

# ORG Project Details

Award Year 2004

5 Research Projects

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# The Transitioning Dairy: Identifying and Addressing Challenges and Opportunities in Milk Quality and Safety

<b>Accession No.</b>	0201463
<b>Subfile</b>	CRIS\
<b>Project No.</b>	NYCV-478572
<b>Agency</b>	NIFA NYCV
<b>Project Type</b>	OTHER GRANTS
<b>Project Status</b>	TERMINATED
<b>Contract / Grant No.</b>	2004-51106-03103
<b>Proposal No.</b>	2004-05169
<b>Start Date</b>	15 SEP 2004
<b>Term Date</b>	14 SEP 2009
<b>Fiscal Year</b>	2009
<b>Grant Amount</b>	\$518,306
<b>Grant Year</b>	2004
<b>Investigator(s)</b>	Garrison-Tikofskey, L. L.; Schukken, Y. H.; Zadoks, R. N.
<b>Performing Institution</b>	POPULATION MEDICINE & DIAGNOSTIC SCIENCES, CORNELL UNIVERSITY, ITHACA, NEW YORK 14853

## NON-TECHNICAL SUMMARY

The organic dairy (OD) sector is growing rapidly, due to increased consumer interest in animal welfare, environmental stewardship and potential health benefits of OD. To meet the demand for organic milk and dairy products, farmers who farmed conventionally are transitioning to organic production. In conventional farming (CF), antibiotics are often used to maintain cow health and milk quality, specifically to control bacterial infections of cows' udders. Without antibiotics, maintenance of infection-free udders is a major challenge. As a result, cow health, milk quality, and milk safety may be at risk. Organic management may have benefits. Cows may develop healthier immune systems and milk may contain increased levels of selenium and conjugated linoleic acid (CLA) as a result of grazing. Withdrawal of antibiotics may result in a lower risk of antimicrobial resistance in milk. Researchers and farmers will work together during the transition of 5 farms from (CF) to organic farming. During the transition, (pre-transition, transition, and post-transition years), cow health and milk quality will be monitored closely, with emphasis on udder infections, bacteria and antimicrobial resistance, and levels of selenium and CLA in milk. They will identify challenges and opportunities in udder health and milk quality associated with the transition to organic farming, and will develop management strategies to produce high quality milk from healthy cows under organic farming conditions. They will share their experience and advice through workshops, pasture walks, newsletters and websites.

## OBJECTIVES

The goal of this project is to gain insight into changes in udder health, milk quality and milk safety that may arise during the transition of dairy cow herds from conventional farming to organic farming, and to propose and disseminate methods to maintain or promote udder health and milk quality in organic dairy farming. Conventional farming relies heavily on use of antimicrobials to maintain udder health and milk quality. Withdrawal of antimicrobials constitutes a major change in mastitis control options during the transition to organic farming. This

project aims to identify challenges in mastitis control and maintenance of milk quality and safety as a result of withdrawal of antimicrobial treatment and other changes in management associated with the transition to organic farming. In addition, this project aims to determine whether changes in management, housing and nutrition may benefit milk quality and safety, for example in terms of presence of neutraceutical components or absence of bacteria with antimicrobial resistance genes. The objectives will be pursued through analysis of milk samples and interaction with participating farmers. Specifically, five herds will be monitored longitudinally during their pre-transition, transition and post-transition years. Data will be collected on udder health (incidence of clinical mastitis, prevalence of subclinical mastitis, mastitis pathogens), bulk tank milk quality (bacteriology, somatic cell count, selenium level, conjugated linoleic acid content) and food safety (food-borne pathogens, antimicrobial resistance). Subsequently, intervention strategies will be proposed so that future transitioning dairy producers can be proactive in addressing the challenges. The findings of this study and the strategies derived from it will be developed in collaboration with and disseminated to the organic community through participatory evaluation, farmer discussion groups, traditional extension approaches, newsletters, the internet and pasture walks on certified and transitioning dairy farms.

## APPROACH

Through collaboration with NOFA-NY (Northeast Organic Farming Association of New York, Inc.) and NODPA (Northeast Organic Dairy Producers Alliance) we will enroll five dairy herds in the North-Eastern USA that are in the process of transitioning from conventional farming to organic farming. Transition of soils and crops will be in progress, while conventional methods, including antimicrobials, will still be in use for mastitis control. Herds will be identified and enrolled during the first six months of the project. Each herd will be monitored for three subsequent years: 1. the last year before withdrawal of antimicrobials and other non-organic inputs for dairy animals (pre-transition year); 2. the first year of withdrawal of non-organic inputs (the transition year); and 3. the first year of certified organic farming (post-transition year). During each of those years, bulk tank milk samples will be collected monthly and whole herd surveys (quarter milk samples) will be performed quarterly. In addition, animal health data and quarter milk samples from cows with clinical mastitis, at calving, and at dry-off will be collected by herdsmen. Bulk tank samples will be analyzed for conjugated linoleic acid, selenium, somatic cell count, fat, protein, and bacteria, including food-borne pathogens and bacteria with antimicrobial resistance. Quarter milk samples will be used for mastitis bacteriology, detection of antimicrobial resistance and SCC measurements. Detailed longitudinal observations will allow us a) to identify challenges and opportunities in terms of maintenance of udder health and milk quality and safety; b) to identify specific testable hypotheses for future investigation, and c) to propose intervention strategies to prevent or address udder health and milk quality issues. Participating farms will be involved in quarterly farm evaluations and self-assessments and in general and customized training sessions on milk quality, food safety, and cow health. A combination of quantitative and qualitative information will be collected to help farms make improved management decisions and to develop a manual to help guide other farms and their consultants to improve organic dairy management. Towards the last two years of the four-year project, an increasing amount of time will be devoted to education and outreach. Participatory evaluation meetings will be held, in which stakeholders from all participating farms and the project team will be provided with an opportunity to communicate and interact and to develop an experience and reality-based management program that can be used to support newly transitioning herds in the future. The results of the project and the materials developed from it will be disseminated to other existing and transitioning organic producers in a variety of ways, including 2-day workshops for farmers, pasture walks, newsletters and websites from organic organizations (e.g. NODPA, NOFA-NY), and a Dairy Transition Manual, so that producers, veterinarians, extension educators and industry personnel throughout the country will have access to the information and insight gained from this project.

## PROGRESS

2004/09 TO 2009/09 OUTPUTS: Five dairy herds were enrolled in the project; one herd dropped out of the project in the first year because they were unsure about continuing their transition to organic production. All herds were enrolled as they entered their transition year from conventional to organic dairy production and were followed through their second year of organic production (four total years). Herds were not enrolled at the same time, but over the course of two and a half years which delayed the project longer than expected. Herd size ranged from 30 to 100 lactating cattle; the majority of cows included in this study were Holstein-Friesian. Three herds continuously produced milk around the calendar; one herd was seasonal and dried cattle off in December to freshen in March. Prior to their transition year, all herds were using intramammary and parenteral antibiotics for the treatment and prevention of intramammary infections and for common herd health diseases. Three herds practiced some level of grazing; one herd was strict confinement for all stages of lactation and added rotational

grazing to their herd management plan during the transition year. Quarter milk samples were collected from all lactating cattle on all four remaining farms every three months and cultured aerobically. Major mastitis pathogens obtained from quarter milk samples also were subcultured and frozen at -80 °C for future studies on antimicrobial resistance in mastitis pathogens. At the time of each quarterly sampling, composite milk samples were collected for individual cow Somatic Cell Counts and bulk milk samples were collected for aerobic and mycoplasma culture, bulk milk somatic cell counts and standard plate, coliform and preliminary incubation counts. All farms were asked to collect additional quarter samples at dry-off, freshening and from all cases of clinical mastitis for aerobic culture although one herd was non-compliant. A questionnaire was administered to each farmer, which recorded current herd health information, current management techniques and treatments in use at that farm at that time. Dates of freshening, dry off and dates of clinical mastitis episodes were recorded. New best management practices implemented between surveys were also recorded. Bulk milk samples from these farms were also used during the first two years of the project to develop real-time PCR methodology for the detection of *Salmonella* DT-104, *E. coli* H7:O157; *Campylobacter jejuni*, *Listeria monocytogenes* and STEC organisms in raw bulk milk. All herd health information, quarter milk culture information, individual somatic cell counts and fresh, dry off and clinical episode dates have been entered into a database and will be used to describe mastitis epidemiology at the quarter, cow and herd level in herds moving to a management system with the strict non-use of antibiotics.

**PARTICIPANTS:** Participants: Linda Garrison-Tikofsky DVM was project coordinator and oversaw the data collection and will prepare the data analysis and reporting. Ruth Zadoks, DVM PhD developed the real time PCR screening for foodborne pathogens, along with staff working under her (Sharinne Sukhananand and Natasha Belosteymykh) at the molecular laboratory of Quality Milk Production Services. Aerobic culture work and preservation of isolates was performed by Dr. Carlos Santisteban and Ms. Andrea Walsh at Quality Milk Productions Services. Milk sample collection and questionnaire administration was performed by field technicians at Quality Milk Production Services (Kerry Case, Joan Taber and Sharon Melendes). Ms. Belinda Gross has been developer of the database and will be an integral to the development of the website to transmit the results of this study. Dr. Ynte Schukken will provide analytical expertise in describing the epidemiology of mastitis in herds transition to a non-antibiotic model. Four dairy farmers provided access to their farms and cattle and participated in collecting samples between surveys and in provided descriptive informations. Partner Organizations: DairyOne milk testing laboratory in Ithaca performed the somatic cell counting and milk quality bacteriologic testing. Northeast Organic Farming Association of New York cooperated heavily on this project by encouraging farmers to participate, in advising on grazing and herd health management and in allowing QMPS time at venues to discuss the project, its progress and results as they developed. Organic Valley, Upstate-Niagara and Horizon (all milk processors active in New York milk markets) provided time at their meetings to update farmers on the project and provided historical milk quality information for these farms that will be used in the final data analysis. Throughout the project undergraduate and veterinary students participated in sampling and data collection. Most of these students had no familiarity with organic dairy production and so this project allowed them to gain experience in working and advising organic dairy producers. Because of this project, annual lectures in organic herd health were instituted at Cornell for both veterinary and animal science students, raising awareness of the unique needs and approaches to management of these farms.

**TARGET AUDIENCES:** Organic Dairy Farmers: received science-based information on udder health and milk quality management on their farms. Best management practices for mastitis control and food safety were shared and when implemented, resulted in increased profitability from better production and attainment of milk quality premiums. Veterinarians: Three meetings for veterinarians working with organic dairies were held in New York State and an additional one in Vermont to discuss science-based approaches to treatment and management of milk quality on their clients organic farms. Additional veterinarians were reached during these meetings via video linkage. Veterinary and Animal Science students: these students represent the future of dairy and veterinary medicine and so principles of organic dairy management, milk quality and udder health information was provided to them via lecture and through visits to farms participating in this project.

**PROJECT MODIFICATIONS:** Five herds were initially enrolled but one dropped out of the project during the first year because of financial issues and because they were unsure if they would actually complete the transition to organic production. This project went longer than initially anticipated because of delays in enrolling herds that were willing to commit for such a long period. Antimicrobial resistance testing was not performed because of termination of the project and funds being returned or OREI. Data analysis has been delayed because of multiple commitments on the part of the project coordinator.

**2009/01/01 TO 2009/12/31 OUTPUTS:** Five dairy herds were enrolled in the project; one herd dropped out of the project in the first year because they were unsure about continuing their transition to organic production. All herds were enrolled as they entered their transition year from conventional to organic dairy production and were followed through their second year of organic production (four total years). Herds were not enrolled at the same time, but over the course of two and a half years which delayed the project longer than expected. Herd size ranged from 30 to 100 lactating cattle; the majority of cows included in this study were Holstein-Friesian. Three herds continuously produced milk around the calendar; one herd was seasonal and dried cattle off in December

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## IMPACT

2004/09 TO 2009/09 Development of the rapid real-time PCR methodology for the detection of Salmonella DT-104, E. coli H7:O157; Campylobacter jejuni, Listeria monocytogenes and STEC organisms in raw bulk milk is current regular use at the Quality Milk Production Services and is routinely requested by dairy farmers in the Northeast. Raw milk permits and consumer demands for raw milk products have increased over the past few years. Farmers now submit samples for real-time PCR detection of foodborne pathogens as a quality control measure for their raw milk sales. Additionally a bulk tank surveillance project has been instituted in New York for all dairy farmers (regardless of whether they sell milk raw or for processing) and this surveillance project incorporates this developed service in the testing menu. Milk culture results for the farms have been incorporated into the database and will be statistically analyzed over the next year to describe the mastitis epidemiology in farms representative of the organic farming model and will be associated with best management practices for organic herds. This information will be distributed to both organic and conventional farms via pasture walks, extension meetings, fact sheets, newsletters and webpages. Information from this project was used to develop udder health parameters and information for organic dairy farms and has already been presented at farm and extension meetings in New York, Vermont, Maine, Pennsylvania and New Hampshire. Information gleaned from this project also contributed to a chapter on Organic Dairy Herd Health in the Organic Dairy Handbook.

**\*\*PUBLICATIONS (not previously reported):\*\*** 2004/09 TO 2009/09 No publications reported this period

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## **PUBLICATIONS**

2009/01/01 TO 2009/12/31 No publications reported this period

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# Soybean Aphid Suppression Using a Fall-seeded Rye Cover Crop

<b>Accession No.</b>	0201258
<b>Subfile</b>	CRIS\
<b>Project No.</b>	MIN-17-G18
<b>Agency</b>	NIFA MIN
<b>Project Type</b>	OTHER GRANTS
<b>Project Status</b>	TERMINATED
<b>Contract / Grant No.</b>	2004-51106-02240
<b>Proposal No.</b>	2004-05204
<b>Start Date</b>	01 SEP 2004
<b>Term Date</b>	31 AUG 2008
<b>Fiscal Year</b>	2008
<b>Grant Amount</b>	\$463,645
<b>Grant Year</b>	2004
<b>Investigator(s)</b>	Heimpel, G. E.; Porter, P. M.; Ragsdale, D. W.; Potter, B. D.

## NON-TECHNICAL SUMMARY

Organic soybean growers have few options for controlling the soybean aphid, which can severely depress soybean yields. We will determine whether planting a fall-seeded rye cover crop prior to soybean can alleviate soybean aphid pressure by decreasing soybean aphid colonization and/or by increasing soybean aphid biological control.

## OBJECTIVES

The over-arching research objective of this proposal is to determine the extent to which fall-seeded winter rye cover crops planted prior to soybeans can reduce soybean aphid pressure. This objective is broken down into 3 sub-objectives. In sub-objective 1a, we will compare soybean aphid colonization and population dynamics in soybeans planted following a winter rye cover and a tilled winter fallow on six focal organic farms in Minnesota. In sub-objective 1b, we will make this comparison as part of a state-wide soybean aphid sampling network including 30 or more organic farms co-ordinated by the Minnesota Department of Agriculture. Finally, in sub-objective 1c, we will use certified organic Univ. of Minnesota experiment station land to more carefully determine cause-effect relationships underlying effects uncovered in sub-objectives 1a and 1b. The extension/demonstration objectives of this proposal revolve around disseminating results obtained in Objective 1 to organic growers in Minnesota and other soybean-growing states, and surveying organic farmers with respect to effectiveness of the cover-cropping system and their likelihood of adopting to retaining it.

## APPROACH

For research sub-objective 1a, we will monitor densities of soybean aphids and their natural enemies in organic soybean fields that have either followed a winter rye cover crop or that have not. We will also monitor densities of grain aphids and their natural enemies in the rye prior to soybean establishment. For sub-objective 1b, we will sample soybean aphid densities on 30-50 organic farms in Minnesota that either do or do not use the rye winter cover crop. For sub-objective 1c, we will compare soybean aphid and natural enemy dynamics in soybeans following a winter rye cover crop in conventional and organic settings, and with narrow and wide soybean row

spacing. For the extension/demonstration objective, we will prepare fact-sheets, organize field demonstrations of the research sites, and give presentations at grower meetings in the off-season to disseminate our results. We will also survey organic growers through mailings and at meetings to determine their interest in rye winter cover crops, and their likelihood of adopting rye winter cover cropping systems if there is demonstration of increased soybean aphid control.

## PROGRESS

2004/09 TO 2008/12 OUTPUTS: We have completed three field seasons of field experiments and associated laboratory studies and analyses on this project. During all years, plots with and without a winter-planted rye cover crop were established both at experiment station sites and on farmer's fields. Separate field studies were conducted at one site (Lamberton, MN) where effects of row spacing were investigated. Also, more detailed studies were done in Rosemount, MN, where more intensive sampling was done for aphid natural enemies using techniques such as pitfall trapping, pan trapping, sticky-card sampling and predator exclusion. Laboratory work consisted primarily of processing field samples and analyses consisted of statistical determination of effects of the rye cover crop on aphid and natural enemy densities. We also conducted analyses to determine the effect of predators on aphid densities. As in the first two years, experimental field data were complemented by sampling conducted by the Minnesota Department of Agriculture (MDA), and the MDA data corroborated our experimental results. These analyses are currently being written up as two publications for scholarly journals. In addition, this information has been disseminated in a number of presentations at professional meetings. In 2008, these included symposium presentations at the annual meeting of the North Central Branch of the Entomological Society and at the MN Organic Farming conference. The information was also discussed at Farm days in Waseca and St. Paul, MN. PARTICIPANTS: Paul Porter, Professor Agronomy and Plant Genetics, David Ragsdale, Professor of Entomology, Bruce Potter, IPM Specialist, Mark Abrahamson, Specialist, Minnesota Dept. of Agriculture, Zeynep Sezen, Post-doc, Karrie Koch, graduate Student TARGET AUDIENCES: Organic soybean farmers, Conventional soybean farmers, Entomologists, Weed Scientists, Agronomists PROJECT MODIFICATIONS: We received a one-year no-cost extension to finish harvesting from the last field season and laboratory processing.

2008/01/01 TO 2008/12/31 OUTPUTS: We have completed three field seasons of field experiments and associated laboratory studies and analyses on this project. During all years, plots with and without a winter-planted rye cover crop were established both at experiment station sites and on farmer's fields. Separate field studies were conducted at one site (Lamberton, MN) where effects of row spacing were investigated. Also, more detailed studies were done in Rosemount, MN, where more intensive sampling was done for aphid natural enemies using techniques such as pitfall trapping, pan trapping, sticky-card sampling and predator exclusion. Laboratory work consisted primarily of processing field samples and analyses consisted of statistical determination of effects of the rye cover crop on aphid and natural enemy densities. We also conducted analyses to determine the effect of predators on aphid densities. As in the first two years, experimental field data were complemented by sampling conducted by the Minnesota Department of Agriculture (MDA), and the MDA data corroborated our experimental results. These analyses are currently being written up as two publications for scholarly journals. In addition, this information has been disseminated in a number of presentations at professional meetings. In 2008, these included symposium presentations at the annual meeting of the North Central Branch of the Entomological Society and at the MN Organic Farming conference. The information was also discussed at Farm days in Waseca and St. Paul, MN. PARTICIPANTS: Paul Porter, Professor Agronomy and Plant Genetics, David Ragsdale, Professor of Entomology, Bruce Potter, IPM Specialist, Mark Abrahamson, Specialist, Minnesota Dept. of Agriculture, Zeynep Sezen, Post-doc, Karrie Koch, graduate Student TARGET AUDIENCES: Organic soybean farmers, Conventional soybean farmers, Entomologists, Weed Scientists, Agronomists PROJECT MODIFICATIONS: We received a one-year no-cost extension to finish harvesting from the last field season and laboratory processing.

2007/01/01 TO 2007/12/31 OUTPUTS: We have completed three field seasons on this project. The third field season confirmed what was found in the first two, namely that the rye cover crop did lead to lower soybean aphid densities. Yields were not negatively affected in the third year by the cover crop with the exception of at one site (Lamberton, MN) which experienced a rather severe drought. Overall, our data do not indicate that natural enemies are mediating the suppression of soybean aphids, although the ratio of predatory insects to aphids does tend to be higher in the cover-cropped plots. We suspect that the mechanism involves a decrease in colonization rate in the rye plots although we were not able to confirm this using pan-trapping during the third field season because of the relatively low overall soybean aphid colonization rates. Field cage studies suggest that there was no difference in the quality of soybean plants as hosts for soybean aphid as a function of whether they

were growing with rye or not. As in the first two years, experimental field data were complemented by sampling conducted by the Minnesota Department of Agriculture (MDA), and the MDA data corroborated our experimental results. PARTICIPANTS: Zeynep Sezen, post doc Karrie Koch, graduate student Partner organizations Minnesota Department of Agriculture TARGET AUDIENCES: Organic soybean farmers Entomologists Agronomists

2006/01/01 TO 2006/12/31 We have completed two field seasons on this project. The second field season confirmed what was found in the first, namely that the rye cover crop did lead to lower soybean aphid densities. One of our farms had very high levels of soybean aphid, and this apparently led to a yield increase in the rye cover crop plots, which had not been seen previously. In the other sites, there was either no effect on yield, or a decrease in yield (at one site) due to the rye cover crop. So far, our data do not indicate that natural enemies are mediating the suppression of soybean aphids. Instead, we suspect that the mechanism involves a decrease in colonization rate in the rye plots. We also did a laboratory study that suggested that there was no difference in the quality of soybean plants as hosts for soybean aphid as a function of whether they were growing with rye or not. The experimental field data were complemented by sampling conducted by the Minnesota Department of Agriculture (MDA), and the MDA data corroborated our experimental results.

2005/01/01 TO 2005/12/31 We have completed one field season, and conducted one farmer survey. The survey indicated that organic farmers that are not currently using fall-seeded rye cover crops would be likely to do so if this practice could lead to the suppression of soybean aphids. The field research showed that the rye cover crop did lead to lower soybean aphid densities on most, but not all farms studied. The experimental field data were complemented by sampling conducted by the Minnesota Department of Agriculture (MDA), and the MDA data corroborated our experimental results.

2004/01/01 TO 2004/12/31 Work on this project will commence Spring 2005

## IMPACT

2004/09 TO 2008/12 The third field season confirmed what was found in the first two, namely that the rye cover crop did lead to lower soybean aphid densities. Yields were not negatively affected in the third year by the cover crop with the exception of at one site (Lamberton, MN) which experienced a rather severe drought. Overall, our data do not indicate that natural enemies are mediating the suppression of soybean aphids, although the ratio of predatory insects to aphids does tend to be higher in the cover-cropped plots. We suspect that the mechanism driving the suppression of soybean aphid by the rye cover crop involves a decrease in colonization rate in the rye plots although we were not able to confirm this using pan-trapping during the third field season because of the relatively low overall soybean aphid colonization rates. Field cage studies suggest that there was no difference in the quality of soybean plants as hosts for soybean aphid as a function of whether they were growing with rye or not. Our results suggest that planting a rye winter cover crop prior to soybeans can lead to lower densities of soybean aphids and an increase in yield when soybean aphid pressure is high. This is an important finding for organic farmers that have no reliable insecticides to use against soybean aphid. Given our survey results it is therefore likely that our research will lead to an increase in the adoption of rye cover crops prior to soybean. \*\*PUBLICATIONS (not previously reported):\*\* 2004/09 TO 2008/12 No publications reported this period

2008/01/01 TO 2008/12/31 The third field season confirmed what was found in the first two, namely that the rye cover crop did lead to lower soybean aphid densities. Yields were not negatively affected in the third year by the cover crop with the exception of at one site (Lamberton, MN) which experienced a rather severe drought. Overall, our data do not indicate that natural enemies are mediating the suppression of soybean aphids, although the ratio of predatory insects to aphids does tend to be higher in the cover-cropped plots. We suspect that the mechanism driving the suppression of soybean aphid by the rye cover crop involves a decrease in colonization rate in the rye plots although we were not able to confirm this using pan-trapping during the third field season because of the relatively low overall soybean aphid colonization rates. Field cage studies suggest that there was no difference in the quality of soybean plants as hosts for soybean aphid as a function of whether they were growing with rye or not. Our results suggest that planting a rye winter cover crop prior to soybeans can lead to lower densities of soybean aphids and an increase in yield when soybean aphid pressure is high. This is an important finding for organic farmers that have no reliable insecticides to use against soybean aphid. Given our survey results it is therefore likely that our research will lead to an increase in the adoption of rye cover crops prior to soybean.

2007/01/01 TO 2007/12/31 Our results suggest that planting a rye winter cover crop prior to soybeans can lead to lower densities of soybean aphids and an increase in yield when soybean aphid pressure is high. This is an important finding for organic farmers that have no reliable insecticides to use against soybean aphid. Given our survey results it is therefore likely that our research will lead to an increase in the adoption of rye cover crops prior to soybean.

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2005/01/01 TO 2005/12/31 Our results suggest that planting a rye winter cover crop prior to soybeans can lead to lower densities of soybean aphids. This is an important finding for organic farmers that have no reliable insecticides to use against soybean aphid. Given our survey results it is therefore likely that our research will lead to an increase in the adoption of rye cover crops prior to soybean.

2004/01/01 TO 2004/12/31 Work on this project will commence Spring 2005

## **PUBLICATIONS**

2008/01/01 TO 2008/12/31 No publications reported this period

2007/01/01 TO 2007/12/31 No publications reported this period

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

2005/01/01 TO 2005/12/31 Heimpel, G. E., P. M. Porter, D. W. Ragsdale, R. L. Koch, and B. Potter. 2005. The potential role of insect suppression in increasing the adoption of cover crops. M. S. Hoddle, ed. Second International Symposium on Biological Control of Arthropods:185-191.

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

[↑ Return to Index](#)

# Nutrient Dynamics, Soil Biota and Functional Biodiversity at an Organic Farm

<b>Accession No.</b>	0201465
<b>Subfile</b>	CRIS\
<b>Project No.</b>	CA-D\*-XXX-7345-CG
<b>Agency</b>	NIFA CALB
<b>Project Type</b>	OTHER GRANTS
<b>Project Status</b>	TERMINATED
<b>Contract / Grant No.</b>	2004-51106-02242
<b>Proposal No.</b>	2004-05207
<b>Start Date</b>	15 SEP 2004
<b>Term Date</b>	14 SEP 2008
<b>Fiscal Year</b>	2009
<b>Grant Amount</b>	\$297,814
<b>Grant Year</b>	2004
<b>Investigator(s)</b>	Jackson, L. E.; Klonsky, K.; Scow, K. M.
<b>Performing Institution</b>	INTERDEPARTMENTAL, UNIV OF CALIFORNIA, DAVIS, CALIFORNIA 95616

## NON-TECHNICAL SUMMARY

In this landscape-level project, a representative organic farm in California's Central Valley will be the focal point for studies on 1) biodiversity and community composition of plants and soil biota in various habitats in the farm landscape, 2) some of the ecological functions of this biodiversity, and 3) socioeconomic factors that promote human interest and value for increasing biodiversity in organic farm landscapes, as perceived by local growers and processors. Our approach will entail inventories and surveys of biodiversity in the farm landscape that is relevant to nutrient cycling, and of human factors and attitudes regarding biodiversity and organic agriculture. At five habitats on the farm (cropland, drainage ditch, runoff pond, riparian corridor, and hedgerow), inventories of plant species composition, cover, biomass, soil microbial communities with phospholipid fatty acid analysis, nematodes, and earthworms will be made. Productivity, nutrient levels, soil disease, water quality and estimates of water flow will also be measured. Based on these results, selected management practices for biodiversity that promote specific ecosystem services will be studied. Information from local growers and processors will show incentives for increasing biodiversity in organic farm landscapes. Outreach activities to the local community will occur via newsletters, a webpage, field days, and a workshop for growers to learn to monitor and understand roles of biodiversity and nutrient cycling on their farms.

## OBJECTIVES

A case study of an organic farm in California's Central Valley will investigate the biodiversity and community composition of plants and soil biota in various habitats in the farm landscape, some of the functions of this biodiversity, and socioeconomic factors that promote human interest and value for increasing biodiversity in organic farm landscapes. There are six specific objectives: Inventory landscape patterning of plant biodiversity and soil community composition on cropland and the surrounding landscape of the organic farm. Monitor productivity, nutrient resources and water quality, and relate to biodiversity and management practices on cropland and the surrounding landscape of the organic farm. Study selected management practices, based on

these results, for biodiversity that promote specific ecosystem services for nutrient utilization and retention. Obtain information from local growers and processors to reveal their incentives for increasing biodiversity in organic farm landscapes. Develop a conceptual model that identifies key biological and socioeconomic factors by which biodiversity leads to sustainability on organic farms, and which becomes the framework for outreach activities for the project.

## APPROACH

Inventories and surveys of biodiversity in the farm landscape that is relevant to nutrient cycling, and of human factors and attitudes regarding biodiversity and organic agriculture will be conducted, using a case-study of an organic farm in California. At five habitats on the farm (cropland, drainage ditch, runoff pond, riparian corridor, and hedgerow), inventories of plant species composition, cover, biomass, soil microbial communities with phospholipid fatty acid analysis, nematodes, and earthworms will be made. Productivity, nutrient levels, soil disease, water quality and estimates of water flow will also be measured. Based on these results, selected management practices for biodiversity that promote ecosystem services for nutrient cycling will be studied, e.g. cover crops, weed distribution, soil disease suppression, intercropping or native grass buffers in a runoff pond. Information from local growers and processors will be obtained to show incentives for increasing biodiversity in organic farm landscapes. A conceptual model will be developed to demonstrate key linkages between biological and socioeconomic factors to better enable farmers to exploit biodiversity for environmental and economic sustainability related to nutrient cycling on organic vegetable farms. Outreach activities to the local community will occur via newsletters, a webpage, field days, and a workshop for growers to learn to monitor and understand roles of biodiversity and nutrient cycling on their farms.

## PROGRESS

2004/09 TO 2008/09 OUTPUTS: There have been many outputs during the 3 years of the project period: >10 seminars, oral talks and posters at scientific meetings; several extension presentations and newsletters regarding soil biology, biodiversity, nutrient cycling, and carbon sequestration; direct communication with farmers about soil management; high-school field projects for students to learn about carbon sequestration in soil and plants in farm restoration, in collaboration with the SLEWS project in Yolo County; >10 presentations and field trips for non-governmental agencies about soil and plants in farm restoration; collaborative work with state agencies on agricultural mitigation and adaptation to climate change; and interaction with international groups involved in climate change and biodiversity conservation. A highlight in 2008 was the international symposium on "Biodiversity and Ecosystem Services in Agricultural Landscapes" at UC Davis, with attendees from 11 countries. For the field trip, the group visited the organic farm site and the grower-cooperator explained the farm management and project outcomes, while the various researchers presented results on the ecosystem services provided by the various habitats of the farm. The on-farm project provided the initial foundation for developing a county-wide project on how agricultural productivity and ecosystem services may be impacted by climate change; this report is now in press as a white paper published by the California Energy Commission. Outcomes/Impacts Farmers in the United States are beginning to manage non-production areas of their farms to create a more diverse set of habitats, i.e., farmscaping. To better our understanding of farmscaping, this study quantified biodiversity and its associations with ecosystem functions by inventorying communities of plant and soil organisms in the six distinct habitats of an organic farm in California's Central Valley; and monitoring multiple ecosystem functions provided by each. Two years of inventories of a riparian corridor, hedgerows, two separate production fields, a system of drainage ditches, and tailwater ponds showed different functional groups and greater native plant diversity in non-cropped areas, but less pronounced differences for belowground organisms. Multivariate statistics indicate associations of nematode functional groups, microbial communities (phospholipid fatty acid analysis) and certain earthworm taxa with particular habitats. Monitoring showed that some habitats were almost entirely responsible for certain ecosystem functions but sometimes at a cost of other functions. Riparian and hedgerow habitats with woody vegetation stored 19% of the farmscape's total carbon, despite their relatively small size (only 6% of the total area). Surface water infiltration rates in the riparian corridor were >230% higher than those in the production fields while concentrations of dissolved organic carbon (DOC) collected in soil solution using ceramic cup lysimeters were as much as 65% higher. PARTICIPANTS: This project provided training opportunities for two graduate students and two postdocs. There were also many undergraduates (approx. 10) and one high school student who did laboratory and field work for the projects. The on-farm research involved a group of five faculty members, and there were associations with local NGOs and farm advisors. Over 20 farmers were phone-interviewed for their perspectives and attitudes toward farmscaping. This project is one of the sites for the agrobiodiversity network of the international program on biodiversity science, DIVERSITAS. The project served as the foundation for a larger scale analysis of climate change impacts

on agriculture and ecosystem services in Yolo County, California. TARGET AUDIENCES: Farmers, ranchers, government agencies involved in resource management and energy use, and non-governmental agencies involved in biodiversity conservation are the public target audiences. The work is also aimed at scientific audiences in biogeochemistry, plant ecology, and sustainable agriculture. PROJECT MODIFICATIONS: Not relevant to this project.

2007/01/01 TO 2007/12/31 OUTPUTS: The following outputs have been produced: seminars, oral talks and posters at scientific meetings; extension presentations and newsletters regarding soil biology, biodiversity, nutrient cycling, and carbon sequestration; direct communication with farmers about soil management; high-school field projects for students to learn about carbon sequestration in soil and plants in farm restoration; presentations and field trips for non-governmental agencies about soil and plants in farm restoration; collaborative work with state agencies on agricultural mitigation and adaptation to climate change; and interaction with international groups involved in climate change and biodiversity conservation. PARTICIPANTS: This project provided training opportunities for two graduate students and a postdoc. This was on-farm research involving a group of five faculty members. Over 20 farmers were phone-interviewed for their perspectives and attitudes toward farmscaping. This project is one of the sites for the agrobiodiversity network of the international program on biodiversity science, DIVERSITAS. TARGET AUDIENCES: Farmers, ranchers, government agencies involved in resource management and energy use, and non-governmental agencies involved in biodiversity conservation are the public target audiences. The work is also aimed at scientific audiences in biogeochemistry, plant ecology, and sustainable agriculture.

2006/01/01 TO 2006/12/31 Biodiversity is a key aspect of organic farm management, not only for crop production practices, but for the entire farmscape, e.g., crop fields, riparian corridors, hedgerows, detention ponds, and ditches. At an organic farm in California's Central Valley, the ecological and economic contribution of various habitats of the farmscape is being assessed by: 1. Inventorying the plant biodiversity and the associated belowground composition of microbial, nematode, and earthworm communities; 2. Determining key ecosystem functions, such as nutrient cycling and water quality, associated with these habitat types; and 3. Developing a model to evaluate the economic trade-offs resulting from providing different types of ecosystem services, and to choose the management regimes that are most cost-effective in terms of environmental quality and crop-based income. Preliminary results show greater differences in aboveground species diversity of non-production areas of the farm than in belowground communities. One of the largest differences between habitats was in carbon sequestration. Greenhouse gas emissions were greatest in ponds and ditches, but these occupied little of the farm area. Ecological and economic impacts from restoration practices will also be considered in a survey of local landowners for their willingness to invest in biodiversity-based practices to increase farm stewardship. A farm stewardship survey is underway to understand attitudes of local farmers and landowners toward management of wetland margins and farm edges. In the first phase, we are focusing on farmers' current methods for managing vegetation on various types of farm edges, including non-cropped field edges and roadsides, stream and ditch banks, tailwater ponds, hard-to-access field corners, and steep hillsides. This is a phone survey of all farm operators managing land within a 150 km<sup>2</sup> area in western Yolo Co. In a larger context, this grant has contributed to the support of publications on utilizing and conserving biodiversity in agricultural landscapes.

2005/01/01 TO 2005/12/31 Ecological and economic cost/benefit analyses of landscape management alternatives can show how agricultural practices affect biodiversity, carbon and nitrogen retention, and economic outcomes for farmers. The many habitat types existing on and around an organic farm in California Central Valley are the focus of this landscape level study. These habitat types represent various management options to enhance habitat within a farming system (riparian corridor, hedgerows, detention ponds, ditches, and two different rotations in production fields). In this first year, these habitats were assessed by: 1) inventorying the existing biodiversity and the associated below-ground community structure and composition (3 sites per habitat); 2) monitoring key ecosystem functions such CO<sub>2</sub> and N<sub>2</sub>O emissions, and water quality in ponds, ditches, and fields and 3) initiating development of a simple land use model that will enable stakeholders to evaluate the economic trade-offs required to provide specific ecosystem services. LI-COR 8100 environmental chambers are used to monitor diurnal CO<sub>2</sub>, along with short-term chamber measurements for CO<sub>2</sub> and N<sub>2</sub>O at monthly intervals, and for water quality, ISCO automated samplers are deployed to monitor stormwater and irrigation runoff. Suction lysimeters and anion resin bags for nitrate leaching are installed at all of the habitat types. In addition, soil samples for microbial biomass and nutrient pools have been collected several times during the growing season. The preliminary results from the first inventory in the spring of this year show that although the plant species richness of non-production areas of the farm were significantly more different than production areas, the differences in belowground communities were not as dramatic. The Spring, 2005, inventory of vegetation, nematodes, earthworms, soil microbial communities (phospholipids fatty acid) as well as monitoring

data of carbon and nitrogen losses through emissions throughout the Spring, Summer and Fall, 2005 are now being analyzed.

2004/09/15 TO 2008/09/14 OUTPUTS: There have been many outputs during the 3 years of the project period: >10 seminars, oral talks and posters at scientific meetings; several extension presentations and newsletters regarding soil biology, biodiversity, nutrient cycling, and carbon sequestration; direct communication with farmers about soil management; high-school field projects for students to learn about carbon sequestration in soil and plants in farm restoration, in collaboration with the SLEWS project in Yolo County; >10 presentations and field trips for non-governmental agencies about soil and plants in farm restoration; collaborative work with state agencies on agricultural mitigation and adaptation to climate change; and interaction with international groups involved in climate change and biodiversity conservation. A highlight in 2008 was the international symposium on "Biodiversity and Ecosystem Services in Agricultural Landscapes" at UC Davis, with attendees from 11 countries. For the field trip, the group visited the organic farm site and the grower-cooperator explained the farm management and project outcomes, while the various researchers presented results on the ecosystem services provided by the various habitats of the farm. The on-farm project provided the initial foundation for developing a county-wide project on how agricultural productivity and ecosystem services may be impacted by climate change; this report is now in press as a white paper published by the California Energy Commission. Outcomes/Impacts Farmers in the United States are beginning to manage non-production areas of their farms to create a more diverse set of habitats, i.e., farmscaping. To better our understanding of farmscaping, this study quantified biodiversity and its associations with ecosystem functions by inventorying communities of plant and soil organisms in the six distinct habitats of an organic farm in California's Central Valley; and monitoring multiple ecosystem functions provided by each. Two years of inventories of a riparian corridor, hedgerows, two separate production fields, a system of drainage ditches, and tailwater ponds showed different functional groups and greater native plant diversity in non-cropped areas, but less pronounced differences for belowground organisms. Multivariate statistics indicate associations of nematode functional groups, microbial communities (phospholipid fatty acid analysis) and certain earthworm taxa with particular habitats. Monitoring showed that some habitats were almost entirely responsible for certain ecosystem functions but sometimes at a cost of other functions. Riparian and hedgerow habitats with woody vegetation stored 19% of the farmscape's total carbon, despite their relatively small size (only 6% of the total area). Surface water infiltration rates in the riparian corridor were >230% higher than those in the production fields while concentrations of dissolved organic carbon (DOC) collected in soil solution using ceramic cup lysimeters were as much as 65% higher. PARTICIPANTS: This project provided training opportunities for two graduate students and two postdocs. There were also many undergraduates (approx. 10) and one high school student who did laboratory and field work for the projects. The on-farm research involved a group of five faculty members, and there were associations with local NGOs and farm advisors. Over 20 farmers were phone-interviewed for their perspectives and attitudes toward farmscaping. This project is one of the sites for the agrobiodiversity network of the international program on biodiversity science, DIVERSITAS. The project served as the foundation for a larger scale analysis of climate change impacts on agriculture and ecosystem services in Yolo County, California. TARGET AUDIENCES: Farmers, ranchers, government agencies involved in resource management and energy use, and non-governmental agencies involved in biodiversity conservation are the public target audiences. The work is also aimed at scientific audiences in biogeochemistry, plant ecology, and sustainable agriculture. PROJECT MODIFICATIONS: Not relevant to this project.

2004/01/01 TO 2004/12/31 Plans for winter and spring sampling of soils and water quality at the organic farm are being made. Advice on nematode, hydrologic flows, and pedological sampling has been solicited, to add these components to our list of other soil variables. Specific locations of sampling sites are being identified. The grower has provided a detailed information on all water sources on the farm, runoff ponds, reservoirs, pipes, pumps, and channels.

## IMPACT

2004/09 TO 2008/09 The tailwater pond reduced mean total suspended solid concentrations in irrigation runoff by 97% but was also a source of high N<sub>2</sub>O-N emissions. The drainage ditches however, had the highest losses in terms of both N<sub>2</sub>O-N emissions (16.7 MU g m<sup>-2</sup> hr<sup>-1</sup>) and NO<sub>3</sub><sup>-</sup>-N leaching (mean values for losses in the second year were 12.1 g m<sup>-2</sup>). To assess the relative tradeoffs between ecosystem functions plot level analyses were extrapolated to the entire farmscape. This study indicates habitat enhancement through farmscaping increases both biodiversity and multiple ecosystem functions of agricultural lands. Cultivar diversity is another

factor that may change ecosystem functions, as a result of differences in soil nutrient cycling, plant nutrition and growth habitats. Plant diversity was manipulated temporally and spatially: mustard cover crop vs. no cover crop (fallow) in winter, and planting of mixtures with one, three or five tomato cultivars in summer, which compared a monoculture with the grower's favorite choice for a high-yielding cultivar with mixtures of it and other high-yielding cultivars in the region. Soil N, soil microbial biomass, crop nutrient uptake, canopy light interception, disease, greenhouse gas (GHG) emissions, and biomass were measured. Preliminary results show that mustard reduced NO<sub>3</sub>- content in the soil through the winter and also during the tomato crop. Preliminary comparison of the cultivar mixtures indicates fairly similar yield and shoot biomass, GHG emissions, soil microbial biomass, and N leaching. Thus, mixtures may have little benefit in terms of performance possibly due to the high genetic similarity of currently-used cultivars. In a survey of local growers, two principal patterns relating to the maintenance of biodiversity in farm edges among our sample of 27 farms in Yolo County. First, water courses are managed differently than road edges and hedgerows. Second, the most biodiversity friendly practices, such as planting hedgerows, are practices used by a minority of producers, but there is interest among many producers in learning more about their benefits. Additional publications will be submitted in 2009. \*\*PUBLICATIONS (not previously reported):\*\* 2004/09 TO 2008/09 1. Drenovsky, R.E., K.L. Steenwerth, L.E. Jackson, and K.M. Scow. 2008. Land use and climate factors structure regional patterns in soil microbial communities. *Global Ecology and Biogeography*. In press. 2. Gaskell, M. R. Smith, L. Jackson, and T.K. Hartz. 2008. Nitrogen fertility management. Section 6. 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Biodiversity in agricultural landscapes: saving natural capital without losing interest. *Agriculture, Ecosystems, and Environment* 121:193/195. 13. Jackson, L.E., U. Pascual, and T. Hodgkin. 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agriculture, Ecosystems, and Environment* 121:196/210. 14. Perrings, C., L.E. Jackson, K. Bawa, L. Brussaard, S. Brush, T. Gavin, R. Papa, U. Pascual, and P.D. Ruiter. 2006. Biodiversity in agricultural landscapes: saving natural capital without losing interest. *Conservation Biology* 20:263-264.

2007/01/01 TO 2007/12/31 Organic farmers increasingly manage the margins of previously monocultured farmed landscapes to increase biodiversity, e.g. they restore and protect riparian corridors, plant hedgerows and construct vegetated tailwater ponds. This study attempts to link habitat enhancements, biodiversity and changes in ecosystem functions by: 1. inventorying the existing biodiversity and the associated belowground community structure and composition in the various habitats of an organic farm in California's Central Valley; and 2. monitoring key ecosystem functions of these habitats. Two years of inventories show greater native plant diversity in non-cropped areas. While nematode diversity did not differ between habitats, functional groups were clearly associated with particular habitats as were soil microbial communities (phospholipid fatty acid analysis). Earthworm diversity did not differ between habitats, but biomass was higher in non-cropped areas. Habitats with woody vegetation stored 20% of the farmscape's total carbon (C), despite their relatively small size (only 5% of the total farm). Two years of monitoring data of farmscape C and nitrogen (N) through emissions, run-off and

leaching showed distinct tradeoffs in function associated with each habitat but that habitat restoration in field margins increases both landscape biodiversity and multifunctionality. In a survey of local growers, two principal patterns relating to the maintenance of biodiversity in farm edges among our sample of 27 farms in Yolo County. First, water courses are managed differently than road edges and hedgerows. Second, the most biodiversity friendly practices, such as planting hedgerows, are practices by a minority of producers.

2006/01/01 TO 2006/12/31 Presentations on the project were given at meetings of the international program for biodiversity science (DIVERSITAS), a UC Davis departmental seminar, and at the International Conference on the Future of Agriculture: Science, Stewardship and Sustainability, Sacramento, CA. The project has received local interest among various farmer/environmental organizations for its potential for changing incentives for managing farm edges for greater environmental quality.

2005/01/01 TO 2005/12/31 Presentations on the project were given at the International Plant Genetic Research Institute in Rome, Italy (September 20, 2005) and the DIVERSITAS Open Science Conference in Oaxaca, Mexico (November 11, 2005).

2004/09/15 TO 2008/09/14 The tailwater pond reduced mean total suspended solid concentrations in irrigation runoff by 97% but was also a source of high N<sub>2</sub>O-N emissions. The drainage ditches however, had the highest losses in terms of both N<sub>2</sub>O-N emissions (16.7 MU g m<sup>-2</sup> hr<sup>-1</sup>) and NO<sub>3</sub><sup>-</sup>-N leaching (mean values for losses in the second year were 12.1 g m<sup>-2</sup>). To assess the relative tradeoffs between ecosystem functions plot level analyses were extrapolated to the entire farmscape. This study indicates habitat enhancement through farmscaping increases both biodiversity and multiple ecosystem functions of agricultural lands. Cultivar diversity is another factor that may change ecosystem functions, as a result of differences in soil nutrient cycling, plant nutrition and growth habitats. Plant diversity was manipulated temporally and spatially: mustard cover crop vs. no cover crop (fallow) in winter, and planting of mixtures with one, three or five tomato cultivars in summer, which compared a monoculture with the grower's favorite choice for a high-yielding cultivar with mixtures of it and other high-yielding cultivars in the region. Soil N, soil microbial biomass, crop nutrient uptake, canopy light interception, disease, greenhouse gas (GHG) emissions, and biomass were measured. Preliminary results show that mustard reduced NO<sub>3</sub><sup>-</sup> content in the soil through the winter and also during the tomato crop. Preliminary comparison of the cultivar mixtures indicates fairly similar yield and shoot biomass, GHG emissions, soil microbial biomass, and N leaching. Thus, mixtures may have little benefit in terms of performance possibly due to the high genetic similarity of currently-used cultivars. In a survey of local growers, two principal patterns relating to the maintenance of biodiversity in farm edges among our sample of 27 farms in Yolo County. First, water courses are managed differently than road edges and hedgerows. Second, the most biodiversity friendly practices, such as planting hedgerows, are practices used by a minority of producers, but there is interest among many producers in learning more about their benefits. Additional publications will be submitted in 2009.

2004/01/01 TO 2004/12/31 Based on these results, selected management practices for biodiversity that promote specific ecosystem services will be analyzed. Information from local growers and processors will show incentives for increasing biodiversity in organic farm landscapes. Outreach activities to the local community will occur via newsletters, a webpage, field days, and a workshop for growers to learn to monitor and understand roles of biodiversity and nutrient cycling on their farms.

## PUBLICATIONS

2007/01/01 TO 2007/12/31 1. Jackson, L.E., M. Potthoff, K.L. Steenwerth, A.T. O'Geen, M.R. Stromberg, and K.M. Scow. 2007. Soil biology and carbon sequestration. Chapter 7. In: Ecology and Management of California Grasslands (Corbin, J., C. d'Antonio, and M.R. Stromberg, eds.). University of California Press, Berkeley, CA. 2. Sanchez-Moreno, S., S. Smukler, H. Ferris, and L.E. Jackson. The soil nematode fauna reflects aboveground farmscape patterns. In press 2007, Biology and Fertility of Soils.

2006/01/01 TO 2006/12/31 1. Jackson, L.E., U. Pascual, and T. Hodgkin. 2006. Utilizing and conserving agrobiodiversity in agricultural landscapes. In press, Agriculture, Ecosystems, and Environment. 2. Jackson, L.E., L. Brussaard, P.C. de Ruiter, U. Pascual, C. Perrings, and K. Bawa. 2006. Agrobiodiversity. In press, Encyclopedia of Biodiversity. Elsevier Inc. 3. Potthoff, M., K.L. Steenwerth, L.E. Jackson, R.E. Drenovsky, K.M.

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2005/01/01 TO 2005/12/31 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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# The Activity and Suppression of Soil-borne Pathogens and Pests in Organic Vs. Conventional Plots with Conservation Vs. Conventional Tillage

Accession No.	0201268
Subfile	CRIS\
Project No.	CA-D\*-XXX-7343-CG
Agency	NIFA CALB
Project Type	OTHER GRANTS
Project Status	TERMINATED
Contract / Grant No.	2004-51106-02228
Proposal No.	2004-05151
Start Date	01 SEP 2004
Term Date	31 AUG 2007
Fiscal Year	2007
Grant Amount	\$186,624
Grant Year	2004
Investigator(s)	Epstein, L.
Performing Institution	INTERDEPARTMENTAL, UNIV OF CALIFORNIA, DAVIS, CALIFORNIA 95616

## NON-TECHNICAL SUMMARY

We have a multi-disciplinary approach with a plant pathologist, an entomologist and a nematologist/soil ecologist as part of a larger, long-term (hopefully 100-year) research project at the University of California at Davis Sustainable Agricultural Farming Systems at the Long Term Research on Agricultural Systems (SAFS-LTRAS). The group of PIs and associated collaborators that directs the SAFS-LTRAS experiment includes five farmers (including two organic farmers), two Cooperative Extension Farm Advisors, four Cooperative Extension Specialists (including an economist) and five UC Davis researchers (including agronomists and a hydrologist). The PIs who are not on this grant are supported by other funds and are collecting complementary data on crop productivity, nutrient and water utilization, environmental impact, and economic sustainability. We will use standard methods to enumerate incidence of disease and selected pathogens, pests, and nematodes in a tomato-corn rotation in replicated plots managed using four strategies: organic versus conventional farming systems with conservation versus standard tillage. The project, through grower and advisor participation, newsletters and field days, allows testing, evaluation and adoption or rejection by growers in our area at the commencement of their next tillage cycle. Adoption of techniques that pass the test of grower evaluation will result rapidly in benefits in pest management, economic profitability, long-term resource sustainability, and environmental quality. Website for the "century experiment": <<http://asi.ucdavis.edu/programs/rr/about/century-experiment>>.

## OBJECTIVES

Our goals are to increase our knowledge regarding the activity, management, and suppression of soil-borne pathogens, arthropods, and nematodes in a replicated experiment comparing organically and conventionally managed plots that have either conservation or conventional tillage. Results will be compared to those from plots at the same site that are not managed organically. Our goals are the following: i) to incorporate a pathogen and

pest-management perspective into an on-going trial in which one of the goals is to produce practical, farm-level information on whether and how conservation tillage and other management alternatives can work for organic, irrigated row-crops; and ii) to examine mechanisms for suppression of soil-borne pathogens and pests. For this study, we will utilize long-term research/production plots in their 11th to 14th years of either organic or conventional production and their 2nd through 4th years of either conservation or standard tillage in a tomato-corn rotation at the University of California Davis SAFS-LTRAS project. Our objectives are as follows. First, we will determine whether there are differences in the incidence and severity of soil-borne diseases in plots in the four management regimes. For those diseases that are having a negative impact on plant productivity in some treatments, we will determine the basis of the suppression or proliferation of the pathogen. Second, we will characterize, compare and contrast the arthropod community structure and function of the common species in soils in the four management regimes, and determine the impact, if any, of members of the resident arthropod communities on plant stand establishment. Third, we will use the distribution of different ecological groups of nematodes throughout the year to characterize the soil food web in the different management regimes. The amount of pathogen suppressiveness of soil from the different treatments will be tested. Results will be used to determine if diseases or pests may threaten.

## APPROACH

We have a multi-disciplinary approach with a plant pathologist, an entomologist and a nematologist/soil ecologist as part of a larger, long-term (hopefully 100-year) research project at the University of California at Davis Sustainable Agricultural Farming Systems at the Long Term Research on Agricultural Systems (SAFS-LTRAS). The group of PIs and associated collaborators that directs the SAFS-LTRAS experiment includes five farmers (including two organic farmers), two Cooperative Extension Farm Advisors, four Cooperative Extension Specialists (including an economist) and five UC Davis researchers (including agronomists and a hydrologist). The PIs who are not on this grant are supported by other funds and are collecting complementary data on crop productivity, nutrient and water utilization, environmental impact, and economic sustainability. We will use standard methods to enumerate incidence of disease and selected pathogens, pests, and nematodes in a tomato-corn rotation in replicated plots managed using four strategies: organic versus conventional farming systems with conservation versus standard tillage. The project, through grower and advisor participation, newsletters and field days, allows testing, evaluation and adoption or rejection by growers in our area at the commencement of their next tillage cycle. Adoption of techniques that pass the test of grower evaluation will result rapidly in benefits in pest management, economic profitability, long-term resource sustainability, and environmental quality.

## PROGRESS

2004/09 TO 2007/08 The PIs participated and presented in the University of California Sustainable Agriculture Farming Systems (SAFS) Project field days on June 22, 2007 at Muller and Sons Farm in Woodland, and in June 2005 and 2006 at the SAFS site at the University of California at Davis. The PIs submit a SAFS report, some of which are widely distributed. In 2007, for example, Zalom et al. wrote Soil Arthropod Research in Association with SAFS/LTRAS, 2005 & 2006. In 2005, Ferris et al. wrote 'Managing the soil food web in legume-vegetable rotations' for the University of California Davis Sustainable Agriculture Farming Systems Project Newsletter in Fall 2005. (Vol. 6, No. 1, p. 1-3). Ferris and colleagues presented research from the project at the following meetings: the ONTA Meeting in San Jose, Costa Rica in 2006; the Future of Agriculture Conference in Sacramento in August, 2006; the California Plant and Soil Conference, Sacramento, February 2007; and the a keynote presentation on 'The importance of nematodes in ecosystems and their advantages as biological indicators' at the first International Symposium on Nematodes as Environmental Bioindicators in Edinburgh, Scotland. Epstein presented results yearly in November at the California Tomato Research Institute Meetings at either the University of California at Davis or at the Farm Bureau in Sacramento. Recipients of training and mentoring included three undergraduates, one graduate student, one post-doctoral associate, a post graduate researcher and a staff research associate. A reference collection of the soil mite species and contributed these to the Bohart Museum of Entomology at UC Davis, the 7th largest insect collection in the US. The mites were permanently slide mounted and labeled, and over 100 were prepared representing the taxa found in the study.

2007/01/01 TO 2007/12/31 We are quantifying the pest and beneficial arthropods and nematodes, and the plant pathogenic fungi, in the soil in long-term research/production plots in their 11th to 14th years of either organic or conventional production and their 2nd through 4th years of either conservation or standard tillage in a tomato-corn rotation. Soil arthropods have now been extracted, identified and counted from 4 seasonal sampling dates in

March, June, August and November over 2 annual cycles with tomatoes in the first year and corn in the second year. All samples were taken from the same plots in each year. A fifth system represented no till in the organic system. An incredible diversity of soil arthropods were collected, the most numerous being the Acari - soil mites. In all, 75 genera and 133-145 different species were collected from the samples, and representatives of each slide mounted for future reference. Currently, literature is being searched to ascertain the trophic status of these taxa when known, their reproductive strategies, and responses to soil disturbance. Significant differences among taxa occur based on the variables of season, tillage system, and conventional vs organic farming system. Nematodes also were sampled from the same soils, and provide an informative view of the soil food web because they can be both quantified and classified as bacterivores, fungivores or herbivores. The microplots in the organic, conservation tillage plots that had the least soil disturbance; these plots were the most differentiated from all the others in terms of the food web indicators. Structured soil food webs in natural areas with abundant predatory nematodes effectively suppressed plant-parasite populations while disturbed communities in agricultural soils did not. Soil suppressiveness was related to the ratio of predators to prey and with the prevalence of omnivore and predator species. The predominate soil-borne disease is corky root, caused by the fungus *Pyrenochaeta lycopersici*. We did not observe significant differences between either incidence or severity of corky root or other soil-borne diseases in the organic versus conventional systems, but there was significantly more severe disease in the reduced than in the standard tillage. Overall, during the 2004 and 2005 seasons, in 17 of the 18 farming system whole plots, the mean number of corky root bands was greater in the reduced than in the standard tillage ( $P < 0.0001$ , paired t-test, mean difference + SEM = 2.2 + 0.4), and the median number of corky root bands was greater in 16 of the 18 plots ( $P = 0.001$ , paired t-test, mean difference + SEM = 2.0 + 0.5).

2005/01/01 TO 2005/12/31 We are quantifying the pest and beneficial arthropods and nematodes, and the plant pathogenic fungi, in the soil in long-term research/production plots in their 11th to 14th years of either organic or conventional production and their 2nd through 4th years of either conservation or standard tillage in a tomato-corn rotation. The predominate soil-borne disease is corky root, caused by *Pyrenochaeta lycopersici*. We did not observe significant differences between either incidence or severity of corky root or other soil-borne diseases in the organic versus conventional systems, but there was significantly more severe disease in the reduced than in the standard tillage. Overall, during the 2004 and 2005 seasons, in 17 of the 18 farming system whole plots, the mean number of corky root bands was greater in the reduced than in the standard tillage ( $P < 0.0001$ , paired t-test, mean difference + SEM = 2.2 + 0.4), and the median number of corky root bands was greater in 16 of the 18 plots ( $P = 0.001$ , paired t-test, mean difference + SEM = 2.0 + 0.5). Results of our first year of arthropod sampling yielded a diverse taxa that includes at least four suborders and 15 families of mites, as well as species of Collembola (springtails), Pauropoda, Protura, Chilopoda (centipedes), Hemiptera, Coleoptera, Diptera, Hymenoptera (ants) and spiders. A voucher collection is being made which includes slide mounts of all microarthropods. We used nematode faunal analysis as a bioindicator of the structure and function of the soil food. The channel index (CI) indicates the relative flow rates of resources in the fungal versus bacterial channels of the food web. The organic plots had a greater bacterial/fungal activity than the conventionally farmed plots. For both the arthropod and nematode analyses, we had microplots in the organic, conservation tillage plots that had the least soil disturbance; these plots were the most differentiated from all the others in terms of the food web indicators. Top-down soil suppressiveness of a parasitic nematode, *Meloidogyne incognita*, was determined in laboratory assay. Soil food web indices, based on the composition of the nematode fauna, were calculated to infer soil food web condition. Structured soil food webs in natural areas with abundant predatory nematodes effectively suppressed plant-parasite populations while disturbed communities in agricultural soils did not. Soil suppressiveness was related to the ratio of predators to prey and with the prevalence of omnivore and predator species.

2004/01/01 TO 2004/12/31 Our goals are to increase our knowledge regarding the activity, management, and suppression of soil-borne pathogens, arthropods, and nematodes in a replicated experiment comparing organically and conventionally managed plots using either conservation or conventional tillage. Our study utilizes long-term research/production plots in their 12th year of either organic or conventional production and their 3rd year of either conservation or conventional tillage in a tomato-corn rotation at the University of California Davis SAFS-LTRAS project. This report was submitted in the third month of a 24-month project, and consequently we only report results from the first objective. Our first objective was to determine whether there are differences in the incidence and severity of soil-borne diseases in the four management regimes. In the tomato plots, corky root, caused by *Pyrenochaeta lycopersici* and black dot, caused by *Colletotrichum coccodes*, were present in sufficient frequencies for analysis. The following diseases were occasionally observed, but not in sufficient frequency for analysis: vascular discoloration caused by *Verticillium dahliae* and *Fusarium solani* f. sp. *lycopersici*; root knot nematode; and crown gall. The effect of the farming and tillage system on corky root and black dot were analyzed by a two-factor ANOVA. There were no significant differences in incidence of either of the diseases in

any of the treatments. Severity of corky root on the lateral roots was significantly ( $P$  equals 0.02) greater in conservation tillage than in standard tillage. Although severity of corky root was not significantly ( $P$  is more than 0.05) affected by farming system, i.e., conventional versus organic; the  $P$ -values were somewhat borderline, and if we have similar results in year 2, there may be significantly ( $P$  less than 0.05) less severity of corky root in the organic plots than in the conventional ones. We are currently using real-time polymerase chain reaction (PCR) to examine the amount of *Fusarium moniliforme* (= *Fusarium verticillioides*) in the grain from the corn plots. This is a multi-disciplinary project and our second objective, which is in progress, is to characterize, compare and contrast the arthropod community structure and function of the common species in soils in the four management regimes, and determine the impact, if any, of members of the resident arthropod communities on plant stand establishment. Our final objective, which is also in progress, is to use the distribution of different ecological groups of nematodes throughout the year to characterize the soil food web in the different management regimes.

## IMPACT

2004/09 TO 2007/08 Our studies were primarily conducted in 2005 and 2006 in plots with a tomato-corn rotation, grown using either organically-acceptable or conventional practices, and farmed under standard tillage or conservation tillage. There were three replicate plots per treatment with tillage as a split-plot. Within the organic, conservation tillage, there were no-till microplots. The major objectives of our study were to: 1) analyze the effects of different agricultural treatments on the nematode assemblage and on the soil food web; 2) compare nematode and arthropod sensitivity to agricultural practices, in soils under organic and conventional management and subjected to different tillage intensities; 3) seek robust relationships between nematodes and arthropods, including causal (for example predation) and casual (for example trophic redundancy) relationships, and 4) validate the efficacy of soil food web indices, based on nematode abundances, as indicators of the characteristics of the soil mite community. Across all sampling dates, 38 nematode taxa were found in the field. Taxa richness, bacterial-feeder abundance and enrichment index values were higher in organic than in conventional plots. Abundance of predatory nematodes and of all nematode taxa combined were higher in the organic plots than in conventional standard tillage. Across all sampling dates, absolute numbers of fungal-feeding, plant-feeding and omnivore nematodes did not differ among treatments but they were significantly influenced by sampling date. The structure index was higher in the organic-no till treatment than in conventional plots. Of the arthropods, mites were of greatest abundance and were identified as members of seventy five genera in five suborders. After mites, Collembola in four families were most abundant. Mite trophic groups were also significantly affected by treatments. Predators and omnivores were both affected by system  $\times$  tillage interactions. Predators were in greatest abundance in organic and organic-conservation tillage and in lower abundances in conventional-standard tillage. Fungivore, detritivore and saprophyte mites were affected by management system and tillage separately, with greatest abundances in organic and conservation tillage and no-tillage. Fungal and fluid feeders were only affected by system; they were in greatest abundance in conventional plots. Nematode and mite populations in agricultural fields respond similarly to agricultural management. There were functional parallels between predator nematodes and mites, fungal and plant-feeding nematodes and fungal and fluid feeding mites, and bacterial-feeding nematodes and fungivore, detritivore and saprophyte mites. The predominate soil-borne disease is corky root, caused by the fungus *Pyrenochaeta lycopersici*. We did not observe significant differences between either incidence or severity of corky root or other soil-borne diseases in the organic versus conventional systems, but there was significantly more severe disease in the reduced than in the standard tillage.

\*\*PUBLICATIONS (not previously reported):\*\* 2004/09 TO 2007/08 1. Ferris, H. and T. Bongers. 2006.

Nematode indicators of organic enrichment. *Journal of Nematology* 38:3-12. 2. Sanchez-Moreno, S., H.

Minoshima, H. Ferris and L.E. Jackson. 2006. Linking soil properties and nematode community composition:

effects of soil management on soil food webs. *Nematology* 8:703-715. 3. Sanchez-Moreno, S. and H. Ferris.

2006. Suppressiveness of the soil food web: Effects of environmental management. *Agriculture, Ecosystem*

and Environment 119:75-87. 4. Sanchez-Moreno, S., and H. Ferris. 2006. Suppressiveness of the soil food

web. *Journal of Nematology* 38:290 5. Sanchez-Moreno, S., H. Ferris, N.L. Nicola and F.G. Zalom (submitted

2007). Effects of agricultural management on nematode - mite assemblages: soil foodweb indices as predictors of mite community composition. *Ecological Modelling*.

2007/01/01 TO 2007/12/31 Our long-term goal is to increase the knowledge base regarding management and suppression of soil-borne pathogens and pests in organic agriculture managed under conservation vs. conventional tillage. We are working as a team, in some cases on the same soil samples, to quantify both the pest and beneficial insects and nematodes, and the plant pathogenic fungi. We are still in the midst of analyzing an extremely large dataset. Nonetheless, our research results are disseminated to local organic growers, partly because the larger committee that manages the plots includes commercial organic growers, and the larger

program has regular and excellent outreach. Our project is unusual in several regards, and consequently there is the potential for major impact. First, organic growers rarely use reduced-tillage procedures because of concern about weeds and diseases. Nonetheless, reduced-tillage can reduce fossil fuel emissions and cost, and can have several environmental advantages, including less soil erosion and dust emission. Second, we are trying to develop methods that will predict if an individual organically-farmed soil is suppressive to disease. Consequently, our data should result in both a greater understanding of nematode and arthropod species associated with pest and pathogen suppression, and of indicators of environments that are conducive or suppressive of pests and pathogens.

2005/01/01 TO 2005/12/31 Our long-term goal is to increase the knowledge base regarding management and suppression of soil-borne pathogens and pests in organic agriculture managed under conservation vs. conventional tillage. We are working as a team, in some cases on the same soil samples, to quantify both the pest and beneficial insects and nematodes, and the plant pathogenic fungi. Since we are only mid-way through the project, we do not have final results. Nonetheless, our research results are disseminated to local organic growers, partly because the larger committee that manages the plots includes commercial organic growers, and the larger program has regular and excellent outreach. Our project is unusual in several regards, and consequently there is the potential for major impact. First, organic growers rarely use reduced-tillage procedures because of concern about weeds and diseases. Nonetheless, reduced-tillage can reduce fossil fuel emissions and cost, and can have several environmental advantages, including less soil erosion and dust emission. Second, we are trying to develop methods that will predict if an individual organically-farmed soil is suppressive to disease. Consequently, our data should result in both a greater understanding of nematode and arthropod species associated with pest and pathogen suppression, and of indicators of environments that are conducive or suppressive of pests and pathogens.

2004/01/01 TO 2004/12/31 We have two specific goals, particularly with a focus on organic agriculture: 1) to functionally identify soil microbial communities and ways to manage microbial dynamics to enhance disease suppression; and 2) to develop systemic approaches to insect, nematode and disease management. For this study, we are utilizing the University of California at Davis SAFS-LTRAS project, which is a long-term (hopefully 100-year) study designed to maintain long-term economic and resource productivity, and environmental quality, of an irrigated tomato-corn rotation. The replicated research/production plots are starting their 12th year of either organic or conventional production and their 3rd year of either conservation or standard tillage. We have a multi-disciplinary approach with a plant pathologist, an entomologist and a nematologist/soil ecologist, who are part of a larger group of PIs and associated collaborators, including organic and conventional farmers, who manage the experimental plots. The larger project, through grower and farm advisor participation, newsletters and field days, allows testing, evaluation and adoption or rejection by growers in our area at the commencement of their next tillage cycle. Adoption of techniques that pass the test of grower evaluation will result rapidly in benefits in pest management, economic profitability, long-term resource sustainability, and environmental quality.

## **PUBLICATIONS**

2007/01/01 TO 2007/12/31 No publications reported this period

2005/01/01 TO 2005/12/31 No publications reported this period

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

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# Slow-growing Broilers in Organic Poultry Production: an Alternative to Supplemental Methionine and a Marketing Opportunity

<b>Accession No.</b>	0201432
<b>Subfile</b>	CRIS\
<b>Project No.</b>	ARK02033
<b>Agency</b>	NIFA ARK
<b>Project Type</b>	OTHER GRANTS
<b>Project Status</b>	TERMINATED
<b>Contract / Grant No.</b>	2004-51106-02247
<b>Proposal No.</b>	2004-05187
<b>Start Date</b>	15 SEP 2004
<b>Term Date</b>	31 AUG 2009
<b>Fiscal Year</b>	2009
<b>Grant Amount</b>	\$305,015
<b>Grant Year</b>	2004
<b>Investigator(s)</b>	Owens, C. M.; Moritz, J. S.
<b>Performing Institution</b>	POULTRY SCIENCE, UNIVERSITY OF ARKANSAS, FAYETTEVILLE, ARKANSAS 72703

## OBJECTIVES

1) Determine the MET requirement for slow-growing broilers, 2) evaluate the impact of feeding strategies with slow-growing broilers that do not incorporate MET on production performance, meat quality, and economics, and 3) disseminate findings to the organic and scientific communities.

## APPROACH

A multi-state team approach will be used, with multi-disciplinary faculty at two mid sized Land-Grant institutions responsible for conducting feeding and meat quality trials with slower-growing genotypes. This project addresses program needs, with an emphasis on improving the competitiveness of organic poultry producers, developing the scientific basis to improve current organic standards and conducting advanced on-farm research and development in the areas of production and marketing.

## PROGRESS

2004/09 TO 2009/08 OUTPUTS: The team has shared findings with the scientific community at annual Poultry Science Association meetings and abstracts have been published in Poultry Science. The team has placed a summary of findings on the [www.sustainablepoultry.ncat.org](http://www.sustainablepoultry.ncat.org) website (see Organic Poultry Production under Projects/Partners). The team has extensively shared findings of this project. Fanatico has maintained regular contact with leaders of the Methionine Task Force (including Dave Martinelli of Coleman Natural Meats, specifically Petaluma Poultry, and David Bruce of Organic Valley). Fanatico made the following presentations 2008: 1. Organic Poultry Production, Univ. of Arkansas Food Science Seminar, Fayetteville, AR, February 25,

2008. 2. Genetics for Alternative Poultry Production. Midwest Poultry Federation, St. Paul, MN, March 19, 2008. 3. Organic Broiler Production in the U.S., Natural and Organic Poultry Symposium, Poultry Science Association Annual meeting, Niagara Falls, Canada, July 20, 2008. 4. Organic Poultry Production. International Organic Inspectors Association, Organic Livestock training, Warren, VT, August 19, 2008. Fanatico has also been in contact with the Livestock Committee Chair of the National Organic Standard Board on the subject of methionine in organic poultry production. Fanatico has been in contact with others by email. PARTICIPANTS: University of Arkansas Jason Emmert, Ph.D. Casey Owens, Ph.D. Anne Fanatico, Ph.D. Tanika O'Connor-Dennie West Virginia University Joe Moritz, Ph.D. Amanda Rack Nancy Buchanan National Center for Appropriate Technology Holly Born Methionine Task Force Chair Dave Martinelli (Coleman Natural Meats, Petaluma Poultry) TARGET AUDIENCES: Organic community, organic poultry producers Large organic poultry producers are very concerned about the upcoming ban on synthetic methionine and have no viable alternative. Small producers are increasingly using alternative genetics; they usually do not produce meat birds year round. Scientific community PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

2008/01/01 TO 2008/12/31 OUTPUTS: The team has shared findings with the scientific community at annual Poultry Science Association meetings and abstracts have been published in Poultry Science. The team has placed a summary of findings on the [www.sustainablepoultry.ncat.org](http://www.sustainablepoultry.ncat.org) website (see Organic Poultry Production under Projects/Partners). The team has extensively shared findings of this project. Fanatico has maintained regular contact with leaders of the Methionine Task Force (including Dave Martinelli of Coleman Natural Meats, specifically Petaluma Poultry, and David Bruce of Organic Valley). Fanatico made the following presentations 2008: 1. Organic Poultry Production, Univ. of Arkansas Food Science Seminar, Fayetteville, AR, February 25, 2008. 2. Genetics for Alternative Poultry Production. Midwest Poultry Federation, St. Paul, MN, March 19, 2008. 3. Organic Broiler Production in the U.S., Natural and Organic Poultry Symposium, Poultry Science Association Annual meeting, Niagara Falls, Canada, July 20, 2008. 4. Organic Poultry Production. International Organic Inspectors Association, Organic Livestock training, Warren, VT, August 19, 2008. Fanatico has also been in contact with the Livestock Committee Chair of the National Organic Standard Board on the subject of methionine in organic poultry production. Fanatico has been in contact with others by email. Manuscripts from trials conducted in the grant period have been prepared with expected publication in 2009. PARTICIPANTS: University of Arkansas Jason Emmert, Ph.D. Casey Owens, Ph.D. Anne Fanatico, Ph.D. Tanika O'Connor-Dennie West Virginia University Joe Moritz, Ph.D. Amanda Rack Nancy Buchanan National Center for Appropriate Technology Holly Born Methionine Task Force Chair Dave Martinelli (Coleman Natural Meats, Petaluma Poultry) TARGET AUDIENCES: Organic community, organic poultry producers Large organic poultry producers are very concerned about the upcoming ban on synthetic methionine and have no viable alternative. Small producers are increasingly using alternative genetics; they usually do not produce meat birds year round. Scientific community PROJECT MODIFICATIONS: Nothing significant to report during this reporting period.

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2007/01/01 TO 2007/12/31 OUTPUTS: According to the Organic Trade Association's 2007 Manufacturer Survey, organic foods are one of the fastest growing segments in the food industry with sales growing at an annual rate of 21% in 2006. Poultry accounts for about 75% of the total organic meat market. In light of the impending ban on synthetic methionine in organic poultry diets, researchers have focused on finding alternative strategies to supply this amino acid. A study was conducted to assess performance and carcass characteristics of a slow-growing and fast-growing broiler genotype fed diets devoid of synthetic methionine, and to determine the impact of choice feeding on performance and carcass quality. Inclusion of fish meal and high percentages of soybean meal enabled the specific genotype methionine requirement to be met. All diets were certified organic. Slow-growing broilers (Gourmet Black) were raised from 1 to 83 days, and fast-growing broilers (Cobb 500) were raised from 1 to 54 days, both on the West Virginia University certified organic farm. Broilers had access to pasture for at least eight hours daily, and were exposed to natural fluctuations of environmental conditions. Choice or no choice feeding management was implemented in the grower and finisher periods. Choice-feeding management was defined as providing one feeder of ground corn and one feeder of the remaining complete diet ingredients in each pen. No choice-feeding management was defined as providing two feeders of complete diet in each pen. A second study was conducted with the objective of evaluating performance and production cost of choice-feeding management using one of two different grains. Three hundred one-day-old broilers were reared from 0 to 3 weeks in floor pens and fed a certified organic diet that met all nutrient recommendations. On day 21, broilers were transferred to houses located on the West Virginia University certified organic farm. Broilers had access to pasture 12 hours daily and were exposed to natural fluctuation in environmental conditions. Experimental grower diets were certified organic and consisted of two feeding strategies (choice or no choice) arranged in a factorial structure with two grains (corn or oats). Diets were formulated to contain 30% grain and 70% of a complementary grain-specific premix. Findings have been shared with the scientific community at annual Poultry Science Association meetings and the team has placed a summary of findings on the [www.sustainablepoultry.ncat.org](http://www.sustainablepoultry.ncat.org) website (see Organic Poultry Production under Projects/Partners). The team has maintained regular contact with leaders of the Methionine Task Force, and project member Fanatico attended a Tufts University meeting on Animal Welfare and Health in Organic Livestock Production in 2007 and shared findings with other attendees. Fanatico has also been in contact with the Livestock Committee Chair of the National Organic Standard Board on the subject of methionine in organic poultry production. PROJECT MODIFICATIONS: Due to a high level of concern regarding avian influenza nation-wide, the Center of Excellence for Poultry Science at the University of Arkansas made a decision not to conduct the free-range poultry research portion of the trial. Northwest Arkansas is one of the highest poultry producing areas of the country and there were concerns that free-range poultry could contract AI from wild birds. Instead collaborator West Virginia University carried out this portion of the trial. West Virginia is a less intense area of poultry production and therefore there was less concern.

2006/01/01 TO 2006/12/31 Interest continues to grow in natural and organic poultry products, and in particular there is growing interest in the U.S. in raising poultry on pasture, with small independent producers reporting good local market conditions and an interest in expansion. There is an upcoming ban on the use of synthetic methionine (MET) in organic poultry diets, but the use of MET in traditional commercial poultry diets has facilitated the formulation of lower-cost diets that do not compromise growth performance or bird health. Slower-growing broiler chickens are less heavily muscled than commercial broiler chickens, which could impact their requirement for MET. The objective of this project was to assess the MET requirements of slow-growing broiler chickens so that in the future when synthetic MET is no longer available nutritionists may still formulate diets that meet the needs of organic broilers. Six trials were conducted to determine the MET requirements of commercial and slow-growing broiler chickens during the starter (7 to 21 d), grower (28 to 42 d), and finisher (49 to 63 d) phases. In each trial, five graded levels of MET were added to diets that were deficient in MET. For each genotype, weight gain and feed efficiency increased with the addition of MET to the experimental diets. The MET requirements for each genotype during each period were assessed, and were very similar among genotypes, although the requirements for the commercial birds appeared to be lower than previously thought. These data indicate that despite substantial differences in body composition, the MET requirements of slow-growing and commercial broiler chickens are similar. Specifically, MET requirement values (for slow-, medium-, and fast-growing genotypes, respectively) were 0.33, 0.30, and 0.33% for the starter phase and 0.28, 0.29, and 0.28% for the grower phase. In the finisher phase, the estimated MET requirement for the S genotype was 0.25%; no weight gain or feed efficiency response occurred in the M genotype in response to DL-MET addition, indicating that the basal diet contained adequate MET (0.22%). For the starter and grower periods estimates of SAA requirements ranged from 0.57 to 0.60%, regardless of genotype; extreme variability prevented the estimation of SAA requirements during the finisher phase. These data indicate that the MET and SAA requirements of the various genotypes are similar during the starter and grower phases.

2005/01/01 TO 2005/12/31 One of the greatest challenges in the transition to organic poultry production is finding viable solutions to the elimination of supplemental methionine (MET) as an available feed ingredient for organic broiler diets. The long-term goal of this project is to investigate means of minimizing the impact of eliminating supplemental MET as a dietary feed ingredient for organic broiler production. The potential use of slow-growing broilers and alternative feeding strategies will be evaluated and economic assessments will be conducted. Information will be disseminated to policy makers and stakeholders (including producers). With this goal in mind, the proposal addresses several key areas identified in the request for applications, including developing a scientific basis for improving current organic standards, analyzing potential economic costs, returns and risks of organic production systems, analyzing regulatory barriers and developing solutions to these challenges, conducting advanced on-farm research and development, including research related to production and marketing, and conducting long-term, interdisciplinary systems research.

## IMPACT

2004/09 TO 2009/08 The team has met yearly at the Poultry Science Association meetings and has also maintained contact with the Methionine Task Force throughout the project to keep them apprised of findings and search for new alternatives to synthetic methionine in organic poultry production. These findings are key in helping the organic poultry community plan for the upcoming ban on synthetic methionine in diets. The NOP had planned a ban in October 2005 but extended it to October 2008. The ban will now be effective in October 2010. The organic poultry community needs alternatives. Because neither synthetic amino acids nor animal by-products are permitted in organic poultry production, significantly higher levels of protein will be needed if only plant proteins are used. It is not advisable for birds to receive a diet that is too high in protein because of the additional stress on their kidneys to excrete the excess nitrogen (N), and in addition the birds experience more heat stress in summer. In addition, high N in the poultry house contributes to higher ammonia and excess nutrients in the environment, including emissions. Animal proteins such as fishmeal are high in methionine and can help provide methionine in the diet; however, there is little available without prohibited substances such as ethoxyquin and the amount that can be used is limited due to fishy taint. There is interest in alternative sources such as algae, earthworms, and larvae. A natural methionine product would be helpful but currently there is none available commercially for use in agriculture. Although some European literature encourages the use of slow-growing broilers due to lower protein requirements, our research has not shown that slow-growing broilers have lower methionine requirements than fast-growing. It is important that when the ban becomes effective, organic broilers and layers have sufficient methionine with no negative effects on bird health, welfare, and performance.

**\*\*PUBLICATIONS (not previously reported):\*\*** 2004/09 TO 2009/08 1. Fanatico, A. C., P. B. Pillai, L. C. Cavitt, J. L. Emmert, J. F. Meullenet, and C. M. Owens. 2006. Evaluation of slower-growing broiler genotypes grown with and without outdoor access: sensory attributes. *Poultry Sci.* 85:337-343. 2. Fanatico, A. C., P. B. Pillai, T. O'Connor-Dennie, and J. L. Emmert. 2006. Methionine requirements of alternative slow-growing genotypes. *Poultry Sci.* 85: (Suppl. 1):110 (Abstr.) 3. Fanatico, A. C., P. B. Pillai, J. L. Emmert, J. F. Meullenet, and C. M. Owens. 2006. Impact of alternative broiler genotype and production system on sensory attributes. *Poultry Sci.* 85 (Suppl. 1):198 (Abstr.) 4. Fanatico, A.C., T. O'Connor-Dennie, C. M. Owens, and J. L. Emmert. 2007. Performance of alternative meat chickens for organic markets: impact of genotype, methionine level, and methionine source. *Poult. Sci.* 86 (Suppl. 1):522-523 (Abstr.) 5. Rack, A.L., N. P. Buchanan, J. M. Hott, S. E. Cutlip, J. S. Moritz, and J. L. Emmert. 2007. The effect of genotype and choice-feeding on organically-reared broilers fed diets devoid of synthetic methionine. *Poult. Sci.* 86 (Suppl. 1):398 (Abstr.) 6. Fanatico, A. C., P. B. Pillai, C. M. Owens, J. F. Meullenet, and J. L. Emmert. 2007. Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. *Poultry Sci.* 86:2441-2449. 7. Fanatico, A. C., P. B. Pillai, J. L. Emmert, and C. M. Owens. 2007. Meat quality of slow- and fast-growing broiler genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. *Poultry Sci.* 86:2245-2255. 8. Fanatico, A.C., C.M. Owens, and J.L. Emmert. 2009. Organic poultry production in the United States: Broilers. *J. Appl. Poult. Res.* 18:355-366. 9. Fanatico, A. 2009. Organic Poultry Production: Providing Adequate Methionine. ATTRA publication. National Center for Appropriate Technology, Fayetteville, AR 10. Rack, A.L., K.G.S. Lilly, K.R. Beaman, C.K. Gehring and J.S. Moritz, 2009. The Effect of Genotype, Choice-Feeding and Season on Organically-Reared Broilers Fed Diets Devoid of Synthetic Methionine. *J. Appl. Poult. Res.* 18: 54-65

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The organic poultry community needs alternatives. Because neither synthetic amino acids nor animal by-products are permitted in organic poultry production, significantly higher levels of protein will be needed if only plant proteins are used. It is not advisable for birds to receive a diet that is too high in protein because of the additional stress on their kidneys to excrete the excess nitrogen (N), and in addition the birds experience more heat stress in summer. In addition, high N in the poultry house contributes to higher ammonia and excess nutrients in the environment, including emissions. Animal proteins such as fishmeal are high in methionine and can help provide methionine in the diet; however, there is little available without prohibited substances such as xanthoxanthin and the amount that can be used is limited due to fishy taint. There is interest in alternative sources such as algae, earthworms, and larvae. A natural methionine product would be helpful but currently there is none available commercially for use in agriculture. Although some European literature encourages the use of slow-growing broilers due to lower protein requirements, our research has not shown that slow-growing broilers have lower methionine requirements than fast-growing. It is important that when the ban becomes effective, organic broilers and layers have sufficient methionine with no negative effects on bird health, welfare, and performance.

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2007/01/01 TO 2007/12/31 In the first study, birds on no-choice management showed higher weight gain compared to choice managed birds. Slow-growing broilers had higher feed conversion ratios than the fast-growing genotype. Slow-growing birds also had lower breast yield than the fast-growing genotype. The fast-growing no-choice birds had higher breast yield than the choice birds of the same genotype. Fast-growing genotypes were superior in performance and carcass characteristics. Choice-feeding management did not improve performance and carcass characteristics. In the second trial, broilers with the no-choice feeding option exhibited improved live weight gain, feed conversion ratios, and carcass weight compared to broilers with a choice feeding option. Broilers fed oats exhibited improved feed conversion ratios and smaller fat pad weights compared to broilers fed corn. Grain type did not affect weight gain. When utilizing a choice-feeding system, broilers fed oats consumed a grain to premix ratio more similar to formulated values (oats, 21.3 to 78.7 vs. corn, 58.1 to 41.9). However, the cost of the oat premix was approximately twice that of the corn premix. These results demonstrate that utilizing oats, a grain that may be produced on-farm, can improve broiler performance. However, choice-feeding may not be a viable economic option for small-scale poultry producers. These findings are key in helping the organic poultry community plan for the upcoming ban on synthetic methionine in diets. The NOP had planned a ban in October 2005 but extended it to October 2008. The organic poultry community needs alternatives. Because neither synthetic amino acids nor animal by-products are permitted in organic poultry production, significantly higher levels of protein will be needed if only plant proteins are used. It is not advisable for birds to receive a diet that is too high in protein because of the additional stress on their kidneys to excrete the excess nitrogen, and in addition the birds experience more heat stress in summer. Moreover, high nitrogen in the poultry house contributes to higher ammonia and excess nutrients in the environment, including emissions. Animal proteins such as fishmeal are high in methionine and can help provide methionine in the diet; however, little fish meal is available without prohibited substances such as xanthoxanthin, and the dietary amount that can be fed is limited due to fishy taint of the resulting meat. There is interest in alternative sources such as algae, earthworms, and larvae. A natural methionine product would be helpful but there is none available commercially for use in agriculture. Although some European literature encourages the use of slow-growing broilers due to

lower protein requirements, our research has not shown that slow-growing broilers have lower methionine requirements than fast-growing genotypes.

2006/01/01 TO 2006/12/31 Evaluation of slow-growing and commercial broiler chickens should help small producers with decisions about production systems and marketing efforts. These data indicate that MET requirements of slow-growing broiler chickens are similar to commercial birds, but were lower than previously assumed. These results will be used to assess diets formulated to meet the MET requirement for slow-growing broiler chickens without the use of supplemental MET. This information will be of interest to poultry producers that are seeking the most cost-effective means of raising organic broilers

2005/01/01 TO 2005/12/31 There are impending limitations on the utilization of synthetic methionine in organic poultry diets. Synthetic methionine is routinely utilized in the commercial broiler industry to provide a low-cost means of meeting the relatively high methionine requirement of broilers. Without availability of synthetic methionine it is important that alternatives be sought for formulating organic broiler diets. This research provides valuable methionine and cysteine requirement estimates for three types of birds (fast-, medium-, and slow-growing) that could be used in organic poultry production. With accurate requirement estimates available nutritionists can begin to work on diet formulations that meet broiler nutrient requirements while adhering to organic poultry diet restrictions.

## **PUBLICATIONS**

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