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Sustainable Agriculture Research and Education
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Annual Results
SW99-008

The Transition from Conventional to Low-Input or Organic Farming Systems: Soil Biology, Soil Chemistry, Soil Physics, Energy Utilization, Economics and Risks

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University of California at Davis

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Project Coordinator:
Steve Temple
Department of Agronomy and Range Science
One Shields Avenue
University of Calif. At Davis
Davis, CA 95616
(530) 752-8216
srtemple@ucdavis.edu

Major Participants:
Howard Ferris, Professor
Nematology
UC-Davis
(530) 752-8432

Ariena van Bruggen,
Associate Professor
Plant Pathology
University of Wageningen
The Netherlands

For a list of more major participants and cooperators, please scroll to the bottom of this report.

Objectives

The project's broad-based research team lists three objectives.

1. Over 12 years, encompassing three different four-year rotations, compare four farming systems with varying levels of reliance on nonrenewable resources regarding:
   a. Crop growth, yield and quality as influenced by different pest management, agronomic and rotational schemes for each system
   b. Abundance and diversity of weed, pathogen, arthropod and nematode populations and their impacts on crop growth, yield and quality
   c. Changes in soil biology, physics, chemistry and water relations and their impact on soil quality and productivity
   d. Cost of production inputs, value of production, economic risk and energy budgets for each system
2. Compare and evaluate novel low-input and organic farming tactics with emphasis on innovations that correct deficiencies, enhance profitability or decrease risk
3. Distribute information about the project and encourage adoption of successful options the project generates

Abstract

A team of researchers, farmers and farm advisors established the Sustainable Agriculture Farming Systems project (SAFS) in 1988 to study the transition from conventional farming systems to low-input organic systems. The project has compared four systems: 1) organic, 2) low-input, 3) conventional four-year rotations, and 4) a conventional two-year rotation.

Cash crops in the four-year rotations include processing tomatoes, safflower, dry beans, wheat and corn. The two-year rotation includes tomatoes and wheat.

Conventional management employs the area's current farming practices. The low-input and organic systems reduced or eliminated synthetic fertilizers and pesticides mainly through cover crops, organic amendments, mechanical cultivation and residue management and modifying irrigation and planting schedules.

Specific Results

Objective 1 has assessed a dozen plant and soil responses in the four systems over the span of the SARE-funded project.

Crop yields have been comparable among the different systems, although tomato and corn yields in the organic system are a little lower than in the low-input and conventional systems, mainly from N limitations. Differences in yields are much greater between years than between systems.

Fruit quality, based on a measure of soluble solids, was lower than the state average for the organic and low-input systems and higher under conventional practices. The soluble solids are inversely proportional to the amount of water applied to the system. It appears that the higher infiltration rate and the corresponding amount of water that percolated through the soil profile in the organic and low-input systems have a negative effect on fruit quality. The researchers are trying to fine-tune water management to solve the problem.

Weeds proliferate in the organic systems but not in the conventional systems with their chemical interventions. The tendency is for the weed community to shift from predominantly annual to perennial in the conventional systems and from broadleaf to grass under organic and low-input.

Microbial biomass tended to be higher – up to two times higher – in the organic and low-input systems than in the conventional. Measured microbial activity showed the same pattern. Microbial communities in the low-input system fell between those of the organic and conventional systems.

Tomatoes in the two-year rotation showed much more severe symptoms of corky root **disease** than those in the four-year rotations. Likewise, soft root tips caused by pythium or phytophthora and red root caused by fusarium were also more severe in the two-year rotations. It appears that the short, intense rotation reverts to host crops too often for natural regulation of root diseases.

Nematode faunal analysis showed that creating conditions conducive for microbial activity in the early fall – such as adjusting soil moisture and enhancing carbon levels – enhanced the abundance of bacterial grazers on the microbial biomass the following spring. That, in turn, increases mineralization rates in the spring to provide nutrients during summer growth.

After eight years of the study, levels of **soil organic matter** were 20% greater in the organic system and 10% greater in the low-input system than in the two conventional systems, reflecting the rates of organic inputs**.** **Carbon levels** doubled in the organic system, with 10 tons per hectare sequestered over the eight years.

As for **soil fertility**, nitrogen is released slowly from organic pools in the organic and low-input systems, resulting in lower levels of mineral N from mid to late season compared with the side-dressed conventional systems. Still, the organic and low-input systems have more stored nutrients.

Water infiltrates more readily in the organic and low-input systems owing to changes in soil structure. Also, the proportion of rainfall lost as runoff in these systems is much lower – 15% compared with 43% in the conventional system – which also means higher water content in the organic and low-input systems.

As for **economic viability**, the organic system, with its premium prices, has performed better than the low-input system and conventional four-year rotation. And while the cumulative net return for the conventional two-year rotation is always the highest, owing to the greater frequency of high-value tomatoes in the rotation, pests and diseases and the consequent reliance on pesticides threaten the economic and environmental viability of the system.

Pesticide use has been greatest in the conventional two-year rotation, followed by conventional four-year, low-input and organic. Pesticides in the conventional and low-input systems are used mainly to fight weeds.

Objective 2 compared existing or novel organic or low-input tactics, emphasizing innovations that might correct deficiencies, improve profits or decrease risk.

Cover-crop studies showed that when planted after the harvest of early fall tomatoes, the cover crops recycle free soil N and produce large amounts of biomass, as long as the cover crop can be established before Sept. 1. A large trial showed potential in mixtures containing sorghum-sudan; compatibility of lablab with sorghum-sudan; and the potential to choose cowpea genotypes less sensitive to photoperiodic effects, lygus attack and root knot nematodes.

Several studies looked at practices in the fall that might enhance the activities of bacterial- and fungal-feeding nematodes in cover-crop decomposition and soil fertility. These include a late-summer irrigated cover crop, irrigation alone and a winter cover crop. Fall irrigation and fall irrigation plus a late-summer cover crop provided much more N the following spring and higher yields in the following tomato crop.

“We conclude that ‘feeding and activating’ the soil food web during the early fall when soil temperatures are conducive to biological activity increases the bacterial grazing community the following spring,” the research team says in its annual report.

Growers and scientists in the project have indicated strong interest in reduced or no tillage in field row-crop production systems in the Sacramento Valley. Among concerns raised are how to deal with fertilizer and herbicide inputs; furrow irrigation, which is much different from Midwest reduced-tillage practices; the difficulty of finding cover crops and rotations that will fight weeds; and the economics of reduce tillage.

Farmers plan to evaluate several types of no-till equipment, including Buffalo planter, sub-surface tiller transplanter, Ferguson strip-till machine and 5-foot cover crop seeder. At the same time, the SAFS team is evaluating reduced- and no-tillage methods for producing tomatoes, including one that uses nonchemical or reduced-chemical cover crop management, transplanting and cultivating high residue.

For the results to date of Objective 3, please look at the Dissemination of Findings section below.

POTENTIAL BENEFITS

The project has demonstrated that tomatoes grown organically can be profitable; yields can be maintained in organic and low-input systems; and cover cropping can provide many benefits, including carbon sequestration, reduced nitrogen leaching, increased infiltration, decreased runoff and improved soil quality. The project team is working to place dollar values on some of the benefits.

FARMER ADOPTION AND DIRECT IMPACT

A survey has been designed to assess the direct impact of the project on farm practices. Farmers have expressed strong interest in the results, including one, Ed Sills who farms 2,500 acres organically in Sutter County. Sills, a farmer advisor to the project for 12 years, wrote:

"I am growing many of the same crops as the SAFS project. My involvement with SAFS has helped me develop a successful organic rotation for my farm. The present emphasis on reduced tillage is extremely important. In a little over a year, our fuel prices have doubled. In consideration of increased energy costs and other associated benefits of reduced tillage, the SAFS investigations are timely and relevant."

FUTURE RECOMMENDATIONS OR NEW HYPOTHESES

The project team offers four arenas for future study:

1. **Weed management**. While other pests are typically regulated by rotations and other practices, the high soil nutrients, irrigation and frequent tillage provide environments for specific communities of weed competitors in each farming system. Research is needed on how to better manage weed pressure in organic and low-input systems.
2. **Fertility management for organic and low-input systems**. Cover crop biomass and associated N input has decreased in recent years, and weed severity has increased. Optimizing cover crop decomposition with properly timed incorporation and managing microbial and nematode communities continue to be challenges.
3. **Reducing the frequency and intensity of tillage operations**. Intense tillage practiced in the area contributes to dust, stimulates soil respiration with the loss of sequestered carbon, degrades the soil structure, increases compaction and disrupts soil biology activity. Still, skeptics decline to reduce tillage owing to practical difficulties, including fertilizer and herbicide application, furrow irrigation and effective weed control using cover crops. And the economic viability of reduced tillage, especially in irrigated field row-crop systems in the West, is unknown.
4. **Water-use efficiency**. The public in the Sacramento valley is concerned about the increasing demands for water and drought-induced limitations. An important challenge of the project is to improve irrigation management to optimize water use.

DISSEMINATION OF FINDINGS

In addition to more than 65 peer-reviewed journal articles, the project has generated seven popular press articles and a home page, http://agronomy.ucdavis.edu/safs/home/htm. Results have been presented in more than 80 national and international conferences, and the project has hosted more than 1,500 visitors from more than 30 countries at its 11 field days, six workshops, tours and individual visits. The SAFS plots serve as living laboratories for field trips and provide lab samples more many UC-Davis classes and Cooperative Extension courses in soils, agronomy and pest sciences.

PRODUCER INVOLVEMENT

Three farmers are directly involved in every phase of the SAFS project, from planning and design of research to interpretation and dissemination of results. Many other farmers contribute ideas and ask questions during field days and farm tours.

Major Participants:

Kate Scow, Assoc. Prof., Land, Air, Water Resources, UC-Davis, (530) 752-4632

Willi Horwath, Asst. Prof., Land, Air, Water Resources, UC-Davis, (530) 754-6029

Karen Klonsky, Farm Mgt. Spec., Ag Economics, UC-Davis, (530) 752-3536

Tom Lanini, Weed Scientist, Vegetable Crops, UC-Davis, (530) 752-4476

Jeff Mitchell, Extension Spec., Vegetable Crops, UC-Davis, (530) 646-6565

Tom Kearney, Farm Advisor, Yolo County, (530) 666-8736

Gene Miyo, Farm Advisor, Yolo County, (530) 666-8143

Jim Durst, Farmer, Yolo County, (530) 787-3390

Bruce Rominger, Farmer, Yolo County, (530) 662-5787

Ed Sills, Farmer, Sutter County, (530) 655-3391

Lynn Epstein, Assoc. Prof., Plant Pathology, UC-Davis, (530) 754-7916

Leisa Huyck, Research Manager, Agronomy, UC-Davis, (530) 752-2023

Peter Brostrom, Production Manager, Agronomy, UC-Davis, (530) 752-2023

Cooperators:

Brian Joyce, Doctoral Student, Land, Air, Water Resources, UC-Davis,

Bruce Jaffe, Professor, Nematology, UC-Davis, (530) 752-0862

Mike Singer, Professor, Land, Air, Water Resources, UC-Davis, (530) 752-7499

Rich DeMoura, Research Associate, Ag Economics, UC-Davis, (530) 752-3589

Robert Bugg, Entomologist, UC-SAREP, (530) 754-8549

Sean Clark, Assoc. Prof., Berea College, Kentucky, (606) 986-9341