

OREI Project Details

Award Year 2004

6 Research Projects

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Use of Resident Biological Resources for the Management of Replant Disease in Organic Tree Fruit Production Systems

Accession No.	0201286
Subfile	CRIS
Project No.	WNW-2004-05153
Agency	NIFA WN.W
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02223
Proposal No.	2004-05153
Start Date	15 SEP 2004
Term Date	14 SEP 2008
Fiscal Year	2008
Grant Amount	\$303,267
Grant Year	2004
Investigator(s)	Mazzola, M.

NON-TECHNICAL SUMMARY

Replant disease is a major impediment to the establishment of economically viable orchards on sites that were previously occupied by the same or closely related crop species. In organic production systems there is a lack of feasible alternatives to the application of pre-plant soil fumigants as a means to control this biologically complex disease syndrome. This research program will examine the development and use of disease control practices that function through biological resources resident to orchard ecosystems. External inputs, when required, will be chosen based on the capacity to serve multiple management objectives. The mode of action of brassicaceae seed meals in control of pathogens and weeds resident to orchard ecosystems will be determined.

OBJECTIVES

The research program outlined in this proposal seeks to identify and implement methods, which are compatible with organic production systems, for the control of replant diseases of fruit trees; disease phenomena that are biologically complex. Our goal is to develop a soilborne disease management program that ensures the successful establishment of new fruit trees on old orchard sites and sustains productivity of these orchards through the use of biological resources resident to the orchard ecosystem, with minimal use of external inputs. As such, strategies will be developed to utilize inputs that have potential to serve multiple management or production goals. The goal is to employ an approach to manage replant diseases in organic tree fruit production systems which will take into account the influence of the host plant on resident soil microorganisms and how host genotype may modulate the activity or composition of beneficial elements of these microbial communities. These studies also will evaluate multiple Brassicaceae seed meals possessing varying glucosinolate contents for the capacity to control soilborne pathogens and parasites that incite this disease. The impact of these seed meals on microbial communities resident to orchard soils and the rhizosphere of apple will be assessed. Specific emphasis will be given to the resident population of *Streptomyces* spp. as preliminary evidence suggests that enhanced activity of these bacteria may have a role in the disease control elicited via the application of *Brassica napus* seed meals. In addition, the ability of the seed meal to suppress weed growth and the mechanisms of growth suppression will be investigated. Although Brassicaceae plant residues most commonly are thought to provide

weed and/or disease control through the release of glucosinolate hydrolysis products (biofumigation), preliminary evidence supports the role of resident soil microorganisms in eliciting these activities in certain instances. The capacity of apple rootstock genotypes to derive benefit from these organic soil amendments, either directly or through the activity of the resident soil microbial community, will be determined. Based on findings from these studies, a system based on selection of the appropriate host genotype and biologically active soil amendment will be evaluated in the field for its utility as an alternative to pre-plant soil fumigation for the control of replant disease in organic agricultural ecosystems.

APPROACH

Our preliminary findings indicate that populations of *Streptomyces* spp. resident to orchard soil ecosystems function in the control of certain fungal root pathogens that contribute to replant disease, including *Rhizoctonia solani*. The capacity of different Brassicaceae seed meals to stimulate populations of resident *Streptomyces* and the resulting level of disease control will be attained. Populations will be monitored using conventional isolation methods, and presence of pathogens and parasites of apple will be determined using culture-based methods. The presence of nitric oxide (NO) producing capacity in the *Streptomyces* population will be assessed by probing individual isolates with a NO synthase gene probe. These studies are conducted as NO is a chemical known to stimulate host defense responses. Commercial and developmental apple rootstocks will be utilized in plant assays to determine whether tolerance/resistance exists toward the pathogen *Rhizoctonia solani* and the complex that incites replant disease. These studies will be conducted in the greenhouse and at multiple orchard sites. Qualitative and quantitative aspects of the *Streptomyces* population from these rootstocks will be ascertained should earlier studies demonstrate a role for these bacteria in the disease suppression induced by seed meal amendment. Individual *Streptomyces* will be characterized by sequence analysis of the 16S rRNA gene and comparison to sequences published in GenBank. The capacity of different seed meals to suppress specific plant weed species will be assessed in greenhouse studies. The role of *Pythium* spp. as a potential biological incitant of the observed weed suppression will be ascertained by evaluating weed control in the presence and absence of the fungicide Ridomil, a material specific to the control of Pythiaceae fungi. The role of glucosinolate hydrolysis products in weed control will be discerned by utilizing meals of differing glucosinolate content, and comparing weed control with and without Ridomil application. Field trials will be conducted at multiple sites and will employ a systems approach designed based upon the findings obtained in earlier greenhouse and field assays.

PROGRESS

2004/09 TO 2008/09 OUTPUTS: In addition to the technical publications listed below, findings were communicated directly to growers at various venues including the Third National Organic Tree Fruit Conference (2005), the annual Washington State University Organic Field Day, an invited presentation at the Fifth National Integrated Pest Management Symposium (2006), in offered and invited presentations at annual meetings of the Washington State Horticulture Association, annual Washington Tree Fruit Commission Research Review and at various orchard industry meetings such as the Yakima Pomology Club and Northwest Fruit Wholesale. Likewise, in partial fulfillment of the requirements for the PhD in Soil Science, the graduate student (L. Hoagland) supported by this program completed a guide entitled *Managing Orchard Understory and Organic Amendments for Nitrogen Fertility*, which will be published by Washington State University as an extension bulletin. This program provided training in the study of organic orchard soil biology to undergraduate and graduate students from a number of institutions including Washington State University; University of Idaho; Sonoma State University, California; and Ithaca College, NY. PARTICIPANTS: In addition to participants noted in previous reports, a graduate student from the University of Idaho received training in assessment of brassicaceous seed meal effects on resident soil microbial populations and soilborne disease suppression. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: Not relevant to this project.

2006/10/01 TO 2007/09/30 OUTPUTS: A new brassicaceae seed meal formulation was devised which possesses a broader spectrum of biological activity toward the pathogen/parasite complex that incites replant disease of fruit trees and other crop plants. These findings were disseminated at a variety of grower, professional and university workshops, conferences and seminars including the Annual Meeting of the Washington State Horticultural Association, annual meeting of the American Phytopathological Society and the Department of Crop and Soil Sciences at Washington State University. This information has also been disseminated through personal interactions with numerous organic growers both during the conduct of this research, through participation in industry priority setting sessions, and through the dissemination of results to Washington State University

Extension Personnel who use findings from these studies in their presentations. These findings have also been relayed to a variety of individuals conducting similar research programs who have expressed interest in utilizing our approach to manage other soilborne diseases in organic cropping systems, including faculty at the University of Florida and Washington State University. A graduate student supported by this project completed her PhD in soil sciences and produced an extension bulletin on the use of brassicaceae seed meals for weed control in newly established orchard systems. Information concerning the appropriate use of these materials for disease control was relayed to growers, agricultural supply companies, and product development firms through electronic communication and conference calls. PARTICIPANTS: Individuals: Mark Mazzola, Research Plant Pathologist/Project Director Training or professional development: Several undergraduate, graduate and postdoctoral students received support and training as a result of funds provided by this grant. These included opportunities to obtain training concerning the pest problems faced by organic farmers as well as the discovery of means to solve these issues. Within that context, specific training ranged from the use of novel materials methods in the field to the use of molecular biology to discover the biological limitations to the system. These individuals included: Dr. Lori Hoagland: Former PhD student in the department of soils, Washington State University Aaron Florea: Undergraduate student, Ithaca College, Ithaca, NY Emi Yamamoto: Master of Science student in Biology, Sonoma State University, Sonoma, CA Dr. Antonio Izzo, Former Postdoctoral Research Associate, currently Assistant Professor, Elon College, Elon, NC Partner Organizations, collaborators: Dr. Gennaro Fazio, USDA-ARS, Geneva, NY David Granatstein, Co-ordinator Center for Sustaining Agriculture, Washington State University Dr. Lynne Carpenter-Boggs, BioAg Coordinator, Washington State University Ray Fuller, Organic Tree Fruit Producer, Chelan, WA Jerry Hatteberg, Natural Plant Products, Salem, OR Vincent Phillion, Phytopathologist, IRDA, St. Bruno-de-Montarville, Quebec, Canada TARGET AUDIENCES: The target audience for the efforts of this research program are organic growers and specifically that segment of the population lacking suitable measures for the control of soilborne diseases and weeds. In many instances, alternatives to non-compatible measures such as soil fumigation, for pest control are lacking or completely unavailable. This program seeks to provide solutions to this issue. It is perceived that this program will serve the need of a range of organic producers but the solutions will be of most interest for small to mid-sized farming operations. This program contributed several outreach training efforts that included training of graduate students in the department of plant pathology at Washington State University, the department of crop and soil sciences at Washington State University and the Department of Biology at Sonoma State University. In addition, the program included extension efforts in the form providing talks at grower meetings and the generation of a bulletin (in preparation) that will focus on the use of brassicaceae seed meals and other methods for weed control in organic crop production systems.

2005/10/01 TO 2006/09/30 Irrespective of the brassicaceae seed meal type employed, 18 month post-plant growth increment of Gala/M26 apple in soils receiving a pre-plant seed meal amendment in conjunction with a post-plant mefenoxam soil drench was as great or greater than trees grown in soils receiving pre-plant soil fumigation. In the absence of post-plant Ridomil (mefenoxam) drench, only seed meal from the mustard *Sinapis alba* cv. *IdaGold* improved tree growth to a level equivalent to soil fumigation. When applied in a commercial organic orchard, a composite *Brassica napus*+*Brassica juncea* seed meal amendment suppressed amplification of *Pythium* populations which is consistently observed in response to *B. napus* seed meal alone. The composite *Brassica napus*+*Brassica juncea* amendment significantly improved tree growth, at times to a level superior to pre-plant fumigation, but the response was rootstock dependent. Suppression of plant parasitic nematodes, specifically the lesion nematode *Pratylenchus penetrans*, in response to the composite seed meal amendment was equivalent to or better than that attained in response to pre-plant fumigation. Again, this response was rootstock dependent. All seed meals were shown to provide control of *Rhizoctonia* by modifying the orchard soil microbial community, but *Brassica juncea* was shown to have an additional chemical mechanism, production of allyl-isothiocyanate. This finding provides further evidence to previous reports from this program demonstrating that the presumed "biofumigation" role in brassicaceae tissue-induced pest suppression may have little if any role in disease control for certain systems.

2004/09/15 TO 2005/09/14 *Brassica napus* seed meal amendment provides control of specific elements (*Rhizoctonia solani* and *Pratylenchus penetrans*) of the causal complex that incites apple replant disease in Washington. However, this material induced a proliferation of *Pythium* spp., which required the use of a post-plant mefenoxam (oomycete-specific fungicide) soil drench, a practice not suitable to organic systems. In the current reporting period, additional brassicaceous seed meals including *Brassica juncea* and *Sinapis alba* were evaluated during orchard establishment at a site replanted with GalaM26 apple. *B. napus* and *S. alba* seed meal amendments enhanced tree growth relative to the non-treated control, and tree growth in *S. alba* treated soils was equivalent to the fumigated control. Interestingly, *B. juncea* seed meal amendment did not enhance tree growth but when used in conjunction with a post-plant mefenoxam soil drench, the increase in tree diameter was

73% greater than the fumigated control. The result was unexpected as this seed meal was the lone amendment that did not enhance populations of *Pythium* and a corresponding increase in *Pythium* root infection. Molecular analysis of fungal populations indicated that trees established in *B. juncea* amended soils possessed roots heavily infested by *Phytophthora cambivora* and *Phytophthora megasperma*. Brassicaceous seed meal-induced disease control is, in part, dependent upon the resident microbial community. Greenhouse and field trials were established to assess the capacity of apple rootstocks to utilize this biological resource. Across rootstocks the *S. alba* seed meal amendment resulted in significantly better tree growth in WVC orchard replant soil. However, for certain rootstocks (G11) growth performance was numerically better across orchards in *B. napus* amended soil and seedling rootstock performed statistically better in *B. juncea* amended soil. Analyses are in progress to ascertain whether this was a biologically-induced growth response. *B. napus* seed meal amended soils possess stable populations of *Streptomyces* spp. that are 20-100 fold greater than non-treated soils, and the vast majority of isolates from these soils possess a nitric oxide synthase gene and produce nitric oxide (NO). The capacity of *B. napus* seed meal to control *R. solani* was abolished in soils pasteurized prior to infestation with this fungal pathogen. Pasteurization treatment eliminated *Streptomyces* from the soil system, but *Bacillus* spp. were present in high numbers. Disease suppression was restored to pasteurized *B. napus*-amended soil by adding any of several *Streptomyces* strains. Seed meal amendment elevates populations of ammonia oxidizing bacteria and the release of NO. Maximal rates of nitrification in orchard soil were observed within two weeks following seed meal amendment. Inhibition of nitrification via application of nitrapyrin abolished control of *R. solani* infection of seedlings planted one day after soil amendment. These data indicate the disease control is dependent upon NO release through nitrification and suggest that *Streptomyces* are a functional element contributing to longer-term disease control.

IMPACT

2004/09 TO 2008/09 Brassicaceous seed meals (BSMs) controlled all elements of the pathogen complex inciting apple replant disease, but not all BSMs controlled all elements or provided the same level of disease control. Brassica *juncea* seed meal (BjSM) was the only BSM to suppress populations of *Pythium* spp. and provided better control of *Cylindrocarpon* than did Brassica *napus* seed meal (BnSM). BjSM provided extended control of *Pratylenchus penetrans* relative to other BSMs, but was less effective in controlling *Rhizoctonia solani*. Our findings refuted the broadly held assumption of the primary or exclusive role of glucosinolate hydrolysis products in suppression of soilborne pathogens by Brassicaceae plant amendments, and demonstrated the functional role of the resident soil biology in achieving BSM-induced disease control. In field trials, BjSM amendment resulted in amplified infection of Gala/M26 apple roots by resident *Phytophthora* spp., which was not observed in response to BnSM or *Sinapis alba* seed meal (SaSM) amendment. Gala/M26 apple tree growth and yield was enhanced to a level equivalent to soil fumigation with each seed meal, but only when used with a post-plant mefenoxam drench. Yields attained in response to SaSM alone were equivalent to pre-plant fumigation, however vegetative growth as of August 2008, while enhanced relative to the control, was inferior to the fumigation treatment. As a result of these findings, studies to address the use of BSMs in concert with the "appropriate apple rootstock germplasm" were postponed until a suitable composite seed meal was identified. We now possess such a material as a composite seed meal was formulated based upon these findings, which in rootstock trials provided the spectrum of disease control desired without need of the post-plant mefenoxam treatment. Relative tolerance of apple rootstocks to the causal pathogens and parasites differed significantly with germplasm from the USDA/Cornell-Geneva breeding program in general being less susceptible than that derived from the Malling series rootstocks. Populations of resident *Streptomyces* spp. recovered from the rhizosphere differed among rootstocks, with Geneva rootstocks such as G41 typically supporting significantly greater numbers than Malling rootstocks such as M9 or M26. This is of major importance due to the functional role of native *Streptomyces* spp. in eliciting BSM-induced control of *R. solani*. BSMs significantly reduced weed emergence in greenhouse trials. Reduced weed emergence and increased weed seedling mortality were not related to BSM glucosinolate content but did require activity of the resident soil microbial community. Soil pasteurization and application of semi-selective chemistries conclusively demonstrated that weed control was dependent in part or in total on resident pathogenic *Pythium* spp. populations. When incorporated into the soil profile at the time of orchard establishment, all BSM treatments effectively controlled broad leaved weeds. Optimal weed control required short-term tarping after incorporation of BjSM or BnSM, but SaSM amendment did not require tarping to yield weed control.

PUBLICATIONS (not previously reported): 2004/09 TO 2008/09 1. Mazzola, M. 2008. Consideration of soil biology in the Brassica seed meal-induced control of *Rhizoctonia solani*. *J. Plant Pathology* 90:S2-415. 2. Mazzola, M. Brown, J., Zhao, X., Izzo, A., and Fazio, G. 2008. Influence of Brassicaceous seed meal and rootstock on recovery of *Pythium* spp. and *Pratylenchus penetrans* from apple roots grown in replant soils. *Plant Dis.* (accepted 9.19.08). 3. Wissuwa, M., Mazzola, M. and Picard, C. 2008. Novel approaches in plant breeding

for rhizosphere-related traits. *Plant Soil* (accepted) 4. Hoagland, L., Carpenter-Boggs, L., Reganold, J., and Mazzola, M. 2008. Role of native soil biology in brassicaceae seed meal induced weed suppression. *Soil Biol. Biochem.* 40:1689-1697.

2006/10/01 TO 2007/09/30 Brassicaceae plant residues have gained intensive study and interest as a means to control various plant parasites, pathogens and weeds due to production of specific plant chemistries (glucosinolates) which upon hydrolysis yield various biologically active compounds, the most important being isothiocyanates. Scientists in general have attributed the efficacy of these residues in pest control to these chemistries and have designated this process "biofumigation" as the chemistry is similar to certain synthetic fumigants. However, research from this program demonstrated that brassicaceae seed meal induced control of specific plant pathogens and weed control functions through a variety of biological and chemical mechanisms, and in some instances only the resident soil biology was essential for the pest control that was attained. This is a fundamental change in our knowledge of how these materials function and will lead to dramatic changes not only in how they are study but also how brassicaceae seed meals are utilized in this and all other crop production systems. The efficacy of brassicaceae seed meal amendments for control of replant disease was demonstrated in the field. These studies employed a highly susceptible apple rootstock to ensure maximum levels of disease pressure in the system. To date, growth and yields with individual seed meals were significantly improved relative to the non-treated control, but did not attain a level equivalent to soil fumigation. The biological limitations were identified and when seed meals were used with a narrow-spectrum chemistry (mefenoxam) that specifically targeted the limiting factor, seed meal amendments provided initial growth and yield of apple that was superior to soil fumigation. Such a strategy while not applicable in organic systems, has potential to replace the use of soil fumigants for replant disease control resulting in significant environmental benefits. Based upon these studies a novel seed meal formulation has been devised for use in organic systems which should address the limitations identified when seed meals were employed individually.

2005/10/01 TO 2006/09/30 In concert with our previous studies (Mazzola and Mullinix, 2005), the data to date demonstrate that consistent control of replant disease can be attained using the *B. napus*/mefenoxam treatment on sites lacking significant lesion nematode populations. Likewise, superior pathogen control attained with *B. juncea*/mefenoxam treatment relative to soil fumigation may provide enhanced tree performance, which has been realized to date. While the initial finding from the *B. juncea* alone treatment was unexpected and disappointing, these data provided further information for developing effective and consistent control of replant disease in organic systems. The documented suppression of both lesion nematode and *Pythium* spp. in the field by composite *B. napus*/*B. juncea* seed meal amendment suggests its potential value for use in organic production systems. Preliminary findings indicate that designer seed meal formulations may be developed for specific orchard replant sites based upon knowledge of the pathogen complex (e.g. presence or absence of lesion nematode) and the desired rootstock to be planted. These trials and associated laboratory studies, also point to a potential need for tarping soil immediately after *B. juncea* application to contain allyl-isothiocyanate produced to yield optimum disease control performance, specifically the control of lesion nematode, a procedure that was omitted from the 2006 field trial.

2004/09/15 TO 2005/09/14 While the initial finding from the *B. juncea* alone treatment was unexpected and disappointing, these data provide further information for developing effective and consistent control of replant disease in organic systems without the use of soil fumigation. This trial utilized the *Phytophthora*-susceptible root stock, M26. The fact that we determined why disease control failed in the absence of a mefenoxam post-plant soil drench will now enable us to effectively modify the system, for example through the use of a *Phytophthora* resistant rootstock in subsequent trials or modification of the irrigation protocol. As plant genotype significantly alters soil microbial communities, the rootstock employed is apt to modulate the efficacy of this treatment. Therefore, matching the appropriate rootstock with the most suitable seed meal will allow for optimization of disease control. Greenhouse studies supported this ascertainment; whereas *S. alba* consistently was superior to other seed meal amendments in promoting growth of M26 rootstock in orchard soils, the *B. napus* and a bagged *B. juncea* treatment provided the greatest growth increment in G11 and seedling rootstock, respectively. Again, direct implication of soil biology in this response awaits further analysis.

PUBLICATIONS

2006/10/01 TO 2007/09/30 1. Hoagland, L., Carpenter-Boggs, L., Granatstein, D., Mazzola, M., Smith, J., Peryea, F., and Reganold, J. P. 2007. Impact of floor management strategies on nitrogen fertility and biological soil quality in newly established organic apple orchards. *Biology & Fertility of Soils* (pending) 2. Mazzola, M. and Zhao, X. 2007. Potential of brassicaceae seed meal formulations for replant disease control in conventional and organic orchard systems. *Proceedings, annual meeting of the Washington State Horticultural Association* (in press). 3. Hoagland, L., Carpenter-Boggs, L., Reganold, J., and Mazzola, M. 2007. Role of native soil biology in brassicaceae seed meal induced weed suppression. *Soil Biol. Biochem.* (pending). 4. Mazzola, M. 2007. Manipulation of rhizosphere bacterial communities to induce suppressive soils. *Journal of Nematology* 39: (in press) 5. Mazzola, M. 2007. Differential impact of brassicaceae seed meals on numbers and composition of Pythium populations indigenous to orchard soils. *Phytopathology* 97:S73 6. Mazzola, M., Brown, J., Izzo, A, and Cohen, M. F. 2007. Mechanism of action and efficacy of seed meal-induced suppression of pathogens inciting apple replant disease differ in a Brassicaceae species and time-dependent manner. *Phytopathology* 97:454-460. 7. Hoagland, L., Carpenter-Boggs, L. Granatstein, D., Mazzola, M., Peryea, F., Smith, J., and Reganold, J. 2007. Nitrogen cycling and partitioning under alternative organic orchard floor management strategies. *Proceedings Western Nutrient Management Symposium*. 7:117-123.

2005/10/01 TO 2006/09/30 1. Mazzola, M., Brown, J., Abi-Ghanem, R., Izzo, A., and Cohen, M.F. Progress towards development of biologically-based strategies for the management of apple replant disease. *Phytopathologia Polonica* 39:11-18. 2006. 2. Cohen M. F., and Mazzola, M. Impact of resident bacteria, nitric oxide emission and particle size on root infection by *Pythium* spp. and *R. solani* AG-5 in *Brassica napus* seed meal amended soils. *Plant and Soil* 286:75-86. 2006. 3. Fazio, G., Robinson, T., Aldwinckle, H., Mazzola, M., Leinfelder, M., Parra, R.. Traits of the Next Wave of Geneva Apple Rootstocks. *Compact Fruit Tree* 38:7-11. 2006. 4. Cohen, M. F., and Mazzola, M. Effects of *Brassica napus* seed meal amendment on soil populations of resident bacteria and *Naegleria americana*, and the unsuitability of arachidonic acid as a protozoan-specific marker. *Journal of Protozoology Research* 16:16-25. 2006. 5. Cohen, M. F., Mazzola, M., and Yamasaki, H. Nitrogen oxidations in bacterium-plant interactions. *Microbe* 1:347. 2006. 6. Mazzola, M. Mechanisms and efficacy of brassicaceae seed meal-induced disease control. pp53.1-53.4, In, *Proceedings Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions*. MBAO, Fresno, CA. 2006. 7. Mazzola, M., Hoagland, L., Carpenter-Boggs, L., Abi-Ghanem, R. and Cohen, M. F. 2006. Contribution of resident soil microorganisms to brassicaceae seed meal-induced disease and weed suppression. Page 57, in *Proceedings, 2nd International Biofumigation Conference, Moscow, ID. June 26-28, 2006*. 8. Mazzola, M., and Abi-Ghanem, R. 2006. Application of brassicaceous seed meals for the management of apple replant disease. Page 56, in *Proceedings, 2nd International Biofumigation Conference, Moscow, ID. June 26-28, 2006*. 9. Izzo, A. D. and Mazzola, M. 2006. Differential impact of *Brassica* spp. seed meal amendments on fungal populations associated with roots of *Malus domestica* from a replant orchard site. *Phytopathology* 96:S53.

2004/09/15 TO 2005/09/14 1. Cohen, M. F., Yamasaki, H., and Mazzola, M. 2005. *Brassica napus* seed meal soil amendment modifies microbial community structure, nitric oxide production and incidence of *Rhizoctonia* root rot. *Soil Biology & Biochemistry* 37:1215-1227. 2. Mazzola, M., and Mullinix, K. 2005. Comparative field efficacy of management strategies containing *Brassica napus* seed meal or green manure for the management of apple replant disease. *Plant Disease* 89:1207-1213. 3. Fazio, G., and Mazzola, M. 2005. Marker assisted selection of apple rootstocks-prospects, benefits, and limitations. *ACTA Horticulturae* 663:823-828. 4. Mazzola, M., Cohen, M. F., and Brown, J. 2005. Effect of Brassicaceae seed meals on microbial communities and growth of apple in replant soils. *Phytopathology* 95:S67 (abstract) 5. Cohen, M. F., Brown, J. and Mazzola, M. 2005. Infectivity of *Pythium* toward apple seedlings in soil amended with low-glucosinolate *Brassica napus* seed meal. *Phytopathology* 95:S20 (abstract). 6. Cohen, M. F., and Mazzola, M. 2005. Suppression of *Rhizoctonia* root rot by *Streptomyces* in *Brassica napus* seed meal-amended soil. *Phytopathology* 95:S20 (abstract).

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Profitability and Transitional Analysis of Northeast Organic Dairy Farms

Accession No.	0201265
Subfile	CRIS
Project No.	VT-0049SG
Agency	NIFA VT.
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02250
Proposal No.	2004-05131
Start Date	15 SEP 2004
Term Date	31 AUG 2009
Fiscal Year	2009
Grant Amount	\$301,161
Grant Year	2004
Investigator(s)	Parsons, R. L.; Wang, Q.; Rogers, G.; Kauppila, D.; Dalton, T.; Kersbergen, R.; Goode, T.
Performing Institution	COMMUNITY DEVELOPMENT AND APPLIED ECONOMICS, UNIVERSITY OF VERMONT, BURLINGTON, VERMONT 05405

NON-TECHNICAL SUMMARY

Organic milk production is the fastest growing ag sector in New England. Yet there is a dire lack of financial information to aid farmers, lenders, and policymakers on making the decision to move to organic milk production. This project will gather financial data to produce education material on the profitability of organic dairy farms, budgets and benchmarks, and develop a manual for use by farmers in the transitional process.

OBJECTIVES

b) Study Objectives The specific objectives of the joint project are: 1) To collect data and assess the current financial and production status of Maine and Vermont's organic dairy sector, analyze profitability, costs of production, develop financial and production benchmarks, 2) To analyze the procedure and costs of converting from conventional dairy production to organic production with the objective of providing organic dairy farmers, conventional dairy farmers, lenders, and policymakers with rigorous, quantified data; 3) To develop and publish reports, fact sheets, and educational material from the data analysis in (1) and (2). The publications and training material will be available to farmers, lenders, other service providers, policymakers, and the public; and 4) To plan and conduct educational workshops based on educational material developed from the data analysis. These workshops will be part of University of Vermont (UVM) and University of Maine Cooperative Extension (UMCE) educational programs. These workshops will be conducted in cooperation with NOFA, and the VAAF in Vermont and MOMP, MOFGA and MDIA in Maine. Through the above research objectives, this study is expected to address the following research questions: a) What is the current financial and production characteristics of Maine and Vermont's organic dairy sector? b) What are the benchmarks to which organic dairy farms can compare themselves? c) How does organic dairy farmers' financial and production characteristics compare to conventional dairy farms as reported in the Northeast Dairy Farm Summary and The Cost of Producing Milk in

Maine? d) What is the economic cost of incurred by conventional dairy farmers that are converting to organic dairy production? e) What are the questions that need to be addressed to educate farmers, lenders, service providers, and policymakers about organic dairy production?

APPROACH

Objective 1) Year 1: Step 1) The research team will identify production and financial data needs, develop the research procedure and input forms, and select the computer analysis program. Step 2) The input forms will be field tested on at least 4 organic dairy farms in both states. Step 3) The test data will analyzed to identify any weaknesses or omissions in the data collection and analysis and permit corrections. Step 4) The research sample will be drawn from all organic producers in both states. Step 5) Each farm will be visited as soon as possible after February 1, 2005 to collect 2004 financial and production data. Step 6) Farm data will be analyzed to produce financial statements and returned to the farmers to review for accuracy. Step 7) The financial data will be merged into one data set for analysis with the SAS. Year 2: Steps 4-7 above will be replicated in Year 2. Objective 2) Year One: Step 1) Identify a selected group of key informants who have successfully transitioned from conventional production to organic for a focus-group discussion of problems and challenges. Step 2) Develop a survey instrument to be administered to all cooperating farmers on the costs and issues faced in the transition process. Step 3) Process and analyze the results from this survey. Step 4) Farmers will be identified who are in their first year of transition and visited every 3 months to gather financial and management data. Year Two: Step 1) The farmers will continue to be visited every 3 months to document their step by step transitional process. Step 2) The data from the survey and the farm visits will be compiled and analyzed. Data will be used to develop factsheets and a step by step transitional instructional manual. Objective 3) Year One: Step 1) A set of benchmarks will be produced to be used as management and financial guides by organic dairy farmers. These benchmarks will be similar to those used by conventional dairy farmers. Step 2) The second publication will be a report on the profitability of organic dairy farms in a format that will enable comparison between organic and conventional dairy farms on identically measured production and financial measures. Year Two: Step 1) Benchmarks will be developed from the year 2 data collection as it Step1, year 1. Step 2) An informational manual that provides key data for farmers considering switching to organic milk production will be published. The publication will include an explanation of the transition procedure, budgets, and identify key management challenges. Step 4) The final publications will be educational material that will be used in farm workshops. The material will be made available in electronic format from the UVM Extension and UMCE web sites. Objective 4) Year Two: Step 1) The above publications will be used in producer education workshops conducted by UVM Extension, NOFA, and VAAFM, UMCE, MOMP, MDIA, Maine Milk Commission, and MDA. Step 2) Workshops will be held to provide guidance to farmers considering the transition to organic milk production. Step 3) The study will provide a basis for a series of articles for publication in regional farm magazines.

PROGRESS

2004/09 TO 2009/08 Target Audience: The target audience for this project was organic dairy farmers, dairy farmers thinking about transitioning to organic, the organic dairy industry, support businesses, lenders, policymakers, and the general public. Before this study we had no study examining the comparative economics of organic dairy. The project provided 5 years of data to provide the longest on-going economic study of organic dairy in the US. The data from the study provided key info to current farmers, those thinking about transitioning to organic, lenders, and policymakers for use in decision making and expectations of the returns from organic dairying. Changes/Problems: Nothing Reported What opportunities for training and professional development has the project provided? While the researchers have the competent skills to conduct the research, the project left our cooperating farmers with a more sound appraisal of their economics of their farm operations. The project has also allowed the researchers professional development thorough presenting the results at professional venues across the US and Canada. How have the results been disseminated to communities of interest? Results from eash years analysis have been released to the public. The primary results was the summary of the farms as well as broken down by profit group. While much went into the data collection, analysis, and distribution, the results could be summarized by lenders in a short time but more importantly, became one of the lenders\' most used information aids. What do you plan to do during the next reporting period to accomplish the goals? Project is completed.

2007/10/01 TO 2008/09/30 OUTPUTS: This project is examining the comparable profitability of organic dairy farms in Vermont and Maine through the on-farm collection of financial and demographical data. Vermont, with over 200 farms, and Maine, with over 60 farms, have the highest concentration of organic dairy farms in the US.

This data is the first 4 year study of the profitability of organic dairy farms in the US. For 2007, the data from Vermont organic dairy farms finds that profitability dropped in 2007 16% from record high profits in 2006 (Maine data is incomplete at this time). Milk prices were static from 2006 but total farm expenses rose by 6.3% to dampen farm profits. Farmers have faced feed prices that have jumped nearly 70% and fuel prices that have gone up more than 200% since 2005. In adjustment to these price jumps, farmers have cut back on the use of purchased organic grains and fuel use. In fact, feed expenses have only gone up by 23%, indicating a significant cutback in grain use. The farms in the study for 2007 averaged 65.7 cows, sold 13,152 pounds of milk per cow, and received an average price of \$29.35 per cwt. The major expense categories, accounting for 80% of farm expenses, were feed, repairs and supplies, labor, interest, custom work, utilities, and fuel. Results have been disseminated through release to farmers, lenders, and policymakers, through news releases, presentations, and an experiment station bulletin (in cooperation with the University of Maine). Farmers can use the data to examine their farm and compare receipt and expenses to the group. Lenders use the data for budgets for farmers applying for credit and those thinking of going into organic dairy. Policymakers use the data to examine how policies can be put in place to assist farmers moving into organic dairy as this appears to be one of Vermont's fastest growing ag sectors. This project will collect data for a 5th year in 2009, providing a long term analysis of northeast organic dairy farms. Most economic studies examine just one year of data. In this case, we are conducting a long term study to provide key information on the profitability of the organic dairy sector over time. PARTICIPANTS: Not relevant to this project. TARGET AUDIENCES: Farmers, lenders, and policymakers. PROJECT MODIFICATIONS: Not relevant to this project.

2005/10/01 TO 2006/09/30 The first study in the US to examine the profitability of a large number of organic dairy farms was conducted by the Universities of Vermont and Maine and the Northeast Organic Farming Association-Vermont (NOFA-VT). Organic dairy farms now account for 8.5% (105) and 18% (63) of dairy farms in Vermont and Maine, respectively. The retail market is growing at 20% per year. The purpose of this study was to examine the cost and profitability of producing organic milk. This study consisted of 30 organic dairy farmers who averaged 48 cows, sold 14,060 lbs of milk per cow at \$22.97 per cwt while production cost was \$22.58 per cwt. The farms averaged \$41,355 in operational income. Deducting depreciation of \$19,487 left net farm revenue of \$21,898. At a family living cost of \$37,178 (reported by Farm Credit for farms in Vermont under 90 cows), the average organic farm shows a loss of -\$15,280, a -3.0% return on farm equity (ROE). The study also found that while one-third of the farms earned an economic profit, a few of these farms were very profitable. However, the study also revealed that two-thirds of the farms were not profitable enough to meet family living expenses. The study revealed that organic milk prices remained practically unchanged from 1999. However, expenses jumped from \$18.20 to \$22.58 per cwt. The bottom line is that net farm revenue for organic dairy farms dropped 42% from \$38,364 in 1999 to \$21,898 in 2004! We then compared the organic dairy farms to conventional dairy farms with fewer than 90 cows as published in Farm Credit's Northeast Dairy Farm Summary. These farms averaged 67 cows, sold 18,819 lb of milk per cow, and earned net farm revenue of \$41,741 for a ROE of 1.6%. The average conventional dairy farm had higher net farm revenue, higher net revenue per cow, and higher net revenue per cwt. But 2004 was unusual because of record high milk prices while organic profitability was declining. In 2003, according to the Northeast Dairy Farm Summary, the average conventional dairy farm with fewer than 90 cows averaged 65 cows producing 18,898 pounds of milk per cow for a net farm revenue of \$22,035 and a -1.6% ROE. The reality is that the average conventional dairy farm in 2003 had to milk an additional 17 cows more than their organic herd counterparts to earn \$137! The organic dairy farms also earned more net revenue per cow and cwt. Conclusion: First, this study found that the average organic dairy farm did have a taxable income but was not profitable enough to provide an adequate return for the owner's labor and no return on the farm's investment in cows, land, and equipment. Second, the study confirmed that profits for organic dairy farms declined 42% since 1999! This finding supports farmers' claims that profits were down and a higher milk price was needed. Third, this study found that with record high milk prices, conventional farms did better than the average organic dairy farm in 2004. But when we examined 2003, we found that organic dairy farms had nearly identical net farm revenue as conventional dairy farms.

2004/10/01 TO 2005/09/30 Our project has conducted one year of data collection from 30 organic dairy farms that is currently being analyzed and will be released in the near future. A second part of the study is currently producing a case study for an article on the transition of a dairy farm from conventional to organic production. In the past year the project started with a joint meeting with the University of Maine and University of Vermont researchers to coordinate research objectives and procedures. We have incorporated 2 partners, Northeast Organic Farming Association and the Maine Organic Milk Producers into the study to reach the organic dairy farming sector. Preliminary work developed a survey instrument and financial data collection procedures and forms. The forms were tried out on 4 farmers to get their input, comments, and data. The data was then analyzed to make sure the collection procedure worked appropriately. Letters went out to dairy farmers eliciting their

participation in the study. For those deciding to participate, data collection was begun in February and ended in August. Balance sheet and expenditure, and receipt information were collected by farm visits from 30 participating farms. The data was merged for analysis. Preliminary analysis indicates organic dairy farms were not as profitable as conventional dairy farms in 2004 because of record conventional milk prices. However, when compared to 2003, organic dairy farms were more profitable than corresponding conventional dairy farms. Full analysis will examine profitability on a per farm, per cow, and per cwt basis.

IMPACT

2004/09 TO 2009/08 What was accomplished under these goals? The project accomplished and went beyond initial goals. Due to the project support, additional support and funding was found, enabling continuing the project for an additional 2 years and sufficient funding to continue the project after the Grant funding expires. The project is the longest ongoing economic analysis of organic dairy in the US. We collected data and released results for calendar years 2004-2008. The information provided cumulative data on the profitability of organic dairy farms as well as comparable analysis to similar size conventional dairy farms. The results have been shared with farmers, the organic dairy sector, lenders, and policymakers. The data is well received and anticipated each year by the groups, especially farm lenders. This study had been the only resource they have to consider as a benchmark for organic dairy farms. However, this data did not just appear. The results can from the efforts of the researchers working with the farmers to obtain the data, conducting the analysis, and publishing in factsheets and bulletins usable by the ag community. **PUBLICATIONS (not previously reported):** 2004/09 TO 2009/08 1. Type: Other Status: Published Year Published: 2008 Citation: Dalton, T. and R. Parsons. A comparative Analysis of Organic Dairy Farms in Maine and Vermont.: Farm Financial Information from 2004-2006. Maine Agricultural and Forestry Experiment Station, The University of Maine. Bulletin 851. July 2008. 2. Type: Conference Papers and Presentations Status: Accepted Year Published: 2006 Citation: Parsons, Robert*, Timothy Dalton, and Qingbin Wang. ?How Profitable are Northeast Organic Dairy Farms?? Selected Paper presentation at the 2006 Northeast Agricultural and Resource Economics Association Annual Meeting, Mystic, Connecticut, June 11-14, 2006. 3. Type: Conference Papers and Presentations Status: Accepted Year Published: 2007 Citation: Parsons, Robert*, Qingbin Wang, and Rick Kersbergen. ?Profitability and Economics of Northeast Organic Dairy Farms for 2005.? Presented at the Northeast Grazing Consortium Annual Meeting, State College, PA. February 2, 2007. 4. Type: Conference Papers and Presentations Status: Accepted Year Published: 2007 Citation: Parsons, Robert*, Qingbin Wang, and Rick Kersbergen. ?Profitability of Northeast Organic Dairy Farms for 2005.? Presented at the 2007 Extension Risk Management Education Conference, Phoenix, AZ. April 17-18, 2007. <http://www.agrisk.umn.edu/conference/agenda.aspx?ConfID?4&Output?Sum#> 5. Type: Conference Papers and Presentations Status: Accepted Year Published: 2007 Citation: Parsons, Robert*, Qingbin Wang, and Rick Kersbergen. ?Profitability of Northeast Organic Dairy Farms for 2005.? Presented at the 2007 North Central Farm Management Workshop, Rochester, MN. June 11-14, 2007. <http://www.agrisk.umn.edu/conference/agenda.aspx?ConfID?3&Output?Sum#/rparsons0> 263.ppt 6. Type: Conference Papers and Presentations Status: Accepted Year Published: 2008 Citation: Parsons, Robert*, Qingbin Wang, and Timothy Dalton. ?Costs and Returns to Northeast Organic Dairy Farms: A 3-Year Analysis.? Presented at the Northeast Agricultural and Resource Economics Association (NAREA) Annual Meeting, June 29-July 2, 2008. Quebec, Canada. 7. Type: Conference Papers and Presentations Status: Accepted Year Published: 2009 Citation: Parsons, Robert* and Qingbin Wang. ?Long Term Profitability of Northeast Organic Dairy Farms.? Presented at the National Extension Risk Management Education Conference, March 29-April 1, 2009. Reno, NV. www.agrisk.umn.edu/conference/uploads/RParsons059301.ppt 8. Type: Conference Papers and Presentations Status: Accepted Year Published: 2009 Citation: Parsons, Robert*, and Qingbin Wang. ?Long Term Profitability of New England Organic Dairy Farms: A 4 Year Analysis.? Presented at the 2009 Northeastern Agricultural and Resource Economics Association Meetings, June 7-9, 2009. Burlington, VT. 9. Type: Conference Papers and Presentations Status: Accepted Year Published: 2009 Citation: Parsons, Robert.* ?Economic Overview of the Organic Dairy Sector.? Presented at The 2009 Northeast Branch-Crops, Soils, and Agronomy Conference, July 13-15, 2009. Portland, Maine. 10. Type: Conference Papers and Presentations Status: Accepted Year Published: 2006 Citation: Parsons, Robert.* ?Profitability of New England Organic Dairy Farms.? Presented at the New Hampshire Grazing Conference. Concord, NH. February 1-2, 2006. 11. Type: Conference Papers and Presentations Status: Accepted Year Published: 2005 Citation: Parsons, Robert* and Qingbin Wang. ?Comparable Profitability of Northeast Organic Dairy Farms.? Presented at ?Identifying Strategies to Support Sustainable Agriculture in Canada.? Quebec, Quebec, Canada. Nov. 6-9, 2005. http://www.aic.ca/conferences/aic_forum2005.cfm 12. Type: Other Status: Published Year Published: 2007 Citation: Robert Parsons, Rick Kersbergen, and Lisa McCrory. ?Is Organic Dairying a Cash Cow?? Hoard?s Dairyman. 152-8:309. April 25, 2007.

2007/10/01 TO 2008/09/30 We found that while profitability for 2007 was down by 16%, the average Vermont organic dairy farm reported a positive net farm returns of \(\$18,500 (accounting for unpaid family labor) for a positive Return on Assets of 3.0%. Profitability was down but organic dairy farms were still more profitable than comparable size conventional dairy farm. Organic dairy farms are getting slightly larger while milk production per cows remains fairly static despite lower use of purchased grain. From this study, organic appears to be a viable option for smaller size dairy farms. The future depends on any increase in the organic milk price vs. the rising feed and fuel prices. With feed prices up over 70% since 2005, northeast organic dairy farmers are showing interest in raising their own grains to reduce costs. The result of this project is an accurate assessment of the profitability of the organic dairy sector, an assessment that has not been available to date. The impact is the accurate information now available to farmers, processors, lenders, policymakers, and the public on the profitability of the rapidly growing organic dairy sector. This data assists those in business, those thinking of going into organic dairy, and policymakers on consideration of what is needed to promote further growth. On an individual basis, this data provided key information so the farmer can decide whether transitioning to organic will be a good business move. The stakeholders in this project need this information because there is no other available data on northeast organic dairy farms. Decisions by farmers, processors, policymakers, and the public on whether to embrace organic dairy as a viable alternative for Vermont depends on whether there is reliable information on its profitability, expense and profit levels, and the cost of farms transitioning to organic dairy. Without this multi-year organic dairy study, decision would be made blindly without any guidance on whether efforts should be enhanced or discontinued.

2005/10/01 TO 2006/09/30 This study confirmed that Northeast organic dairy farmers were receiving the same prices in 2004 as in 1999 while production costs increased by more than 40%. As a result, this study found profitability was down, costs up, and the average farm had a negative net farm income and return on equity. The results of this study were used to justify a higher organic milk price that was delivered to farmers in late 2005. Collection of 2005 data is almost complete and will be distributed in early 2006. The results of this study benefit the numerous dairy farms in transition to organic, current organic dairy farms, and conventional dairy farms thinking of transitioning to organic.

2004/10/01 TO 2005/09/30 This project will produce publications that will allow producers, lenders, and policymakers to compare the relative profitability of organic and conventional dairy farms. The analysis will provide a summary of expenses, receipts, return on assets, total investments, debt, and profitability margins. The case studies will provide information to farmers and lenders on the transitional process from conventional to organic. Included will be budgets and financial analysis on the year to year process and barriers to adoption of organic production.

PUBLICATIONS

2007/10/01 TO 2008/09/30 No publications reported this period

2005/10/01 TO 2006/09/30 1. Bragg, Lisa A., Timothy J. Dalton, Rick Kersbergen, and Robert Parsons. Profitability of Northeast Organic Dairy Farms. Presented at International Federation of Organic Agriculture Movements Conference, Minneapolis, MN. August 22-24, 2006. 2. Parsons, Robert. Comparable Profitability of Northeast Organic Dairy Farms. Presented at Identifying Strategies to Support Sustainable Agriculture in Canada. Quebec, Quebec, Canada. Nov. 6-9, 2005. 3. Parsons, Robert, Timothy Dalton, and Qingbin Wang. How Profitable are Northeast Organic Dairy Farms? Selected Paper presentation at the 2006 Northeast Agricultural and Resource Economics Association Annual Meeting, Mystic, Connecticut, June 11-14, 2006. Parsons, Robert. Comparable Profitability of Northeast Organic Dairy Farms. Presented at Identifying Strategies to Support Sustainable Agriculture in Canada. Quebec, Quebec, Canada. Nov. 6-9, 2005. http://www.aic.ca/conferences/aic_forum2005.cfm

2004/10/01 TO 2005/09/30 No publications reported this period

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The Organic Seed Partnership

Accession No.	0201292
Subfile	CRIS
Project No.	NYC-149550
Agency	NIFA NY.C
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02229
Proposal No.	2004-05205
Start Date	15 SEP 2004
Term Date	14 SEP 2008
Fiscal Year	2008
Grant Amount	\$894,450
Grant Year	2004
Investigator(s)	Jahn, M.
Performing Institution	PLANT BREEDING, CORNELL UNIVERSITY, ITHACA, NEW YORK 14853

NON-TECHNICAL SUMMARY

Since October of 2001, under the United States Department of Agriculture (USDA) National Organic Program (NOP), the NOP Final Rule (United States Department of Agriculture, 2000) requirements specify that producers 'must use organically grown seeds, annual seedlings, and planting stock.' The Organic Seed Partnership will enhance and expand a set of existing complementary, regionally-focused activities to create a strong national network aimed at developing and delivering improved vegetable varieties for organic systems. This federated approach builds upon a successful model for integrating public sector research/education with the capacity offered by farmer-based non-profit organizations and small businesses. Curriculum development opportunities that arise as a consequence of basing our trial hubs at schools will be addressed by cooperators who will be able to demonstrate trialing strategies, organic agricultural production and farmer-based participatory trialing and selection. Finally, the Organic Seed Partnership represents an effective strategy to harness national research and education capacity for locally- and regionally-defined needs in organic agriculture.

OBJECTIVES

The Organic Seed Partnership will enhance and expand a set of existing complementary, regionally-focused activities to create a strong national network aimed at developing and delivering improved vegetable varieties for organic systems. Achieving this goal requires both new varieties and improved capacity to produce large quantities of commercial grade seed. This project integrates participatory farm-based crop breeding and selection activities in organic systems, supported by regional research centers that ensure the early engagement of growers, consumers and seed companies. Vegetable germplasm for this project will originate from small businesses (e.g., farmer/breeders and regionally focused, smaller seed companies), non-profit organizations and from public sector research institutions including universities and the USDA. The focus of this project is on vegetable species because of the paramount importance of vegetables such as tomato, broccoli and cucurbit crops in organic farming systems and because of the relative value of these products for the businesses that engage in organic agriculture. Results from these trials will guide individual, public sector and seed company breeders in developing varieties that perform well in organic production systems.

APPROACH

Vegetable germplasm for this project will originate from small businesses (e.g., farmer/breeders and regionally focused, smaller seed companies), non-profit organizations and from public sector research institutions including universities and the USDA. Appropriate procedures to manage the transfer of these materials between breeders and to our trialing network are in place that preserve the originators' rights, if desired. Our national trialing network has been set up to consist of a series of hubs representing key production areas and regions, each supporting farmer-based trialing networks similar to those already used successfully by the USDA IFAFS-funded Public Seed Initiative. Trials conducted at these hubs (U. California at Davis, New Mexico State U., Alcorn State U., W. Va. State U.) and farmers trials linked to each hub will occur on certified organic ground or land in transition, and will be organically managed in every case. Unfunded partners include seed companies with a history of serving the organic agriculture community and with the capacity to produce commercial vegetable seed organically. Particular emphasis has been placed on serving diverse regions in the U.S., particularly those where minorities are well represented among small farmers.

PROGRESS

2004/09 TO 2008/09 OUTPUTS: The Organic Seed Partnership (OSP) project has created a strong national network emphasizing participatory approaches to develop and deliver commercial quality seed of improved vegetable varieties for organic agricultural production systems. Key components of the project included trialing, breeding and outreach. Over the course of the project a over 290 varieties (29 crops) and nearly 300 breeding lines/populations (12 crops) were evaluated in observational and replicated trials on cooperating grower, university-based and seed company organic farms. Seed for trialing was donated by the private sector (11 seed companies), public sector (4 institutions) and organic growers (12 grower-breeders). Most on-farm trialing activity occurred in the NE (179 farms) with a significant number of grower participants at our national trialing locations (38 farms). Replicated trials of advanced breeding lines, newly released and standard varieties were completed on organic research farms at Alcorn State, Cornell, NMSU, OSU, UC Davis, WSU and on-farm in NY and WV. Final trial results will be distributed to cooperators and/or posted on the OSP website <http://www.plbr.cornell.edu/psi/OSP%20home.htm>. Cucurbit and pepper breeding work at Cornell focused on the development of broad disease resistance, improved product quality and adaptation. Breeding at OSU focused on the late blight resistance in tomato, OP broccoli adapted to organic systems, disease resistance, improved flavor and type in summer squash. OSP public breeders worked closely with grower-breeders who provided over 230 breeding lines/populations of broccoli, cucumber, melon, pepper, summer and winter squash, to public breeders, seed companies and other growers for further breeding and/or evaluation. As a direct result of these activities a number of organically bred varieties are listed, or soon to be listed, in seed company catalogs (3 early red CMV tolerant OP bell peppers, 3 novel PMT mini-butternuts and 1 PMR small white cucumber), are finished and available (6 novelty PMR summer squash, 4 melons and 3 white cucumbers), or will be available next year (3 OP broccoli populations, 2-3 cherry and slicer tomatoes with improved late blight resistance, 1-2 bush Tromboncino summer squash). OSP collaborators sponsored or participated in a total of 66 outreach and education events in 10 states, primarily in the NE by NOFA-NY and PGRU. These events held on grower farms, research farms and at regional conferences included workshops, demos and presentations on breeding basics, pollination techniques, seed production, seed cleaning and saving methods, taste testing and farm tours. Outreach activities reached over 4500 interested farmers, gardeners and members of the public one-on-one and many thousands more at 5 national and 8 regional conferences. Training and educational materials on breeding and seed saving are readily available on the OSP website which has served as an effective outreach mechanism with more than 4,800 hits by over 3,500 stakeholders in 81 countries. Valuable feedback on OSP activities was gathered from 111 grower participants in a 2007 survey performed by NOFA-NY. 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.

2006/10/01 TO 2007/09/30 The Organic Seed Partnership (OSP) project has created a strong national network emphasizing participatory approaches to develop and deliver commercial quality seed of improved vegetable varieties for organic agricultural production systems. In 2007, seed of 136 vegetable varieties and 62 experimental lines (total 28 crops) was donated by Fedco, Flander's Bay Farm (NY), Frosty Morning Farm (NY), Genesis Seeds, Green Dragon Farm (CT), Harris Seeds, High Mowing, Johnny's, Seeds of Change, Southern Exposure Seed Exchange, Territorial, Turtle Tree, Cornell, OSU and USDA-ARS PGRU to cooperating organic growers and university-based organic farms in 21 states. The experimental material included a broad array of crops - cucumbers, melons, onions, peppers, tomatoes, summer and winter squash from Cornell, OP broccoli

and tomato from OSU, tomatillos from PGRU, celtuce, melon, pumpkin, pepper and summer and winter squash from Flander's Bay Farm (NY) and tomato and winter squash from Green Dragon Farm (CT), which illustrates the magnitude and breadth of our participatory breeding effort. Most on-farm trialing activity occurred in the NE, but in 2007 there was a significant increase in the number of grower participants at our national trialing locations. A total of 175 farmers/gardeners received seed of over 185 varieties/lines. Trial results were distributed to cooperators and will be posted the OSP website <http://www.plbr.cornell.edu/psi/OSP%20home.htm>. Replicated trials of experimental material, newly released and standard varieties of pepper, cucumbers, onions and winter squash were completed on organic research farms at Cornell, UC Davis, WA, WSU and on-farm NY and WV. Observational trials of improved released varieties were also conducted at these sites. Cucurbit and pepper breeding work continues at Cornell with the emphasis on developing broad disease resistance, improved product quality and adaptation to diverse environments. Breeding at OSU continues to focus on the development of late blight resistance in tomato, breeding for OP broccoli adapted to organic systems and for disease resistance, improved flavor and type in summer squash. Outreach and education events were also held in 2007 to further develop organic growers' capacity to both breed their own vegetable varieties and produce commercial grade lots of organically grown seed. In the Northeast, NOFA-NY, PGRU and Cornell sponsored 12 outreach and education events, including public taste-testing and workshops held on farms and at research stations that demonstrated breeding basics, pollination techniques, and seed production and cleaning methods to interested farmers, gardeners, and members of the public. Reaching beyond the NE, OSP collaborators participated in the SSAWG (KY), NM Organic Farming (NM) and PASA (PA) conferences, held breeding workshops at the MOSES conference (WI) and at the Raymond Experiment Station (MS), and conducted field days at Alcorn State, MS State and UC Davis (CA). Training and educational materials on these breeding and seed saving have also been made readily available on the OSP website.

2006/01/01 TO 2006/12/31 The Organic Seed Partnership (OSP) project has created a strong national network emphasizing participatory approaches to develop and deliver commercial quality seed of improved vegetable varieties for organic agricultural production systems. In 2006, seed of 193 vegetable varieties and experimental lines (30 crops) was donated by Fedco, Flander's Bay Farm, High Mowing, Johnny's, Rupp, Seeds by Design, Seeds of Change, Southern Exposure Seed Exchange, Territorial, Turtle Tree, Cornell, OSU and USDA-ARS PGRU and USDA-ARS Salinas, CA to cooperating organic growers and university-based organic farms in CA, CT, MA, MS, NY, NM, OH, OR, PA, VT, WI and WV. Most on-farm trialing activity occurred in the NE, but in 2006 there was a substantial increase in the number of grower participants at our national trialing locations. A total of 175 farmers/gardeners received seed of 188 varieties/lines; 112 growers identified 139 new varieties rated winners that they will continue to grow. Trial results were distributed to cooperators and will be posted: <http://www.plbr.cornell.edu/psi/OSP%20home.htm>. Replicated trials of pepper, cucumbers and squash were completed on organic research farms at Cornell, OSU, UC Davis, WSU and on-farm at WVSU. Grower-managed on-farm breeding activities contributed 11 lines of squash, 71 lines of pepper and 2 OP broccoli populations to public breeders and other growers for further evaluation. Cucurbit and pepper breeding work continues at Cornell with the emphasis on developing broad disease resistance, improved product quality and adaptation to diverse environments. Breeding at OSU continues to focus on the development of late blight resistance in tomato, breeding for OP broccoli adapted to organic systems and for disease resistance, improved flavor and type in summer squash. At the termination of this project is expected that there will be an early, sweet red pepper, a white cucumber, a PMT novelty summer squash, two disease resistant heirloom melons and an advanced OP broccoli population suitable for release. Outreach and education events were also held in 2006 to further develop organic growers' capacity to both breed their own vegetable varieties and produce commercial grade lots of organically grown seed. In the Northeast, NOFA-NY, PGRU and Cornell sponsored 10 outreach and education events, including public taste-testing and workshops held on farms and at research stations that demonstrated breeding basics, pollination techniques, and seed production and cleaning methods to interested farmers, gardeners, and members of the public. Training and educational materials on these topics are also readily available on the OSP website. As part of our training activities a graduate student in plant breeding is actively engaged in the project, assisting with all aspects of the breeding process as well as outreach to the organic community. In 2006, presentations on the project were made at the NOFA-NY winter conference and at the 2006 Organic Seed Conference in OR. An annual project meeting of OSP collaborators was piggybacked on the latter conference where many new and valuable connections were made for future cooperation.

2005/01/01 TO 2005/12/31 The Organic Seed Partnership (OSP) involves an integrated set of activities that will enhance and expand existing complementary, regionally-focused organic seed production, variety evaluation and breeding activities. This project has created a strong national network to develop and deliver commercial quality seed of improved vegetable varieties for organic agricultural production systems. Vegetable germplasm for this project originates from small businesses (e.g., farmer/breeders, seed companies), non-profit organizations and

from the public sector (universities, USDA). In early 2005 a list of nearly 200 vegetable varieties gathered from Fedco, Johnny's, Rupp, Seeds by Design, Seeds of Change, Territorial, Turtle Tree, Cornell, OSU and USDA-ARS, Salinas, CA was offered to cooperating organic growers and university-based organic farms in CA, MS, NY, NM, PA and MD. Most on-farm activity occurred in the NE through a trialing network established by the Public Seed Initiative (PSI). A total of 85 farmers/gardeners requested and received seed of 162 vegetable varieties/lines. Of the 81 farmers who requested seed for main season trialing, 55 returned evaluations (response rate = 68 percent). Results have been distributed to cooperators and will be posted on the web. Specific breeding objectives were set based on stakeholder input provided through NOFA-NY, OFRF, OSA, ROS, and by a NESARE award to Cornell and U. Maine. Cornell cucurbit and pepper breeding emphasized broad disease resistance, improved product quality and adaptation to diverse environments. Breeding at OSU focused on the development of late blight resistance in tomato, breeding for OP broccoli adapted to organic systems and for disease resistance, improved flavor and type in summer squash. In 2005, the most popular breeding projects with farmers were selecting for an improved zucchini from crosses of the heirloom Costata Romanesca with disease-resistant high quality parents, mass selection for superior OP broccoli, and selecting for early maturing, cucumber mosaic tolerant, red and yellow bell peppers. In each project, farmers contributed their selections for further evaluation by breeders and other farmers. The participatory structure of this partnership ensures that we are addressing objectives perceived as important by growers and seedspeople. Outreach and education events were also held in 2005 to further develop organic growers' capacity to both breed their own vegetable varieties and produce commercial grade lots of organically grown seed. In the Northeast, NOFA-NY OSP and PGRU sponsored 11 outreach and education events, including public taste-testing and workshops held on farms and at research stations that demonstrated breeding basics, pollination techniques, and seed production and cleaning methods to interested farmers, gardeners, and members of the public. Presentations at two annual organic growers' meetings in New England, at the second annual Seed and Breeds Conference, EcoFarm, and at the annual meeting of the Crop Science Society of America have helped to further inform the public about OSP goals and activities.

2004/01/01 TO 2004/12/31 Specific breeding objectives have been set in response to extensive formal and informal surveys and roundtables to solicit stakeholder input conducted by non-profit organizations, NOFA-NY, OFRF, OSA, ROS, and by a newly awarded NESARE award to Cornell and U. Maine. Clearly the participatory structure of this partnership assured that we are addressing objectives perceived as important by growers and seedspeople. Plans are underway under OSP to: 1) expedite the cooperation, where desired, between breeders across sectors (farmers, seed companies, public sector) working on organically managed ground to develop locally adapted varieties; 2) engage a number of cooperators who presently do not have breeding or seed growing capacity, but do have interested communities of organic producers and the capacity to perform variety trials on certified organic farms or land in transition; 3) have regional trialing hubs that will work with their respective farm-based trialing networks to rapidly disseminate and evaluate promising vegetable varieties; and 4) develop classroom-based curricula for undergraduate students, extension staff and farmers. We are setting up extensive trials and selection environments for the 2005 growing season. Field days and outreach activities are also being planned. This project, The Organic Seed Partnership (OSP), involves an integrated set of activities that will enhance and expand existing complementary, regionally-focused organic seed production, crop variety evaluation and breeding activities. Our goal is to create a strong national network capable of developing and delivering commercial quality seed of improved vegetable varieties for organic agricultural production systems. The OSP integrates participatory research in farm-based crop breeding and selection activities in organic systems, based on strategies developed as part of our USDA-IFAFS project, the Public Seed Initiative. The focus of the OSP is on vegetable species because of the paramount importance of vegetables in organic farming systems and because of their relative value for the businesses that engage in organic agriculture. Vegetable germplasm for this project will originate from small businesses (e.g., farmer/breeders and regionally focused, smaller seed companies), non-profit organizations and projects (e.g., Restoring our Seed, Oregon Tilth) and from public sector research institutions including universities (Cornell, Oregon State, U. of Maine) and the USDA.

IMPACT

2004/09 TO 2008/09 OSP objectives addressed three critical linkages in the chain that begins when a grower plants a seed and ends at the supper table. First, the partnership has worked to expedite the cooperation between breeders across sectors (farmers, seed companies, public sector) working on organically managed ground to develop locally adapted varieties. This cooperation served to break the typically one way flow of varieties from breeder/seed company to grower thereby facilitating development of the best adapted material while ensuring that grower priorities were being met. As an indicator of this enhanced cooperation, the NOFA-NY

grower survey found that 79% of responders would be willing to establish a relationship with seed companies to perform on-farm variety trails. Second, the partnership worked to establish farm-based trialing networks at the regional hubs to evaluate and identify promising new vegetable varieties. While the most success was seen in the NE, where the combined efforts of NOFA-NY, USDA-ARS PGRU and Cornell facilitated a high-level of grower engagement, strong connections on a smaller but just as passionate scale were also made between public institutions at the other trialing hubs and their grower communities, particularly in NM and WV. In the NE, grower survey feedback indicated 88% of responders found the trialing of new varieties useful and many wished to participate in this activity in future projects. Seventy-nine percent indicated they are more likely to trial new varieties as a result of the project and 30% indicated they had identified new seed companies they will continue to buy seed from. Seventy-six percent of survey responders identified a total of 122 varieties as true "winners", varieties that they will continue to grow as standards on their farms, thereby enhancing overall success and profitability. Many more found varieties they would grow again for further evaluation. Third, through extensive outreach activities the partnership directly reached grower cooperators who did not have breeding or seed growing capacity or desired to enhance this capacity. Of NOFA survey responders, 82% actively practiced seed saving and 55% of this group indicated that OSP activities improved their capacity to save seed. Twenty-six percent of survey responders actively practiced breeding and 56% of this group indicated that OSP activities enhanced their ability to perform breeding. Many growers indicated that the project had enhanced their ability to evaluate new varieties by improving their observational skills and record-keeping. These enhanced skills and knowledge will have a long-lasting and positive impact on continued farm-based efforts to address the need for locally adapted varieties and high quality organic seed, which in turn will improve the health and viability of organic farming operations. At the termination of the project there was clearly demonstrated enthusiasm in continuance of the project among grower participants as well as among growers who were only informally exposed to OSP activities. The success of the project is largely attributable to the integrated and participatory nature of the effort. **PUBLICATIONS (not previously reported):** 2004/09 TO 2008/09 1. Dyck, E. 2006. Participation and Projects Grow in the Organic Seed Partnership, Organic Farms, Folks, and Foods, Spring 2006. 2. Dyck, E. 2006. Information Shared- and Generated- at 2006 OSP On-Farm Workshops Organic Farms, Folks, and Foods, Fall 2006. 3. Dyck, E. 2005. The Extraordinary All around Us: Farmer Breeders and Seed Savers Visited during the 2005 Season, Organic Farms, Folks, and Foods, Fall 2005. 4. Mazourek, M , Moriarty, G , Glos, M , Henderson, E , Rumore, D , Palmer, G, Chickering, A , Murphy, J , Fink, M , Kreitingner, M , Kramer, C, Myers, J. 2009. 'Peacework': An early red bell pepper for organic systems with Cucumber mosaic virus resistance. HortScience. In review. 5. Mendum, R. 2009. Cyborg Subjectivity: Decoding the agency of domesticated food crops. Subjectivity. Accepted. 6. Mendum, Ruth. 2009. Facilitating Organic Varieties: Participatory Plant Breeding in the Northeastern US. Special issue on Subjecting the Objective: Participation, Sustainability, and Agri-food Research. Submitted. 7. Chinthakuntla, R., Mentreddy, R.S., Igbowke, P., Jackson, F.D., Matta, F.B., Reddy, O.U.K., Jahn, M., Licata, L. and Keltra, S.D. 2006. Evaluation of different types of mulches for organic production of cucumbers. Mississippi Academy of Science 51(1):25 (Abstract).

2006/10/01 TO 2007/09/30 The OSP aims to address critical linkages in the chain that begins when a grower plants a seed and ends at the supper table. The partnership has worked to expedite the cooperation, where desired, between breeders across sectors (farmers, seed companies, public sector) working on organically managed ground to develop locally adapted varieties. The OSP has decentralized vegetable breeding by breaking the typically one way flow of varieties from breeder/seed company to grower. In 2007, grower-managed on-farm breeding activities contributed 66 breeding lines - 53 pepper, 5 pumpkin, 2 summer squash, 2 melon, 1 tomato, 1 winter squash, 1 celtuce and at least 1 OP broccoli population to public breeders and other growers for further evaluation. Furthermore, public breeders have utilized the OSP on-farm trialing network to gather performance data on their breeding material (a total of 45 breeding lines) from a wide variety of environments and growing conditions thereby enhancing their ability to select the best adapted material for release. One new variety, a early, CMV tolerant, sweet OP red bell pepper named Peacework pepper, has already been released through our participatory breeding efforts and is currently available from one seed company. Other breeding projects are close to fruition and at the termination of this project in 2008 it is expected that there will be an additional early, CMV tolerant, sweet, OP red pepper, a disease resistant white cucumber, a PMT novelty summer squash, two disease resistant heirloom melons and an advanced OP broccoli population suitable for release. In addition to ongoing farmer-breeder activities in the NE, we initiated our first on-farm breeding and selection activities in WV, which was well received by participating growers. Linkages have been strengthened between seed companies and growers as well. To date, 130 (74%) growers identified 219 new varieties as winners that they will grow again on their farms, enhancing the productivity of their farms and quality for the consumer. In addition, a survey of 108 NOFA growers indicated 80% of respondents would be willing to do more on-farm trialing for seed companies, 89% are more likely to try new varieties and 33% identified new seed companies that they had not used before. The partnership has actively engaged organic communities through our extensive outreach and education efforts. In 2007 our outreach activities reached nearly over 6,000 organic

growers and other stakeholders through breeding and seed production and cleaning workshops, demonstrations and presentations at conferences held in 10 states. This included several events in underserved communities; in MS a workshop with over 70 participants and two field days with close to 450 participants, in KY a booth visited by over 500 participants and in NM a workshop and presentation reaching over 270 participants. Our website has also served as an effective outreach mechanism with more than 3,000 hits by stakeholders in 81 countries. This represents a 2,000 hit, 24 country increase since 2006.

2006/01/01 TO 2006/12/31 The OSP aims to address four critical linkages in the chain that begins when a grower plants a seed and ends at the supper table. First, the partnership will expedite the cooperation, where desired, between breeders across sectors (farmers, seed companies, public sector) working on organically managed ground to develop locally adapted varieties. Second, the partnership will engage a number of cooperators who presently do not have breeding or seed growing capacity, but do have interested communities of organic producers and the capacity to perform variety trials on certified organic farms or land in transition. Third, regional trialing hubs will work with their respective farm-based trialing networks to rapidly disseminate and evaluate promising vegetable varieties. Each member of the trialing network is the hub for a community of farmer/evaluators and farmer/breeders. Fourth, classroom-based curricula are being developed and will be posted on a centralized web site with links to other resources for undergraduate students, extension staff and farmers and disseminated to all partners and collaborators wishing to include plant breeding for organic systems in course work or workshop settings.

2005/01/01 TO 2005/12/31 The OSP aims to address four critical linkages in the chain that begins when a grower plants a seed and ends at the supper table. First, the partnership will expedite the cooperation, where desired, between breeders across sectors (farmers, seed companies, public sector) working on organically managed ground to develop locally adapted varieties. Second, the partnership will engage a number of cooperators who presently do not have breeding or seed growing capacity, but do have interested communities of organic producers and the capacity to perform variety trials on certified organic farms or land in transition. Third, regional trialing hubs will work with their respective farm-based trialing networks to rapidly disseminate and evaluate promising vegetable varieties. Each member of the trialing network is the hub for a community of farmer/evaluators and farmer/breeders. Fourth, classroom-based curricula are being developed and will be posted on a centralized web site with links to other resources for undergraduate students, extension staff and farmers and disseminated to all partners and collaborators wishing to include plant breeding for organic systems in course work or workshop settings.

2004/01/01 TO 2004/12/31 It is too early to report on impacts of the OSP, but as the project unfolds, direct impacts on organic crop production and its profitability are expected.

PUBLICATIONS

2006/10/01 TO 2007/09/30 1. Boches, P., Kuslowa, P., Kean, D. and Myers, J. 2007. Vegetable Variety Trials 2006. OSUES <http://extension.oregonstate.edu/catalog/pdf/em/em8777-06-e.pdf> 2. Colley, M.R. and Myers, J.R. 2007. On-farm variety trials: A guide for organic vegetable, herb, and flower producers. Organic Seed Alliance, Port Townsend, WA. <http://www.seedalliance.org/uploads/pdf/OVTguide.pdf>. 3. Dyck, E. 2007. The Organic Seed Partnership Project in its Final Year. Organic Farms, Folks, and Foods, NOFA-NY summer newsletter 4. Miles, C., Granatstein, D., Huggins, D., Jones, S. and Myers, J. 2007. Making the Conversion to Sustainable Agroecosystems: Principles, Processes, and Practices. CRC Press Advances in Agroecology Series. Pacific Northwest USA. In: Stephen R. Gliessman, Martha Rosemeyer, and Sean Swezey (editors). (in press). 5. Myers, J., and D. Kean. 2007. Breeding open pollinated (OP) broccoli cultivars for organic production systems. Hortscience. 42:813 (Abstract). (podcast available at <http://ashes.org/resources/horttalks/detail.lasso?id=137>) (invited presentation)

2006/01/01 TO 2006/12/31 No publications reported this period

2005/01/01 TO 2005/12/31 1. Yeam, I., B.C. Kang, J.D. Frantz and M.M. Jahn. 2005. Allele-specific CAPS markers based on point mutations in resistance alleles at the pvr1 locus encoding eIF4E in Capsicum. TAG 112:178-186. 2. Kang, B.C., I. Yeam and M.M. Jahn. 2005. Genetics of resistance to plant viruses. Ann. Rev.

Phytopathology 42:581-621. 3. Quirin, E.A, E. Ogundiwin, J.P. Prince, M. Mazourek, M. O. Briggs, T. S. Chlanda, B.C. Kang, L.G. Landry, K.T. Kim, and M. M. Jahn. 2005. PCR-based detection of Phyto.5.2, a major QTL controlling resistance to Phytophthora capsici in Capsicum. TAG 110:605-612. 4. Henning, M.J, H.M. Munger and M.M. Jahn. 2005. 'Hannah's Choice F1' : A new muskmelon hybrid with resistance to powdery mildew, Fusarium race 2 and potyviruses. HortScience 40(2):492-493. 5. Henning, M.J, H.M. Munger and M.M. Jahn. 2005. 'PMR Delicious 51': An improved open-pollinated melon with resistance to powdery mildew. HortScience 40(1):261-262.

2004/01/01 TO 2004/12/31 No publications reported this period

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Building on the Best: a Systems Research and Education Partnership for Increased Competitiveness of Organic Grain and Vegetable Farms

Accession No.	0201262
Subfile	CRIS
Project No.	NYC-125569
Agency	NIFA NY.C
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02230
Proposal No.	2004-05218
Start Date	01 SEP 2004
Term Date	31 AUG 2009
Fiscal Year	2009
Grant Amount	\$575,028
Grant Year	2004
Investigator(s)	Mohler, C. L.; Abawi, G.; Allee, L.; Rangarajan, A.; Thies, J.
Performing Institution	CROP & SOIL SCIENCES, CORNELL UNIVERSITY, ITHACA, NEW YORK 14853

NON-TECHNICAL SUMMARY

Weeds, insect pests and poor nutrient availability are often problems during the transition from conventional to organic agriculture. By comparing cropping systems that use different approaches to building soil quality this project will reveal interactions between soil quality and pest management and identify practices for rapid transition from conventional to organic management. An extension course based around the experiments will provide in-depth information on how organic systems work.

OBJECTIVES

1. Objective 1 is to develop more productive and competitive organic systems by building on practices of experienced organic growers to improve overall system health during and after transition from conventional agriculture. 2. Objective 2 is to determine the impact of soil quality and nutrient levels in organic systems on weed, disease and insect populations. Hypotheses to be tested include: a. effectiveness of cultivation will improve with improving soil physical quality, b. weed density and growth rates will be greater in systems with higher early soil nutrient levels, c. weed seedling density will be reduced in soil with recently incorporated cover crop organic matter and this will correlate with pathogenic fungi populations, d. soil biological quality (abundance, activity and diversity of beneficial organisms) will improve with improving soil physical quality and soil organic matter status, e. populations of disease organisms (plant-parasitic nematodes and plant pathogenic bacteria and fungi) will be suppressed as soil biological quality improves, f. increasing levels of soil organic matter, reduced tillage and increased rotation with cover crops will reduce populations of and damage by soil-borne pathogens, especially in vegetable production systems, g. higher soil quality and nutrient availability will result in lower insect pest density and lower insect pest damage to crops. h. increasing soil organic matter and cover crops will increase beneficial insect diversity and population size. 3. Objective 3 is to develop a living laboratory course

based on the cropping system studies for training agricultural professionals and leading organic farmers to work more knowledgeably with beginning organic farmers, and to strengthen the network of individuals providing extension support to organic farmers.

APPROACH

The approach of this project is to take the best managed organic vegetable and grain farms we know of and test system modifications that these farmers and the participating scientists believe are likely to either (i) overcome residual problems these farms are experiencing, (ii) make their systems more usable by many organic growers, and (iii) speed the rate at which a field transitions biologically from a conventional to a mature organic cropping system. To do this, farming system experiments will be established at two sites on experiment station farms. One will be a vegetable experiment and will compare (i) a system typical of land limited organic vegetable growers that relies on compost for nitrogen, (ii) a reduced tillage system with alternate year fallow periods that relies on cover crops for N, (iii) a reduced tillage system with cash crops each year that relies on cover crops for N, and (iv) a ridge tillage system with cash crops each year that relies on cover crops for N. The second experiment will be a cash grain experiment with four treatments: (i) a high compost treatment, (ii) a low compost treatment, (iii) a low compost treatment with intensive weed management, and (iv) a low compost treatment with ridge tillage. Treatment plots will be intensively sampled for insects, weeds, indicators of soil physical and biological health, and soil nutrient dynamics. Examination of the differences between systems and the changes in the systems through time during transition will indicate relations between soil conditions and pests. Specific hypotheses will be tested through intensive sampling during particular time periods and laboratory bioassays. An additional on-farm experiment will allow in-depth study of the effects of compost type and application rate on soil quality and weed populations in a cash grain-processing vegetable system. The experiments will form the basis of a living laboratory course targeted at extension personnel and organic farmer mentors. The course will integrate web-based learning modules with in-depth field experience at the experiments. Course participants will collaborate in fine-tuning the experiments, and evaluate the study.

PROGRESS

2004/09 TO 2009/08 OUTPUTS: We conducted many extension and education activities over the life of the project. Field days were held at both the vegetable and grain cropping systems experiments each year. In 2007, 2008 and 2009 these focused on soil health, weed management and cover crops for crop nutrition. These field days followed a Living Lab format using hands-on exercises linked to the experiments. In addition, the project participated in general farm field days each year at both experiments which allowed a broader though less intensive contact with stakeholders. Field days and related activities resulted in contact with 930 stakeholders and 1,046 contact hours in a total of 20 events. Talks and workshops about the project at grower meetings, professional society meetings and Cornell's Organic Program Work Team meetings that bring together extension personnel and growers to further organic research and extension reached an additional 630 stakeholders through 436 contact hours. The project director gave a featured presentation about the project at the 2008 Integrated Organic Program Project Directors meeting. The cropping systems experiments are now integrated into the curricula of four Cornell courses, with several talks and field trips to the experiments each year. Altogether, the project has reached 276 students during classroom and field presentations totaling 351 contact hours. In addition, the project has been successful at incorporating a total of 36 undergraduate students and three graduate students into the research process. All of these students gained a good understanding of the goals and methods of the research as well as obtaining a variety of skills during hands-on training. Two graduate students worked on research papers and extension materials. One graduate student did about half of her thesis project in the context of the organic grain cropping systems experiment. An undergraduate did an independent research project related to the organic vegetable cropping systems experiment. The project maintains an extensive web site: Organic Cropping Systems Project. Organic Agriculture for the Future: Designing Farms for Better Soil and Pest Management. <http://www.organic.cornell.edu/ocs/index.html> PARTICIPANTS: In addition to Charles Mohler, the Project Director, researchers participating in the project included George Abawi, Leslie Allee, Brian Caldwell, Antonio DiTommaso, Laurie Drinkwater, Quirine Ketterings, Anusuya Rangarajan, Janice Thies, Harold van Es, Thomas Bjorkman, Abby Seaman, Robert Schindlebeck, Ann Piombino, Melissa Madden and Greg Godwin. Farmers participating in the project include Eric and Anne Nordell, Klaas and Mary Howell Martens, Anton Burkett, Chaw Chang, Lou Johns, Casey Kunes, Louis Lego, Anthony Potenza, John Saeli, Tor Oechsner and Erick Smith. Extension personnel participating in the project include Kieth Waldron, Robert Hadad and Janice Degni. Rachel Shuler, Krista Isaacs and Megan Shipanski are graduate students who worked on the project. Undergraduate students that worked on the project included Danya Glabau, Min Par, Hans Spalhol, Rachel SchellLamber, Joonsik par, Shonbetty L, Sam Greenwoo, Shawn Hall, Peeter Aarismaa, Lynda Zakrzewsk,

Purba Mukerjee, Steve Mulke, Rumi Solaguren, Feng Zhang, John Orlowski, Steve Peever, Tanya Prado, Van Otero, Karen Wozniak, Megan Crney, Misha Kwasniewski, Thomea Paul, David Her, Marlene van Es, John Means, Melanie Ho, Noah Slovin, Daniel Demaree, Steve Pietstruska, K. C. Alvey, Christina Dykeman, Brian Karlowitz, Lori Moshman, Devin Isenecker, Loden Mohler, Erica Rogers, Kurt Rogers and Donna Remnick provided occasional help with field work. Elizabeth Dyck, an employee of the Northeast Organic Farming Association - New York, coordinated much of the outreach program of the project. **TARGET AUDIENCES:** The target audiences are organic and transitioning farmers, farmers considering transitioning to organic, extension personnel, and university students. **PROJECT MODIFICATIONS:** The research program has proceeded nearly as planned, with only minor deviations in response to field conditions. Sampling of beneficial insects has been scaled back because high mobility of these insects between plots makes system differences slight. Further development of the Cornell soil health testing protocols has led to increased soil health evaluations. Development of the Living Lab course began more slowly than expected but has been proceeding as planned for the past three years. Equipment problems have forced us to modify grain system 4 from a strict ridge till system to a reduced tillage system with controlled wheel traffic. That is, the field operations are no longer just ridging and scraping as originally planned, but the objective of the system remains the same.

2007/10/01 TO 2008/09/30 OUTPUTS: The project conducted many extension and education activities during the 2008 reporting period. Weed management Living Lab exercises were conducted at both the Vegetable and Grain experiments, reaching a total of 85 people. During farm field days, 65 people toured the vegetable experiment and 115 people toured the grain experiment. Tours of the vegetable experiment were given to three foreign scientists. Talks about the grain experiment were given to 13 growers at the Northeast Organic Farming Association annual meeting and to 70 growers and extension personnel at a joint meeting of NY Certified Organic (growers) and the Cornell Dairy and Field Crops Program Work Team (extension). A talk about the on-farm compost experiment was given to 75 people at the annual meeting of the Weed Science Society of America. The cropping systems experiments are now integrated into the curricula of four Cornell courses, with 5 separate field trips run during the reporting period. Altogether, during the reporting period, we reached 371 growers and extension personnel for a total of 387 contact hours, and 44 students for a total of 36 contact hours. In addition, the project has been successful at incorporating students into the research process. Nine undergraduate students worked on the project at various times during the reporting period. Three of these worked full time on the project during the summer of 2008. All of these students gained a good understanding of the goals and methods of the research as well as obtaining a variety of skills during hands-on training. Two graduate students worked on research papers and extension materials during the reporting period. The project maintains an extensive web site: Organic Cropping Systems Project. Organic Agriculture for the Future: Designing Farms for Better Soil and Pest Management. <http://www.organic.cornell.edu/ocs/index.html> **PARTICIPANTS:** In addition to Charles Mohler, the Project Director, researchers participating in the project during the reporting period included George Abawi, Brian Caldwell, Antonio DiTommaso, Laurie Drinkwater, Quirine Ketterings, Anusuya Rangarajan, Janice Thies, Harold van Es, Abby Seaman, Robert Schindlebeck, Ann Piombino, Melissa Madden and Greg Godwin. Farmers participating in the project include Eric and Anne Nordell, Klaas and Mary Howell Martens, Anton Burkett, Chaw Chang, Lou Johns, Casey Kunes, Louis Lego, Anthony Potenza, John Saeli, and Erick Smith. Extension personnel participating in the project include Kieth Waldron, Robert Hadad and Janice Degni. Rachel Shuler, Krista Isaacs and Megan Shipanski are graduate students who worked on the project. Undergraduate students working on the project during the reporting period included John Orlowski, Megan Carney, Misha Kwasniewski Thomas Paul, David Her, Marlene van Es, John Means, Melanie Ho and Noah Slovin., Elizabeth Dyck, an employee of the Northeast Organic Farming Association - New York, has played an important role in the project. **TARGET AUDIENCES:** The target audiences are organic and transitioning farmers, farmers considering transitioning to organic, extension personnel, and university students. **PROJECT MODIFICATIONS:** The research program has been proceeding nearly as planned, with only minor deviations in response to field conditions. Sampling of beneficial insects has been scaled back because high mobility of these insects between plots makes system differences slight. Further development of the Cornell soil health testing protocols has led to increased soil health evaluations. Development of the Living Lab course began more slowly than expected but has been proceeding as planned for the past two years. Equipment problems have forced us to modify G4 from a strict ridge till system to a reduced tillage system with controlled wheel traffic. That is, the field operations are no longer just ridging and scraping as originally planned, but the objective of the system remains the same.

2006/10/01 TO 2007/09/30 OUTPUTS: The project conducted many extension and education activities during the 2007 reporting period. Soil health Living Lab exercises were conducted at both the Vegetable and Grain experiments, reaching a total of 49 people. Tours of the Vegetable experiment, which is close to Cornell, were given to a group from the Toward Sustainability Foundation, an undergraduate course on organic agriculture, and a group of PhD students and agricultural advisors from India. These reached a total of 60 people. In addition,

talks about the project were given to 30 farmers at a meeting of New York Certified Organic, 16 people at the Northeast Organic Farming Associations summer conference, 70 farmers and extension personnel at the Cornell Cooperative Extension Organic Field Crops and Dairy Program Work Team meeting, 50 agricultural advisors during a short course on organic agriculture in Lebanon, 16 students in an undergraduate course in weed science and 15 students in a graduate course in weed science. Altogether, during the reporting period, we reached 168 growers and extension personnel for a total of 255 contact hours, and a total of 167 students for a total of 199 contact hours. In addition, the project has been successful at incorporating students into the research process. Five undergraduate students worked on the project during the academic year. Three undergraduates worked full time on the project during the summer of 2007 and an additional two worked on the project occasionally. All of these gained a good understanding of the goals and methods of the research as well as obtaining a variety of skills during hands-on training. Three graduate students worked on research papers or extension materials during the reporting period. PARTICIPANTS: In addition to the Charles Mohler, the Project Director, researchers participating in the project included George Abawi, Leslie Allee, Brian Caldwell, Antonio DiTommaso, Laurie Drinkwater, Quirine Ketterings, Anusuya Rangarajan, Janice Thies, Harold van Es, Thomas Bjorkman, Daniel Brainard, Robert Schindlebeck, Ann Piombino and Greg Godwin. Farmers participating in the project include Eric and Anne Nordell, Klaas and Mary Howell Martens, Anton Burkett, Chaw Chang, Lou Johns, Casey Kunes, Louis Lego, Anthony Potenza, John Saeli, and Erick Smith. Extension personnel participating in the project include Abby Seaman, Kieth Waldron and Janice Degni. Rachel Shuler, Krista Isaacs and Megan Shipanski are graduate students working on the project. Undergraduate students working on the project during the reporting period include Tanya Prado, Stephen Peever, Van Otero, Rumi Sologuren, Feng Zhang, John Orlowski, Megan Carney, Misha Kwasniewski, Lynda Zakrezewski, and Karen Wozniak. Elizabeth Dyck, an employee of the Northeast Organic Farming Association - New York, continues to play an important role in the project. TARGET AUDIENCES: The target audiences are organic and transitioning farmers, farmers considering transitioning to organic, extension personnel, and students. PROJECT MODIFICATIONS: The research program has been proceeding nearly as planned, with only minor deviations in response to field conditions. Sampling of beneficial insects has been scaled back because high mobility of these insects between plots makes system differences slight. Further development of the Cornell soil health testing protocols has led to increased soil health evaluations. Development of the Living Lab course began more slowly than expected and is behind schedule. Progress during the current reporting period, however, was at the proposed pace.

2006/01/01 TO 2006/12/31 The project compares organic cropping systems that use different approaches to building soil quality (compost, cover crops, reduced tillage), and how soil quality interacts with weed, insect, and disease management to affect productivity and economic return. The vegetable experiment compares (V1) a system that relies on compost for nitrogen and uses conventional tillage, (V2) a mixed tillage system that relies on cover crops for N, (V3) a mixed tillage system with alternate years in cover crops and fallow, and (V4) a ridge till system that relies on cover crops for N. The grain experiment compares (G1) a system that maximizes gross income through high nutrient input, (G2) a minimal input system, (G3) an intensive weed management system, (G4) a ridge till system, and (G5) a conventional system (not randomized with the others). Data collected in 2006 included soil physical and chemical properties, weed counts and biomass, insect and disease scouting, crop density, yield, yield components and produce quality and cover crop quality and N. Number of marketable heads and head weight of lettuce (Entry point 1) was lowest in V4 and highest in V1. Tarnished plant bug damage was greatest in V4 and least in V1. Soil P levels (high overall) were greater in V1, indicating a potential problem with this high yield system. Weed control from cultivation and one hand hoeing was good in all systems. Cabbage yields (Entry point 2) were above state average and about equal in all systems, despite 1 week later planting in V1 following a good crop of snap peas. Early flea beetle problems were controlled with one application of Surround + Entrust. Caterpillar populations crashed in all systems, possibly due to a parasitoid wasp. Weed control in cabbage was good due to cultivation plus hand hoeing. Due to wet soil conditions in fall 2005, spelt (Entry point 1) was no-till surface sown. G3 and G4 with substantial ridges from cultivation had less winter kill and higher densities in the spring. G1 and G2 had intermediate topography and moderate stands and G5 (uncultivated) had the lowest stand. Nevertheless, G1 and G5, which received fertilizer, had highest yields (1,400 and 1,700 lbs/A). G2 which had relatively low stands and no fertilizer yielded only 800 lb/A. G3 and G4 both yielded 1,300 lb/A. Weeds were worst in G1 (1,100 lb/A), possibly due to high fertility, and best in G2 and G3 (600 lb/A). Spring sown red clover established well in G1, G2 and G3 but failed to grow after spelt harvest, possibly due to excessive wetness. Crimson clover in G4 barely grew. Soybeans in Entry point 2 had lower stand in G3 due to a double tine weeding but yields of G1, G2 and G3 were all about 42 bu/A. Yield in G4 (ridge till) was lower due to greater loss during cultivation and missing lower pods during harvest. G4 did not have significantly more weeds, but it had more perennials and fewer ragweed than other treatments. Spelt was planted without problems after soybeans this year. An economic analysis was developed and the Living Lab course was initiated at <http://www.organic.cornell.edu/ocs/index.html>.

2005/01/01 TO 2005/12/31 The project compares organic cropping systems that use different approaches to building soil quality with compost, cover crops and reduced tillage practices. It simultaneously investigates how soil physical and biological quality interacts with weed, insect, and disease management. The vegetable experiment compares (1) a system that relies on compost for nitrogen, has occasional cover crops and uses conventional tillage, (2) a mixed tillage system that relies on cover crops for N, (3) a mixed tillage system with alternate years in cover crops and fallow periods, and (4) a ridge tillage system with cash crops each year that relies on cover crops for N. The grain experiment compares four organic systems and a conventional one: (1) a system that maximizes gross income through high nutrient input, (2) a minimal input system, (3) an intensive weed management system, and (4) a ridge till system, and (5) a conventional system (not randomized with the others). Soil data collected in 2005 included nutrients, physical properties, disease suppressiveness, soil ecology, and nutrient inputs in compost. Weed data included, assessment of seed bank, counts before and after cultivation, and harvest counts and biomass. Pest data included scouting for insects and disease symptoms, sticky traps, and pitfall traps for beneficials. Crop data included stand counts, yield, quality measurements estimation of nutrient export, cover crop biomass and N. Sweet corn in the vegetable experiment had some Powell amaranth that escaped cultivation and became very large. Weed control by cultivation was best in system 4 but corn establishment was lower there due to dry ridges. System 3 was hand weeded to prevent seed shed and yielded 6.6 marketable ton/a vs. 3.5 to 4.7 ton/a for other systems. Insect damage to ears was highest in system 1 (18 percent) and lowest (0 percent) in system 4. Early flea beetle problems in the cabbage were controlled with Surround + Entrust, and only 4 percent of heads were unmarketable. Marketable cabbage yields were similar among systems (average 52,000 lb/a), despite a lower stand and one week later planting in system 1 which had an early snap pea crop. Weed control in cabbage was good due to cultivation plus hand hoeing. Bell beans interseeded after last cultivation produced 780 lb/a biomass by winter, but Japanese millet seeded with it emerged poorly and grew poorly. Emergence was slow and sporadic in both corn and soybean in the grain experiment due to drought, and some seedlings were killed pre-emergence by tine weeding. Soybean yields were equivalent in all treatments at 38 bu/a, despite higher stand counts in the conventional system. Corn yields were around 100 bu/a in the organic systems which is a good yield for beginning transition with corn, but lower than the 125 bu/a in the conventional. Weed control was good and insect damage was negligible in all systems. A simulated aerial overseeding of a rye plus spelt cover crop into corn established well. A satellite on-farm nutrient study showed that yield peaked at low rates of compost but that size and density of some weed species increased up to the highest compost rates.

2004/01/01 TO 2004/12/31 This project began Sep. 1, 2004, and so we have no results to report as yet. We are in the process of setting up a web site and doing detailed planning for the coming field season.

IMPACT

2004/09 TO 2009/08 We established vegetable and grain cropping systems experiments on certified organic fields at Cornell Experiment Station farms. Large plots and farmer guided management have led to four realistic but divergent organic cropping systems in each experiment. The following important findings have emerged from our project. A more detailed progress report can be found at <http://www.organic.cornell.edu/ocs/index.html>. (1) Systems with the best economic return show potential for long term soil problems: System G2 which has the best grain returns due to low inputs is mining P and K while system V1 which has the best vegetable returns due to intensive cropping is showing declines in measures of soil health. (2) Ridge tillage holds promise as a reduced tillage organic vegetable production system. (3) Cover crop management must be integrated with a general weed management plan. Choice of cover crop can determine whether the weed seed bank increases or decreases. Conversely, if the seed bank is substantially reduced then a wider range of cover crops can be used without creating weed problems. (4) As compost application rates increase, weed competition also increases. Even moderate compost rates have increased weed pressure relative to more conservative rates. (5) Soil health indicators varied in their ability to detect differences in management during the transition to organic cropping. Soil aggregate stability and active carbon respond quickly to tillage, cover crops, and organic matter additions. Whether long term soil health improves or declines under a given type of management depends on both management and initial conditions. (6) Organic soil fertility practices commonly used in the Northeast result in nutrient imbalances with potentially detrimental long-term effects. The fertility management systems we compared agreed with our on-farm research and resulted in accumulation and/or depletion of major nutrients, with outcomes determined by crop rotation and compost amount and composition. Potassium showed a negative balance in several vegetable and grain systems. (7) Soil conditions affect crop growth with consequences for

insect populations. For example, in 2008, V3 (bioextensive), had the best soil conditions at planting, winter squash grew fastest, and had higher initial striped cucumber beetle densities but these subsequently declined relative to other systems. We have observed related patterns in other crops. (8) Shifting small compost additions from corn to small grains could increase profitability. Winter grain yields responded to compost whereas corn following plowed-down clover did not. This is contrary to the typical organic farm practice in NY cash grain systems. (9) Green manures supplied sufficient nitrogen during the transition years. Nitrogen fixation rates measured in years 3 and 4 were high in these organic cropping systems. As long as stand establishment succeeds, ample new N is added through N fixation. Evaluation of workshops and field days have been favorable. A telephone survey of field day participants indicated that over half were using skills gained at field days. **PUBLICATIONS (not previously reported):** 2004/09 TO 2009/08 1. Godwin, G., Q. M. Ketterings, C. L. Mohler, B. Caldwell, and K. Czymmek. 2009. Impact of clover incorporation and ammonium nitrate sidedressing on ammonium, nitrate and Illinois Soil Nitrogen Test dynamics over time. *What's Cropping Up* 19(3):12-15. 2. Mohler, C. Outwitting weeds, part II. *Organic Farms, Folks and Foods* Spring 2009:18-19. 3. Isaacs, K., Caldwell, B. and Mohler, C. L. 2008. Organic Ridge Till Vegetables. *Organic Farms, Folks & Foods*, Spring 2008: 20-21. 4. Isaacs, K., Mohler, C. L. Caldwell, B., Schindlebeck, R. and van Es, H. 2008. Organic management improves soil health: results from the Organic Grain Cropping System Experiment. *What's Cropping Up*, 18(1):5-7. 5. Mohler, C. L., Bjorkman, T. and DiTommaso, A. 2008. Control of weed size by compost application rate in an organic cropping system. *Weed Science Society of America, Abstracts* 48. (Released on CD). 6. Roberson, K. 2008. A kernel of difference: the growing demand for organic corn means healthier soil , cleaner water and perhaps even better tasting food.. *Greenwise Market*, June: 6.

2007/10/01 TO 2008/09/30 The project compares organic cropping systems that use different approaches to building soil quality (compost, cover crops, reduced tillage), and examines how soil quality interacts with weed, insect, and disease management to affect productivity and economic return. The vegetable experiment compares (V1) a system that relies on compost for nitrogen and uses conventional tillage, (V2) a system that relies on cover crops for N, (V3) a mixed tillage system with alternate years in cover crops and fallow, and (V4) a ridge till system that relies on cover crops for N. The grain experiment compares (G1) a system that maximizes gross income through high nutrient input, (G2) a minimal input system, (G3) an intensive weed management system, (G4) a ridge till system, and (G5) a conventional system (not randomized with the others). Data collected in 2008 included soil physical, biological and chemical properties, weed counts and biomass, insect and disease scouting, crop density, yield, yield components, produce quality and cover crop biomass and N. Delicata squash yields in Entry Point 1 (EP1) differed significantly in all systems with the ranking V3 (11,000 lb/A), V2, V4, V1 (4,400lb/A). Striped cucumber beetle pressure was exceptionally high despite a perimeter trap crop and (ineffective) organic sprays, but pressure tended to be greater in the higher yielding systems. System V4 was difficult to cultivate due to the need to maintain 2 bare ridges between planted ones. System V1 squash suffered from N tie up by an exceptional rye cover crop despite a 5X higher compost rate. Poor crop growth led to high weed biomass in V1 and V4. Marketable yield of Yukon Gold potato (EP2) was overall better than in 2007 due to good total yield and fewer defects. Insect, disease, and weed control was good in all systems. Soil tests show nutrient levels mostly staying the same or diminishing slightly in the vegetable trial, with the exception of K, which has increased in all systems except V2. In all vegetable systems, pH has increased by about 0.5 points, and the compost source was changed to prevent further increase. Differences in aggregate stability among systems were less pronounced than in 2007, but general trends remained: V1 relatively low, and G5 less than in the organic grain systems. In both experiments, systems with legume cover crops have better soil health parameters like aggregate stability than those that do not. Overwintered red clover in EP2 in G1, G2 and G3 produced 2.3 dry T/A, containing roughly 160 lb of N. Soybean (EP1) yields averaged 45 bu/A and corn (EP2) yields averaged 167 bu/A in G1, G2 and G3. Yields did not differ between these systems or with the chemical G5. G4 had much lower yields due to problems with planting and cultivation and consequent weed competition. N, P and K have increased in G1, which appears to be driving an increase in weed pressure.

2006/10/01 TO 2007/09/30 The project compares organic cropping systems that use different approaches to building soil quality (compost, cover crops, reduced tillage), and examines how soil quality interacts with weed, insect, and disease management to affect productivity and economic return. The vegetable experiment compares (V1) a system that relies on compost for nitrogen and uses conventional tillage, (V2) a mixed tillage system that relies on cover crops for N, (V3) a mixed tillage system with alternate years in cover crops and fallow, and (V4) a ridge till system that relies on cover crops for N. The grain experiment compares (G1) a system that maximizes gross income through high nutrient input, (G2) a minimal input system, (G3) an intensive weed management system, (G4) a ridge till system, and (G5) a conventional system (not randomized with the others). Data collected in 2007 included soil physical and chemical properties, weed counts and biomass, insect and disease scouting, crop density, yield, yield components, produce quality and cover crop biomass and N. Total yield of Youkon Gold

potato (Entry Point 1) was average but scab decreased marketable yield substantially. Insect control was good. In contrast to 2006, the number of marketable heads and head weight of lettuce (EP 2) was lowest in V1 and highest in V4. Weed control from cultivation and one hand hoeing was adequate in all systems. We implemented a novel cover crop regime in systems 2 and 3, consisting of buckwheat and red clover planted together. This was suggested by one of our advisors and appears to work well to suppress weeds and provide N. Soil tests show nutrient levels mostly staying the same or diminishing slightly in the vegetable trial, with the exception of potassium, which has increased in EP 1, systems 1 and 3. pH has increased markedly in all vegetable systems, typically by 0.5 points. Aggregate stability values diverged in both trials. In the vegetable trial, V1 levels tended to be lowest, while G5 had significantly lower values than the organic systems in the grain trial. We are investigating the reasons for this and analyzing data to see if tillage and cover crop intensities play important roles. Overwintered red clover in EP 1 in G1, G2 and G3 grew well in the spring of 2007. Biomass of red clover plowed down before corn was 2900-3600 dry lb/acre, containing roughly 100-130 lb of N. Corn gave the same yields in all systems, except G4 where it failed due to excessive competition from volunteer spelt. Yields were only 87 bu/acre, due to spotty germination and drought. Weed control was good. G4 was replanted to buckwheat, which also did not produce a crop due to drought. Spelt performed very well in 2007. G1 and G5, which received fertilizer, again had highest yields (3,100 and 3,200 lbs/A). G2, G3 and G4 which had no fertilizer yielded 1,800, 2,100, and 2,100 lb/A, respectively. This confirms 2006 results from the compost rate satellite trial. Weed pressure was low, but worst in G4 due to perennials. Spring sown red clover established well in G1, G2 and G3. Berseem clover in G4 failed to grow. Economic analyses for both trials were further refined.

2006/01/01 TO 2006/12/31 During 2006, 137 people toured the experiments at two field days. Many growers seemed to be impressed by the vigorous crops, good weed control, and adequate yield despite excessively wet conditions. The experiments thus seem to be changing the mindset of conventional growers and encouraging organic growers to consider new options for tillage and fertility.

2005/01/01 TO 2005/12/31 One hundred sixty three people toured the experiments at three field days. Many growers seemed to be impressed by the vigorous crops, good weed control, and adequate yield despite drought conditions. The experiments thus seem to be changing the mindset of conventional growers and encouraging organic growers to consider new options for tillage and fertility.

2004/01/01 TO 2004/12/31 By comparing cropping systems that use different approaches to building soil quality this project will reveal interactions between soil quality and pest management and identify practices for rapid biological transition from conventional to organic management. A course based around the experiments will provide in-depth information on how organic systems work to train extension personnel and farmer mentors.

PUBLICATIONS

2007/10/01 TO 2008/09/30 1. Isaacs, K., Caldwell, B. and Mohler, C. L.. 2008. Organic Ridge Till Vegetables. 2. Organic Farms, Folks & Foods, Spring 2008: 20-21. 3. Isaacs, K., Mohler, C. L. Caldwell, B, Schindlebeck, R. and van Es, H. 2008. Organic management improves soil health: results from the Organic Grain Cropping System Experiment. *What's Cropping Up*, 18(1):5-7. Mohler, C. L., Bjorkman, T. and DiTommaso, A. 2008. Control of weed size by compost application rate in an organic cropping system. *Weed Science Society of America*, Abstracts 48. (Released on CD). 4. Roberson, K. 2008. A kernel of difference: the growing demand for organic corn means healthier soil , cleaner water and perhaps even better tasting food.. *Greenwise Market*, June: 6.

2006/10/01 TO 2007/09/30 No publications reported this period

2006/01/01 TO 2006/12/31 No publications reported this period

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2004/01/01 TO 2004/12/31 No publications reported this period

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Strengthening the Scientific Foundation of Organic Standards on Animal Health and Welfare

Accession No.	0201444
Subfile	CRIS
Project No.	MASV-DAG104
Agency	NIFA MASV
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02238
Proposal No.	2004-05216
Start Date	15 SEP 2004
Term Date	14 SEP 2007
Fiscal Year	2007
Grant Amount	\$197,768
Grant Year	2004
Investigator(s)	Lockeretz, W.
Performing Institution	FRIEDMAN SCHOOL OF NUTRITION SCIENCE & POLICY, TUFTS UNIVERSITY, 200 WESTBORO ROAD

NON-TECHNICAL SUMMARY

Since October 2002, all foods and food products sold in the US as organic must have been produced in accordance with USDA National Organic Standards. In the US, while there is general agreement at least on the broad features of organic crop production and processing standards, further refinement of standards for organic animal production is particularly needed. The purpose of this project is to identify and elucidate specific options for animal health and welfare standards, with their potential to positively and negatively affect organic production and trade.

OBJECTIVES

Since October 2002, all foods and food products sold in the US as organic must have been produced in accordance with USDA National Organic Standards (NOS), as required by the Organic Foods Production Act of 1990 (OFPA). These standards, which were issued in December 2000 by the Agricultural Marketing Service, deal with crops, animals, and processed foods. Further refinement of standards for organic animal production is particularly needed, because organic animal standards are very difficult and complex. In the US, while there is general agreement at least on the broad features of organic crop production and processing standards, major areas of the animal standards remain highly contentious, such as just what is meant by requiring that animals have access to outdoors. Many other areas of animal health and welfare are reflected in the standards only incompletely, if at all. The first objective is to make full use of existing research to bolster the scientific foundations of the National Organic Standards in the areas that directly or indirectly affect animal health and welfare. This objective falls under Goal 5 of the Organic Transitions Program: Develop the scientific basis to improve current organic standards. The second objective is to apply this scientific understanding to suggest possible ways to reconcile conflicting international standards for organic livestock. This falls under Goal 3 of the

Organic Agriculture Research and Extension Initiative, which includes Comparing compatibility of certification standards used in different parts of the world, with the ultimate goal of harmonization and reciprocity.

APPROACH

Identification of priority topics will come from multiple sources. National Organic Standards (NOS)-related sources will include: records of the National Organic Standards Board (NOSB) meetings; recommendations of the NOSB livestock committee; policy statements and guidance statements posted on the National Organic Program website; and the preambles to NOP Final Rule and second Proposed Rule (USDA, 2000a; 2000b). Comparing NOS with other important standards will be another way to select priority topics. Standards to be compared will include: the IFOAM Basic Standards (IFOAM, 2002), the Codex Alimentarius standards (FAO, 2001), the European Union standards (EC, 1999), the Organic Trade Association voluntary American Organic Standards (OTA, 2003), and those of several national certifying bodies in other countries. For each of the priority areas identified in the previous task, we will gather the relevant international literature. Beyond our synthesis of the purely scientific side of each area, we will analyze the feasibility of incorporating such scientific information into workable future standards. On completion of the literature synthesis just described, we will engage in the process of expert review. Current NOP standards lack specificity in relation to individual species needs. Initially we will divide our work into four areas: dairy cattle; beef cattle and sheep; hogs; and poultry. We will identify and call upon expert consultants for each of these four work areas. We expect to include both American and foreign experts. Following completion of the report described above, we will convene a three-day workshop to explore the implications of the report and identify potential options for NOP standards enhancement, including an analysis of the impact of all potential options on the major stakeholder groups: certifiers, organic livestock producers, organic consumers, and environmentalists. The final report will not make recommendations for livestock standards, but will seek to identify and elucidate specific options for animal health and welfare standards, with their potential to positively and negatively affect organic production and trade. The purpose of this project is to support the NOP by providing in-depth analysis of opportunities in an area of the standards identified by the USDA as needing further work.

PROGRESS

2004/09 TO 2007/09 OUTPUTS: Since October 2002, foods sold in the US as "organic" must have been produced in accordance with the standards of USDA's National Organic Program (NOP), as required by the Organic Foods Production Act of 1990. The goal of this research was to identify areas in which science and other organic standards together can guide the refinement of US standards to promote the health and welfare of organic livestock. To do this, we first did a detailed review of 14 sets of relevant materials: seven national or international standards for organic certification; the recommendations of the National Organic Standards Board; and the standards or guidelines of six US organizations that deal with livestock well-being, although not specifically in organic production. By comparing these materials in detail, we identified areas that are covered in some but not all of them. By highlighting gaps and inconsistencies, we sought to identify topics requiring further analysis. Second, we systematically searched databases, journals, bibliographies, and major works in the field of livestock health and welfare for items relevant to organic production of dairy, beef cattle, swine, and poultry (broilers and layers). The search covered the databases Science Citation Index, Organic Eprints Archive, Compendium of Animal Health and Welfare in Organic Farming, Science Direct, CAB Abstracts, Animal Behavior Abstracts, and Agricola; the journals Animal Welfare, Livestock Production Science, and Journal of Animal Science; and the series of proceedings issued by two international consortia: the Network for Animal Health and Welfare in Organic Agriculture and Sustaining Animal Health, and Food Safety in Organic Farming. A preliminary compilation of the results of these searches was discussed at length at a two-day meeting of stakeholders and livestock production experts held in April 2007. Examples of general issues involving more than one livestock type that the NOP covers either much less specifically than many of the other standards examined, or not at all, and for which a substantial scientific literature exists, include the following: 1) emphasizing preventive approaches to maintaining animal health, 2) providing colostrum and milk to young mammals, 3) grouping herd animals so as to permit expression of social behavior, 4) minimizing length of transport, 5) keeping animals in appropriate groups during transport and providing them with adequate food and water. The following are examples for specific livestock types: 1) inclusion of perches in poultry housing, 2) prohibition of gestation crates for sows, 3) provision of sufficient space for beef cattle to lie down together, 4) prohibition of tail docking in dairy cows except when called for by a veterinarian for medical reasons. A full listing of areas for possible elaboration of the standards is found in Lockeretz and Merrigan (2006). The arguments behind them and the scientific literature supporting them are summarized in Merrigan and Lockeretz (2007) and Merrigan et al. (submitted). We also are preparing a series of papers treating all such recommendations for each category of livestock in detail.

PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: We held one joint meeting involving both animal science experts and other stakeholders, rather than meeting with them separately. The reason was that many people fell into both groups that we thought it would be more efficient to have one large meeting. This turned out to be a good decision, because the meeting was extremely fruitful.

2004/09/15 TO 2007/09/14 OUTPUTS: Since October 2002, foods sold in the US as "organic" must have been produced in accordance with the standards of USDA's National Organic Program (NOP), as required by the Organic Foods Production Act of 1990. The goal of this research was to identify areas in which science and other organic standards together can guide the refinement of US standards to promote the health and welfare of organic livestock. To do this, we first did a detailed review of 14 sets of relevant materials: seven national or international standards for organic certification; the recommendations of the National Organic Standards Board; and the standards or guidelines of six US organizations that deal with livestock well-being, although not specifically in organic production. By comparing these materials in detail, we identified areas that are covered in some but not all of them. By highlighting gaps and inconsistencies, we sought to identify topics requiring further analysis. Second, we systematically searched databases, journals, bibliographies, and major works in the field of livestock health and welfare for items relevant to organic production of dairy, beef cattle, swine, and poultry (broilers and layers). The search covered the databases Science Citation Index, Organic Eprints Archive, Compendium of Animal Health and Welfare in Organic Farming, Science Direct, CAB Abstracts, Animal Behavior Abstracts, and Agricola; the journals Animal Welfare, Livestock Production Science, and Journal of Animal Science; and the series of proceedings issued by two international consortia: the Network for Animal Health and Welfare in Organic Agriculture and Sustaining Animal Health, and Food Safety in Organic Farming. A preliminary compilation of the results of these searches was discussed at length at a two-day meeting of stakeholders and livestock production experts held in April 2007. Examples of general issues involving more than one livestock type that the NOP covers either much less specifically than many of the other standards examined, or not at all, and for which a substantial scientific literature exists, include the following: 1) emphasizing preventive approaches to maintaining animal health, 2) providing colostrum and milk to young mammals, 3) grouping herd animals so as to permit expression of social behavior, 4) minimizing length of transport, 5) keeping animals in appropriate groups during transport and providing them with adequate food and water. The following are examples for specific livestock types: 1) inclusion of perches in poultry housing, 2) prohibition of gestation crates for sows, 3) provision of sufficient space for beef cattle to lie down together, 4) prohibition of tail docking in dairy cows except when called for by a veterinarian for medical reasons. A full listing of areas for possible elaboration of the standards is found in Lockeretz and Merrigan (2006). The arguments behind them and the scientific literature supporting them are summarized in Merrigan and Lockeretz (2007) and Merrigan et al. (submitted). We also are preparing a series of papers treating all such recommendations for each category of livestock in detail. PARTICIPANTS: Nothing significant to report during this reporting period. TARGET AUDIENCES: Nothing significant to report during this reporting period. PROJECT MODIFICATIONS: We held one joint meeting involving both animal science experts and other stakeholders, rather than meeting with them separately. The reason was that many people fell into both groups that we thought it would be more efficient to have one large meeting. This turned out to be a good decision, because the meeting was extremely fruitful.

IMPACT

2004/09 TO 2007/09 Setting satisfactory standards for organic foods is a complex process that in part, but only in part, involves scientific knowledge and understanding. It also involves industry codes, interactions with other federal regulations, and economic and other interests of diverse stakeholders, including producers, processors, distributors, retailers, and consumers. For livestock health and welfare, the potential scientific underpinnings of sound organic standards are substantial, even though additional research is needed on some topics. However, much of the scientific knowledge that might be applied to the elaboration of standards is not readily available or usable to the range of stakeholders who could take advantage of it. It is published in a wide range of media, typically in a highly specialized style accessible primarily to other specialists in the field. To be of value in setting standards, this literature needs to be systematically compiled, categorized, and interpreted. That is what this project has attempted to achieve. It makes accessible to standard-setters and other involved groups a large body of scientific information drawn not just from research specifically about organic livestock, but also from conventionally oriented research that is relevant to organic standards. However, it is much too soon to know the impact that this work will have on standard-setting. As noted, the process involves much more than purely scientific considerations, and to change or expand standards typically takes many years. **PUBLICATIONS (not previously reported):** 2004/09 TO 2007/09 W. Lockeretz and K. Merrigan (2006) Ensuring comprehensive

organic livestock standards. In: Proceedings of the First IFOAM International Conference on Animals in Organic Production, August 23-25, 2006.

2004/09/15 TO 2007/09/14 Setting satisfactory standards for organic foods is a complex process that in part, but only in part, involves scientific knowledge and understanding. It also involves industry codes, interactions with other federal regulations, and economic and other interests of diverse stakeholders, including producers, processors, distributors, retailers, and consumers. For livestock health and welfare, the potential scientific underpinnings of sound organic standards are substantial, even though additional research is needed on some topics. However, much of the scientific knowledge that might be applied to the elaboration of standards is not readily available or usable to the range of stakeholders who could take advantage of it. It is published in a wide range of media, typically in a highly specialized style accessible primarily to other specialists in the field. To be of value in setting standards, this literature needs to be systematically compiled, categorized, and interpreted. That is what this project has attempted to achieve. It makes accessible to standard-setters and other involved groups a large body of scientific information drawn not just from research specifically about organic livestock, but also from conventionally oriented research that is relevant to organic standards. However, it is much too soon to know the impact that this work will have on standard-setting. As noted, the process involves much more than purely scientific considerations, and to change or expand standards typically takes many years.

PUBLICATIONS

2004/09/15 TO 2007/09/14 W. Lockeretz and K. Merrigan (2006) Ensuring comprehensive organic livestock standards. In: Proceedings of the First IFOAM International Conference on Animals in Organic Production, August 23-25, 2006.

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Improving Fertility and Pest Management Strategies for Organic Crop Production and Strengthening Researcher/grower Networks

Accession No.	0201343
Subfile	CRIS
Project No.	CALW-2004-05136
Agency	NIFA CALW
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51300-02232
Proposal No.	2004-05136
Start Date	15 SEP 2004
Term Date	31 AUG 2009
Fiscal Year	2009
Grant Amount	\$571,902
Grant Year	2004
Investigator(s)	Gliessman, S. R.; Shennan, C.; Swezey, S. L.; Muramoto, J.; Koike, S. T.; Smith, R. F.; Bolda, M. P.
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NON-TECHNICAL SUMMARY

The California organic agriculture industry is growing in size and consumer acceptance. In 2003, approximately 1,800 registered organic farmers produced \$340 million in sales on over 180,000 acres. Unfortunately, this rapid expansion in organic farming is taking place with a very limited scientific research base. Organic vegetable and strawberry growers in California consistently voice concerns about the lack of knowledge that can be used to manage soil, insect pests, pathogens, and fertility in an integrative manner. The long-term goals of this project are two fold: first, to strengthen an existing organic research and extension network to support organic vegetable and strawberry producers in the region; and second, to develop and evaluate integrated fertility and pest management strategies in order to improve farm management and sustainability, minimizing negative impacts of agriculture on surrounding sensitive natural ecosystems, and improve the economic viability of organic farming. A team of organic growers, multidisciplinary researchers from multi-institutions, extension specialists, and three regional NGOs will work closely on this research, education and extension project, and evaluate improvements in knowledge and networks to support organic production.

OBJECTIVES

The goals of this project are: 1) To strengthen an existing organic research and extension network to support organic vegetable and strawberry producers in the region, and 2) To develop and evaluate integrated fertility and pest management strategies. The underlying hypothesis for goal 1 is that the capacity and effectiveness of regional research, education and extension networks for organic agriculture will be strengthened by the participatory collaborations proposed. For goal 2, we will test the following hypotheses: A. Fertility management
1) The use of field level nutrient budgets combined with nutrient content database and simulation models to predict periods of greatest vulnerability to nutrient losses will enable farmers to significantly improve nutrient use

efficiency by optimizing timing, quality and amounts of inputs used and crop rotations. 2) Tissue tests based on total N levels will be better predictors of N sufficiency and deficiency for organically produced crops than those based on tissue nitrate levels previously developed for chemically fertilized crops. B. Disease management 1) The use of non-host rotation crops for Verticillium wilt plus bio-fumigation with broccoli and compost application will suppress disease development sufficiently to grow strawberries in rotation every 3 or 4 years without negatively affecting soil microbial diversity. 2) Incorporating mustard cover crops can be an effective means of controlling Verticillium wilt, but the degree of control will depend on the amount of biomass incorporated and the type of mustard. 3) Anaerobic decomposition of crop residues can be an effective means of controlling Verticillium wilt, but the degree of control will depend on the ability to sustain anaerobic conditions, accumulated degree days of anaerobic decomposition, and the amount of biomass incorporated. C. Insect pest management 1) By avoiding excess N fertilization, organic growers can reduce abundance of two-spotted spider mites and other foliar pests. 2) By planting and managing a system of alfalfa trap crops, organic strawberries can be economically protected from lygus bug damage. 3) Organic annual crop fields with hedgerows will support a higher number of arthropod natural enemies and fewer pests than similar fields with unmanaged margins due to enhanced biological control of insect pests in fields with hedgerows. D. Weed management 1) Incorporating mustard cover crops can be an effective means of reducing the seed bank of some weeds, but the degree of control will depend on the amount of biomass incorporated and the type of mustard. 2) Anaerobic decomposition of crop residues can be an effective means of reducing the seed bank of some weeds, but the degree of control will depend on the ability to sustain anaerobic conditions, accumulated degree days of anaerobic decomposition, and the amount of biomass incorporated, rather than the type of biomass used. E. Economic impacts 1) Improved fertility and disease management will result in economic savings to growers through reduced input costs.

APPROACH

For goal 1, we will form a network advisory board that includes researchers, farmers, extension specialists, representatives from an existing statewide organic growers association (CCOF), and two-regional NGOs to review progress and examine data as it emerges. This board will also develop outreach and extension programs, to include field days, workshops, short courses, a project web site, and a variety of publications aimed at farmers, resource management agencies, environmental organizations and the academic community. Improvements in the information available for organic producers and in research/extension capacity will be assessed by tracking the number and types of growers and industry representatives attending outreach activities, collecting feedback on the quality and usefulness of the findings to different attendees, and pre-assessment and post-assessment surveys on knowledge and practices used by organic growers before and after the project. For goal 2, by conducting multiple replicated trials on local organic farms, we will examine the effects of diverse vegetable/cover crop/strawberry rotations, fertility management and different disease and pest management options on crop yields, soil quality, weed population dynamics, arthropod pest pressure, and suppression of *Verticillium dahliae*, a key pathogen of organic vegetables and strawberries. To optimize fertility management, we will: a) develop a nutrient budget tool backed by a comprehensive nutrient content database of organic amendments, cover crops, and crop residues; b) evaluate three N simulation models, EPIC (Erosion-Productivity Impact Calculator), DNDC (DeNitrification and DeComposition), and NDICEA (Nitrogen Dynamics in Crop Rotations in Ecological Agriculture), for their use in fertility management planning in organic production, and c) develop nitrogen sufficiency tissue tests for organic broccoli and strawberries. For suppression of *Verticillium* wilt, we will evaluate anaerobic decomposition of cover crop residues under silage tarps after residue incorporation and biofumigation with *Brassica* spp. Changes in soil *Verticillium dahliae* populations and soil microbial diversity analyzed by PLFA method will be assessed in a replicated on-farm trial with diverse rotations and integrated ecological practices. Biological control of insect pests using in-field insectaries, trap crops, and hedgerows will be evaluated and demonstrated on local farms. Responses of spider mite (on strawberries) and aphid (on broccoli) population to different N application rates will be examined. The effects of rotation design and fertility and disease management on weed population dynamics will also be monitored. Finally, the economic feasibility for each of the management alternatives under investigation will be determined and models for a representative small organic farm as well as a larger operation will be developed. A team of organic growers, multidisciplinary researchers from multi-institutions, extension specialists, and three regional NGOs will work closely on this research, education and extension project, and evaluate improvements in knowledge and networks to support organic production.

PROGRESS

2004/09 TO 2009/08 OUTPUTS: The outputs of the project include studies on N fertility management, pest management, and their interactions, in organic strawberries and broccoli production; economic evaluation of management options developed; and network building among researchers, organic growers, and NGOs for

coastal California. We conducted replicated on-farm experiments of organic strawberries and broccoli (2 years/farm x 2 farms for each crop), which provided fundamental information on N management for organic production and how to reduce N losses and environmental impacts. In the broccoli experiments, N release from legume/cereal mixed cover crops for successive broccoli, and relationships between aphid populations and N fertility level were also examined. Data from broccoli experiments were used to calibrate and validate two simulation models, NDICEA and DNDC, by which different management options were evaluated. N fixation by two legume cover crops was estimated using the natural abundance method for use in field level N budgets. The effect of alfalfa trap crops on damage by the western tarnished plant bug (*Lygus hesperus*) in organic strawberries and its economic implications were examined. Populations of *Peristenus relictus*, a solitary braconid endoparasitoid of the European tarnished plant bug introduced into California via a quarantine-based testing scheme for host specificity, were monitored at two organic strawberry farms in Monterey County. A cover crop/biofumigation field experiment in Ventura County was conducted to test the effect of biofumigation using mustard 'Ida Gold' on disease severity, crop yield, and soil microbial activity. A series of field and greenhouse experiments were performed to optimize anaerobic soil disinfestation for suppressing *Verticillium* wilt in organic strawberries. Studies of effects of hedgerow species planted adjacent to annual vegetable systems on the abundance of arthropod natural enemies and pests, dispersal patterns of insects from hedgerows into adjacent crop fields, and parasitism rates between fields with and without hedgerows were conducted in six organic mixed vegetable systems. An on-farm organic strawberry/vegetable rotation experiment was carried out to determine the effects of integrated biological approaches and diverse rotations on strawberry yield, *Verticillium dahliae* populations in the soil, and soil quality. Major dissemination activities were organic strawberry/vegetable seminar series held in summers of 2006, 2008 (with a field day), and 2009. Twenty to 70 attendants including growers, industry representatives, and researchers came to each seminar presented by project members providing up-to-date information on nutrient management, pest and weed management, disease management, and economics in organic strawberries/vegetables. Other outreach activities include a workshop on organic strawberry/vegetable rotations at the Eco Farm Conference 2008 (>100 attendants), and ALBA-hosted bilingual, practical series in Integrated Pest Management in 2008 and 2009. Finally, two graduate students received Ph.D.'s from the Department of Environmental Studies, UCSC for their dissertations partially funded by the project.

PARTICIPANTS: During the 5-year period, PD Stephen Gliessman (UCSC) oversaw the entire project. He chaired the annual organic network meetings held in January or April of each year. Co-PD Carol Shennan (UCSC) supervised nutrient budget and legume N fixation studies by graduate student Katie Monsen and work on effects of hedgerows on biocontrol by graduate student Tara Pisani Gareau. She also conducted the pre and post project surveys. Co-PD Sean Swezey (UCSC) supervised his research associates, Janet Bryer and Diego Nieto, and conducted studies on cultural and biological control of lygus bugs using alfalfa trap crop/insectaries. Co-PD Joji Muramoto assisted PD Gliessman in coordinating the entire project among participants. Muramoto conducted the strawberry/vegetable rotation study with Gliessman, Koike, Schmida, Shennan, Bull, Swezey and Robert Stephens (Elkhorn Ranch), anaerobic soil disinfestation study with Shennan, Koike, and Leap, and broccoli N fertility trial (the Santa Cruz site) with Leap. Muramoto also coordinated studies on N simulation models with Gerard Oomen, the developer of the NDICEA model, Changsheng Li, the developer of the DNDC model, and Bill Salas (Applied GeoSolutions). Co-PD Steven Koike (UCCE Salinas) conducted *Verticillium dahliae* tests and disease diagnosis for strawberry studies in the project. Co-PD Richard Smith (UCCE Salinas) implemented N fertility trial for organic broccoli (the Salinas site). Co-PD Mark Bolda (UCCE Watsonville) conducted N fertility on-farm trials for strawberries with Steve Pedersen (High Ground Organics), Kevin Healy (Reiter Associates Inc.), Natalia Neerdaels and Fred Cook (Driscoll's Inc), and Muramoto. He also organized the organic strawberry seminar series in summers of 2006, 2008 and 2009. Karen Klonsky (UC Davis) conducted economic analysis of practices developed in the project. Oleg Daugovish (UCCE Ventura) performed mustard biofumigation study. Mark Gaskell (UCCE Santa Maria) conducted a field trial on N management in organic strawberries in Santa Maria. Carolee Bull (USDA-ARS Salinas) worked on PLFA analysis of soil samples from the rotation trial. Brett Melon, Craig Ficenecc, and Chris Goodson (Agriculture and Land-Based Training Association (ALBA)) organized the IPM workshop and field demonstrations at ALBA in 2008 and 2009. Viella Shipley and Jane Baker (California Certified Organic Farmers (CCOF)) helped announce the organic seminar series and assisted dissemination of the outcomes from the project. Sam Earnshaw (Community Alliance with Family Farmers (CAFF)) assisted dissemination of project events. Steve Pedersen (High Ground Organics), Dan Schmida (Sandpiper Farm), Jim Cochran and Tim Champion (Swanton Berry Farm), and Jim Leap (UCSC farm) served as core farmers who consulted on the experimental design, progress, and the direction of the project. Outcomes of each study were presented by the leader of each study at academic meetings, extension meetings, Eco Farm workshop, and organic strawberry/vegetable seminar series. **TARGET AUDIENCES:** Our target audiences included strawberry and/or vegetable growers who are practicing or interested in organic production, pest control advisors, and representatives from the agricultural industry on the Central to the South Coast of California, the main strawberry and vegetable production areas in the state. Resource-limited and new farmers who speak mainly Spanish were also important target audiences. To disseminate updated information to these people, we collaborated with

ALBA, an NGO specialized in outreach to Hispanic growers, consistently providing simultaneous Spanish translation at our workshops and seminars. In 2008 and 2009, ALBA hosted two-part, bilingual, practical series in Integrated Pest Management at its Rural Development Center. The series targeted growers, field managers, and foremen of both large and small operations. Project results were also presented in agroecology courses in the Environmental Studies Department at UCSC, reaching more than 400 students in the course of the project. PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2007/10/01 TO 2008/09/30 OUTPUTS: An annual organic networking meeting was held on Jan. 23, 2008 to review our progress and discuss the plan for 2008. For outreach, a workshop on organic strawberry/vegetable rotations was conducted as a part of the Eco Farm Conference 2008 on Jan. 24, 2008 at Asilomar, CA. Focusing on the outcomes from the project, five presentations from different perspectives were made by the project members. There were more than 100 attendants in the audience. Power point presentations are available online at: <http://www.agroecology.org/Ecofarm08.html>. On Apr. 8 and 15, ALBA hosted a two-part, bilingual, practical series in Integrated Pest Management in Salinas in which many of the project members participated as presenters. Topics included agronomic, regulatory, and marketing advantages of using reduced-risk pest management approaches. Twenty-five growers and industry representatives, with influence over management of more than 4000 acres, attended one or both of the workshops. Upon a request from the California Strawberry Commission, an organic strawberry seminar series was organized by the project members and was held in the summer of 2008 in Watsonville, CA. The series consisted of field demonstration of alfalfa trap crops at ALBA (8/27) and seminars on nutrient management (9/3), pest and weed management (9/10), and disease management and economics (9/17) in organic strawberries. Field demonstrations had 12 attendants and two local television stations, one in English and the other in Spanish, broadcasting the event on their local newscast. At each seminar, three to four speakers presented updated information including outcomes obtained from the project to 20 to 40 attendants. Simultaneous Spanish translation was provided for all seminars. Evaluation indicated that the series was well received. In Jul. 2008, outcomes of the project were shared at The International Conference on Sustainable Agriculture and Environment 2008 at Sapporo, Japan, as well as multiple seminars held in Japan. On research, N budgets of two local organic farms were calculated using data collected from the project and others. In this we also examined how the choice of %Ndfa estimate affects the balance of N budgets in these systems. A two-year dataset on N dynamics in organic broccoli trials in Santa Cruz and Salinas were compiled. Using the datasets parameterization of simulation model NDICEA was completed and the model DNDC is in progress. Results from organic broccoli trials on the effect of cover crop N to successive broccoli were presented at ASA meeting. The first year of a strawberry trial at the second site in Watsonville with pre-plant application (none, 150, or 300 lbs-N/acre) and supplemental N rate (0, 75, or 150 lbs-N/acre) as treatments was initiated in October 2007 and fruit yield, N dynamics, and mite population were monitored till October 2008. We continued to monitor two organic strawberry farms in Monterey County into which the parasitoid, *Peristenus relictus*, of the European tarnished plant bug, *Lygus rugulipennis*, had been released into vacuumed alfalfa trap crops. PARTICIPANTS: PD Stephen R. Gliessman at UCSC oversaw the entire project. He spoke at the workshop on organic strawberry/vegetable workshop in Eco Farm Conference 2008 in Jan. 2008 and at the organic strawberry seminar series in Sep. 2008. Co-PD Carol Shennan at UCSC supervised nutrient budget studies by graduate student Katie Monsen and work on effect of hedgerows in biocontrol by graduate student Tara Pisani Gareau. Co-PD Sean L. Swezey at UCSC supervised his research associates, Janet Bryer and Diego Nieto, and conducted studies on cultural and biological control of lygus bugs and mites using alfalfa trap crop/insectaries. He also gave a talk at the organic seminar series on his study. Co-PD Joji Muramoto assisted PD Gliessman in coordinating the entire project among researchers, growers, and NGOs. He also coordinated and participated in studies on N simulation models, and N fertility trials on organic strawberries and organic broccoli. Dr. Muramoto presented data from the project at the workshop on organic strawberry/vegetable workshop in Eco Farm Conference 2008 as well as the organic strawberry seminar series. Co-PD Steven T. Koike at UCCE Salinas spoke at the workshop on organic strawberry/vegetable workshop in Eco Farm Conference 2008. Co-PD Richard Smith at UCCE Salinas facilitated the workshop on organic strawberry/vegetable workshop in Eco Farm Conference 2008. He also summarized the second-year field trial on effect of N rates on organic broccoli in Salinas. Diego Nieto analyzed the effect of N on aphid population in the same trial. Co-PD Mark Bolda at UCCE Watsonville conducted the field trial on the effect of N rates on organic strawberries at the second site in Watsonville collaborating with Kevin Healy of Reiter Associates, Fred Cook of Driscoll's, and Joji Muramoto. He also organized the organic strawberry seminar series in which he gave three talks. Karen Klonsky at UC Davis spoke at the organic seminar series on economic implications of the rotation trial. Oleg Daugovish at UCCE Ventura gave a talk at the organic seminar series on weed management in organic strawberries. Mark Gaskell at UCCE Santa Maria initiated a field trial on N management in organic strawberries in Santa Maria. Carolee T. Bull at USDA-ARS in Salinas worked on PLFA analysis of soil samples from the organic rotation trial. Craig Ficencen at Agriculture and Land-Based Training Association (ALBA) organized the IPM work shop (April, 2008) and field demonstrations (Aug. 2008) at ALBA. Viella Shipley of

California Certified Organic Farmers (CCOF) helped disseminate the outcomes from the project through the CCOF website. Steven Pedersen at High Ground Organics, Dan Schmida at Sandpiper Farms, and Tim Campion at Swanton Berry Farm served as core farmers who consulted the progress and the direction of the project. TARGET AUDIENCES: Our target audiences include strawberry and/or vegetable growers who are practicing or interested in organic production, pest control advisors, and representatives from the agricultural industry on the Central to the South Coast of California, the main strawberry and vegetable production areas in the state. Resource-limited and new farmers who speak mainly Spanish are also important parts of the target audiences. To disseminate updated information to these people, we collaborate with ALBA, an NGO specialized in outreach to the audience, providing simultaneous Spanish translation in our workshops and seminars consistently. On April 8th and 15th, 2008, ALBA hosted a two-part, bilingual, practical series in Integrated Pest Management at its Rural Development Center. The series targeted growers, field managers, and foremen of both large and small operations. Outreach for the events included announcement to nearly 200 Spanish speaking local growers at the annual "Ag Expo" in Salinas, a bilingual color postcard mailing to approximately 500 regional growers and partners in the central coast, and an email announcement to approximately 100 partners. Please see "Outputs" for more information on our outreach efforts. PROJECT MODIFICATIONS: The second site for N management trial in organic strawberries in Watsonville was selected in year 3, a year later than the original plan. The trial is supposed to run for two years at each site. To complete the trial, therefore, no cost extension of the project for one year was requested, which was approved by USDA in July 2008. The new end date of the project is 8/31/2009.

2006/10/01 TO 2007/09/30 OUTPUTS: We held an annual organic network meeting in Jan. 2007 and agreed to prepare a proposal for a workshop on organic strawberry/vegetable rotations at Eco Farm Conference 2008. Our proposal was accepted and the workshop was scheduled on Jan 24, 2008. Manuscripts for organic strawberry manual were submitted to UC ANR press for review. Two greenhouse experiments were conducted to improve N fixation estimates for two winter legume cover crops, bell beans (*Vicia faba*) and woollypod vetch (*Vicia dasycarpa*) using the natural abundance method. Results were presented at ESA meeting. A two-year dataset on N dynamics in organic broccoli trial in Santa Cruz was compiled. Using the dataset parameterization of simulation models NDICEA and DNDC is in progress. Economic implications of the five-year organic strawberry/vegetable rotation experiment were explored. Results were shared through organic strawberry workshop, NASGA symposium, ASA meeting, Elkhorn research symposium, and Florida Phytopathological Society meeting. The second year of organic broccoli trial in Salinas with cover crop application (+/-) and organic N fertilizer rate (0, 75, 150 or 225 lbs-N/acre) as treatments was conducted. Results were disseminated through a UC extension event and ASA, CASA, and ASHS meetings. The second year of a strawberry trial in Watsonville with pre-plant application (none, Sudan grass, or compost) and supplemental N rate (75, 150 or 225 lbs-N/acre) as treatments was completed. A demonstration trial at ALBA in Salinas was conducted to examine effect of pre-plant pelleted organic N fertilizer application on fruit yield. The second site for organic strawberry trial in Watsonville was selected. Glucosinolates in three mustard cultivars used for the cover cropping/biofumigation field experiment in Ventura County were determined. Results were presented at ASHS meeting and International Symposium of Sustainable Agriculture. To optimize anaerobic soil disinfestation for suppressing *Verticillium* wilt in organic strawberries, we compared the effect of different C sources (none, wheat bran, molasses) on viability of *Verticillium* propagules in Santa Cruz site. C sources were applied in November and water was irrigated through drip tapes buried in plastic-mulched beds. Populations of *Peristenus relictus*, a single solitary braconid endoparasitoid of the European tarnished plant bug, *Lygus rugulipennis*, were introduced into California organic strawberries in 2004, via a quarantine-based testing scheme for host specificity. We continued to monitor two organic strawberry farms in Monterey County into which parasitoids had been released into vacuumed alfalfa trap crops. Results were presented at NASGA symposium. Our studies on 1) effects of hedgerow species planted adjacent to annual vegetable systems on the abundance of arthropod natural enemies and pests, 2) dispersal patterns of insects from hedgerows into adjacent crop fields, and 3) parasitism rates between fields with and without hedgerows continue in six organic mixed vegetable systems. Results were presented at Pacific branch-ESA meeting, STEPS's Institute workshop, and ESA meeting. PARTICIPANTS: PD Stephen R. Gliessman at UCSC supervised and coordinated the overall project. He prepared a proposal for a workshop on organic strawberry/vegetable workshop in Eco Farm Conference 2008. Co-PD Carol Shennan at UCSC supervised N fixation and nutrient budget studies by a graduate student Katie Monsen and work on effect of hedgerows in biocontrol by a graduate student Tara Pisani Gareau. She also collaborated with Gerard Oomen, Changsheng Li at Univ. of New Hampshire, Bill Salas at Applied GeoSolutions, Katie Monsen, and Joji Muramoto on simulation model evaluation. Dr Shennan supervised studies on anaerobic soil disinfestation (ASD) for *Verticillium* wilt in organic strawberries. Co-PD Sean L. Swezey at UCSC supervised his research associates, Janet Bryer and Diego Nieto, and conducted studies on cultural and biological control of lygus bugs and mites using alfalfa trap crop/insectaries. Co-PD Joji Muramoto assisted PD Gliessman in coordinating the entire project among researchers, growers, and NGOs. He also coordinated and participated in studies on N simulation models,

organic strawberry/vegetable rotation, N fertility trials on organic strawberries and organic broccoli, and ASD for organic strawberries. Dr. Muramoto collaborated with UC Cooperative Extension (UCCE) farm advisors (four co-PDs), Sam Earnshaw at Community Alliance with Family Farmers (CAFF), Craig Ficenech at Agriculture and Land-Based Training Association (ALBA), and Viella Shipley at California Certified Organic Farmers (CCOF) for organizing and advertising outreach activities. A demonstration trial was conducted at ALBA by Craig Ficenech and Joji Muramoto. Co-PD Steven T. Koike at UCCE Salinas quantified populations of *Verticillium dahliae* in the soils and diagnosed pathological diseases in organic crop rotation trial, ASD trial, and N fertility trials. Co-PD Richard Smith at UCCE Salinas conducted the second-year field trial on effect of N fertility on organic broccoli in Salinas. Diego Nieto examined effect of N on aphid population in the same trial. Co-PD Mark Bolda at UCCE Watsonville led the second-year field experiment on effect of N on organic strawberries in Watsonville collaborating with Steve Pedersen at High Ground Organics and Joji Muramoto. Daniel Schmida at Sandpiper Farms collaborated with Joji Muramoto for data analysis of the rotation trial he managed during 2001 and 2006. Jim Leap at CASFS-UCSC collaborated with Joji Muramoto for data analysis of the organic broccoli trial at UCSC. He also managed an ASD field trial at UCSC farm in 2005-2006. Karen Klonsky at UC Davis analyzed economic implications of the rotation trial and organic broccoli trial. Oleg Daugovish at UCCE Ventura continued work on biofumigation with Brassica cover crops. Mark Gaskell at UCCE Santa Maria participated in designing field trials for organic strawberries. Carolee T. Bull at USDA-ARS in Salinas worked on PLFA analysis of soil samples from the organic rotation trial. Our collaboration with Kevin Healy at Reiter Associates began in 2006 to conduct N fertility trial on organic strawberries in Watsonville. TARGET AUDIENCES: Our main target audiences are organic strawberry growers and organic vegetable growers on the South to the Central Coast of California. These areas cover majority of strawberry production acreages in California where approximately 85% of fresh market strawberries in the US are produced. Although current organic production represents only 4% of the total strawberry acreages in the state, this number has been on the rise and more strawberry growers in the state appear to be interested in organic production. Our new collaboration with Reiter associates, one of largest strawberry growers in the country, indicates this trend. Given its highly susceptible character to soil-borne diseases, organic strawberry production must have a crop rotation system. Therefore we decided to organize a workshop on organic strawberry/vegetable rotation in Eco Farm Conference 2008. Results from our 5-year rotation study and related information on organic crop rotation including disease management, economic implications, and grower's experiences and perspectives will be presented by our project members in the workshop. N dynamics data in two organic strawberries field trials on the Central Coast were presented at multiple seminars for strawberry growers along the coast including Spanish speaking growers on the South Coast. This led a development of a similar trial on the South Coast. Collaborating with ALBA, a demonstration trial on the effect of N fertility in organic strawberries was conducted with a new grower in Salinas. Results will be disseminated specifically to new and resource-limited growers in the area through newsletters and seminars both in English and in Spanish. Further ALBA are planning a two-day workshop for IPM and biocontrol in vegetable and strawberry production in April 2008, in which many of our project members will present results from our studies. The workshop will be advertised through CCOF and CAFFs' extensive networks among organic growers and family farms throughout California. For more information on our dissemination efforts, please see Outputs and Publications.

2005/10/01 TO 2006/09/30 In 2006 we held two organic network meetings, a field day, and three seminars on fertility, soil-borne disease and insect pest management in organic strawberries. The seminar series was well attended (40-70 for each) and well received by local growers and industry people. We developed a prototype of N budgets spread sheet and handout, and continue our efforts to improve estimates of N fixation by two legume cover crops using the natural abundance method. Parameterization of simulation models NDICEA and DNDC is underway using locally collected data sets of cover crops, broccoli, and strawberries. We completed the five-year organic strawberry/vegetable rotation experiment in Moss Landing. It demonstrated that under low *Verticillium* pressure, using a combination of ecological practices enabled strawberries to be grown in a 1 to 3 year-break rotation without significant yield difference from a 7 year-break rotation. Organic broccoli trials with cover crop application (+/-) and organic N fertilizer rate (0, 75, 150 or 225 lbs-N/acre) as treatments were conducted in Santa Cruz and Salinas. In both sites, yield of broccoli was significantly increased by the rate of organic fertilizer N and cover crop application. N uptake by broccoli indicated cover crop incorporation provided 37 and 27 lbs-N/acre to broccoli biomass in Santa Cruz and Salinas, respectively. Fertility treatments had no effect on cabbage aphid (*Brevicoryne brassicae*) abundance on broccoli, but broccoli harvest rate was higher in Santa Cruz where 10 times more predacious syrphid larvae were found than in Salinas. The first year of a strawberry trial in Watsonville with pre-plant application (none, feather meal, or compost) and supplemental N rate (50, 100 or 150 lbs-N/acre) as treatments was also completed. Neither pre-plant fertilizer nor supplemental N rate significantly affected marketable fruit yield, probably due to pre-plant cover crop incorporation across all treatments. Thus for the second year trial in Watsonville, we varied both pre-plant application (none, cover crop, or compost) and supplemental N rate (75, 150 or 225 lbs-N/acre). The cover cropping/biofumigation field experiment in Ventura

County demonstrated a reduction in disease severity, increased crop yield, and higher soil microbial activity with biofumigation using mustard 'Ida Gold'. To optimize anaerobic soil disinfestation for suppressing *Verticillium* wilt in organic strawberries, we compared the effect of different C sources (none, wheat bran, molasses) on viability of *Verticillium* propagules. We continued to monitor two organic strawberry farms where parasitoids had been released into vacuumed alfalfa trap crops. At one farm, average seasonal western tarnished plant bug, *Lygus hesperus*, nymphal density in strawberries has declined each year since the release of parasitoids in 2004. Our studies on 1) effects hedgerow species planted adjacent to annual vegetable systems on the abundance of arthropod natural enemies and pests, 2) dispersal patterns of insects from hedgerows into adjacent crop fields, and 3) parasitism rates between fields with and without hedgerows continue in six organic mixed vegetable systems.

2004/10/01 TO 2005/09/30 We had three organic network meetings during the first year. Since most project participants are able to attend meetings, it was decided that the Project Team and Network Advisory Board would be the same group. A pre-project assessment was conducted by semi-structured interviews with project participants. A newly created email list serve has been extensively used among members throughout the year. We continued to collect data on nutrient budgets from three local organic farms. Work on improving estimates of N fixation by four legume cover crops using the natural abundance method was continued. Simulation models NDICEA and DNDC are being parameterized by locally collected data sets of mustard, organic broccoli, and organic strawberries. We completed the 4th year of the five-year organic strawberry/vegetable rotation experiment. Numbers of *Verticillium dahliae* microsclerotia in soils were frequently reduced after broccoli residue incorporations, whereas no such reduction was observed after mustard incorporation. By limiting the preplant compost application rate, N loss during the rainy season from the strawberry plots was reduced to 10% of the previous year's level without sacrificing fruit yield. We established three replicated N fertility/pest monitoring trials for broccoli and strawberries. An organic broccoli trial with compost application (0 or 5 tons/acre) and organic N fertilizer rate (0, 75, 150 or 225 lbs-N/acre) as treatments was conducted in Santa Cruz. Yield of broccoli was significantly affected by the rate of organic fertilizer N ($P=0.004$) but not by compost. Although cabbage aphid (*Brevicoryne brassicae*) abundance was generally greater on plants that were given more N, parasitism and predation were substantial enough to provide biological control, regardless of application rate, in the highly diverse organic farm. Another organic broccoli trial with similar design is being conducted in Salinas in a less diverse environment. An organic strawberry trial in Watsonville is in progress. Cover cropping/biofumigation field experiment in Ventura County is in progress. A series of field and greenhouse experiments were conducted to optimize anaerobic soil disinfestation for suppressing *Verticillium* wilt in organic strawberries. Significant reduction of *V. dahliae* microsclerotia in recovered inoculants was observed in anaerobic treatment (mortality 98%, $P=0.0001$). When soil Eh was reduced to -100mV during the first week, 6 weeks of anaerobic treatment was sufficient to reduce *V. dahliae* to non-detectable level. Twice-weekly summer vacuuming treatment of alfalfa trap crops reduced damage due to the western tarnished plant bug (*Lygus hesperus*) in associated organic strawberries by an average of 25% compared with the organic strawberry grower's standard whole-field vacuuming treatment. The overall positive return for the three months of trap cropping treatments was calculated at +\\$648/acre. Work examining influences of the diversity of hedgerow plant species planted on the borders of annual vegetable systems on the presence and abundance of arthropod natural enemies and pests is in progress in five organic mixed vegetable systems.

IMPACT

2004/09 TO 2009/08 In contrast to the previous three seasons, in the last on-farm organic strawberry trial in Watsonville, fruit yield responded significantly to pre-plant fertilizer rates rather than to supplemental N rates. The results appear to be attributed to two factors; a warm and dry winter, and heavier soil at this site. To minimize N loss during the winter without sacrificing fruit yield, therefore, a low to minimum amount of pre-plant N is suggested for sandy soils, whereas modest amounts (~ 75 lbs-N/acre) of N can be applied for clayey soils. For warm and dry winters, earlier N fertigation may help develop side crowns of strawberry plants, which can later increase fruit yield on the Central Coast of California. In the same study, petiole NO_3 concentration showed a much stronger correlation with fruit yield over Total N in the leaf blades. Simulation models NDICEA and DNDC were calibrated and validated by data from two organic broccoli field trials, and initial results suggest there may be a trade-off between high yield and N loss through leaching in this organic system, and that significant N loss during the winter rainy season could take place even with winter cover crops especially at higher preplant N rates. An initial survey of project participants (researchers, extension, growers and NGO representatives) asked what their expectations and motivations were for joining the project. Most expectations centered on building and strengthening research, extension and farmer linkages, and increasing knowledge about organic strawberry and

vegetable production. Motivations for participation included the desire to build community, increase opportunities to be involved in collaborations, improve linkages between farmers and researchers, and improve access to and exchange of information. At the end of the project participants were surveyed to see if expectations had been met. Of 18 respondents 15 said it had met or exceeded their expectations, 2 mostly, and 1 that it had partially met them. Participating growers commented that there were many opportunities for interactions with researchers, the project provided useful information, and that it had either reinforced or changed practices used on their farm. Extension agents commented on the successful collaborations and improved knowledge of organic production and the impact it had on growers in the area - "There has been a quantum leap in the knowledge obtained about strawberry fertility. The study has become a standard and is routinely referred to by growers, researchers and industry professionals." Evaluations of seminar series in 2006, 2008, and 2009 by attendants showed that the overall average of rating was "excellent" 64.3% and "good" 35.7%. Top ten topics requested for future seminars were soil-borne disease management (14.6%), N management (8.3%), fruit quality (8.3%), soil fertility (7.3%), irrigation (6.3%), crop rotation (5.2%), organic pest management (5.2%), organic disease management (5.2%), compost (4.2%), and intercropping of strawberries (4.2%). **PUBLICATIONS (not previously reported):** 2004/09 TO 2009/08 1. Brown, M. 2006. Center researchers find pest control help for Central Coast strawberry growers. *The Cultivar*, Newsletter of Center for Agroecology and Sustainable Food Systems, University of California, Santa Cruz, 24 (1):5-6 2. Brown, M. 2007a. 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2007/10/01 TO 2008/09/30 A N budget was developed for a seven-year rotation for a vegetable production field at Farm A. Assuming 50% of legume cover crop N was derived from fixation, the field had a total of 799 kg N/ha

of inputs and a positive balance of 354 kg N/ha over the 7 yrs and an average annual potential loss of 51 kg N/ha. The N budget for a field at Farm B covered 5 yrs for a total N output of 650 kg N/ha. Assuming 50% of legume cover crop N came from fixation, the total input was 1414 kg N/ha, giving a 5-yr positive balance of 764 kg N/ha, or an average annual potential loss of 153 kg N/ha. Changing the biological N fixation budget from 50 to 95% more than doubled the estimated annual potential loss N from 51 to 129 kg N/ha at Farm A and from 153 to 251 kg N/ha at Farm B. Organic broccoli field experiments at the UCSC farm (organically managed over 30 years. Trial 1) and Salinas site (cover crops have been incorporated for the last several years. Trial 2), indicated that broccoli yield, broccoli-N, and soil mineral N were increased by cover crop applications only in 2006 at both trials and not in 2007 at Trial-2. In Trial-2, the cover crop in 2006 had a greater percentage and total amount of N in the cover crop tops (3.10% and 218 kg-N/ha) than in 2007 (2.07% and 172 kg-N/ha), which was similar to one in Trial-1 (2.08% and 179 kg-N/ha). Although both sites had sandy loam soil, C/N ratio of the topsoil was higher in Trial-2 (TC: 1.39%, TN: 0.11%, C/N: 12.6) than in Trial-1 (TC: 1.03%, TN: 0.10%, C/N: 10.1), indicating 1) the importance of having sufficient N in the cover crops to stimulate short-term N release and crop N response, and 2) the availability of N from cover crops may vary depending on soil C/N ratio. A part of the study dealing with organic broccoli N content and aphid infestation was also reviewed, with there being a trend between more N and more aphids at Trial 2, but no differences at Trial 1. This may be due to better bio-control at Trial 1 or as a result of the time of year the latter project was carried out. In the first year of organic strawberry field trial at the second site in Watsonville, pre-plant fertilizer rates did not affect fruit yield but supplemental N rate significantly increased marketable fruit yield. This demonstrated again that a pre-plant pelleted organic N fertilizer application, a common practice among local growers, can be significantly reduced or even eliminated without sacrificing fruit yield on the Central Coast. Monitoring in 2007 to 2008 confirmed the establishment in the field of a new parasitoid (*Peristenus relictus*) and its correlation with lower *Lygus* populations. These data indicate that *P. stygicus* has been established as an exotic, new association parasitoid of the Western tarnished plant bug, and can adapt to, over-winter, and colonize organic strawberry production in central coastal California. The parasitoids are also harbored over winter on weedy vegetation in and around fields. There appears to be a density dependent relation between more *Lygus* and higher rates of parasitism.

2006/10/01 TO 2007/09/30 Greenhouse experiments indicated bell beans and vetch had active nodules early in growth across different fertility levels (0 to 200 kg-N/ha). Estimated %Ndfa by bell beans and vetch ranged from 51 to 91%Ndfa, much higher than a conventional belief of ~50%. This could significantly affect N budget estimates in leguminous cover crop-based agroecosystems on the Central Coast. Organic broccoli field experiments in Santa Cruz and Salinas indicated that 14 to 23% of cover crop N was utilized by the successive broccoli crop. Incorporated cover crops increased broccoli-N in a manner similar to 67 to 90 kg-N/ha of applied organic N fertilizer. In the second year of organic strawberry field trial in Watsonville, as seen in the first year, neither pre-plant fertilizer nor supplemental N rate significantly affected cumulative marketable fruit yield. An organic strawberry demonstration trial at ALBA in Salinas also showed no difference in fruit yield between with and without pre-plant pelleted organic N fertilizer application plots, suggesting a pre-plant pelleted organic N fertilizer application, a common practice among local growers, may be significantly reduced or eliminated without sacrificing fruit yield on the Central Coast. The cover cropping/biofumigation field experiment in Ventura County demonstrated a reduction in disease severity, increased crop yield, and higher soil microbial activity with biofumigation using mustard *Ida Gold*. Presence of 4-hydroxybenzyl glucosinolates in roots of *Ida Gold* and its absence in the other Brassica crops may explain beneficial effects of *Ida Gold*. A bed-applied ASD significantly reduced *Verticillium dahliae* population in naturally-infested soils. With this and other promising results, our proposal to optimize ASD in conventional strawberry in California and vegetables in Florida as an alternative to methyl bromide was accepted for funding by USDA-CSREES methyl bromide transition program. Alfalfa trap crops constitute a large reservoir of parasitoids associated with lower densities in adjacent strawberries. These data indicate that *P. stygicus* has been established as an exotic, new association parasitoid of the Western tarnished plant bug, and can adapt to, over-winter, and colonize organic strawberry production in central coastal California. Weedy field margins and alfalfa trap crops both form a source/reservoir area for release and subsequent dispersal to organic strawberries. We have 2 years of data on insect abundance at six different hedgerow plants commonly used in hedgerow design: *Achillea millefolium*, *Baccharis pilularis*, *Ceanothus* spp., *Eriogonum giganteum*, *Heteromeles arbutifolia*, and *Rhamnus californica*. We have found that the plants, the bloom period, time of the sample and the particular hedgerow all significantly affect insect abundances for the different taxa. For all 2007 trials we found no significant differences in parasitism rates between hedgerow and non-hedgerow fields due most likely to the variability in cropping systems, management style, acreage and surrounding landscape across the different sites.

2005/10/01 TO 2006/09/30 Developing practical strategies for fertility/pest management in organic farming and strengthening the networks among organic farmers and researchers in California will increase the knowledge

base and the flow of information among researchers and farmers as well as increase the viability, sales and acreages of organic crops in California. Ultimately, this will further contribute to sustainability of California agriculture by reducing dependence on synthetic pesticides and fumigants, conserving biodiversity, protecting surface/ground water quality, improving soil health and nutrient cycling, and enhancing the quality of life of growers and consumers. Specifically, results from the fertility trial in organic strawberries demonstrated that significant reduction in pre-plant N fertilizer is possible without sacrificing fruit yield. This will decrease growers' production costs and improve organic N fertilizer use efficiency, by which impacts on the environment through N leaching and run-off will be reduced.

2004/10/01 TO 2005/09/30 Developing practical strategies for fertility/pest management in organic farming and strengthening the networks among organic farmers and researchers in California will increase the knowledge base and the flow of information among researchers and farmers as well as increase the viability, sales and acreages of organic crops in California. Ultimately, this will further contribute to sustainability of California agriculture by reducing dependence on synthetic pesticides and fumigants, conserving biodiversity, protecting surface/ground water quality, improving soil health and nutrient cycling, and enhancing the quality of life of growers and consumers.

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