Completed

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
FERTILIZER RESEARCH AND EDUCATION PROGRAM (FREP)
FINAL REPORT

A. Project Title

Impact of Microbial Processes on Crop Use of Fertilizers from Organic and Mineral Sources.
#92-0639

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B. Statement of Objective

The primary objectives are to determine relationships among: i) microbial biomass and activity, ii) soil fertility parameters, particularly N pools; and iii) crop yield and quality at the end of the growing season. Studies were conducted in tomato and corn plots under three different N management systems: i) N from mineral sources only; ii) N from cover crops and manure; and iii) N from cover crops supplemented with mineral sources.

C.Executive Summary

The premise of this study is that sustainable farming practices need to address the below-ground, as well as above-ground, components of an agroecosystem. Thus the objectives of this study were to develop an understanding the dynamics of microbial communities associated with different farming management systems and to determine whether differences in soil biology are associated with differences in soil fertility. The study was carried out at the Sustainable Agriculture Farming Systems (SAFS) project which is a comparison of two or four year rotations (tomatoes, safflower, corn, wheat/beans) managed by four farming systems (conventional 2- and 4-yr rotations, low input and organic). Major findings for the 3-yr funding period include:

1. During the growing season, soil microbial populations were usually higher in size and activity in organic and low input than conventional farming systems. In the organic-amended systems (e.g., with cover crops and manure), microbial populations rapidly responded to organic additions, steadily increased until the middle of the growing season, and then declined. The decline was greater in some years than other. With the increase in microbial populations, there was usually a small associated increase in soil inorganic nitrogen. Fluctuations in micobial biomass and activity

were much less in conventional than the organic-amended systems. During the growing season, soil nitrate levels were usually significantly lower in organic than conventional tomato soils, yet often significantly higher in organic than conventional corn soils. Whereas soil nitrate levels were inversely correlated with microbial biomass levels in organic, they were positively correlated with microbial biomass in conventional tomatoes.

2. The low input system (combining cover crops and mineral fertilizer) supported crop yields in corn, and usually tomatoes, that were comparable to yields in the conventional 4-yr system. The organic system (combining cover crops and composted poultry manure) on the other hand, usually had lower tomato and corn yields than did the other farming systems. The lower yields in the organic system are hypothesized to be due to the inability of the manure to provide sufficient fertility during periods of major crop demand. Differences between the organic and low input tomato systems with respect to microbial biomass were usually negligible, whereas the low input system had significantly higher microbial activity than did the organic during the period of high crop demand for nitrogen in 1995. The very high carbon to nitrogen ratio of organic inputs in 1993 and a viral disease in organic and low input tomatoes in 1994 made fertility relationships difficult to interpret in these years.

3. Some differences between farming systems in soil fertility and structure appear to be related to differences in soil biology. Microbial biomass was positively correlated with water stable aggregation; water stable aggregation increased from the conventional to low input to organic system. High microbial biomass and activity, and high numbers of bacterial-feeding nematodes, may have been responsible for adequate tomato yields during one year when the carbon to nitrogen ratio of organic inputs was higher than normal. This finding has led to spin-off studies to determine the optimum C/N ratio of organic inputs in the companion research plots of SAFS. We hope to find a C/N ratio resulting in low soil nitrate levels due to microbial immobilization while providing sufficient fertility due to release of nitrogen from microbial biomass by nematode activity.

4. Though certain soil biological parameters are enhanced in organic compared to conventional systems, the conventional soil was nevertheless very active biologically. Under controlled conditions, added cover crop residues were found to decompose at the same rate in soils managed by conventional or organic farming practices. Using a test that estimates the metabolic diversity of the microbial community (Biolog), we found no differences between the conventional and organic tomato soils.

D. Work Description

TASK: To determine the relationship among microbial, soil fertility, and crop parameters under three N management systems over the growing season in tomato and corn plots.

Subtask 1.1: In tomato and corn plots in the three N management systems, measure microbial and soil fertility parameters over the growing season.

The research plots are located on 28 acres of the Agronomy Farm at UC Davis. The experiment is conducted on Yolo silt loam, a medium to heavy soil. The climate is Mediterranean with average summer day temperatures of 90°F. The majority of rainfall is between December and March with a yearly average of 25 inches. The soils are fairly representative of the Sacramento Valley, as are the crops grown in the rotation. The plots are 60 by 220 feet (1/3 acre), to allow for use of large-scale farm machinery for all operations, including planting, discing and harvesting.

Measurements were made of microbial biomass C and N, microbial activity, nitrate, ammonium, and potentially mineralizable N n the 0-15 cm layer. Samples were removed (30 randomly selected 2.5 cm diameter cores making up a composite sample) from plots in each of farming systems.

Each composite sample was subdivided and used for microbial assays and soil fertility measurements. Crop yield and quality parameters were also measured. In the tomatoes, sampling in the organic and conventional-4 yr plots began in late March and occurred frequently through May, then less frequently over the remainder of the growing season. The major emphasis was on organic and conventional tomatoes; however, samples were also collected from low input tomatoes and organic, low input, and conventional corn soils.

Subtasks 1.2: Complete biological and chemical analyses on samples.

Microbial biomass carbon (MBC) was measured by the fumigation-carbon extraction method (adapted from Vance et al., 1987) with determination of C using a Shimadzu Automatic Organic Carbon Analyzer (by method adapted from Wu et al, 1990). Microbial biomass N was measured according Amato and Ladd (1986) (ninhydrin-reactive N). The net mineralizable N fraction in soil was measured by anaerobic incubation (Waring and Bremner, 1964). Microbial activity measures included short-term measurement of carbon dioxide evolution according to Anderson and Domsch (1978) and arginine ammonification which is an indicator of N mineralization rates (Alef and Kleiner, 1986). Some of the data wer analyzed by ANOVA or multivariate analysis, to determine if relationships among parameters are significant.

Subtask 1.3: Submit progress report
Subtask 1.4: Submit interpretive summary
Subtask 1.4: Prepare final report

E. Results, Discussion and Conclusions

Over the past year,we combined field sampling--emphasizing organic and conventional tomatoes--with microcosm experiments to test specific hypotheses identified in the field. The research described here was partially funded by a USDA Western Regional SARE grant and a USDA/EPA ACE grant. These grants paid the salaries of the research and field managers, as well as graduate students, and paid for the operations needed to maintain the larger project. These grants also supported collection of soil samples, analyses of soil fertility and crop parameters, and data analysis. Although the microcosm studies are funded by other grants, we have included selected results that are directly related to our field studies. In this section, we summarize major findings by objective.

a. Trends in fertility, microbial parameters and crop yield during the 1993-1995 growing seasons.

Table 1 summarizes the fertility managment for the conventional, low input and organic tomatoes for the 1993-1995 growing seasons.

Table 1. Fertilizer Rates in Tomatoes

1993

Conventional: 6-20-20 applied as starter at 100 lbs /ac in March; fertilizer side-dress with 34-0-0 at 120 lbs/ac in May.

Low-input: Purple vetch planted in October, incorporated in April; starter fertilizer 8-24-6-1 applied at 10 gals/ac to transplants in April.

Organic: Purple vetch planted in October, incorporated in April; starter fertilizer of fish powder (12-0.25-1 at 4 lbs/ac) and seaweed (3-0.25-0.15 at 1/2 gal./ac) applied to transplants in April; turkey manure (1% N) applied at 5 t/ac in April. Top-dress of fish powder (12-0.25-1 at 4 lbs/ac) and seaweed (3-0.25-0.15 at 1/2 gal./ac) applied in July.

1994

Conventional: 8-24-6 applied as starter at 15 gal /ac in March; fertilizer side-dress with 46-0-0 at 304 lbs/ac in May.

Low-input: Purple vetch planted in November, incorporated in April; starter fertilizer 8-24-6 applied at 15 gals/ac to transplants in April and side-dress with 46-0-0 applied at 150 lbs/ac in May.

Organic: Purple vetch planted in November, incorporated in April; poultry manure of 3.4% N applied at 2.15 t/ac; starter fertilizer of fish powder (12-0.25-1 at 4 lbs/ac) and seaweed (3-0.25-0.15 at 1 gal./ac) applied to transplants in April. Top-dress of fish powder (12-0.25-1 at 4 lbs/ac) and seaweed (3-0.25-0.15 at 1/2 gal./ac) applied in July.

1995

Conventional: 8-24-6-0.5 Zn applied as starter at 15 gal /ac at end of March; fertilizer side-dress with 11-52-0 at 100 lbs/ac and 46-0-0 at 302 lbs/ac in mid-May.

Low-input: Purple vetch planted in October, incorporated in April; starter fertilizer 8-24-6-0.5 Zn applied at 15 gals/ac to transplants in April and sidedress with 46-0-0 at 174 lbs/ac.

Organic: Purple vetch planted in October, incorporated in April; poultry manure of 2.8% N applied at 2.66 t/ac; starter fertilizer of fish powder (12-0.25-1 at 5 lbs/ac) and seaweed (3-0.25-0.15 at 1 gal./ac) applied to transplants in April.

Soil fertility. In general nitrate levels were lower in organic than conventional tomatoes, whereas they were higher in organic than conventional corn. As an example of fertility trends, in 1994, soil nitrate levels were originally higher in conventional (approximately 20 $\mu g/g$) than in the organic and low input tomatoes (2-3 $\mu g/g$). After cover crop incorporation, nitrate levels in organic and low input rose to almost 35 $\mu g/g$ by early April and then declined and held steady at about 10 $\mu g/g$ for the remainder of the growing season. Even though the organic system receives manure in addition to cover crop, the differences in nitrate between the organic and low input systems were minor. In the conventional system, nitrate rose to about 40 $\mu g/g$ in early April following side-dress and declined more slowly than in the other systems. By the end of the growing season, there were no differences between the systems. In corn, levels of nitrate ranged between 10 and 20 $\mu g/g$ over the entire growing season. In the organic and low input systems, however, levels ranged between 20 and 65 $\mu g/g$ following cover crop incorporation. By the end of the growing season, levels in the organic soils were significantly higher than in the low input and conventional soils.

Microbialparameters. During the growing season, soil microbial populations were usually higher in size and activity in organic and low input than conventional farming systems. There were significant differences, however, by year. Differences between conventional and organic or low input farming systems were greater in 1994 than 1995. Fig. 1 shows microbial biomass carbon (MBC), microbial biomass nitrogen (MBN) and soluble carbon (C) in organic, low input, and conventional tomatoes in 1994, whereas Fig. 2 shows the same parameters in 1995. Figs. 3 and 4 show substrate induced respiration (SIR), the ratio of SIR to MBC (an activity per unit biomass measure), and the carbon to nitrogen ratio of the microbial biomass in tomatoes in 1994 and 1995, respectively. In 1994, differences between the conventional and organic input systems were greater during the later than earlier part of the growing season. Fluctuations in micobial biomass and activity were much less in conventional than the organic-amended systems. Both bacterial and fungal populations were higher in organic than conventional tomato soils as measured by direct counts; however, fungi constitute a minor portion of the total microbial community compared to what has been observed in cropping systems in other studies.

There were differences by crop in the relationship between microbial populations and soil mineral nitrogen levels. Associated with increases in microbial populations were usually small increases in soil inorganic nitrogen in tomato plots and generally lower nitrate levels were present in organic than conventional soils. In contrast, soil nitrate levels in corn were often higher in organic than conventional soils, whereas differences in microbial parameters were not as large in corn as in tomato soils. The reasons for these differences among crop types are not yet understood and are under investigation.

Crop parameters. The information presented below was funded by the USDA SARE and UC SAREP research programs but is summarized because of its relationship to this CDFA project. Yields of tomatoes were usually significantly lower in organic than conventional systems, with the exception of 1993 when yields were low thoughout the county (Table 2).

Table 2. Crop Yields in Different Farming Systems

1993	Organic	Low-Input	Conventional
Tomatoes (T/acre)	28.10	32.60	26.60
Corn (T/acre)	3.87b	5.72a	4.76ab
1994	Organic	Low-Input	Conventional
Tomatoes (T/acre)	24.39b	27.97b	41.49a
Corn (T/acre)	6.38a	6.55a	5.16b
1995	Organic	Low-Input	Conventional
Tomatoes (T/acre)	28.80b	35.83a	33.66a
Corn (T/acre)	4.00b	6.19a	5.66a

(Yields followed by different letters indicate significant differences among systems at 5%).

Low input tomato yields usually compared favorably to conventional yields. An exception was in 1994 when transplants for the organic and low input systems contracted a whitefly vectored virus, which severely inhibited nitrogen uptake, decreasing vegetative growth and fruit yield. Organic tomato yields were usually lower than those of conventional tomatoes. For corn, low input yields were equivalent and sometimes higher than yields for conventional or organic systems. Yields of organic corn were usually lower than those of conventional corn.

Current work by Jose Cavero, a postdoctoral fellow associated with the SAFS project, suggest that low rates of decomposition of the composted manure used in the organic system may be partly responsible for the low yields in the organic system (Cavero et al., 1996). This observation is based on estimates of nitrogen mineralization and plant uptake of nitrogen which indicate little available nitrogen added by manure amendments. Supporting this observation is the lack of difference between organic and low input systems with respect to microbial parameters, thus indicating little additional benefit of the extra carbon associated with the manure inputs in the organic system. The hypothesis that manure is not readily decomposable is being pursued in future studies and in more detailed analysis of existing data relating microbial measurements to plant uptake of nitrogen.

b. Relationship between microbial parameters and other soil properties

Soil moisture content is a significant environmental variable for soil populations. Moisture levels in the top 15 cm of soil ranged between 12 and 30% in both organic and conventional systems; whereas levels in the top 5 cm were consistently between 7 and 9%. Microbial populations in the conventional systems dropped considerably when irrigation was terminated late in the growing season. Correlation analyses performed on the relationships between microbial parameters and soil moisture combined from 1992 and 1993 indicated positive relationships ($p<0.0001$) between soil moisture and either MBC or MBN, but negative relationships ($p<0.0001$) with the C/N ratio of the microbial biomass, arginine ammonification, and the ratio of SIR to MBC. In both years, the soil temperature rose from approximately 15° C at the beginning of the growing season to the low 20's in organic and conventional systems. Soil temperature was inversely related ($p<0.0001$) to MBN, the ratio of SIR to MBC, and soil ammonium levels. Variations in both moisture and temperature were not as great in organic as in the conventional system.

Some of the differences between farming systems in soil fertility and soil structure appear to be related to differences in soil biology. Higher microbial biomasses are positively related to significantly higher water stable aggregation in organic compared to conventional soils. Seasonal changes in water stable aggregation corresponded directly to changes in microbial biomass (Amerkeza et al., 1996).

c. Comparison of techniques for measuring microbial populations in soil.

A simple, yet representative, measurement of microbial populations could be useful to growers and farm advisors to help in assessment of soil fertility and changes in microbial populations due to management. Many of the methods used in this study require complex equipment and are not provided by commerical laboratories. A simple method is measurement of potentially mineralizable nitrogen (PMN). This method measures ammonium before and after incubation of soil for a 1 week period and these analyses can be performed by any soil analysis laboratory. The correlation between PMN and microbial biomass was significant at the 0.05 probability level. The relationship was stronger for the organic than conventional system, in part because there appeared to be interference by high levels of soil nitrate in some of the conventional soil samples. Nevertheless, PMN appeared to provide a meaningful and simple estimate of the size of the microbial biomass.

d. Difference in the functional capacity of organic and conventional soils.

Though certain soil biological parameters are enhanced in organic compared to conventional systems, the conventional soil was far from dead. Cover crops added to conventionally managed soil, collected at 5 different times of the year, usually decomposed at rates equivalent to those added to organic soils. Also, there was no difference in the ability of organic and conventionally managed soil to utilize a variety of carbon sources (based on Biolog analysis), thus suggesting no difference in the metabolic diversity (with respect to simple carbon sources) between the two farming systems. These findings suggest that conventionally managed soils maintain large, diverse, and active enough microbial populations to rapidly break down recently added organic material and may imply that the transition period for soil biota may be more rapid than previously thought. This hypothesis requires further testing by examining other measures of microbial process rates and diversity.

e. Conclusions and recommendations.

The topic of this project is soil biology, which is traditionally treated as a black box, with limited understanding of how to translate knowledge of soil biological processes into specific farming practices. Our long-term goal is to understand the links between microbial communities, their predators, nutrient cycling and crop productivity, and how these interactions are reflected in the economics of the various farming systems. Certain phenomena that can be managed, such as irrigation, organic inputs, and excessive levels of mineral N, have already been identified as possibly impacting microbial activity and nutrient cycling; however, more analysis of these relationship are needed to translate these factors into farming practices. We have been in consultation with the farmer advisors associated with this project on what would be the feasibility of utilizing different practices that promote microbial activity. Large variability among the years in critical farming system parameters (e.g. high C/N ratios in organic and low input in 1993; virus causing poor tomato yields in organic and low input in 1994) makes it difficult to make conclusions without additional years of field data or follow-up studies in controlled microcosms.

Our study has already helped to identify measurements of microbial communities with the greatest yield of information for the work required. There is considerable interest, on the part of growers and farm advisors, in what simple measurement can be used as an indicator of microbial activity. Potentially mineralizable nitrogen by the anaerobic incubation method (the most simple-to-measure of the microbial parameters) is thought by many to be correlated with microbial biomass carbon. In our study, we found a strong relationship between potentially mineralizable nitrogen and microbial biomass or activity. The relationship was stronger in organic than conventional system and high levels of mineral N sometimes interfered with the measurement.

There are substantial differences between tomatoes and corn in the behavior of soil fertility and microbial dynamics. It was somewhat suprising not to see the differences in microbial biomass and activity among the farming systems to be maintained across different crops. In the rotational sequence, tomatoes follow the legume rotation in conventional (4 yr), low input, and organic systems and these conditions may be especially favorable for microbial populations (particularily in the organic and low input system). Corn follows safflower (which follows tomatoes) and safflower does not return much to the soil in terms of organic residues. Thus, it is possible that microbial populations decline in all systems under safflower and that it takes a while for these populations to recover. This is only speculation at this point and requires testing. The differences in soil nitrate levels between corn and tomatoes suggests the need to rethink recommendations for optimum C/N ratios for organic inputs, at least for some crops. Differences between corn and tomatoes can be due to differences in root morphology and timing of nutrient demand. This topic warrants additional study because it implies that organic management practices need to be fine-tuned for the specific crop.

F. Project Evaluation

The topic of this FREP project is soil biology, which is traditionally treated as a black box, with limited understanding of how to translate knowledge of soil biological processes into specific farming practices. Clearly, microbiology is further behind other areas of agriculture with respect to being able to turn knowledge into direct recommendations to growers. We need to better understand the links between microbial communities, their predators, nutrient cycling and crop productivity, and how this translates into the economics of the different farming systems. Given that there is little understanding or appreciation of soil biology among the general public, an important part of this project has been to provide information about the below-ground component of agricultural systems. As can be seen below, we have been involved in numerous outreach activities, many of which have promoted a dialogue with growers, as well as generated feedback from growers, about soil biology.

One of the most evident benefits of this project is the development of new information on the management of farming systems receiving organic forms of fertilizer, particularly with respect to the importance of soil biota in crucial processes. Observations from monitoring microbial, nematode and soil fertility parameters in the different farming systems over the past several years have led to several practical hypotheses currently under investigation. For example, our research suggests that higher carbon to nitrogen ratios than previously thought acceptable may be beneficial in providing sufficient plant fertility while at the same time reducing soil nitrate levels. To test this hypothesis, current trials are evaluating the effect of different carbon to nitrogen ratios and different nitrogen inputs from organic sources of fertilizers on inorganic and organic nitrogen pool sizes, microbial populations and tomato fertility. The outcome of this 3-year study will help in the development of practical guidelines for organic fertilizer amendments. Another important finding is that conventionally managed agricultural soils respond quickly to organic inputs and thus may rapidly develop large and metabolically active microbial populations in the presence of such inputs. Based on field observations from previous years, we are currently evaluating whether stimulation of microbial and nematode activity in the fall can lead to better soil fertility in the early part of the growing season in organic farming systems. The results of these studies will hopefully support the development of guidelines concerning how to effectively manage soil communities to promote soil fertility.

Some of the economic implications of this study are worth considering. Over the years, a decreasing amount of supplemental mineral N has been needed in the low input system. This decreasing dependency upon external N may have been due to the build-up of a large labile pool of organic N in the microbial biomass and soil organic matter. Yield decreases in conventional corn appear to be associated with degeneration of soil structure and thus there may be longterm economic costs associated with decline in soil physical properties in the conventional systems. The low input system has advantages over the organic system in that it can be supplemented with inexpensive mineral fertilizer if organic forms of fertilizer are inadequate due to poor quality or climatic conditions. Organic sources of supplemental fertilizer are far more costly than mineral fertilizers. Whether the benefits of this flexibility in fertilizer source will, over the longterm, offset the absence of premium prices for low input produce (in contrast to organic produce) remains to be seen.

G. Outreach activities summary

The following summarizes both oral and written publication outreach activities.

1. Field Days/Presentations/Outreach.

1993

January 15 Presentation to Agriculture Systems and the Environment graduate class and visiting Humphrey Fellows, UC Davis campus. 19 participants.

February 2 Presentation to Ecology 200 graduate class, UC Davis campus. 50 participants.

February 15 Laboratory exercise for Soil Microbiology class, UC Davis campus. 44 participants.

February 18 Presentation to Richard Rominger, Asst. Secretary of Agriculture, and other USDA members. 17 participants.

April 1993 UC Davis Picnic Day, Presentation to 200 participants.

April 30 Field Tour to Advisory Committee for US EPA Center for Environmental Health Research at UC Davis. 30 participants.

May 4 Presentation and field tour for Introduction to Soil Fertility class, UC Davis campus. 35 participants

June 22 6th Annual Sustainable Agriculture Farming Systems Project Field Day. Field tours, equipment demonstrations, presentations and laboratory demonstrations. Attended by approximately 125 people.

July 7 Field tour with two visiting researchers from Australia.

July 13-15 Presentation, field tour and hands-on laboratory using the SAFS field site to high school teachers from the Summer AgriScience Institute, UC Davis. 40 participants.

October 27 Field Tour with Steve Schmidt, Environmental Microbiologist, Univ. of Colorado.

November 2 Field Tour and presentation with Dr. Fred Magdoff, Soil Scientist, University of Vermont and Northeast Regional Director, USDA SARE program.

1994

February 2 Presentation on the results of the first four years of the transition. UC Cooperative Extension, Yolo and Solano Counties, CA. 40 participants.

February 10 Presentation on the results of the first four years of the transition. UC-San Joaquin County Farm Advisors Office, Stockton, CA. 15 participants.
March 15 Presentation to Soil Microbiology class, UC Davis campus. 50 participants.
May 8 Presentation and field tour for Soil Fertility class, UC Davis campus. 42 participants
July 8 7th Annual Sustainable Agriculture Farming Systems Project Field Day. Field tours, equipment demonstrations, presentations and laboratory demonstrations. Attended by approximately 175 people.
August 27 Western Regional SARE Coordinating Committee, Evaluating the Transition to Sustainable Agriculture. Presentation to 40 participants.
August 28 Western Regional SARE Coordinating Committee, Evaluating the Transition to Sustainable Agriculture. Field tour to 30 participants

1995
March 15 Presentation to Soil Microbiology class, UC Davis campus. 50 participants.
April 6 Training workshop on methodology for working with soil microorganisms. SAFS training workshop. 20 participants.
April 1995 UC Davis Picnic Day. Presentation to 200 participants.
May 3 Presentation and field tour for Soil Fertility class, UC Davis campus. 40 participants.
June 22 8th Annual Sustainable Agriculture Farming Systems Project Field Day. Field tours, equipment demonstrations, presentations and laboratory demonstrations. Attended by 125 participants.
June 30 Field tour for soil scientist from Boulder, Colorado.
September 21 SAFS project overview, objectives and progress. SAFS training workshop. 20 participants.
September 22 Training workshop and field demonstration on fall cultural practices for enhancing soil biological activity. SAFS training workshop. 20 participants.
October 24 Presentation to 5th grade class at Birch Lane Elementary School. 33 participants.
Fall Quarter- Organized 10 weekly seminars and one hour discussions on Agroecology.

2. Conference Presentations.

1993
August 26 Role of microbial communities in nutrient cycling in tomatoes. Committee on Sustainable Agricuture, Tomato Day. 40 participants.
November 8 The Influence of Management Practices on the Transformation of Soil Nitrogen in Tomato Production in Conventional and Organic Systems. Talk given at National American Society of Agronomy meetings, Cincinnati, Ohio. 180 participants.
November 9 Comparison of Microbial Population Dynamics in Conventionally and Organically Managed Tomatoes. Poster given at National American Society of Agronomy meetings Cincinnati, Ohio. November 7-12. 100 partcipants.
December 9 Comparison of Microbial Population Dynamics in Conventionally and Organically Managed Tomatoes. Poster given at California Department of Food and Agriculture Conference, University of California, Davis, CA. December 9. 200 participants.

1994
April 29 Multiple Stresses in Agroecosystems. Presentation to Advisory Committee and project members of US EPA Center for Environmental Health Research.
November 15 Evaluation of the Transition From Conventional to Low-input and Organic Farming Systems in California's Sacramento Valley. Presentation at American Society of Agronomy Meetings, Seattle, Washington. November 13-17. 60 participants.

1995
January 24 Microorganisms in soil. Symposium on Organic Management of Vineyards. University Extension. University of California, Davis.

March 14 . Effects of wet-dry cycles on microbial dynamics in soil. Poster given at Soil Ecology Meetings. Fort Collins, Colorado.
March 17 Measuring the impact of multiple stresses on microbial communities. EPA Center for Ecological Health Research Annual Meeting. University of California, Davis.
March 17 Development and testing of a nematode assay for ecosystem health. EPA Center for Ecological Health Research Annual Meeting. University of California, Davis.
April 7 Microbial life in soil: Life on the edge. American Society of Microbiology Foundation Lecture, Arizona ASM Meeting, Flagstaff, Arizona.
June 25 Soil biology. Northern California Chapter of the Biodynamic Society, Quarterly Meeting. Winters, California.
November 1 Microbial dynamics in conventional and organic cropping systems: poking holes in the black box. American Society for Agronomy Meetings, St. Louis. MO.
December 9 Comparison of microbial population dynamics in conventionally and organically managed tomatoes. Poster given at California Department of Food and Agriculture Conference, University of California, Davis, CA. 200 participants.

3. Articles published and in press:

Scow, K.M., O. Somasco, N. Gunapala, S. Lau, R. Venette, H. Ferris, R. Miller, and C. Shennan. 1994. Transition from conventional to low-input agriculture changes soil fertility and biology. California Agriculture 48(5):20-26.
Temple, S.R., D.B. Friedman, O. Somasco, H. Ferris, K. Scow, and K. Klonsky. 1994. An interdisciplinary, experiment station-based participatory comparison of alternative crop management systems for California's Sacramento Valley. Amer. J. Altern. Agric. 9 (1 & 2): 64-71.
Bossio, D.A., and K.M. Scow. 1995. Impact of carbon and flooding on the metabolic diversity of microbial communities in soil. Appl. Environ. Microb. 61:4043-4050.
Gunapala, N. 1994. Soil microbial dynamics and nitrogen availability in organic, low input and conventional cropping systems. Ph.D. dissertation in Soil Science.
Gunapala, N. and Scow, K. M., 1996. Comparison of microbial dynamics in conventional, low-input and organic farming systems. Soil Biology and Biochemistry, (in press)
Amezketa, E., M. J. Singer, N. Gunapala, K. Scow, D. Friedman, and E. Lundquist. Soil aggregate stability in conventional, low-input and organic farming systems. Soil Science Society of America (in press).
Scow, K.M., and M.R. Werner. 1996. The soil ecology of cover cropped farming systems (in press, Cover Crops in Vineyards).
Scow, K.M. 1996. Interrelationships between microbial dynamics and carbon flow in agroecosystems. In: Jackson, L.E. (ed.) Agroecology (in press).

4. Use of project in training.

The experimental plots are routinely visited as a teaching/demonstration laboratory by students enrolled in formal courses (as listed above). A graduate student, Nirmala Gunapala, completed a Ph.D. dissertation concerning research conducted on the plots. Another student, Erica Lundquist, is currently working on her Ph.D. at the plots. Over the past year, Scow has employed seven undergraduate interns: Cynthia Hsu, Tom Huang, Imelda Orilla, Ken Graham, Hui Li, Venece Tom, and Sandra Ueseghi.

H. References cited

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