAbee, B., Thomas, B., Leffler, J.W. and Browdy, C.L. 2008. Contribution of natural productivity of two different microbial floc systems on survival, growth performance, and feed conversion rate (FCR) of Pacific white shrimp Litopenaeus vannamei fed diets with variable composition. Aquaculture America 2008 Annual Meeting Abstract Book, Orlando, Florida, February, 2008 (in press). 10. Venero, J.A., McAbee, B., Thomas, B., Browdy, C.L. and Leffler, J.W. 2008. Contribution of natural productivity of two microbial floc systems to growth performance and feed conversion rate (FCR) of Pacific white shrimp Litopenaeus vannamei fed diets with variable composition. Aquaculture America 2008 Annual Meeting Abstract Book, Orlando, Florida, February, 2008. (in press).

↑ Return to Index

Using New Alternatives to Enhance Adoption of Organic Apple Production Through Integrated Research, Education, and Extension

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Subfile	CRIS
Project No.	VT-0052OG
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Performing Institution	PLANT & SOIL SCIENCES, UNIVERSITY OF VERMONT, BURLINGTON, VERMONT 05405

NON-TECHNICAL SUMMARY

Apples are an important component of New England\'s diversified agriculture. Although there is strong interest in organic apple production, there are very few certified organic orchards because of insect and horticultural challenges plus disease challenges associated with the predominant cultivar grown in the New England region (i.e., \`McIntosh\'). Also, students (undergraduate and graduate) who are considering careers in agriculture or just want to be informed on organic production systems need classroom and in-field learning on organic principles and the complex issues associated with organic agriculture. This multi-disciplinary, multi-state research project will examine the two major production systems growers would use in changing to new cultivars and to organic production and will have a closely integrated organic apple extension program to disseminate research findings, information, and insights. We plan to build an interactive, vibrant community of growers, researchers, and educators (academic/extension) for the exchange and generation of information and knowledge to enhance adoption of organic practices and to improve the competitiveness of organic apple producers. Also, an Organic Fruit Production course will be developed in which students will apply organic principles, examine practical aspects, and deal with the multi-dimensional aspects of organic fruit production.

OBJECTIVES

Research and Extension: 1. Incorporate and evaluate new apple cultivars and research-generated knowledge of apple ecosystem dynamics into organic production systems to determine sustainability and profitability. 2. Collaboratively develop and implement with stakeholders a multi-dimensional extension program that addresses their priorities and needs and improves the competitiveness of organic apple producers. This would include developing budgets and other informational publications for producers on organic apple production including a full risk analysis of the impact on production, marketing, financial, legal, and human resource risk. Academic

Education - classroom and hands-on, experiential learning: 3. Collaboratively develop a course on organic fruit production which effectively integrates classroom and experiential learning and which includes principles, practical aspects, and complexities of organic production.

APPROACH

This multi-disciplinary, multi-state research project will examine the two major production systems growers would use in changing to new cultivars and to organic production and will have a closely integrated organic apple extension program to disseminate research findings, information, and insights. We plan to build an interactive, vibrant community of growers, researchers, and educators (academic/extension) for the exchange and generation of information and knowledge to enhance adoption of organic practices and to improve the competitiveness of organic apple producers. Also, an Organic Fruit Production course will be developed in which students will apply organic principles, examine practical aspects, and deal with the multi-dimensional aspects of organic fruit production.

PROGRESS

2006/06 TO 2010/05 OUTPUTS: Apples are an important component of New England\'s diversified agriculture. Although there is significant interest in organic production, there are very few organic apple orchards in New England, in part, because of the challenges associated with the traditional apple cultivar grown (McIntosh). However, because of recent shifts in consumer preference for newer cultivars, growers are planting different apple cultivars. Growers want to know what the potential is for sustainable and profitable organic production with the newer apple cultivars that are being planted in the region. This project holistically examined the opportunities and challenges of organic production within the two major orchard systems growers are using to change to new cultivars and with five of the top apple cultivars that growers identified as important to the future of the industry. The project covered the establishment years of the two orchard systems; the project is being continued with another grant funded by the USDA Organic Research and Extension Initiative to study the early bearing years of the two organic orchards. The long-term goal of this multi-state, multidisciplinary project is to enhance adoption of organic apple production in New England through research that advances the scientific knowledge base and provides practical information to stakeholders through a closely integrated extension/outreach program. Outputs over the duration of the project included development of a organic apple production website (http://www.uvm.edu/organica/); development and offering an undergraduate course on organic fruit production; Organica Workshops and Orchard Tours; presentations at national and regional apple grower and/or research/extension meetings, presentations at international scientific conferences; answering grower questions on organic apple production; publishing Orchard Observations which was a web log of orchard observations during the growing season. A report on the activities, accomplishments and research insights of the project was published at: http://www.uvm.edu/\~organica/OrganicAProject/2009ProgressReport/progr ess.html PARTICIPANTS: The project is a collaborative partnership among three land-grant universities (two small and one large) and with stakeholders throughout in the region. The following are the Principal Investigators of the OrganicA Project. Lorraine P. Berkett, Ph.D., Professor of Plant Pathology & IPM Specialist University of Vermont Department of Plant & Soil Science 105 Carrigan Drive Burlington, VT 05405 lorraine.berkett@uvm.edu Renae Moran, Ph.D. Associate Professor of Pomology University of Maine Dept. of Plant, Soil and Environmental Sciences PO Box 179 Monmouth, Maine 04259 rmoran@umext.maine.edu M. Elena Garcia, Ph.D. Extension Horticulture Specialist-Fruits and Nuts University of Arkansas 310 Plant Sciences Bldg. Fayetteville, AR 72701 megarcia@uark.edu Heather Darby, Ph.D. Agronomist and Nutrient Management Specialist \and organic farmer University of Vermont Extension 278 S. Main St, St. Albans, VT 05478 heather.darby@uvm.edu Robert Parsons, Ph.D. Extension Ag Economist - Professor University of Vermont Department of Community Development and Applied Economics 204 Morrill Hall Burlington, VT 05405 bob.parsons@uvm.edu TARGET AUDIENCES: Target audiences include current apple growers who are interested in transitioning to organic production, prospective apple growers, extension personnel, researchers, and government and industry agricultural personnel. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2008/06/01 TO 2009/05/31 OUTPUTS: This multi-disciplinary, multi-state OrganicA Project is examining the two major production systems growers would use in changing to organic production with new apple cultivars. The project closely integrates a research component with an extension component to disseminate research findings, information, and insights plus, it integrates both undergraduate and graduate education to provide hands-on, experiential learning. A detailed Progress Report of Accomplishments and research results to date can be found at: http://www.uvm.edu/\~organica/OrganicAProject/2009ProgressReport/progr ess.html PARTICIPANTS: The

project investigators have a diverse background and represent the disciplines of horticulture, plant pathology, entomology, soil science, agronomy, and agricultural economics. They have expertise in integrated and organic research, in developing and implementing effective extension/outreach programs, in academic teaching and student advising, and in practical organic farming. Two of the project investigators are diversified organic farmers on their own and bring valuable practical knowledge and insights to the project. The project investigators include: Lorraine Berkett, Heather Darby, Robert Parsons and John Hayden from the University of Vermont; Elena Garcia from the University of Arkansas; and Renae Moran from the University of Maine. Morgan Cromwell and Ben Crockett participated in the project as student interns. Terry Bradshaw and Sarah Kingsley-Richards of the University of Vermont provided valuable technical assistance. Collaborations included apple growers and state organic associations who provided input and guidance to the project. Opportunities for training or professional development included an organic apple orchard tour and hosting and/or participating in grower meetings where organic apple information was exchanged and discussed; answering one-on-one grower questions on organic apple production; a student intern program; and further development and availability of a organic apple production website (http://www.uvm.edu/organica/); and publishing Orchard Observations (a weekly web log of orchard observations). Details on many of these activities are located at: http://www.uvm.edu/\~organica/OrganicAProject/welcome.html TARGET AUDIENCES: The primary target audience of this project is current, transitioning, and prospective organic apple growers. Additional target audiences include extension specialists, researchers, agricultural consultants, government agency representatives, and members of the general public interested in organic apple production. PROJECT MODIFICATIONS: The project has been very successful in meeting its proposed project milestones, in increasing research-generated information and insights in organic apple production, and impacting grower practices. Research has progressed to the level where results are being presented at regional, national, and international scientific conferences besides being presented and made available to growers locally, regionally, and nationally. In summary, the project is proceeding as originally planned.

2007/06/01 TO 2008/05/31 OUTPUTS: This multi-disciplinary, multi-state OrganicA Project is examining the two major production systems growers would use in changing to organic production with new apple cultivars. The project closely integrates a research component with an extension component to disseminate research findings, information, and insights plus, it integrates both undergraduate and graduate education to provide hands-on, experiential learning. Outputs during the second year of the project included further development of a organic apple production website (http://www.uvm.edu/organica/); completion of three case studies of commercial organic apple orchards in Maine and Vermont; an Open House to tour research orchards and provide information about the project; a major workshop on organic apple production at the New England Vegetable and Fruit Conference where insights gained from the project were presented to a \"standing-room only\" large audience; an organic apple production session at the annual NOFA-VT winter conference; hosting and/or participating in grower meetings where organic apple information was exchanged and discussed; answering grower questions on organic apple production; publishing nine issues of Orchard Observations which is a weekly web log of orchard observations; and developing and offering an undergraduate course in organic fruit production which was filled to capacity. Details on many of these activities are located at: http://www.uvm.edu/organica/OrganicAProject/welcome.html PARTICIPANTS: The project investigators have a diverse background and represent the disciplines of horticulture, plant pathology, entomology, soil science, agronomy, and agricultural economics. They have expertise in integrated and organic research, in developing and implementing effective extension/outreach programs, in academic teaching and student advising, and in practical organic farming. Two of the project investigators are diversified organic farmers on their own and bring valuable practical knowledge and insights to the project. The project investigators include: Lorraine Berkett, Heather Darby, Robert Parsons and John Hayden from the University of Vermont; Elena Garcia from the University of Arkansas; and Renae Moran from the University of Maine. Morgan Cromwell and Ben Crockett participated in the project as student interns. Collaborations included commercial apple growers who participated in case studies, state organic associations in the development of educational/outreach opportunities, and numerous growers who provided input and guidance to the project. Opportunities for training or professional development included an Open House to tour research orchards and provide information about the project; a major workshop on organic apple production at the New England Vegetable and Fruit Conference where insights gained from the project were presented to a \"standing-room only\" large audience; an organic apple production session at the annual NOFA-VT winter conference; hosting and/or participating in grower meetings where organic apple information was exchanged and discussed; answering one-on-one grower questions on organic apple production; developing and offering an undergraduate course in organic fruit production; a student intern program; and further development and availability of a organic apple production website (http://www.uvm.edu/organica/); and publishing nine issues of Orchard Observations (a weekly web log of orchard observations). Details on many of these activities are located at: http://www.uvm.edu/organica/OrganicAProject/welcome.html TARGET AUDIENCES: The primary target

audience of this project is current, transitioning, and prospective organic apple growers. Additional target audiences include extension specialists, researchers, agricultural consultants, government agency representatives, and members of the general public interested in organic apple production. PROJECT MODIFICATIONS: The project has been very successful in meeting its proposed project milestones, in increasing research-generated information and insights in organic apple production, and impacting grower practices. Research has progressed to the level where results are being presented at regional, national, and international scientific conferences besides being presented and made available to growers locally, regionally, and nationally. In summary, the project is proceeding as originally planned.

2006/06/01 TO 2007/05/31 Apples are an important component of New Englands diversified agriculture. Although there is strong interest in organic apple production, there are very few certified organic orchards because of insect and horticultural challenges plus disease challenges associated with the predominant cultivar grown in the New England region. However, recent shifts in consumer preference for newer cultivars have led to the planting of different apple cultivars which have different disease susceptibility. Also, research has identified potential alternatives to insect and horticultural obstacles to organic apple production in the region. Research knowledge is at a point where it needs to be integrated into organic production systems and evaluated holistically, including an economic analysis of potential economic costs, returns, and risks associated with the systems. Thus, this multi-disciplinary, multi-state research project is examining the two major production systems growers would use in changing to new cultivars and to organic production with a closely integrated organic apple extension program to disseminate research findings, information, and insights. During the first year of the project, one apple orchard was planted with nursery trees and another established orchard was top-grafted to five cultivars that were identified by growers as priority cultivars for this research project. Both orchards are being managed with organic production methods and are being closely monitored. Also, the extension/outreach component of the project was initiated and included orchard tours, presentations at workshops, an organic symposium, and grower meetings, and the development of a website. In addition, an undergraduate course was developed, advertised, and is fully enrolled with students for the Fall, 2007 semester.

IMPACT

2006/06 TO 2010/05 All aspects of the OrganicA Project have received high praise from growers and the public. The project has increased knowledge of organic apple production and has created a change in action among program participants. A project evaluation by stakeholders is at: http://www.uvm.edu/\~organica/OrganicAProject/2009ProgressReport/stake holderevaluation.html The OrganicA Project has become a leading resource for organic information on the world wide web. Organic apple research results and insights have been presented at regional workshops involving growers, scientists, extension personnel, and agricultural consultants and at national and international scientific conferences. Although the orchards are young and are just beginning to produce a crop, the following are a few insights gained during the orchard establishment years: (i)Trees top-grafted onto established root systems showed varying degrees of success during the establishment years both in initial scion survival and extent of tree development. Growers who choose to top-graft an orchard rather than remove trees and plant a new orchard do so under the conventional wisdom that by-passing a two year fallow period followed by three establishment years for the new trees will give them a marketable crop sooner. The preliminary results indicate that poor survival of top-grafted trees on particular cultivars may negate the benefit of earlier production. (ii)Based on initial foliar disease assessments during the establishment years of the orchards, Honeycrisp appears more resistant to apple scab than the other scab-susceptible cultivars Zestar!, Ginger Gold, and Macoun, but appears more susceptible to rust, than Liberty and Zestar!. Honeycrisp and Liberty appear more attractive to Japanese beetles. Although beneficial insects are prevalent in the orchards, European red mite populations are increasing. The importance of a thorough assessment of the surrounding ecosystem for sources of inoculum and reservoirs of insect pests has been underscored in the two orchard systems being studied. (iii)Weed management in the newly-planted orchard has presented challenges. Various techniques have been implemented with limited success. Tree growth in one of the orchard systems has been sub-optimal with short terminal growth and trees not filling their allotted trellis space despite maintaining appropriate nutrient levels and consistent irrigation. We plan to use wood chip mulch during the next phase of this project and will monitor weeds and soil health plus test alternative nutrient sources. Also, an advanced study of weed management techniques will be conducted in a Maine orchard. (iv)To date we have compared the economics of the two orchard systems through calculating the Net Present Value (NPV) of cash inflows and outflows during the establishment period. To no surprise, neither system has produced a positive cash flow in any year since startup. This establishment period is a time when orchard plantings normally experience negative cash flows simply because it takes several years before any apples are available to

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2008/06/01 TO 2009/05/31 All aspects of the OrganicA Project have received high praise from growers and the public. The project has increased knowledge of organic apple production and has created a change in action among program participants. A full Progress Report which includes stakeholder evaluations of all aspects of the project is at: http://www.uvm.edu/\~organica/OrganicAProject/2009ProgressReport/progr ess.html The OrganicA Project has become a leading resource for organic apple information. The OrganicA Project website (http://www.uvm.edu/organica/) is the first resource listed when a search is conducted using the popular Google search engine on organic apple production or organic apple resources. There have been over 11,000 visits to the various pages on the website since it was launched in 2007. The OrganicA Project is the only organic apple resource developed by a land-grant university in the eastern United States listed on the USDA Agricultural Marketing Resource Center website (http://www.agmrc.org/commodities products/fruits/apples/organic apples.cfm). It is also listed as a farmer resource for organic information on the Northeast Organic Farming Association of Vermont (NOFA-VT) website (http://www.nofavt.org/resources/resources-useful-links/farmer-resour ces), and the Midwest Organic and Sustainable Education Service Tree Fruit Network (MOSES) website (http://www.mosesorganic.org/treefruit/research.htm). In addition to keeping regional growers informed of research results and insights at meetings and workshops, OrganicA Project personnel were recently invited to the 2008 Great Lakes Fruit and Vegetable EXPO, one of the largest grower meetings in North America for fruit growers, to update Midwest growers on the insights and information gained from the project to date. During the 2008 growing season, a weekly blog of observations from the organic orchards was started to share real time information. Also, OrganicA personnel are currently members of the eOrganic Community of Practice and are providing national leadership for the Tree Fruit Discipline Group and the Organic Apple Research and Outreach Group.

2007/06/01 TO 2008/05/31 All aspects of the OrganicA Project have received high praise from growers and the public. The project has increased knowledge of organic apple production and has created a change in action among program participants. Seventy-five percent (75%) of the participants in the Open House described the event as very to extremely educational and all survey respondents (100%) said the OrganicA Project was very to extremely important in increasing information and insights into organic apple production. Similarly, the regional workshop and the website have received high praise with growers stating that they have used the information in decision-making and that the information provided will increase adoption of organic apple production. An organic fruit production academic course was developed and offered in the fall of 2008 and was filled to capacity with undergraduate students. Hands-on organic apple production experience was provided to two student interns (an undergraduate and graduate student) during the growing season. Documentation of three years of practices in the two research apple orchards resulted in organic certification of the orchards. Organic apple research results and insights were presented at regional workshops involving growers, scientists, extension personnel, and agricultural consultants. Research abstracts were developed for presentations at international organic conferences.

2006/06/01 TO 2007/05/31 The long-term goal of this project is to enhance adoption of organic apple production in New England through: (i) establishing an integrated and collaborative certified organic farm at the University of Vermont for the development and implementation of research which addresses opportunities and constraints to organic apple production; (ii) implementing a comprehensive organic apple extension program for current and prospective apple growers within the region; and (iii) developing an educational program for both graduate and undergraduate students in organic fruit production.

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↑ Return to Index