BIOLOGICALLY INTEGRATED FARMING SYSTEMS (BIFS) PROGRAM

A Progress Report to the California State Legislature
on the Implementation of
Assembly Bill 3383 (Chapter 1059, Statutes of 1994)
and
Assembly Bill 1998 (Chapter 434, Statutes of 1998)

University of California
Office of the President
Division of Agriculture and Natural Resources
Statewide Special Programs and Projects
Sustainable Agriculture Research and Education Program

January 2003

The BIFS program is an integral part of the University of California Sustainable Agriculture Research and Education Program (SAREP). SAREP provides leadership and support for scientific research and education in agricultural and food systems that are economically viable, conserve natural resources and biodiversity, and enhance the quality of life in the state's communities. SAREP serves farmers, farmworkers, ranchers, researchers, educators, regulators, policy makers, industry professionals, consumers, and community organizations across the state.

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EXECUTIVE SUMMARY

In 2002 the Biologically Integrated Farming Systems (BIFS) program, administered by the UC Sustainable Agriculture Research and Education Program (UC SAREP), entered its seventh year supporting on-the-ground agricultural chemical risk/use reduction projects. AB 3383 provided the first state funds for the program, followed in 1998 with AB 1998 which expanded the program and provided new state funds. Since 1995, U.S. EPA (Region 9) has also provided matching federal funds to the program and currently is the only source of funds as no new state funds have been provided since 1998. As of January 2003, SAREP has obtained a total of $3,079,272 in outside funding for the BIFS program. This report covers the BIFS program from January 2001 through December 2002. During this time, the program was funding seven on-going projects in seven different major commodities. By December 2002, four of the seven projects have ended (rice, citrus, walnut, and strawberry), and apples and dairy/forage crop BIFS projects will end by March 2003. UC SAREP released a new Request for Proposals in July 2001 which resulted in funding two projects: the Prune BIFS project was granted up to three additional years of funding and a new winegrape project was funded for three years (April 2002 - March 2005).

California growers continue to face major challenges on two fronts: declining profit margins and increased environmental regulations that threaten to reduce the number of chemical pest controls as well as restrict fertility and general crop management practices. Recent pesticide regulations that affect California agriculture include the 1996 Food Quality Protection Act and the Department of Pesticide Regulation's new ground water protection standards which, beginning in January 2004, will create further restrictions on the use of pre-emergence herbicides as well as add expense in hiring specially trained and certified pest control advisers. The U.S. EPA is revising the Clean Water Act permit requirements (finalized in December 2002) and effluent guidelines which will require most dairy farms to prepare comprehensive nutrient management plans to document all nutrient application on fields. This will require improvements and changes in the way in which manure nutrients are managed as they are utilized by forage crops, and necessitate reductions in commercial fertilizer use on these crops. The Clean Air Act and the Montreal Protocol call for the elimination of methyl bromide use by 2005. And finally, the 1994 CALFED agreement to provide ecosystem protection for the Bay Delta estuary provides agricultural water users a guaranteed, if reduced, water supply (CALFED 1997).

BIFS projects help farmers implement biologically integrated farming systems, bringing long-term benefits to California growers by reducing the environmental impact of agriculture on natural resources, reducing production costs, and maintaining yields and quality (Swezey & Broome, 2000). BIFS growers, in partnership with researchers, extensionists, and consultants, have demonstrated and fine-tuned research-based alternative farming practices in the areas of soil building, cover cropping, alternative pest management approaches, and optimized use of inputs including fertilizer, manure, water, and pesticides. The BIFS approach promotes farm management decisions based on monitoring. Local management teams of farmers, researchers, extensionists and other agriculture professionals meet regularly and collaborate to develop and disseminate these alternative methods (Mitchell et al. 2001).

UC SAREP in collaboration with other UC colleagues and researchers has been evaluating the BIFS program, through developing and conducting commodity-focused grower surveys and analyzing the California Pesticide Use Report (PUR). Over half of San Joaquin County's walnut growers responded to SAREP's county-wide survey in 2002, representing almost 75 percent of the total bearing walnut acres in the county. The results showed that almost half of the respondents had been exposed to the BIFS walnut project. The results also indicated that a majority of respondents were willing to use practices that reduce their chemical and fertilizer use even when it takes a little more time or expense. SAREP also conducted a statewide survey of rice growers in 2001, and has developed statewide surveys of prune growers and dairy producers that will be conducted in 2003. Analysis of California's PUR database conducted by UC Davis researchers has revealed trends from 1992 to 2001 in use patterns for several BIFS commodities.

Key agricultural chemicals being targeted for reduction by BIFS projects such as in-season organophosphates like chloropyrifos or phosmet have been decreasing over the past nine and five years, respectively, on walnuts in San Joaquin County. Methyl parathion use has increased on this county's walnut acres starting in 1996; however, by 2001 BIFS walnut growers were only treating 5 percent of their acres with this chemical and the rest of the county was treating 25 percent of their acres. In addition, the miticide propargite was used on only 10 percent of BIFS acres in 2001 in San Joaquin County, but on over 40 percent of the rest of the county acres. The dormant season organophospate, diazinon, known for contaminating California's surface waters, was applied to 30 percent of Sutter County prune acres but to only 2.5 percent of BIFS prune acres in 2001, the latest year that data is available. Analysis of the temporal and spatial patterns of pesticide use will continue.

Nine peer-reviewed publications, eleven abstracts, and several conference proceedings have been published that present results of BIFS projects or related research. Publications have ranged from Andrews et al. 2002, a landmark study in cotton that describes the development of a soil quality index for use by researchers, educators and growers to understand how on-farm practices effect soil quality and yields to the (in press) paper by Grant et al. 2003 that describes the pest management practices and achievements of the walnut BIFS project.

In addition to funding key demonstration projects through the BIFS program, UC SAREP has created a BIFS Workgroup with funding from the University of California Division of Agriculture and Natural Resources to support increased cross commodity cooperation on pressing research and educational needs of California agriculture. Workgroup support funds have enabled researchers, federal and state regulators, consultants, and commodity and nonprofit organizations to share resources and ideas about how to increase the adoption of environmentally sound farming in California. In addition, the BIFS Workgroup is supporting a social science research project to look at the role that partnerships and participation play in the ability of the BIFS and BIFS-like projects to accomplish their environmental and economic objectives.

With only federal funds to support the BIFS program, UC SAREP has attempted to obtain additional funding to enable the continued support of new BIFS projects. UC SAREP successfully obtained a specialty crops block grant from the California Department of Food and Agriculture to extend the key successes of four recent BIFS projects, in walnuts, prunes, dairy/forage crops, and citrus to a statewide audience. With the idea of building on the strong foundation of this ag chemical use/risk reduction program, UC SAREP is working on developing a consortium for on farm conservation biology and restoration ecology. This collaborative effort will attempt to obtain key research support to develop the information needed to assist growers to incorporate on-farm conservation and restoration strategies and wildlife-friendly farming practices.

PROJECT SUMMARIES

Walnut BIFS: January 1999—December 2001

In December 2001, the San Joaquin County Walnut BIFS team successfully completed a three-year project demonstrating the use of a biologically integrated orchard system in farming walnuts in the northern San Joaquin Valley to reduce on-farm disruption and off-site pollution from the routine use of organophosphate insecticides under review due to the Food Quality Protection Act. In addition, this project demonstrated practices to reduce synthetic nitrogen fertilizer on California's 200,000 acres of walnut orchards. To accomplish this, the project has developed a farming system that which relies on an insect pheromone for disrupting mating, natural enemies of pests, cover crops, and monitoring. Twelve enrolled growers established demonstration blocks for BIFS implementation, and designated conventionally managed blocks for side-by-side comparisons. The project showed that it is possible to

greatly reduce the use of conventional pesticides and maintain comparable yields (average yields of 1.6 to 2.5 dehydrated in shell tons per acre). The use of pheromone mating disruption to control codling moth, the major walnut pest, reduced applications of organophosphate insecticides to 17 percent of the BIFS orchards as compared to 88 percent of the grower's conventionally managed orchards. Further, the project reduced synthetic nitrogen use on 324 acres of walnuts by 57 lbs. per acre between 1998 and 2000 with no decline in yields. Growers maintained yields by planting cover crops and lowered nitrogen inputs by monitoring leaf nitrogen and using this crop-based information to make judicious use of fertilizers. A county-wide survey revealed that almost 40 percent of San Joaquin County walnut growers are using a nitrogen budgeting approach to estimate their fertilizer requirements. Project growers were highly motivated to successfully adapt cover cropping in their orchards, which has been shown to improve water penetration, reduce the need for mowing and increase beneficial insects in the orchards. Outreach to area farmers and collaboration with the Community Alliance with Family Farmers and the walnut Pest Management Alliance insure wide dissemination of project results.

Prune BIFS: January 1999—December 2004

The Prune BIFS project, called the Integrated Prune Farming Practices (IPFP) program, completed its first three-year cycle in December 2001. Project managers have emphasized that for this statewide project to succeed, support for five to ten years of work is needed. Project managers applied to UC SAREP and were successful in obtaining additional years of support based on the accomplishments of their first three years and the recognized importance of the projects goals. It is continuing under a new round of funding 2002-2004. The first phase of the project developed and demonstrated alternative reduced-risk farming practices on 33 prune farms in nine counties. During this time, winter applications of diazinon, an organophosphate insecticide, were eliminated from 877 acres of the 33 enrolled farms in the demonstration/research sites, while in 2000, in Sutter County, 30 percent of prune acres received an application. Average yields were the same between the two farming systems and ranged from 4387 to 5139 lbs./acre. Growers and the management team collaborated with PCAs to develop fifteen monitoring decision guides, or protocols, for optimizing the use of pesticides, water, nitrogen and potassium applications. Ten of these are now ready for use by growers and pest control advisors, and have the potential to greatly reduce the use of organophosphate (OP) insecticides, synthetic fertilizers and excess applications of irrigation water. The IPFP is truly a commodity-based statewide initiative, funded by the BIFS program as well as the Department of Pesticide Regulation, the California Prune Board, and the USDA.

Apple BIFS: January 2000—March 2003

The Apple BIFS project focuses on reducing the use of controversial, broad-spectrum insecticides in pome fruits (apples and pears). Rapid urbanization around apple orchards in Contra Costa County has increased concerns about pesticide use in this region. A key component of the project is the use of mating disruption to reduce the numbers of codling moth, the most critical pest in apple and pear production. During this three-year project, a team of growers, pest control advisors and UC researchers used supplemental codling moth sprays in addition to mating disruption to reduce codling moth populations to very low levels. The project has made substantial progress in identifying and demonstrating the products and procedures to use in orchard monitoring that are necessary for the successful implementation of pheromone mating disruption to control codling moth in pome fruit. BIFS fields received 33 percent less organophosphate insecticides than the conventional fields with similar control levels.

Citrus BIFS: October 1998—June 2002

The Citrus BIFS project focused on reducing the use of the herbicide simazine (a known groundwater contaminant), reducing organophosphate insecticide and fertilizer use, improving irrigation efficiency and increasing the use of cover crops. The use of pre-emergence herbicides such as simazine (Princep), diuron (Karmex) and oryzalin (Surflan) can be reduced by relying on more frequent post-emergence herbicide applications, by narrowing the area in the "middles" that the herbicide is applied to, and by

growing a cover crop. It is a common belief among citrus growers that cover crops will increase the risk of frost damage in citrus orchards. However, two years of data from Citrus BIFS show that an appropriately managed cover crop does not increase frost damage. Cover crops are beneficial to citrus orchards in providing habitat for beneficial insects, reducing soil erosion, and reducing off-site movement of agricultural chemicals. The project also showed that monitoring with moisture sensors improves irrigation efficiency, reduces costs and the likelihood of run-off.

Dairy BIFS: July 1999—March 2003

The Dairy BIFS project has been working with 11 dairy and forage crop farmers in the San Joaquin Valley since 1999 in an effort to develop and demonstrate improved liquid manure management practices. Project managers have developed ways to measure nutrients in lagoon water, enabling them to reduce or eliminate applications of synthetic fertilizers to their forage crops. Average use of fertilizer by BIFS growers on their forage crop fields went from 149, 71, 45 lbs/acre of N, P_2O_5, and K_2O, respectively, before the project to 20, 0 and 0 lbs/acre after three years of the project. The results have been cost savings to the growers of on average $55 per acre and as high as $116 per acre, and reductions in groundwater contamination from both chemical fertilizer and dairy manure water. Growers have also maintained their forage crop yields with this method. A crucial accomplishment of the project has been the development of easy-to-use flow meters to measure the amounts of liquid dairy manure to be used as fertilizer on the crop and nitrogen "quick tests," which determine the exact amounts of nutrients in the liquid manure. This will become increasingly important, as future environmental regulations for concentrated farm animal operations will require accurate record-keeping and finely controlled management practices, as well as the development of a comprehensive nutrient management plan.

Rice BIFS: January 1999—December 2001

Several environmental and regulatory issues face California rice growers: air pollution from rice straw burning; movement of pesticides into the Sacramento River; production problems arising from herbicide resistance; and high production costs. The Rice BIFS project addressed these by demonstrating the viability of a variety of practices such a soil incorporation of straw, winter flooding, reduced synthetic nitrogen, deep water and dry down, drill seeding and winter cover crop. Fifteen demonstration fields in Butte County were enrolled; collectively, participating growers control over 12,000 acres of rice. Participating BIFS growers used less herbicides as compared to the Butte County average use rates. For weed control, the alternative non-chemical treatment of "deep water" and "dry down" were demonstrated. This resulted in substantial cost savings during two of the three years of the project. The Rice BIFS growers also reduced nitrogen applications by 30 lbs./acre by using straw incorporation and winter flooding. This practice holds promise for widespread adoption, since, based on the project's statewide survey, approximately one-third of rice growers are already practicing it.

Strawberry BIFS: January 1999—March 2001

The Strawberry BIFS project focused on exploring a variety of biologically based alternatives to the soon-to-be-banned fumigant, methyl bromide, as well as aboveground pests like Lygus. Based on intensive one-on-one scientist-grower interactions, this project enrolled 21 acres of strawberries on 14 farms. Project demonstrations showed that three cultivars, Aromas, Seascape and Pacific, are better adapted to non-fumigated conditions. In attempting to determine mulches, soil inoculants and other cultural practices beneficial to commercial strawberry production, the project showed that bacterial and mycorrhizal inoculants tested and corn gluten meal do not appear to generate benefits. Also, soil solarization is not economical in California because the soil does not get hot enough in the strawberry growing regions. In seeking alternatives to insecticides, the project revealed that periodic vacuuming of alfalfa/mustard plus "trap" crops on the borders of the strawberry plots is a potentially viable, organic control against lygus bug.

Winegrape BIFS – Central Coast Vineyard Team: April 2002 – March 2005
This project has just completed its first growing season. The Positive Point System (PPS), developed by the Central Coast Vineyard Team (CCVT), describes an integrated farming system appropriate for California's Central Coast. This point system allows an evaluation of the extent of sustainable practices incorporated by a farm manager. A higher score indicates more environmentally friendly management. The project will be collecting agricultural chemical use data to determine whether there is a correlation between a high score on the PPS and reduced use of agricultural chemicals. This project has strong grower support and represents a collaborative partnership of growers, wineries, farm advisors, researchers and consultants. The project has potential not only for chemical use/risk reduction, but also to support reduction in the off-site movement of soils and water. The BIFS project is being conducted in addition to a Clean Water Act Section 319(h) grant that the CCVT also recently obtained, that grant will enable monitoring and assessment of off-site movement of soil and how the adoption of the practices in the PPS might affect such movement.

PROGRAM OVERVIEW

California growers continue to face major challenges on two fronts: declining profit margins and increased environmental regulations that threaten to reduce the number of chemical pest controls as well as restrict fertility and general crop management practices. These challenges threaten farm survival. While the farmgate prices have not kept pace with the rising costs of inputs, environmental regulations are requiring changes in management practices. Recent regulations that affect California agriculture include the 1996 Food Quality Protection Act, which requires U.S. EPA to review agricultural commodity pesticide tolerances for all organophosphates, carbamates, and EPA category B2 carcinogens. In addition, regulations such as those proposed by the California Department of Pesticide Regulation (DPR) to begin in January 2004, create further restrictions on the use of pre-emergence herbicides as well as added expense in hiring specially trained and certified pest control advisors (PCAs). These regulations create new ground water protection areas and restrict the use of additional pesticides, requiring permits and users to adopt specific management practices to protect ground water.

The EPA is also revising the Clean Water Act permit requirements and effluent guidelines that will require most dairy farms in the state of California to prepare comprehensive nutrient management plans to document all nutrient application on fields. This will require improvements and changes in the way in which manure nutrients are managed as they are utilized by forage crops, and necessitate large reductions in commercial fertilizer use on these crops. The regulations will be finalized by December 2002 with all permits required by January 2006. In addition, the Clean Air Act and the Montreal Protocol call for the elimination of methyl bromide use by 2005, and the 1994 CALFED agreement to provide ecosystem protection for the Bay Delta estuary provides agricultural water users a guaranteed, if reduced, water supply (CALFED 1997). Alternative production practices that address these economic and environmental challenges have been developed in several crops and demonstrated by BIFS enrolled growers. Researchers and extensionists have shown these practices to be effective in agronomic, environmental and economic terms.

ENABLING LEGISLATION

In 1994, the University of California Sustainable Agriculture Research and Education Program (UC SAREP) was chosen by the UC Division of Agriculture and Natural Resources to implement AB 3383 in consultation with a Program Advisory Review Board. Assembly Bill 3383 and by extension, AB1998 (passed in 1998), request that the Regents of the University of California establish a demonstration program to provide extension services, training, and financial incentives for farmers who voluntarily participate in pilot projects to reduce their use of agricultural chemicals. This program is UC SAREP's Biologically Integrated Farming Systems (BIFS) program.

The goal of AB 3383 is "… to expand the use of integrated farming systems that have been proven to decrease the use of farm chemicals," through integration of the following elements (Section 591):

(1) relying on biological and cultural control to protect crops from pest outbreaks
(2) creating on-farm habitats that harbor populations of beneficial insects and mites
(3) using cover crops to provide some or all of the nitrogen needed by the crop plants
(4) directing overall attention to soil building practices
(5) reducing reliance upon chemicals.

To implement these goals, Assembly Bills 3383 and 1998 specify that pilot demonstration projects be selected through a competitive grant process. The responsibilities of UC SAREP's BIFS program include developing policies and procedures for implementing the pilot demonstration projects; developing and issuing requests for proposals for pilot demonstration projects in relation to monitoring; and summarizing

pesticide and fertilizer use. The bills also outline the review and selection process to be followed in evaluating proposals and funded projects. (For the full legislation, see Attachments A and B).

BIFS PROGRAM ADVISORY REVIEW BOARD

AB 3383 outlines the appointment and role for a 13-member Program Advisory Review Board (Section 593(a)). Members of the board were originally appointed in February 1995 by the UC Vice President of Agriculture and Natural Resources. During the ensuing years, new members have been appointed to replace members who have stepped down (Table 1).

Table 1. Members of the BIFS program advisory review board in 2002.

Name and Affiliation	Category Specified in AB3383, Section 593
William Horwath, Asst. Professor, Land, Air & Water Resources, UC Davis	University of California
Joe Grant, Farm Advisor, UC Cooperative Extension, San Joaquin County	University of California
Kathy Taylor, Associate Director for Agriculture US-EPA Region 9	Relevant Federal Agencies
Tish Espinoza, Agronomist & Plant Resource Specialist USDA-Natural Resources Conservation Service	Relevant Federal Agencies
Sherman Boone, Almond Grower Boone Enterprises, Stanislaus County	Grower
Stephen Griffin, President Misionero Vegetables, Monterey County	Grower
Gregory T. Nelson, President & Manager Nelson & Sons Ranch, Mendocino County	Grower
John Carlon, President Sacramento River Partners	Nonprofit Organization
Dawit Zeleke, Agriculture and Restoration Manager Sacramento River Project	Nonprofit Organization
Patrick Weddle, President Weddle, Hansen & Assoc.	Pest Control Adviser
Paul Gosselin, Chief Deputy Director Department of Pesticide Regulation	Department of Pesticide Regulation
John Steggall, Senior Scientist CDFA	CA Department of Food and Agriculture
Matt Billings, President Sterling Nursery & Insectary	DPR Pest Management Advisory Committee

TOTAL FUNDING TO SAREP FOR THE BIFS PROGRAM

As of January 2003, a total of **$3,079,272** has been obtained for the BIFS program, with **$1,135,909** coming from the California Department of Pesticide Regulation (**$245,000** from the Food Safety Account under AB3383 and **$890,909** in general funds under AB 1998), **$1,834,363** from the U.S. EPA Region 9 (through the EPA's Pollution Prevention Incentives for States (PPIS), Regional initiative funds for the Food Quality Protection Act (FQPA), and Agricultural Initiative programs), and **$109,000** from the UC Division of Agriculture and Natural Resources. This has funded ten projects in nine different commodities around the state.

AB 1998 also provided **$89,091** to SAREP to fund component research projects relevant to BIFS projects. Four research projects were funded; descriptions are included in the previous BIFS Biennial Report (January 2001).

PROGRAM IMPLEMENTATION

Funded Projects

During this reporting period, UC SAREP supported seven three-year BIFS projects around the state in apples, citrus, prunes, rice, strawberries, walnuts and dairy/forage crops (Table 2). Most of these projects have concluded during the current reporting period, or will conclude by March 2003. In 2001, U.S. EPA (Region 9) allocated additional funding to UC SAREP to support new BIFS projects. In July, the BIFS program released a Request for Proposals (RFP) for three-year projects to begin in 2002. The 2001 RFP added the requirement that applicants spell out a post-funding strategy to ensure the sustained impact of their project. It also included a new requirement to complete a logical framework—a tool for project participants to identify project goals and objectives, tasks required to meet those objectives, and the measurable outcomes expected from project activities.

BIFS staff organized a proposal development workshop for potential applicants. The primary goal was to explain the overall concepts of the BIFS program, provide descriptions of typical BIFS projects, and discuss the basic requirements for a successful BIFS project, including the concepts of partnerships and management teams, cooperating growers, and side-by-side plot comparisons. The proposal development workshop was held on August 15, 2001 and was attended by 31 prospective applicants from a variety of public and private groups and institutions, including governmental organizations, UC Extension, county Resource Conservation Districts and grower groups. Proposals submitted for this RFP round were of high quality and conformed closely to the concepts and requirements of the BIFS program.

The BIFS Program Advisory Review Board reviewed the submitted proposals and recommended funding two projects: a continuation of the **Integrated Prune Farming Practices IPFP/BIFS** project and a new **Central Coast Vineyard Team (CCVT)** Winegrape BIFS project, **"Using the Positive Points System to Reduce Chemical Reliance in Vineyards."** The Central Coast Vineyard Team was awarded $99,969 to fund the first year of their three-year project and the IPFP/BIFS team was awarded $80,000 to continue its project. Funding for an additional two years is contingent upon progress as evidenced during the annual review. Each will use the BIFS extension model whose main components include a team approach to project management, on-farm demonstrations, monitoring of key biological and economic variables, and farmer-to-farmer information flow. The farming practices, fine-tuned and evaluated by a team of growers, UC scientists and consultants, are designed to reduce off-farm movement of pollutants and soil, while enhancing natural processes. Both of these BIFS projects will be using successful working vineyards or orchards to demonstrate agricultural operations that have reduced pesticide use in high-value crops. Other area growers have agreed to participate by adapting the methods demonstrated to sections of their own acreage and then monitoring and comparing results with their normal practices. Through their outreach, the two projects will promote practices that reduce environmental problems while maintaining profitability.

Table 2. BIFS projects active during the 2001—2002 funding period. (Funds provided by AB1998 and U.S. EPA Region 9 Agricultural Initiative, U.S. EPA Food Quality Protection Act Regional Funds, and U.S. EPA Pollution Prevention Incentives for States (PPIS) funds.)

Principal Investigator	Institution	Title	Years Funded	Total Funded Amount (through 2002)	Anticipated Funding 2003-2004
Grant, Joseph	UC Cooperative Extension, San Joaquin County	Expansion of the Biologically Integrated Orchard Systems model to Northern San Joaquin Valley Walnut Orchards	Jan 1999—Dec 2001	$173,642	
Mutters, Randall	UC Davis, Department of Agronomy and Range Science; UC Cooperative Extension, Butte County	Biologically Integrated Farming System in Rice	Jan 1999—Dec 2001	$273,700	
Chao, C. Thomas	UC Riverside, Dept. of Botany & Plant Sciences	Citrus Orchard Management BIFS Project	Oct 1998—June 2002	$233,423	
Bull, Carolee	Agricultural Research Service, US Department of Agriculture, Salinas, Monterey County	BASIS (Biological Agriculture Systems in Strawberries): A bio-intensive production methods innovators group in the Monterey Bay region	Jan 1999—Mar 2002	$120,000*	
Pettygrove, Stu	UC Davis, Dept. of Land, Air, & Water Resources	Integrating Forage Production with Dairy Manure Management in California's Central Valley	July 1999— Mar 2003	$331,484	
Caprile, Janet	UC Cooperative Extension, Contra Costa County	Integrated Pome Fruit Production in Contra Costa County	Jan 2000— Mar 2003	$158,910	
Obenauf, Gary	California Prune Board	Integrated Prune Farming Practices IFPF/BIFS	Jan 1999—Dec 2001 Jan 2002—Dec 2004	$277,546 $80,000	$100,000
O'Connor, Kris	Central Coast Vineyard Team	Using the Positive Points System to Reduce Chemical Reliance in Vineyards	April 2002—Dec 2004	$99,969	$199,938
		TOTAL BIFS FUNDED PROJECTS Oct. 1998—Dec. 2002		**$1,748,674**	
		TOTAL ADDITIONAL FUNDS COMMITTED (Prune and Winegrape projects 2003—2004)			**$299,938**

* Project also received an additional $183,500 from methyl bromide funds for a project total of $303,500 over 3 years.

UC SAREP Staff Support

UC SAREP staff provides important support work for the BIFS program using the ten percent program support funds. These funds principally support one Ph.D. level post-graduate researcher (the BIFS Coordinator) over three years (the life of each project). The BIFS Coordinator assists with program management and evaluation of the active projects. In addition, the ten percent program support funds cover expenses to run the BIFS Board meetings, office operating expenses, and transportation expenses related to the BIFS program.

The BIFS Coordinator provides technical support in the areas of natural and social science to management teams through partnership facilitation, management team meetings, information sharing, and attendance at grower field days. The Coordinator also provides or facilitates monitoring and evaluation work (helps to develop appropriate protocols, conducts grower surveys, analyzes data, etc.). The BIFS Coordinator oversees the reporting process for the projects, is the main interface for the BIFS Program Advisory Review Board and assists with documentation and evaluation of the overall BIFS program. In addition, administrative support is provided by the UC SAREP grants manager and accounting officer and additional technical support by the Director, Associate Director and other staff members. UC SAREP staff have conducted site visits, telephone and electronic mail consultations, and reviewed and provided feedback on project materials (e.g. monitoring protocols, data sheets, meeting agendas, etc.), on project reports and newsletters, and prepared the UC SAREP reports. The list below summarizes UC SAREP staff support for the BIFS projects from January 2001 through December 2002.

BIFS Project Support, Oversight, and Reporting

- Developed, distributed, and publicized new Request for Proposals
- Attended field days and made several field visits to each project
- Attended project management team meetings
- Conducted critical review and summary of all project proposals and subsequent reports
- Survey data analysis recommendations for projects (social science technical support)
- Completed project surveys for Rice BIFS and Walnut BIFS
- Initiated development of surveys for dairy and prune BIFS
- Provided recommendations on economic analysis (rice)
- Provided guidance with data management (strawberries, dairies, citrus, walnuts)
- Facilitated budget and contract communications between UC SAREP and the BIFS projects
- Provided input to projects on meetings, newsletters, and other aspects of outreach
- Summarized project annual reports and write Biennial Report to the Legislature
- Maintained BIFS Web site
- Coordinated press releases
- Authored newsletter articles (M. Barzman, J. Broome, J. Ohmart, and B. Ransom)
- Submitted four major grant proposals, of which two were funded - California Department of Food and Agriculture specialty block grant—funded for $100,000, and U.S. EPA Region 9 Agricultural Initiative for FQPA Implementation – funded for $200,000/yr for 3 years – total $600,000.
- Organized and/or attended collaborative meetings with Department of Pesticide Regulation and Community Alliance with Family Farmers

BIFS Program Advisory Review Board

- Conducted four Advisory Board meetings for review of projects and proposals
- Coordinated evaluation of proposals and project reviews
- Maintained regular communications with Advisory Board members
- Evaluated BIFS projects and reported to the Board

BIFS Workgroup (Workgroups are funded by the UC Division of Agriculture and Natural resources to facilitate coordination of geographically distant parties and improve campus and county cooperation on research and extension)

- Planned and organized two BIFS WG plenary meetings, August 16, 2001 and October 1,2002
- Maintained active BIFS listserv. Listserv currently has 133 members and 43 active members, 25 of whom are UC ANR staff or faculty.
- Co-wrote a research proposal to ANR that was funded for $23,359. PIs Fitzsimmons, Broome and Getz. Project funded: "Assessing the Importance of Grower Participation in Agricultural Partnerships," to support the doctoral dissertation research by Keith Warner, UCSC Environmental Studies.
- Wrote annual WG reports to the UC Division of Agriculture and Natural Resources (ANR)

Program Impact Assessment – Surveys and Pesticide Use Reporting (PUR) Analysis

- In cooperation with BIFS rice PI, developed rice survey instrument, pre-tested it and subcontracted out implementation to Ron Strochlic & Associates
- In cooperation with Walnut BIFS PI, Walnut Marketing Board, developed walnut survey instrument, pre-tested it, and subcontracted out the implementation to Ron Strochlic & Associates
- Developed and released a call for proposals for a subcontractor to perform pesticide use analysis for the BIFS program. In the fall of 2001, a contract was awarded to Dr. Minghua Zhang, with her UCD-based Agricultural Geographical Information Systems (AGIS) lab.
- Reviewed Dr. Zhang's PUR analysis for prunes, winegrapes, rice, walnuts, and apples and discussed how to refine the analysis
- Serving on steering committee for UC Pesticide Use Report (PUR) Workgroup newly formed in 2002

BIFS related presentations

- Partnerships for Sustaining California Agriculture: Profit, Environment and Community Conference. J. Broome organized and moderated the viticulture breakout session with 50 attendees. March 2001
- J. Broome guest lecturer on organic and biologically integrated farming systems in California for UCD Plant Pathology 140 class. April 2001
- J. Broome hosted visiting Korean Sustainable Agriculture Delegation. June 2001
- J. Broome invited presentation to Jiangsu Agricultural Delegation, Jiangsu, China on sustainable agriculture and organic in California. June 2001
- J. Broome presented overview of Sustainable Agriculture Research and Education in California to a Chinese delegation of 20 government and university delegates. August 2001
- J. Broome guest lecturer in Peggy LeMaux's class at UC Berkeley, Introduction to Plant Biotechnology: Frankenfoods or Nutraceuticals? The Science Behind the Issues. October 2001
- J. Broome gave an invited presentation to the Pest Management Advisory Committee (PMAC) of the Department of Pesticide Regulation on "The Biologically Integrated Farming Systems (BIFS) Program: Update and Impact Assessment." March 2002
- B. Ransom presented on "Measuring Impacts of BIFS Projects: Walnut Survey Results" at BIFS Workgroup Plenary session. October 1, 2002
- J. Broome presented at CAPCA (California Association of Pest Control Advisors), October 21, 2002, Anaheim, CA: "BIFS Program Update on Applied Research and Demonstration Projects." 250 attendees
- M. Barzman made several presentations on the BIFS program to undergraduate classes at UC Berkeley and Stanford.

Conferences, Meetings, Trainings, and Planning/Organizing

- Coordinated Agricultural Partnership Conference, March 2001
- Proposal Development Workshop for prospective applicants to BIFS, August 15, 2001

Agricultural Partnerships Conference, March 2001

On March 27-28, 2001, UC SAREP sponsored a conference on *Partnerships for Sustaining California Agriculture: Profit, Environment and Community*. UC SAREP's partners for this conference were U.S. Environmental Protection Agency (Region 9), California Department of Pesticide Regulation, California Department of Food and Agriculture, USDA Western Region Sustainable Agriculture Research and Education (SARE) program, and the Clarence E. Heller Charitable Foundation. The Almond Board of California, California Association of Winegrape Growers, California Integrated Waste Management Board, California Prune Board, Community

Alliance with Family Farmers, Lodi-Woodbridge Winegrape Commission, and the California Sustainable Agriculture Working Group were also participants.

The conference was attended by over 230 participants and highlighted innovations in agricultural production, research and extension activities that are profitable as well as environmentally friendly. BIFS projects were highlighted and profiled throughout the conference. Speakers, panel discussions, and workshops focused on efforts to implement "win-win" strategies for agricultural and environmental concerns.

Twenty percent of conference participants were farmers and ranchers, and participated as panelists in commodity-specific sessions. These included **Rick Antle** (Tanamura and Antle), **Randy Lange** (Lange Twins Inc.), **Robert LaVine** (Robert Mondavi Winery), **Craig Weakley** (Small Planet Foods), **Ed Sills** (Pleasant Grove Farms), **Bryce Lundberg** (Lundberg Family Farms), and **Dan Benedetti** (Clover Stornetta Farms). Over 40 farm advisors, specialists and other UC academics attended, and University of California panelists included advisors **Walt Bentley** and **Carolyn Pickel** from the UC Statewide IPM Project, vegetable crop specialist **Jeff Mitchell** from the Kearney Agricultural Center, **Steve Temple**, specialist in the UC Davis agronomy and range sciences department, **Joy Mench**, professor of animal science at UC Davis, and **Neal Van Alfen**, dean of the College of Agricultural and Environmental Sciences at UC Davis. Highlighting each day were keynotes by **Paul Dolan**, president of Fetzer Vineyards in Hopland, Calif., and **John Ikerd**, professor emeritus of agricultural economics at the University of Missouri.

The main goal of the conference was to increase adoption of sustainable agriculture principles and practices through cooperative partnerships. Conference co-sponsors see these partnerships and cooperation between growers, researchers, consultants and industry representatives, governmental agencies, and consumers as one of the most important building blocks of sustainable agriculture in California. A high percentage of farmers and agricultural professionals surveyed after the conference indicated that they were enthusiastic about interaction with other conference participants and that they would become involved in agricultural partnerships to either change farming practices or change recommendations to their clientele. See http://www.sarep.ucdavis.edu/events/ for more information.

BIFS Workgroup

UC SAREP together with other UC colleagues has created a BIFS Workgroup with funding from the University of California Division of Agriculture and Natural Resources to support increased cross commodity cooperation on pressing research and educational needs of California agriculture. Workgroup support funds have enabled researchers, federal and state regulators, consultants, and commodity and nonprofit organizations to share resources and ideas about how to increase the adoption of environmentally sound farming in California. In addition, the BIFS Workgroup is supporting a social science research project to look at the role that partnerships and participation play in the ability of the BIFS and BIFS-like projects to accomplish their environmental and economic objectives. There are currently 155 members of the BIFS listserv. See our BIFS web site for more information, http://www.sarep.ucdavis.edu/BIFS/workgroup.htm.

PROJECT REPORTING AND REVIEW

AB 3383, and by extension AB1998, require that the program director, in consultation with the Program Advisory Review Board, "annually review pilot demonstration projects and determine which projects shall be renewed." (Section 594. (d)). Each project submits six-month and annual reports to UC SAREP, which are reviewed by the BIFS board and UC SAREP staff. Along with the written annual reports, principal investigators (PIs) are asked to give a presentation on their project during the BIFS board meeting. After a question and answer session and discussion, the board provides feedback to project PIs on the direction of their projects and votes on which projects should receive continued funding to provide a recommendation to UC SAREP's Director.

During the last two years, four projects came to completion: Walnut, Citrus, Strawberry and Rice. The Apple BIFS and Dairy BIFS projects will conclude in March 2003. The Prune BIFS project has begun a second cycle of BIFS funding and a new winegrape project was awarded a three-year BIFS grant beginning in April 2002.

At the April 2002 BIFS board meeting, PIs from the prune, strawberry, walnut, and rice projects met with board members to summarize their projects' accomplishments and to discuss their overall assessment of the BIFS program. This provided BIFS board members and UC SAREP staff with a good opportunity to hear the perspective of project PIs on both the common and unique benefits and challenges of conducting a project using the BIFS approach. Board members agreed that this would help them to guide future BIFS projects. The Prune and new Winegrape BIFS projects were reviewed in November 2002, found to be making good progress, and their funding renewed. The board's meeting dates and projects reviewed are listed in Table 3. Comments and decisions of the BIFS Program Advisory Review Board and UC SAREP staff are officially communicated to projects through an award letter and through the BIFS Coordinator.

Table 3. Meetings of the BIFS Program Advisory Review Board

Date of meeting	Projects Reviewed
June 12, 2001	Dairy, Citrus
November 13, 2001	Apple (plus evaluation and review of new proposals)
April 17, 2002	Prune, Strawberry, Walnut, Rice (final review of ending projects)
November 20, 2002	Prune (new funding cycle); Winegrapes

CRITERIA FOR EVALUATION

To qualify for continued funding, a project must demonstrate and document continued and expanding grower participation, progress in agricultural chemical use reduction, and adoption of BIFS practices. To these ends, BIFS projects are evaluated by the board and UC SAREP staff in three basic areas:

1) an organized program of monitoring key biological, agricultural chemical, and economic variables
2) on-farm demonstrations of an innovative biologically-based farming system
3) a collaborative outreach and extension model.

These three areas build on one another. All projects collect data (#1), both for BIFS farm management and project evaluation. Some projects are more developed in implementing a well-defined, biologically integrated, production system (#2), while others are more accomplished at promoting the project with extensive outreach and extension (#3). During evaluation, it is necessary to consider the stage of development of each project.

EVALUATION OF PROJECTS

Each BIFS project is located in a different geographic area and works with a different cropping system. In general, perennial tree crops (such as prunes, walnuts, and apples) have developed a BIFS production system more quickly than the other BIFS projects working with annual crops (rice, strawberries).

BIFS program goals remain 1) increasing the adoption of reduced use/risk practices and whole farming systems, 2) reducing the use/reliance on the most environmentally damaging agricultural chemicals (pesticides and fertilizers), and 3) assessing the impacts of projects. Each project is assessed for how well it is accomplishing these goals.

The following evaluation of projects and how well they accomplished their original project goals, which generally coincide with the overall BIFS program goals, is based on 1) the BIFS board review of project annual and final reports, 2) SAREP program staff reporting to the Board on project progress, 3) survey results (when conducted), and 4) pesticide use analysis (when conducted).

The **Walnut BIFS project** successfully demonstrated the use of a biologically integrated orchard system in walnuts. This project showed that it is possible to greatly reduce the use of conventional pesticides and maintain comparable yields through the use of pheromone mating disruption technology and the use of cover crops and enhancement of natural enemies. Yields were comparable for the three years of the project (with averages ranging from 1.6 dehydrated in-shell tons per acre to 2.5). Motivation was high among growers, and outreach efforts were varied and by the third year more extensive throughout the county. However, the economics of mating disruption in walnuts using the current application technology are such that, without a price premium (for example, one that is gained through organic certification), growers will not be able to adopt the practices. Annual average codling moth management costs in conventional blocks ranged from $76 to $112 per acre. By comparison, reduced risk plots use mating disruption, and based on rough retail prices of $110 per acre per application for Isomate C+ plus application costs of $50 to $90 per acre, mating disruption costs cannot compete (Joe Grant, pers. comm.) Applications using the sprayable emulsion formulation (now available from Suterra, Inc. and 3M Corp.) averaged $7 per acre per application in project tests. Therefore, if shown to be effective in ongoing tests, these offer the prospect of achieving good control at lower costs than the hand applied products. The survey of San Joaquin County walnut growers confirmed that growers believe that mating disruption is not economical. Survey results also show that many growers were not aware that mating disruption could effectively control codling moth. This suggests that if the costs are reduced, further education on the use of mating disruption has the potential to increase its use. (See the Walnut BIFS excerpt in the next section for more details of the project).

The core focus of the **Prune IPFP/BIFS project** was reduced risk pest management but it also included innovations in water use efficiency and reductions in synthetic fertilizer use throughout the prune growing regions of California. Participating growers have eliminated their use of diazinon in the dormant season while on average 30 percent of a key county, Sutter, prune acres still receive a dormant application of this surface water contaminating organophophate. Average yields (and damage ratings) were comparable between the conventional and BIFS orchards in 1999-2000; yields were 4,387-5,139 lbs/acre compared to 4,705-4,903 lbs/acre, respectively. The use of a plant based assessment for irrigation needs (pressure bomb) enabled project growers to reduce their use of irrigation water by 40% with costs savings that will be calculated. This project involves a large number of key industry Pest Control Advisors, who through their work with clients will speed the statewide adoption of these practices. At the end of the first three-year funding cycle, it was determined that the team had made substantial progress towards establishing a series of protocols on which growers could base their pest management decisions. This project began by designing the

alternative system and is now engaging in broader implementation of these alternative practices. A cost analysis of the BIFS system will be conducted during the next funding cycle. A survey is currently being designed for this commodity in cooperation with UC IPM, UCCE, and the California Dried Plum Marketing Board. The project managers had predicted that industry-wide adoption of the BIFS prune practices will take seven to ten years. The continued BIFS support will be key in realizing that prediction. (See the Prune BIFS excerpt in the next section for more details of the project).

The **Apple BIFS project** focused on the use of mating disruption to control codling moth, the most critical pest in apple and pear production, as a means of reducing the use of organophosphate and carbamate insecticides. In 2001, pesticide use in BIFS orchards was 33 percent lower than that of the conventional comparison orchards. This represented a decrease of 27 percent from the last year these BIFS orchards were managed using conventional practices. Transitioning to the use of mating disruption in apples can be expected to take two to three years in order to reduce codling moth populations to levels low enough that mating disruption can be the primary control. During this time, growers typically need to use one to three supplemental insecticide sprays, further increasing the cost of employing a mating disruption program. In 2001, the cost of managing an orchard using mating disruption in BIFS orchards was estimated to be $357/acre, which is $158/acre more than the average costs from the conventional comparison orchards, ($199/acre). To offset these high costs during the transitional years, the Apple BIFS project provided enrolled growers a 50 percent cost share for mating disruption products. Unfortunately, the poor apple market in the last two years resulted in the removal or abandonment of many surrounding orchards, which greatly increased the codling moth pest pressure. Consequently, the project will be unable to demonstrate lowering codling moth populations to the point that mating disruption is the primary control. The project has made substantial progress in identifying and demonstrating the products and procedures to use in orchard monitoring that are necessary for the successful implementation of mating disruption. The principal investigator frequently extends this information to a statewide audience of growers and pest control advisors through presentations at meetings and conferences, and published articles in statewide trade magazines. (See the Apple BIFS excerpt in the next section for more details of the project).

The **Citrus BIFS project** went through many changes during the project. Mid-way through the project, the principal investigator and project manager changed. The citrus industry faces many challenges: new restrictions on simazine use, possible restrictions on organophosphate insecticide use, and a falling market for citrus. Despite a slow start, the Citrus BIFS project demonstrated certain biologically integrated methods of managing citrus production that are environmentally friendly and economically viable. These include the use of cover crops, reducing the size of herbicide treated areas on the orchard floor, and the use of moisture sensors for increasing irrigation efficiency. The project experienced two major obstacles: 1) The project was reorganized when the original principal investigator resigned and a new one was identified after the first year of the project, and 2) In response to September 11th attack, the project manager was called away for extended duty with the California Air National Guard two times during the third year of the project. (See the Citrus BIFS excerpt in the next section for more details of the project).

The **Dairy BIFS project** has been very successful at developing, fine tuning, and now extending a new liquid manure management system that has been shown to reduce groundwater contamination. The Dairy BIFS project has an active group of enrolled dairies and all are highly interested in using dairy waste as fertilizer and protecting groundwater. The project has determined that growers saved an average of $55 per acre and as high as $116 per acre by using the liquid manure and not applying unneeded synthetic fertilizer. Forage silage corn yield data ranged from 20 to 35 tons per acre with no significant differences between the conventional and the improved treatments. In addition, nutrient content (% N, P, and K) of harvested corn silage also show no significant differences due to

treatment. The information on comparable yields and reduction in fertilizer costs has been key in increasing the interest by other dairy and forage crop growers around the state. A survey is currently being designed for this project and dairy producers as a whole to assess current state of practices and the potential for increased adoption of these practices through greater outreach and education. (See the Dairy BIFS excerpt in the next section for more details of the project).

The **Rice BIFS project** focused on herbicide and fertilizer use reduction. Of the alternative practices demonstrated in this project, the practice of straw incorporation coupled with reduced nitrogen fertilizer application was identified as having the greatest potential for widespread adoption. BIFS sites using this practice produced yields that were similar to those sites using the standard rate of nitrogen application. Averaged across years and locations, reduced N fields yielded 88 cwt/acre compared to 85 cwt/acre in conventional fields. This project conducted several complete economic analyses of specific alternative practices; they found that for the straw incorporation and reduced nitrogen, at 2 of the 3 sites, the net return per acre was higher, ranging over the three years from -$18 to $49. The survey of rice growers confirms that growers would be willing to adopt this practice with data showing that 33 percent of respondents used this practice in 2001 on an average of 61 percent of their rice acreage. The principal investigator conducted a very comprehensive PUR analysis of county trends and used this information in its program implementation. This project successfully shared project information through a frequently updated Web site, project newsletters, field days, and presentations at conferences and other meetings. This project identified gaps in a rice biological farming system that are now being researched through six projects that range from fine tuning nitrogen management to understanding water temperature and how it influences rice yields and populations of threatened and endangered fish species. (See the Rice BIFS excerpt in the next section for more details of the project).

The **Strawberry BIFS project** evaluated several biologically based alternatives to methyl bromide, as well as alternative practices to control above ground pests such as lygus in the strawberry fields of enrolled growers. A completely integrated and effective BIFS system for growing strawberries has not yet been developed. Project results showed that several bacterial and mycorrhizal inoculants as well as weed suppressive treatments, which were tested, did not prove to be beneficial. While negative results, it is still useful information for growers to have so they do not waste dollars and time using such materials. Positive results were found in studying the impact of vacuuming trap crops with a tractor-mounted insect vacuum. This was found to significantly reduce lygus in the strawberry fields. This practice, along with others, will be included in an Organic Strawberry Production Manual that is currently being developed by project cooperators. Supplemental funding for the manual is being made available from a California Specialty Crop Block grant. (See the Strawberry BIFS excerpt in the next section for more details of the project).

The **Central Coast Vineyard Team Winegrape BIFS project**, which began in January 2002, has developed a Positive Point System that describes an integrated vineyard farming system appropriate for California's Central Coast. The point system will be used to evaluate the extent of adoption of sustainable practices being used on a participating farm as well as other farms in the three-county region. A higher score indicates more environmentally friendly management. The integrated farming system will be demonstrated at each vineyard and scores over time will be checked to measure progress. This project is building on several years of grower and grant-supported work and as such has a high chance of success. This project has strong grower support and represents a collaborative partnership of growers, wineries, farm advisors, researchers and consultants. The project has potential not only for chemical use reduction, but reducing off-site movement of soils and water. It will collect chemical use data to determine whether there is a correlation between a high score on the Positive Point System and reduced use of agricultural chemicals. (See the Winegrape BIFS excerpt in the next section for more details of the project).

Summary

The prune, walnut, and apple projects made the most progress in terms of pesticide use reduction, data collection, the development of an integrated production system, and in outreach. Prunes, walnuts, and apples are the most advanced projects, mainly because extensive background work has already been done in these, or similar crops. The pheromone mating disruption technology used in apples and walnuts to control codling moth has recently been refined and become more widely available for use. This has allowed the dramatic reduction in the use of broad-spectrum insecticides for control of codling moth.

The Dairy BIFS project was a first for the BIFS program in supporting greater integration and careful environmentally sound management of an animal production system with forage crop production. Liquid manure is a resource that can be managed through the use of the flow meters and nitrogen quick tests and can reduce the synthetic fertilizer bill for forage crop production. The development and extension of the BIFS dairy system is going to be used in educational programs to assist California dairies in complying with new regulations in protecting water quality. It has played a key role in supporting the development of farming system that will enable dairy producers to more easily understand and complete their Comprehensive Nutrient Management Plans that will be required of all dairy producers by 2006. These regulations were finalized in December 2002.

While farmer-to-farmer techniques and hands-on fields days are important parts of the BIFS approach, written documentation is also key to reach those farther away from the actual demonstration projects. The walnut, prune, rice, and dairy projects developed newsletters that communicate to a larger audience the practices and results of their projects (see attachments C & D for examples). In addition, the prune, rice, dairy and winegrape projects have created web sites that provide timely information on program developments (see http://dairybifs.uckac.edu; http://www.agresearch.nu/ipfp.htm, http://www.buttecounty.net.htm, www.vineyardteam.org, http://www.lodiwine.com). In addition, key peer-reviewed publications have been produced by the BIFS projects and include a recent publication by Andrews et al. 2002 (see attachment E), which describes the development of a new tool for assessing soil quality for cotton on the San Joaquin County's west side. This publication is of interest to other academics as it uses multivariate statistical techniques to quantify something of great interest to growers, how alternative practices affect their soils, yields and quality.

The BIFS projects generally excel at developing and refining the alternative farming practices, and are increasing their efforts to encourage statewide adoption. BIFS projects with the best collaborative extension programs are locally based to maximize effectiveness, but this can leave non-BIFS counties without access to the new techniques developed by the BIFS projects. To make the most of the successful projects that just completed their third year, UC SAREP was able to successfully compete for new federal block grant funds through the California Department of Food and Agriculture to build on four of the BIFS projects ($100,000 for two years). However, additional funds are still needed to truly implement the current BIFS environmentally sound and economically viable practices on a statewide level, and to extend this approach to the hundreds of other commodities in California.

MODIFIED EXCERPTS FROM ANNUAL REPORTS

MODIFIED EXCERPTS FROM
WALNUT BIFS—YEAR-END AND FINAL REPORT, FEBRUARY 15, 2002

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Introduction

California produces 99 percent of the walnuts grown in the United States and 38 percent of the world's walnuts. Over 40 percent of the California crop is currently exported. More than 15 walnut varieties are grown commercially; numerous other varieties are planted on a smaller scale. Sacramento and San Joaquin valleys lead California counties in walnut production and San Joaquin County alone comprises about 20 percent of the total walnut production acres.

Walnut pest and disease pressures impact both the farming economy and the environment. These vary from region to region depending on soil, climate, presence of natural enemies, chemical resistance, pesticide application, availability of effective pest control measures and the knowledge to use them. Historically, these problems have been treated chemically. Impending impacts of the 1996 Food Quality Protection Act, concerns over surface and groundwater contamination, and escalating costs and uncertainties of chemical control have heightened the urgency of efforts to find effective and cost-efficient ways of producing walnuts with minimal use of pesticides, herbicides, and synthetic fertilizers.

Walnut varieties vary in susceptibility to diseases, nematodes and insect pests. Codling moth is the key insect pest and growers typically apply one to three treatments of organophosphate insecticides annually on certain varieties. Feeding by codling moth larvae causes direct damage to developing nuts, and also predisposes them to navel orangeworm and mold infestation. Chemical treatments for codling moth are also generally disruptive to the biological control of aphids and mites. Therefore, additional treatments are often used for these pests where broad-spectrum insecticides are applied. Organophosphate insecticides account for approximately 65 percent of insecticide use in walnuts, and much of this is for codling moth suppression.

Like codling moth, navel orange worm (NOW) and walnut husk fly attack nuts directly. To suppress NOW, broad-spectrum insecticides are frequently used, causing secondary pest outbreaks. Broad-spectrum insecticides are also applied for walnut husk fly, but they are not as disruptive because they are applied later in the season.

Overuse of nitrogen fertilizers is another environmental concern. Nitrogen fertilizers are applied to walnut orchards for growth and production needs. Application of around 100 pounds of nitrogen per acre is considered sufficient. However, most walnut orchards are fertilized at rates that exceed this guideline. Tools for assessing nitrogen fertilizer needs such as nitrogen budgeting and leaf tissue analysis are rarely used, even though widely promoted and fairly well understood by growers and fertilizer sales personnel. Reducing supplemental nitrogen applications to levels more consistent with actual demand would save growers money and reduce the potential for leaching and groundwater degradation.

BIOS for Walnuts in the San Joaquin Valley

The Biologically Integrated Orchard Systems (BIOS) approach is holistic, combining biologically intensive farming practices with a hands-on, farmer-to-farmer educational model. It seeks to reduce pesticide use and improve yield and quality through soil building, intensive field monitoring, biological control, and beneficial insect habitat enhancement to control pests. Using a collaborative management team and outreach model, it brings together growers, PCAs, pest management professionals, researchers and extension personnel, government agencies and other agricultural community groups to find solutions to common problems and implement ecologically and economically sustainable farming methods. The UC SAREP-funded walnut BIOS project, implemented from 1998 through 2001, aimed to adapt and extend the model initiated by the Community Alliance with Family Farmers (CAFF) in Yolo and Solano counties to fit the biological, economic, and infrastructure conditions of the walnut farming industry in the northern San Joaquin Valley.

Key accomplishments

In the first year, 1998-1999, a management team was organized and established the infrastructure to accomplish project objectives. By 2000, twelve growers enrolled in the program and allocated a portion of their acreage to BIOS demonstration blocks. The management team provided technical guidance to project growers and PCAs throughout the life of the project. An intensive monitoring program was developed to guide orchard management decision-making and provide information for assessing the effectiveness of BIOS practices. In addition, the project:

- greatly reduced the use of conventional pesticides in BIOS blocks. Successfully pioneered the use of pheromone mating disruption for controlling codling moth.
- successfully controlled codling moth and other key pests in BIOS blocks using a combination of innovative biological practices.
- developed key information on effective implementation of pheromone mating disruption technology in walnuts.
- developed effective and productive collaborative relationships with other research and implementation projects designed for farming walnuts in a biologically integrated context. These relationships benefit project growers directly and contribute to the overall effort to develop reduced-risk practices for growing walnuts.
- implemented a dynamic, proactive and relevant program of grower outreach, including ten educational workshops and field days, newsletters, one-on-one consultations, and nut trade press coverage to extend knowledge of alternative farming practices broadly to Central Valley walnut growers.

Walnut BIOS Alternative Farming Practices

A number of farm management practices comprise a BIOS approach. In this project, the key practices of the BIOS approach were contrasted with their conventional counterparts over a three-year period, 1998—2001 (Table 1).

Table 1. Conventional and BIOS alternative practices for managing key elements of walnut orchard systems in central California (Appears as Table 5 in Walnut BIFS Final Report, March 2002)

Orchard management issue	Conventional system	BIOS alternative
Pest management		
Codling moth	1 to 3 spray applications per season of chlorpyrifos, azinphos-methyl, methyl	Pheromone mating disruption and sprays of non-disruptive

	parathion, esfenvalerate, tebufenozide; spray timing based on insect phenology.	insecticides; tactics combined on case-by-case basis and crop damage to determine need for time, sprays.
Navel orangeworm	Winter sanitation of mummy nuts (overwintering larvae), prompt harvest, late-season insecticide sprays.	Sanitation, prompt harvest, emphasize reducing sources of predisposing damage (sunburn, codling moth, blight) by sound management.
Walnut husk fly	Full coverage insecticide + bait sprays based on presence and phenology of adult flies as determined by trapping.	Alternate row and/or low canopy insecticide + bait sprays; spray decision based on trapping and phenology of gravid female flies.
Walnut aphid Dusky-veined aphid	Sprays of diazinon, chlorpyrifos, or endosulfan; treatment thresholds poorly documented and/or utilized.	Reduce use of disruptive codling moth insecticides and navel orangeworm to promote parasitoid abundance and activity; vigorous orchard monitoring to assess need for control; cover crops to promote generalist predators.
Two-spotted mite European red mite	Miticide sprays based on pest abundance; treatment thresholds poorly understood/utilized.	Intensive population monitoring; limited use of disruptive insecticides for codling moth and navel orangeworm, cover crop and/or insectary plantings to promote generalist predator abundance.
Orchard Floor Management & Fertility		
Nitrogen fertilizers	Annual applications of 100 to 400 pounds soluble N fertilizer per acre.	Nitrogen budgeting to rationalize N applications; leaf tissue analysis to monitor N status and adjust N application rates; cover crops to supply part or all of N need.
Weed control	Combination pre- and post-emergence herbicides in bands along tree rows; herbicide selection per weed surveys.	Cover crops to suppress unwanted vegetation; minimize herbicide band width; emphasize post- over pre-emergence materials.
Soil condition		
Orchard pruning disposal	Burn	Chip or shred; spread on orchard floor.
Orchard middles management	Resident vegetation, disked or mowed to minimize competition with trees for water nutrients.	Cover crops to suppress unwanted vegetation; increase soil tilth and water infiltration; adjust irrigation and other management practices to avoid competition with trees.
Habitat restoration & enhancement	None	Brush piles for bird habitat; owl and/or bat nesting boxes; annual or perennial insectary plantings on farm borders or waste areas.

Alternative pest management practices

Codling moth is the key insect pest of walnuts and as such, has been a major focus of the project's efforts. Not only does codling moth damage have economic consequences for growers, but it also predisposes nuts to other types of damage that require further chemical treatment. The approach to managing codling moth was three-pronged:

1. use of alternatives to conventional insecticides, including pheromone mating disruption and releases of *Trichogramma platneri* and other codling moth parasitoids
2. intensive monitoring of orchards to determine pest thresholds and inform pest management decisions
3. use of non-disruptive insecticides as an alternative to organophosphate insecticides

Pheromone mating disruption

The BIFS project experimented with several types of pheromone mating disruption, making it the largest scale testing in walnuts to date of pheromone mating disruption products. Different technologies for codling moth mating disruption had different results (see below). Overall, all BIOS blocks showed consistently low numbers of codling moth during the three years of the project.

Previously, pheromone mating disruption for codling moth was not considered economically feasible in walnuts because of the high cost of pheromones and the large tree size and air volume needing to be permeated with pheromone for effective mating suppression. However, new products, such as Isomate C+, pheromone dispensers (puffers), and sprayable pheromone formulations, promise more success.

Low trap catches in pheromone mating disruption BIOS blocks indicated that mating was suppressed by all four mating disruption dispensing technologies, though they differed in longevity and in the amount of occasional "breakthrough" captures of male moths. Furthermore, low damage levels were reported. Results of dropped nut counts showed low levels of early season codling moth damage in all blocks. Overall, damage levels reported in growers' commercial grade returns did not exceed the five percent threshold, which triggers a reduction in grade.

Ongoing research is needed to refine these technologies and to determine their long-term efficacy. As an outcome of this project, the California Walnut Marketing Board, Walnut Pest Management Alliance and others have expanded their research efforts aimed at evaluating sprayable and microsprayer pheromone formulations in walnuts. Also, the Center for Agricultural Partnerships (Ashville, NC) initiated a three-year privately funded mating disruption implementation project whose goal is to bring 25,000 acres of walnuts under mating disruption by 2004. The demonstration work from the BIOS project was a catalyst for these efforts. Taken together, they should help accelerate the development of this critical technology in walnuts.

Enhancement of natural enemies is an integral part of the BIOS approach. The field scout noted the presence of general predators during weekly monitoring visits. Seasonal compilation of these showed that predators were generally more prevalent in BIOS than conventional blocks (Table 2). Lady beetles and syrphid flies were significantly more abundant in one of the three project years. Lacewings, an effective general predator of mites and aphids, were more prevalent in BIOS blocks in all years.

Table 2. Seasonal average number of generalist predator observations in BIOS and conventional blocks[1]

(Modified from Table 16 in Walnut BIFS Final Report, March 2002)

	1999	**2000**	**2001**
BIOS	28.3	37.5	25.6
Conv.	18.7	26.9	15.9
P	0.003	0.001	0.002

[1]Only sites with paired BIOS and conventional blocks were used for comparison

Monitoring program
In order to reduce the number of applications of organophosphate insecticides, the management team, in collaboration with growers and other experts, developed a comprehensive monitoring program. A project field scout performed weekly monitoring of key pests in BIOS and conventionally managed comparison blocks from March through October of each year. The scout also made observations on other relevant aspects of orchard development during monitoring visits, including crop development, cover crop growth and beneficial insect activity. Each week, the field scout delivered the collected data to the growers or their PCAs and discussed alternative treatments based on the data. Growers' pesticide use records for BIOS and conventional blocks show that their successes in managing key walnut pests in BIOS blocks were achieved while using few or no conventional pesticides (Table 3).

Table 3. Treatments applied for key pests in walnut BIOS and conventional blocks, 2001. Rates (pounds active ingredient per acre) follow chemical names. Block codes are identified in parentheses. (This table is modified from the original, which appears as Table 22 in Walnut BIFS Year End Report, Feb 2002)

Type of Block	Codling moth	Aphids Dusky-veined or Walnut aphid	mites Two-spotted or European red	Walnut Husk Fly
BIOS	(A-L) Pheromone mating disruption (J) phosmet 4.5 + chlorpyrifos 1.1	(B) chlorpyrifos 0.5; naled 0.94 (G) oxydemeton-methyl 0.5 (H) chlorpyrifos 0.5	(B) clofentezine 0.072 (H) propargite 1.0 (J) fenbutatin-oxide 0.25 (K) propargite 2.25 (L) propargite 1.2	(E) phosmet 0.4; chlorpyrifos 0.6 (F) phosmet 2.1 (I) chlorpyrifos 2.0
CONV.	(A) diflubenzuron 0.50 + chlorpyrifos 2.0 + phosmet 3.5 (C) chlorpyrifos 3.5 + tebufenozide 0.25 (D) chlorpyrifos 2.0 (E) phosmet 0.6 (G) methyl parathion 2.0 (K) chlorpyrifos, 4.0 (L) phosmet 2.8	(B) esfenvalerate 0.02; naled, 0.94 (G) oxydemeton-methyl, 0.5	(A) propargite 1.5 (B) clofentezine 0.072 (C) propargite 1.5 (D) propargite 3.0 (G) propargite 2.5 (K) propargite 2.25 (L) propargite 1.2	(E) phosmet 0.35

Cover crops, orchard floor and fertility management
Use of cover crops to improve soil structure, fertility, biological diversity and water penetration is a key component of the BIOS approach. Each orchard had unique site and cultural features, as well as management objectives that shaped growers' choice of a cover crop. Most growers chose either a perennial grass and clover sod, a low-growing mix of annual legumes and grasses, or a more traditional "high biomass" mixture of legumes and grasses that is mowed or incorporated in spring. Growers reported a range of perceived benefits, including improved water penetration, reduced need for mowing, and increased abundance of generalist predators in their orchards.

To control weeds, growers traditionally use broadcast applications of herbicides based on calendar schedules. Conventional orchard floor management consists of using pre- and post-emergence herbicides to completely eliminate vegetation in eight to twelve foot bands along tree rows. For the BIOS project, growers were encouraged to use narrower herbicide-treated strips in BIOS blocks, replace nonselective pre-emergence materials with post-emergence herbicides, and use spot treatments where feasible.

By the third year of the project, most growers reported using narrower herbicide treated strips in tree rows in both BIOS and conventional blocks. During the project, one grower successfully transitioned to a program consisting entirely of narrow band post-emergence treatments, while another used only post-emergence materials in both BIOS and conventional blocks.

New tools for assessing fertilizer needs, such as leaf sampling and nitrogen budgeting, were emphasized in this project and data from application rates show a reduction in pounds of N applied from 1998 to 2001 (Table 4). In cases where leaf samples indicated that nitrogen levels were greater than considered sufficient for walnuts (2.6 percent), the project worked with growers to use a nitrogen budgeting approach and modify their nitrogen fertilizer applications accordingly. Year to year changes in nitrogen fertilizer rates and the results of leaf nitrogen analyses suggest that seven of the twelve growers attempted to manage tree nitrogen status in BIOS blocks by modulating their nitrogen fertilizer applications.

Comment [MB1]: Did growers use the worksheet?

Table 4. Average nitrogen fertilizer use and leaf nitrogen concentration for BIOS and conventional blocks, 1998-2001 (Appears as Table 20 in the Walnut BIFS Final Report, March 2002)

	Pounds fertilizer N applied				Leaf % N			
	1998	**1999**	**2000**	**2001**	**1998**	**1999**	**2000**	**2001**
BIOS blocks	176	171	93	123	ND[1]	2.9	2.7	2.9
Conventional blocks	181	177	88	133	ND	3.0	2.6	2.9
P	*0.36*	*0.18*	*0.35*	*0.35*		*0.84*	*0.12*	*0.90*

[1]Leaf analyses not done in 1998. The project began in 1999.
P = probability of significant F ratio, based on one -way analyses of variance within project years using individual project sites as replications (n=6 to 8, depending on the year) and BIOS and conventional management as treatments. Averages from BIOS and conventional blocks are considered significantly different when *P* is less than or equal to 0.05.

Comment [MB2]: Pre-project? If so, we should indicate that

Comment [MB3]: Why did it go up in 2001?

Walnut Yields and Quality

Information on farming practices and yields was obtained from year-end questionnaires completed for BIOS and conventional blocks by all growers. Nut quality was evaluated using harvest samples collected when trees were shaken for commercial harvest. Yield and quality data were also obtained after harvest from growers' grade results for loads delivered to commercial handlers from BIOS and conventional blocks. Over three years, yields were comparable in BIOS and conventionally managed comparison blocks (Table 5).

Table 5. Average harvest yield (dehydrated in-shell tons per acre) and nut quality for samples drawn from commercial deliveries from BIOS and conventional blocks[1, 2]
(Appears as Table 10 in Walnut BIFS Final Report, March 2002)

	Block	Yield	% Insect	% Large sound	% Offgrade	% Edible yield	RLI[3]
1999	**BIOS**	2.2	0.7	76.1	5.7	45.2	53.1
	Conv.	2.5	0.3	71.4	4.6	45.6	53.1
	P[4]	*0.29*	*0.42*	*0.27*	*0.62*	*0.79*	*0.94*
2000	**BIOS**	1.6	2.0	81.5	5.4	43.8	49.9
	Conv.	1.6	1.0	77.3	4.4	44.1	50.2
	P		*0.33*	*0.31*	*0.19*	*0.58*	*0.35*
2001	**BIOS**	2.0	0.5	86.2	1.7	50.9	50.9
	Conv.	1.9	0.3	83.7	1.9	48.7	51.6
	P	*0.88*	*0.36*	*0.37*	*0.78*	*0.39*	*0.17*

[1]Only sites with paired BIOS and conventional blocks were used for comparison
[2]Grading performed by Diamond Walnut Growers
[3]Relative Light Index, a measure of kernel color; higher numbers mean lighter color.
[4]In this and all tables, *P* = probability of significant F ratio, based one -way analyses of variance within project years using individual project sites as replications (n=6 to 8, depending on the year) and BIOS and conventional management as treatments. Averages are considered significantly different when *P* is less than or equal to 0.05.

Pesticide Use

Growers' pesticide use records for BIOS and conventional blocks show that our successes in managing key walnut pests in BIOS blocks were achieved while using few conventional pesticides (Figure 1).

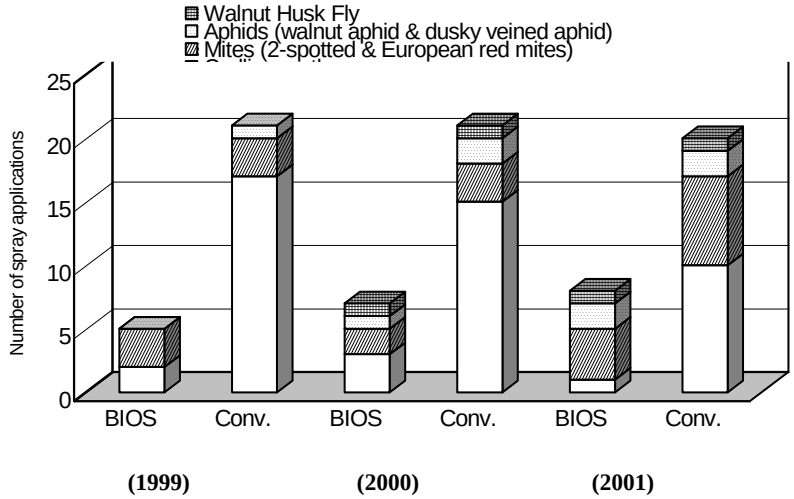

Figure 1. Number and type of annual pesticide treatments applied in BIOS and conventional blocks. (Only sites with paired BIOS and conventional blocks were used for comparison.) (Appears as Figure 3 in Walnut BIFS Final Report, March 2002)

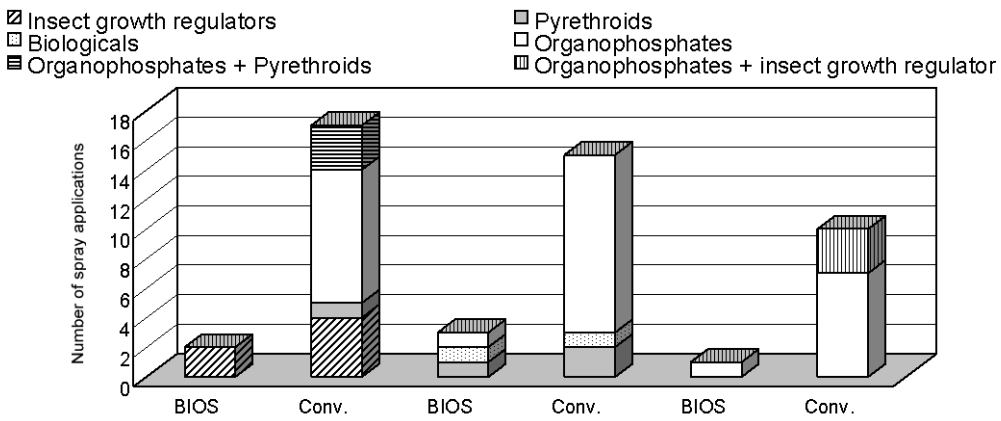

Figure 2. Number and type of annual insecticide treatments for codling moth applied in BIOS and conventional blocks. (Only sites with paired BIOS and conventional blocks were used for comparison.) (Appears as Figure 4 in Walnut BIFS Final Report, March 2002)

Replacing codling moth insecticide sprays with mating disruption accounted for most of the differences between BIOS and conventional blocks (Figure 2).

Barriers to Adoption of Mating Disruption in Walnuts

The biggest current obstacle to promotion and broader use of the alternative codling moth strategies is the experimental nature of the pheromone mating disruption products. For example, the pheromone emulsion used in the project is not likely to be registered for use in California. We are committed to continued testing if the product remains available and has potential for eventual registration. Isomate C+®, though very effective at all project sites, has not been widely tested in walnuts, and the manufacturer has not aggressively pursued development opportunities in walnuts. The BIOS walnut project represents the largest scale testing to date in walnuts. Project coordinators remain in close contact with representatives of Pacific Biocontrol and have encouraged them to expand their research and development efforts in walnuts.

BIOS for Walnuts Outreach and Extension

The primary emphasis in the project's outreach efforts has been on building project expertise and implementing the BIOS farming practices in project orchards. We have worked diligently throughout the three-year term of this project to foster a spirit of well-informed and proactive collaboration among project growers, PCAs, and implementation team members.

Three field workshops were conducted in 2000; a total of ten were held during the three-year term of the project. Typically, these workshops were designed to provide growers with technical information and assistance in implementing alternative management practices. Popular topics included pheromone mating disruption for codling moths in walnuts; pest and beneficial insect monitoring techniques; demonstrations of canopy damage assessment methods for in-season monitoring; nitrogen

budgeting for determining fertilizer needs; cover cropping as an alternative soil building practice; proper tree planting techniques and new information on crown gall biology; chipping and shredding as an alternative to burning.

Flyers publicizing these events were sent to around 2,600 individuals on combined CAFF and UC Cooperative Extension mailing lists targeting Central San Joaquin Valley walnut growers. We are pleased at the large turnouts and interest these events have generated.

In response to an outreach team recommendation, we began holding periodic informal grower "breakfast" meetings this season. Project growers had expressed an interest in seeing other growers' BIOS blocks and having opportunities to interact. Beginning in February, we held four such meetings this season, approximately on a monthly basis. Attendance has varied from four to seven growers and PCAs, and meetings have lasted from one to two hours depending on content and time constraints.

During the project, we collaborated with CAFF to publish a monthly *BIOS Field Notes* newsletter for growers and other clientele. News and information from our project were a regular feature of this newsletter, which was circulated to 250 growers, PCAs, and other readers in eight California counties. The newsletter was discontinued in 2000 due to budget constraints at CAFF. In 2001, we collaborated with CAFF in the publication of a joint newsletter, *Walnut BIOS Notes* (see Attachment C). Four issues were published and mailed to 360 walnut growers and allied agribusiness clientele. Most of this circulation was in the northern San Joaquin Valley.

Project Evaluation

In Fall 1999 and again in 2001, we asked project growers to complete written surveys to evaluate various aspects of the project, including usefulness of technical support they received from the implementation team, farm management plans, and orchard visits, the value and utility of monitoring information supplied by the field scout, and impacts of their involvement in the project on management of blocks other than those enrolled in the project. Growers reported many benefits of participating in the BIOS program: a reduction of fertilizer use; finding better ways of dealing with insect pests; increased knowledge of beneficial insects and trap counts; reductions in spraying costs; better community relations because of urban proximity; better working conditions for employees because of less organophosphate use; good opportunities for comparison to conventional practices. All growers surveyed reported that they would recommend the BIOS program to other farmers or PCAs.

MODIFIED EXCERPTS FROM:
PRUNE BIFS—FINAL REPORT 1999-2001, MARCH 1, 2002

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Introduction

The California Dried Plum Board is a State Marketing Order that represents the 1,400 growers and 21 packers of California prunes. California produces about 200,000 dried tons annually on 81,000 bearing acres. California prune production represents 99 percent of the US total and about 70 percent of the world total. The annual crop value is approximately $200 million.

Economics and regulations are creating change in the way prunes are farmed. The cost of farming is going up and the industry is experiencing problems with over-production. Federal acts, such as the Federal Clean Air Act, Federal Food Quality Protection Act and California's Proposition 65 and 204 dealing with water quality, establish expiration dates and/or threaten the continued use of many pesticides. Regulations established by California Department of Pesticide Regulation (DPR) have created new requirements and certification for application of pesticides. Misuse of natural resources is becoming a common environmental concern.

To adjust to current economics and regulations, alternative low environmental risk practices need to be researched and results demonstrated and implemented. Economic thresholds and monitoring techniques need to be discovered so that pesticide use can be safely reduced, or at least used in a timely fashion when needed. Improved uses of water and other inputs that do not interfere with prune production also need to be researched and demonstrated. The Integrated Prune Farming Practices/BIFS project was established to address these concerns.

IPFP/BIFS project objectives include:

- developing economic thresholds, monitoring techniques, and implement alternative pest control strategies that reduce use of conventional biocides
- demonstrating more effective use of fertilizers and natural resources
- encouraging adoption of reduced risk practices through outreach and extension efforts

Project Infrastructure

The IPFP/BIFS project was conducted on up to 33 prune farms in Tulare, Madera, Fresno, Yolo, Sutter, Yuba, Butte, Glenn and Tehama counties. These sites were chosen to best represent the prune industry in California. In most of these orchards, the project conducted comparisons between a conventional and a "reduced-risk" system. In nine orchards, the comparison was not feasible because participating growers had converted the entire project acreage to reduced-risk practices. Monitoring at these sites was conducted by project field scouts. In addition to grower sites there were also eight sites monitored by PCAs who used management protocols developed specifically for PCAs. Throughout the project, growers provided feedback and made suggestions on how to improve the

program. PCAs and UC researchers provided guidance and input, as well as helped to validate protocols.

Comparison of conventional and BIFS alternative practices

To ensure that growers make well informed, consistent treatment decisions, the project focused on developing protocols for economic thresholds and reliable monitoring techniques (Table 1).

Table 1. Comparison of conventional and BIFS alternative practices
(Extracted from the narrative in the IPFP/BIFS Final Report, March 2002)

Conventional Practice Used	BIFS Alternative Practice Demonstrated
Annual dormant insecticide treatment	Dormant spray decision guide, spring prune aphid monitoring/ reduced risk oil treatment
Annual dormant; annual worm spray	Pheromone trap monitoring for San Jose Scale and Parasitoids
Annual in-season sulfur spray	Prune rust monitoring
Prophylactic mite spray, spray based on visible damage or calendar date	Monitoring for presence/absence of mites/predators, 5-minute search for mites
Prophylactic brown rot spray	Brown rot predictive model
Irrigation timing based on soil moisture measurements, timing of other orchard practices, or calendar schedule	Tree water status to schedule irrigation
Fertilizer needs estimated without leaf and water analysis	Leaf and water analysis to determine fertilization needs

Goal I. Develop economic thresholds, monitoring techniques and alternative pest control strategies to reduce the use of conventional biocides.

Dormant treatment decision guide

Prior to introducing the BIFS approach, prune growers had no way of knowing if they needed to apply a dormant insecticide and oil spray. Traditionally, they applied an annual dormant spray because they have been taught that dormant sprays kill a number of pests (including San Jose Scale (SJS), peach twig borer, European Red Mite (ERM), mealy plum aphid and leaf curl plum aphid), and that it is less harmful to beneficial insects than conventional in-season treatments.

Many prune growers also apply a dormant spray because there is no reliable reduced-risk alternative for controlling high populations of prune aphids. However, recently the dormant spray has been implicated in environmental pollution. These findings suggested that the dormant insecticide spray is being overused. To address this problem, the IPFP/BIFS team developed a monitoring technique to help growers decide to apply a dormant insecticide treatment only when pest and beneficial populations warrant it.

The dormant treatment decision guide developed in 2001 accurately predicted whether or not an orchard needed to be treated for Mealy Plum Aphid (MPA), Leaf Curl Plum Aphid (LCPA), SJS and/or EFL. By using this guide in 2001, we found that

- 78.3 percent of the project orchards did not have an aphid problem and did not need a dormant insecticide and/or oil treatment for aphids.
- 82.6 percent of the orchards did not need treatment for SJS.
- Overall 60.9 percent of the orchards did not need to apply a dormant insecticide for either scale or aphids.

As the distribution of project orchards was intended to represent the California prune industry, we can speculate that not treating 60.78 percent of the bearing prune orchards with a dormant insecticide and oil spray would result in a reduction of 156,812 lbs. a.i. of pesticide (based on all bearing acreage receiving a dormant spray of diazinon at the recommended label rate). Clearly a "Dormant Treatment Decision Guide" such as the one developed by the IPFP team is very useful in making dormant treatment decisions.

Pheromone Traps to Aid with Treatment Decisions

Pheromone traps have long been available but are generally underutilized by prune growers making treatment decisions. Most commonly, they are used to help determine treatment timing. In some cases, they are also used to assess the presence of beneficial insects. Rarely have they been shown to be useful or have they been used to help determine whether or not a treatment is needed. Information of this type could be useful to prune growers who may need to treat against Peach twig borer, Oblique Banded Leaf Roller or San Jose Scale.

a. San Jose Scale (SJS)

The results showed that SJS traps are good indicators of scale and scale parasite presence in the orchard. The traps showed that beneficial SJS parasitoids were more abundant in reduced-risk and check plots where dormant insecticides had not been applied for three or more years. By comparison, dormant insecticide with oil treatments in conventional plots reduced the populations of SJS parasitoids. The traps also showed that the reduced risk approach against SJS is viable.

b. Peach twig borer (PTB*)*

The results show that fruit monitoring based on a PTB biofix using pheromone traps was a useful tool in determining treatment necessity and timing in 2001. However, more research on this method will need to be conducted.

c. Oblique Banded Leaf Roller (OBLR)

Fruit monitoring based on an OBLR biofix, using pheromone traps can be a useful tool in determining treatment necessity and timing. However, more research on this method will need to be conducted.

Spring Prune Aphid Monitoring

With a reduced reliance on dormant insecticide and oil treatments, there is an increased need for in-season monitoring of aphid populations to determine if treatments are needed.

The protocol developed by the IPFP team (Protocol #6 "sequential sampling technique for aphids") was as accurate as and quicker than the more traditional monitoring approach. Using this new sequential sampling technique for presence of aphids gave a good indication of when, and if, a treatment was needed. Of all orchards <u>not</u> receiving a dormant spray, only 8.7 percent needed an in-season insecticide treatment for aphids in 2001, compared to 42 percent of the orchards in 2000 and 45 percent in 1999. According to this information, applying an in-season aphid spray, as opposed to the traditional annual dormant spray, would have resulted in 235,554 lbs. a.i. less pesticide being applied (based on applying diazinon at the recommended label rate to all bearing prune acreage) in 2001.

Prune Rust Monitoring and Treatment Timing Recommendations
Rust is the most common pest treated during the growing season. Prior to the project, growers had no way to monitor prune rust. Most growers simply apply one or more protective wettable sulfur treatments in May, June and/or July following rain.

The prune rust monitoring protocol developed by the project is simple and takes one person less than 30 minutes to evaluate an orchard. Results from this technique suggest that rust monitoring and rust treatments can be eliminated four to six weeks before harvest. The project estimates that had all prune growers followed this rust monitoring program in 2001, they would have saved 1,565,200 pounds of pesticide applied (based on all bearing prune acreage receiving one sulfur application for rust at 20 lbs./acre).

Presence-absence sequential sampling for web-spinning mites
Prunes are occasionally infested by web-spinning mites and require an in-season treatment. There are no established treatment thresholds for web-spinning mites in prunes. Pest control advisors often use subjective or unclear criteria when determining need for mite treatment. When growers make their own treatment decisions it is generally based on visible damage or on calendar date. This is often too late, too early, or unneeded. A presence-absence web-spinning mite monitoring technique originally developed for almonds was tested and modified for use on prunes.

The IPFP/BIFS team is refining the protocol based on the presence-absence sequential sampling of mites for prunes. Further evaluation of the treatment threshold is still needed and the time it takes to monitor also needs to be shortened to accommodate the needs of PCAs. Nevertheless, preliminary results already show that this monitoring technique is a useful method of determining the need for treatment and will reduce the likelihood of treating without justification.

Five-Minute Search for Web spinning Mites Technique
Few PCAs will use the presence-absence technique because it is too time consuming. A "5-minute search" monitoring technique, similar to what PCAs already use, was evaluated in 2001 and results compared with presence-absence technique to determine if any correlation between the two could be made. No treatment decisions were made based on the new technique this past year.

It was determined that the "5-minute search" monitoring technique could be an accurate time saving monitoring technique to determine whether or not a treatment is needed for web spinning mites. The "5-minute search" requires more training and experience than presence-absence. One reason the correlation is not better was human judgment. One person's "low" could be considered another person's moderate. In order to reduce this variability, guidelines will be needed to define what exactly low, moderate, etc., are. Training people in the techniques of scouting orchards will be more extensive next year.

Fruit Brown Rot Predictive Model (ONFIT)
There is currently no way of knowing if fruit brown rot will occur. Consequently, growers have been spraying pre-harvest for fruit brown rot based on a suspicion that it will occur. UC Plant Pathologist Themis Michalaides has created a technique to determine presence of fruit brown rot from latent infections that needs to be validated. The technique is called Over Night Freezing/Incubation Technique (ONFIT).

The ONFIT technique needs to be evaluated under more severe conditions before it can be relied upon. This monitoring technique could provide valuable guidance about the need for a fruit brown rot spray. More research and evaluation of the ONFIT during years of higher brown rot will need to be conducted before any definite conclusions can be made.

Goal II. More Effective Use of Fertilizers and Natural Resources

Using tissue analysis and water samples
Although tissue analysis has been recommended for many years it is an underutilized tool in determining fertilization needs. Water analyses are also valuable; some wells have nitrate nitrogen in their water. Knowledge of nitrogen (N) content of the water could be used by growers to supplement conventional N fertilizer programs. To promote the adoption of these valuable monitoring tools, IPFP/BIFS sought to demonstrate their utility to growers.

Based on UC-established critical mid-summer leaf tissue levels, almost half of the sites in 2001 were deficient in N and a few sites had zinc levels below the recommended level. Nitrogen levels had declined since 1999. In 1999, 20 percent of the sites were N deficient, in 2000 five percent of the sites were N deficient and in 2001 48.5 percent of the sites were N deficient. The advisors involved at these sites will work with their cooperators to determine fertilizer strategies based on these data.

Water samples did indicate several wells with significant levels of nitrate nitrogen. The high nitrate levels were considered when making fertilizer recommendations in the reduced risk plots. These tissue and water analysis have provided useful information and are proving to be valuable tools.

Early leaf analysis to forecast the need of a Potassium (K) fertilizer application
Established guidelines for adequate leaf K levels in prunes are available using July leaf tissue samples. However, if a deficiency is present at that time, detrimental effects to production of the crop may have already occurred. Limited research has been done on using early leaf tissue samples to predict the need for potassium applications. This year (2001), the early leaf tissue sampling for K was compared to the July leaf sample in all of the research and implementation orchards.

Based on the early leaf tissue samples taken in May, no fertilizer applications were recommended and no sites were found deficient in leaf K in July. Also, no sites showed any visual symptoms of K deficiency in June. However, two sites in July and eleven sites in August had visual symptoms of K deficiency.

Irrigation management
Previous research has determined that reducing irrigation (typically 40 percent) in mid-season, and allowing mild stress to occur has no negative economic effect on production or quality. Reducing irrigation saves money and water, reduces pesticide runoff and results in a lower dry away ratio. In order to achieve the goal of reduced irrigation and maximum economic productivity, the project utilized a monitoring technique that determines tree-water status (midday stem water potential or SWP) and evaluates stress using a "pump up" pressure chamber.

Most growers who began with comparison plots of reduced risk and conventional irrigation have adopted the reduced risk irrigation monitoring strategy on their conventional blocks, indicating they have recognized benefits of this approach to irrigation scheduling. Other growers reported unanticipated horticultural benefits of this practice, for instance the suppression of an undesirable and often chlorotic flush of shoot growth in the fall, presumably the result of over-irrigation. The fact that many growers have matched the reduced risk target SWP over the season indicates that the reduced risk monitoring technique is practical and achievable over a range of soil and orchard conditions.

This part of the project has become increasingly popular with growers because using the pressure chamber to schedule irrigations can potentially save them money by applying less water.

Yield and quality at harvest
Based on data obtained from the 1999 and 2000 P-1 grade sheets (Table 2), as well as 2001 Dried Fruit Association quality data, no adverse effects were seen in the reduced-risk program as compared to the conventional program.

Table 2. 1999 and 2000 Yields and quality of prunes in the IPFP reduced risk plots as compared to the conventionally managed plots. (Modified from Table 20 and 21 in Prune BIFS Final Report, March 2002.)

Year	Farming System	Yield (lbs/acre)	Average Count per Pound	Dry Away	% ABC screen	% ABC Offgrade screen
2000	Reduced Risk	4903.07	57.50	3.22	91.60	1.54
2000	Conventional	5139.39	58.80	2.99	91.52	1.26
1999	Reduced Risk	4705	52.5 b	2.8	91.4	2.2
1999	Conventional	4387	54.8 a	2.8	90.1	1.1

For each year, no significant difference at the 95 percent level of confidence according to Duncan's Multiple Range Test for Mean Separation.

Cover Crop and Hedgerow Program
This project developed a robust cover crop, filter strip, hedgerow, and wildlife friendly program statewide with additional funds for three years from the USDA Environmental Quality Incentives Program (EQIP). These environmental practices were the primary feature at 28 meetings sponsored or cosponsored by the California Dried Plum Board. These meetings drew in excess of 1,000 farmers, landowners, agencies, and reporters. In addition to the meetings, there was television coverage by Channel 12 News, multiple press releases announcing the meetings, 14 follow up articles in regional and statewide newspapers and magazines, including the front-page story by *California Farmer*, Jan. 2000.

Cover Crop/Buffer Strip Program
A third of the IPFP growers use cover crops on their IPFP orchards as part of a normal floor management program. Their reasons include: improving water infiltration, nitrogen fixation, beneficial insect habitat, weed suppression, and establishing a durable floor for orchard operations. In spite of low price received for their crop, as a farm group, approximately 10 percent of the prune growers in the state have a perennial or annual cover crop as a normal orchard floor practice.

Eight project farmers established 10 different demonstration cover crops in their prune orchards which were then used as the focus of a number of meetings. The following cover crops were demonstrated, with the first being planted outside the orchard and then the next four non-tillage types being planted in order (Table 3). The last five were covers that required disking and incorporation. By allowing us to plant these 10 covers, each participating grower had a mixture in their orchard that was difficult to manage and mow, and their contribution to the project is commendable.

Table 3. Cover crops planted in Prune BIFS orchards. (Appears as text in IPFP/BIFS Final Report, March 2002)

Hard Fescue	Used as a filter strips and vegetated road
Benefical Blend	A filter strip and insectary reservoir
N. Z. White Clover/Trefoil	A nitrogen fixing sod/insectary
Perennial Sod	A durable, low maintenance orchard floor and water infiltration
NonTillage Clover	A nitrogen fixing, mow able insectary floor

Plowdown Legumes	A nitrogen fixing incorporated mixture of bell beans, peas and vetch
Max Organic Builder	A soil improving incorporated mixture of oats, bell beans, peas and vetch
Juan Triticale	A soil improving, weed suppressing grain
Common Barley	A soil improving, weed suppressing grain
Resident Vegetation	The comparison or check of what would be in the orchard

These efforts contributed to the establishment of a long-term cover crop trial at the CSU Chico Farm to serve as a regional demonstration. Forty perennial and 60 annual cover crops were planted in 2000 and again in 2001. These 5 by 30 foot demonstration plots have been marked and are an open walking tour for any group that wishes to view, cover crops, filter strips, California native grasses, insectaries, vetch, peas, annual clovers, fenoeugreek, brassicas, phacelia, erosion grasses, cereals, and mixtures. This planting has been the site of five walking tour meetings so far and was the site of a regional NRCS and RCD training workshop to be held April 25, 2002.

Insectary Hedgerows
The use of insectary hedgerows has been promoted by IPFP at meetings and a hedgerow project was implemented with the cover crop cooperators. Eight different prune ranches planted hedgerow habitat with signs for demonstration. Two particularly extensive plantings included a four times replicated planting at CSU, Chico prunes where permanent, laminated signs informed all of the visitors to the CSU Farm tours about the hedgerow species, insects attracted and pests controlled. The second planting at Billiou Ranches in Hamilton City is a 20 acre planting of hedgerow species; Coyote Brush, Coffee Berry, Yarrow, and Deergrass with the species placed in clumps in place of missing trees. Many groups have visited this innovative planting over the past four years as an insectary plantings interspersed in the orchard.

Wildlife Friendly Farming
The IPFP program has supported wildlife friendly farming through the cover crop and hedgerow plantings. Four of our hedgerow plantings were specifically planted next to waterways including Deer Creek and Gilsizer Slough to provide diversity, cover, and food for bird species. In addition to the field plantings and demonstrations, the project hosted along with our cosponsors, The Nature Conservancy and the Colusa County NRCS, three 'Wildlife Workshops' at the Colusa Farm and Equipment Show in 1999, 2000, and 2001. The attendance at the 2000 show exceeded 100 participants including; farmers, wildlife biologists, and Future Farmer of America students.

GOAL III. Encourage adoption of reduced risk practices through outreach and extension efforts.

Starting at petal fall, scouts and PCAs visit each orchard at least once a week until harvest. Orchard information such as insect counts and disease findings were reported to growers at least once per week. Ten newsletters were published and distributed to all 1,400 prune growers in California plus about 500 related industry members about the progress of the project. And finally, meetings to share information were numerous and well attended. 1065 people in 2001, over 1,154 in 2000 and over 787 in 1999 received information at meetings on the IPFP project. In addition, the Tehama County Farm Advisor provided insect day degree accumulation to clientele via e-mail on a regular basis. Advisors also wrote several newsletters.

Pest control Advisor involvement
Approximately 15 PCAs were asked to review and if possible try using monitoring techniques under evaluation during the 2000 and 2001 seasons. At meetings held in October 2000 and spring 2001, the PCAs and the project team met and discussed the monitoring techniques.

Overall, the PCAs were pleased to be involved in the project. The PCAs favor more subjective methods of monitoring. However, for this project, quantitative methods must be used in order to determine what treatment threshold and/or monitoring techniques are the most accurate. When the techniques and thresholds are finally presented to all involved in the prune industry, it is understood that many will use subjective techniques and shortcuts in order to save time and money.

Evaluation of Project Impacts

Pesticide Use reporting

One of the main goals of the project since its inception in 1998 was to reduce the amounts of organophosphate pesticides applied. Shown below, in Figures 1 and 2, are pounds of active ingredient applied per acre to prunes from 1998 to 2000 for all bearing prune acreage in California. Both Diazinon® and Supracide® have decreased since 1998, while Asana® has remained almost the same. The amount of sulfur has decreased the most over the three years.

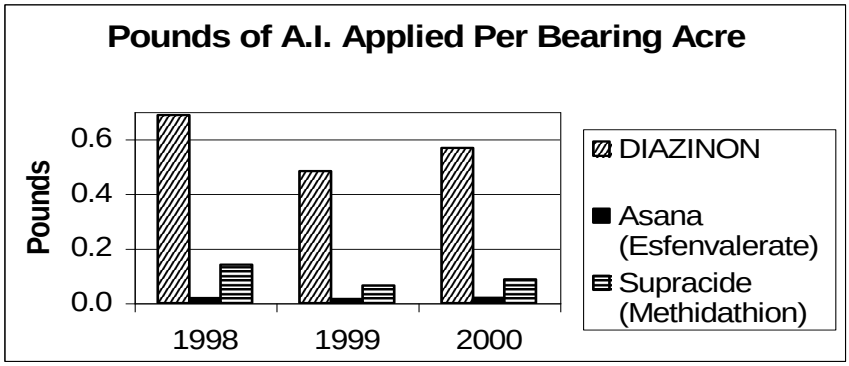

Figure 1. Pounds of active ingredient applied per bearing acre.
(Appears as Fig 19 in the IPFP/BIFS Final Report, March 2002)

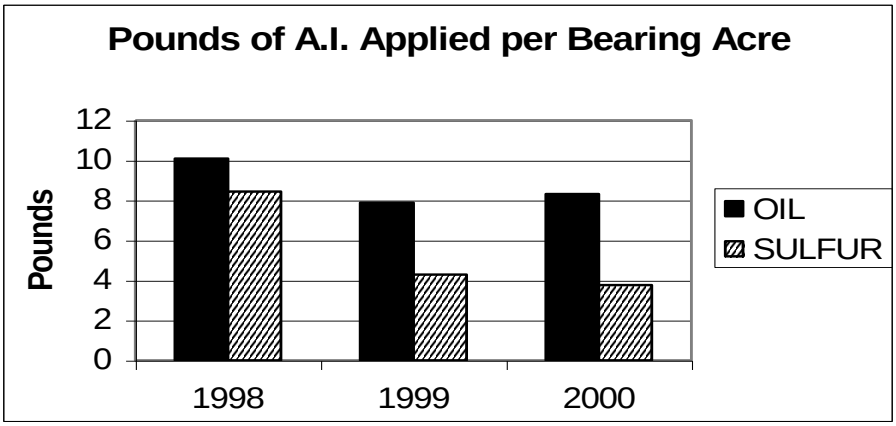

Figure 2. Pounds of active ingredient applied per bearing acre
(Appears as Fig. 20 in the IPFP/BIFS Final Report, March 2002)

MODIFIED EXCERPTS FROM:
APPLE BIFS—FINAL REPORT OCTOBER 26, 2001 AND PROGRESS REPORT, JULY 2002

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Background
Agriculture-urban interface problems have led to an interest in adopting a reduced risk pest management program in Contra Costa County orchards. The use of pheromone mating disruption (MD) and other pheromone based "reduced risk" practices would allow apple growers to significantly reduce the use of controversial materials. However, the cost and risk of these practices have been prohibitive. The BIFS program was developed to offset these factors by providing a cost share for the pheromone products and monitoring assistance to help reduce the risk of failure.

The Reduced Risk Program
The primary goal of this project is to demonstrate and encourage the use of sustainable, reduced risk production practices for apple and pear growers. Pome fruit orchards currently have a fairly sustainable fertility and orchard floor management program. They are not high nitrogen users (0-50 lbs/A annually) and orchard floor management practices routinely include permanent or winter annual cover crops. Therefore the focus of this project has been on assisting growers to improve their pest management program. For the last two years the BIFS project has been run in conjunction with the Integrated Apple Production (IAP) project funded by DPR from 1999-2001. The IAP project was completed last season and the BIFS program continued on its own in 2002.

Codling moth (CM) is the primary pest in all pome fruit orchards. The BIFS orchards have employed mating disruption techniques as the foundation for their codling moth control program. These are non-toxic materials that are safe for people and animals and not disruptive to biological control. Mating disruption works best in large, uniform orchards with low codling moth populations. In the first few years, growers typically need to employ one to three supplemental codling moth sprays in addition to season long mating disruption. This is needed to reduce codling moth populations to very low levels so that mating disruption can become the primary control by the third or fourth years.

Mating disruption is a more expensive control program than conventional sprays, with the transitional years being especially costly due to the supplemental sprays. To offset these high costs during the transitional years, the BIFS (and IAP) program provided a 50 percent cost share for the mating disruption product for participating orchards. Growers pay all other pest management costs. During the first two seasons, BIFS/IAP growers averaged from $56/acre less to $63/acre more than the conventional comparison orchards due to the cost share program.

On Farm Demonstration of an Alternative Farming System
From 1999 to 2001, there were nine orchards (172 acres) that participated in the IAP program, and began the transition to "reduced risk" pest management practices based on mating disruption. In 2000, the BIFS program supported 11 additional orchards (311 acres) into a reduced risk pest management program. Ten of those orchards continued with the program in 2001 and three new orchards were added. Another 45-acre orchard adopted the BIFS management practices but was not an "official" member as funds were not available to include this last orchard. We provided monitoring

assistance for this extra orchard as well as two other orchards that were in their fourth year of mating disruption and transitioning to organic production.

BIFS orchards demonstrated the use of:

1. Four different kinds of **mating disruption products**: Isomate® dispensers; Checkmate XL-1000® dispensers; Checkmate dispenser – experimental design; Suterra puffers
2. A **new type of monitoring** lure based on kairamones (plant volatile attractants) rather than pheromones. The BIFS and IAP orchards have cooperated in testing these lures (under test agreement with the USDA) over the past two years. They represent a tremendous improvement in our ability to track codling moth populations in mating disrupted orchards.
3. **Three reduced risk sprays** – Intrepid®, Assail®, Danitol® - to supplement mating disruption. To date, there have not been very effective, reduced risk supplemental sprays. Both Assail® and Intrepid® are reduced risk, less disruptive materials that are reported to be fairly effective against codling moth. They are expected to get full California registration shortly and would be a great benefit if they prove effective.

Pesticide Use

The 2001 season showed a declining trend in the application of insect and disease management materials in comparison with the 2000 season. This trend reflects the continued poor apple market rather than a decrease in pest problems. The BIFS orchards had a slight (7 percent) increase in these materials while the IAP orchards showed a 70 percent decrease, the MD comparison orchards showed a 80 percent decrease and the conventional comparison orchards showed a 67 percent decrease in the use of these materials.

Although there was a trend for the total amount of pesticides to decrease, the percent of targeted materials actually increased in 2001 in response to the increased pest pressure and the increased use of chemical thinning agents. Again, this is a result of the continued poor apple market. However, in comparison with 2001's conventional orchards, the targeted materials were 33 percent lower in the BIFS orchards, 38 percent lower in the IAP orchards and 46 percent lower in the Mating Disruption (MD) comparison orchard.

Pest Damage

In 2001, codling moth damage in the BIFS orchards averaged 10.6 percent (range 0 to 35 percent), higher than 2000's average of 7.3 percent damage (range 0-54 percent). The IAP orchards averaged 9.6 percent (range 0-20 percent), higher than 2000's average of 3.1 percent damage (range 0-8 percent). The damage was higher than acceptable in 10 of the 21 program orchards. This can be attributed to the continued poor apple market (abandoned orchards, reduced inputs), high codling moth pressure and migration, trap indicator failures, and late mating disruption application coupled with supplemental spray problems (insecticide resistance, timing, materials).

There was additional pressure from secondary pests (scale, mite, leaf miner) in some orchards due to an increase in broad-spectrum sprays to control codling moth. Additional sprays went on to control these pests, averting damage in most cases. Some orchards also had disease problems due to the lack of an effective predictive model and efforts to reduce inputs and the number of preventative sprays.

Project Accomplishments and Challenges

There have been several notable successes to the IAP/BIFS program:

- **Eleven of the 21 program orchards had satisfactory codling moth control in 2001.**

- **Four of the IAP orchards that had low pressure were able to successfully reduce the rate or eliminate the second MD application in 2001, which represented considerable cost savings.**
- **The number of OP or C sprays that went on for codling moth control was significantly reduced in program orchards.** The conventional comparison orchards averaged 4.3 sprays per orchard; the IAP orchards averaged 2.25 full sprays and .75 partial sprays per orchard; the BIFS orchards averaged 2.6 full sprays and .4 partial sprays; the mating disruption comparison orchard used 1 full spray.
- **The organic apple orchard was able to reduce codling moth damage from 54 percent (2000 season) to 10 percent at the end of 2001 season.** This is a significant achievement given the lack of effective organic supplemental controls. An aggressive program of weekly oil sprays and the removal of damaged fruit from the trees toward the end of each generation were the primary tools used to supplement the mating disruption. Mastrus parasites were released at the end of both seasons to aid with the control of the overwintering larva.
- **All the IAP and BIFS growers planned to continue with the Reduced Risk mating disruption program in 2002 even though the IAP growers would not be receiving a cost share.**

Despite successes, some challenges to the project remained:

- **Codling Moth:** There was high codling moth pressure in 2001 throughout the area; both program and conventional orchards had problems controlling codling moth. The damage this season in comparison with the last two years is summarized in Figure 1. Damage in the three conventional comparison orchards was estimated to range from 3 percent to 40 percent. The factors which contributed to high codling moth damage include:

    - **High pressure and migration**: The continued poor apple market compelled some growers to abandon or minimally farm some orchards. This allowed high populations of codling moth to build up and move to adjacent project orchards.
    - **Unexpected late flight:** Unseasonably warm weather in May occurred when thinning, irrigation, or economics prevented a spray and flights were larger than anticipated due to unmanaged blocks.
    - **Insecticide Resistance:** There were several instances of properly timed supplemental sprays that did not provide adequate control.
    - **Late Application of Mating Disruption:** Several orchards coupled an early season spray with a late mating disruption application as a cost cutting measure. This resulted in damage in the more susceptible Bartlett and apple orchards due to high population pressure within the orchard.
    - **Material Selection:** In an effort to cut costs, several orchards opted to use a weak codling moth material with a very limited residual (Sevin) because it could also double as a chemical thinning agent.

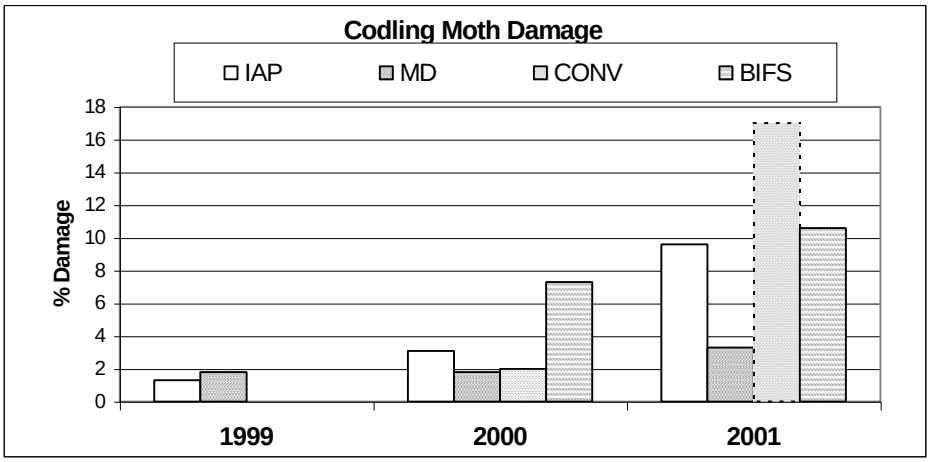

Figure 1. Codling moth damage in the IAP/BIFS and comparison orchards (IAP, BIFS, and MD orchards all used mating disruption with supplemental sprays to control codling moth)
(Appears as Figure 5 in Apple BIFS Final Report, October 2001)

MODIFIED EXCERPTS FROM
CITRUS BIFS—ANNUAL REPORT, 2001-2002

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The mission of the Citrus BIFS program was "To reduce risk associated with agricultural chemical use while maintaining yield, quality, and profitability through increasing the adoption of biologically integrated farming system for citrus growers." The long-term goal was to enhance Fresno County citrus growers' confidence in and adoption of a reduced input system that is economically viable. The short-term goal of the Citrus BIFS program was to develop and implement an extension program in five areas:

- Reliance on contact spray herbicides as an alternative to pre-emergence herbicide use
- Use of cover crops to reduce pre-emergence herbicide use and erosion
- Use of pest control and biological control practices to replace organophosphate use
- Reduction of excess Nitrogen fertilizer use
- Water management / Irrigation monitoring

The Citrus BIFS ended after three years on June 30, 2002. We were able to demonstrate combinations of practices that can reduce pesticide input and reduce the use of pre-emergent herbicides, while demonstrating the benefits (or non-negative effect) of cover crops, a pest monitoring system, and a good irrigation monitoring system. We were able to promote these biological integrated systems to citrus growers in Fresno County and neighboring counties through grower days, seminars, and newsletters. The significant benefits of many of the Citrus BIFS practices can only be realized on a long-term basis (10 to 20 years). It is difficult to clearly demonstrate the direct benefit on such a short-term basis (2.5 years). Continuing efforts should be devoted to the BIFS approach in citrus in order to realize the greatest benefits.

On-farm demonstration of Citrus BIFS system

A comparison of alternative Citrus BIFS practices vs. the conventional citrus production practices is shown in Table 1. There are four demonstration sites for the cover crop trials. Table 2 shows the total acreage of participating growers in the Citrus BIFS program and the alternative practices growers used.

Table 1. Comparison of Citrus BIFS farming practices vs. conventional citrus farming practices. (Appears as Table 1 in Citrus BIFS Final Report, August 2002)

Parameters	Conventional practices	BIFS practices
CA Red Scale control	OP's, Carbamates application	Aphytis release, IGRS, oil
Citricola scale control	OP's, Carbamates application	Monitoring, OP's only if needed
Thrips control	Baythroid, Carzol, Dimethoate	Agrimek, Success, Veretran,
Weed control	Pre-emergents (Princep, Diuron) and Roundup	Cover crops, Roundup, weed ID
Nematode control	OP's, Carbamates	Monitoring and chemical only if necessary; cover crops
Phytophthora control	Ridomil, Alliete	Monitoring; better irrigation management
Nitrogen fertilization	One to two soil applications	Leaf and water analyses; foliar sprays

Parameters	Conventional practices	BIFS practices
		with better timing; multiple soil applications
Other pests	Monitoring	Monitoring
Irrigation	Calendar based irrigation	Scheduling based on ET, flow meters, tensiometers or electronic irrigation monitoring system, proper placement of irrigation microjet

Table 2. The acreage of the Citrus BIFS program and the BIFS practices used.
(Appears as Table 2 in Citrus BIFS Final Report, August 2002)

Growers	Acres enrolled	BIFS acres	Citrus acres	Acres farmed	BIFS practices used
A	17.4	8.9	600	640	Insect monitor, cover crop, leaf & water sample
B-1	29	29	169	169	Insect monitor, cover crop, erosion control, leaf & water sample
B-2	51	20.7	3000	>20,000	Insect monitor, irrigation monitor, leaf & water sample
I	38	38	210	310	Insect monitor, cover crop, leaf & water sample
M	24.2	9.6	50	690	Insect monitor, pre-emergent/contact herbicide, leaf & water sample
S	40	40	40	40	Insect monitor, leaf & water sample
T*	12	12	200	200	Insect monitor, cover crop, leaf & water sample
H**	11	11	400	400	Insect monitor, cover crops, irrigation monitor, leaf & water sample, Aphytis

*Growers enrolled since October 2000. There are two blocks of 6 acres at T's site. Cover crops are used as main weed control practice and no pre-emergence herbicides were used at T's site for the past four seasons.
**H farms over 400 acres of citrus. They use Aphytis release at all their citrus acreage. They also use native vegetative as cover crops to reduce the use of herbicide.

Accomplishments

Insect pest management
Regular pest monitoring is a critical component of the Citrus BIFS program. We continue to monitor the pest population at eight cooperating sites. A close monitoring of pest populations can reduce the use of pesticide and costs to the growers. We supplied the pest monitoring data during the spring and summer seasons to our cooperating growers on a monthly basis.

Temperature data collection at cover crop and non-cover crop demonstration sites
One of the major concerns for all citrus growers about using cover crops in citrus orchard floor management is the risk of lowering the temperature during a freeze. In theory, cover crops in the citrus orchard floor can lower the temperature as compared to orchards without any cover crops (bare ground). This belief is common among citrus growers. To promote the use of cover crops in citrus orchard, we installed environmental data loggers at four cover crop demonstration sites (Table 3).

Table 3. Cover crops planted at three BIFS Citrus orchards.
(Appears as text, p. 7 in Citrus BIFS Final Report, August 2002)

Site	Cover crop planted
A	oats
I	Sweet peas, oats, native grasses
T	Crimson clover, sweet peas, oats

Two data loggers were installed at each location, one on the ground with cover crops and one on the ground without cover crops. There were very little differences in daily minimum low temperature between the cover crop site vs. the non-cover site at all three locations in the 2001-2002 season. Overall, there was no significant difference in temperature between the cover crop sites vs. the non-cover crop sites in the past two years (2000-2002). There was no damage to citrus trees in any of the cover crop sites. These results indicate that the use of cover crops combined with proper cover crop management such as late seeding should reduce potential frost damage to citrus trees.

Cover crops provide additional benefits. It was demonstrated that they have a significant effect in reducing soil erosion on hill sites. Cover crops also can reduce irrigation input and enhance population of beneficial insects.

Irrigation efficiency monitoring
Since July 2001, irrigation monitoring systems were installed at three sites. The systems can accurately monitor irrigation efficiency, timing of irrigation, and the depth of the wet zone. Growers were very satisfied with the information obtained from the monitoring systems. They were able to make proper adjustments in their irrigation management system that resulted in higher irrigation efficiency, lower cost, better tree health, and low chances of runoff. This system was also able to identify any problems in the irrigation practices and particular problem spots in the orchards. Overall, an efficient irrigation monitoring system is a critical component for successful integrated farming systems.

Nitrogen leaf analyses of participating grower sites
Leaf samples from all participating growers' sites were collected in December 2001 for leaf analyses. Macro elements (N, P, K, Ca, Mg) and microelements (Zn, Mn, Fe, Cu, B, Na) were measured. In general, all orchards have normal level of nitrogen.

In 2000, the level of nitrogen was too high in most orchards. With advice from the Citrus BIFS team, all growers reduced their nitrogen input and the results were shown in 2001 analyses. Most of the other elements are in the normal ranges. Leaf nitrogen analyses, in combination with analyses of irrigation water, allowed growers to better monitor and predict the nutrient status of their trees and take corrective measures.

MODIFIED EXCERPTS FROM

DAIRY BIFS—INTEGRATING FORAGE PRODUCTION WITH DAIRY MANURE MANAGEMENT IN THE SAN JOAQUIN VALLEY—ANNUAL REPORT, SEPTEMBER 2001 AND SEMI-ANNUAL REPORT, MAY 2002

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Introduction

The Dairy BIFS project seeks to develop and demonstrate improved dairy manure management practices for reduction of nutrient related environmental problems. The focus is primarily on liquid manure water stored in on-site ponds or lagoons including all the manure, flush water from paved feed lanes, freestalls and milking parlors, and a portion of the storm runoff that is stored in lagoons. In California, this lagoon water is typically applied to cultivated fields via the flood irrigation system and in combination with commercial fertilizer application, is often associated with nutrient leaching. Excess nutrient application can be addressed through monitoring manure nutrient application and reducing commercial fertilizer application accordingly. The project implemented a nutrient monitoring and application system in 11 dairies throughout the San Joaquin Valley to improve the balance of nutrient application and removal in the dairy forage system. The project's approach, based on flow measurement and nutrient analysis, makes it possible for dairies to accurately record and estimate nutrient application to fields.

Methods

Side-by-side comparisons of conventional and alternative practices serving as demonstrations were set up on farms. Contrasting conventional and improved BIFS practices are summarized in Table 1. Flow measurement of manure water onto fields is the main alternative practice, and it is being used to record nutrient application for non-BIFS project fields at some farms. Flow meters measure flow of dairy manure water. Nitrogen "quick tests" determine the exact amount of nutrients in the liquid manure. Flow rates of manure water into the irrigation are recorded as well as nutrient analysis, data on field area, and time required for an irrigation set. Nutrient application is then calculated from the collected data.

Table 1. Contrasted practices on Dairy BIFS fields (Appears as Table 2 in Final Report)

Dairy	***Conventional Practices***	***Improved Practices***
D1	- Apply manure as in past for disposal purposes	- Use torpedoes in furrows to reduce total irrigation water use - Reduce manure application by eliminating one or more manure water irrigations
D2	- Apply manure as in past for disposal purposes	- Reduce manure application by eliminating one or more manure water irrigations
D3	- Apply manure water to ryegrass in spring only	- Apply manure water as pre-irrigation on ryegrass, and in spring, monitoring to ensure proper amounts applied
D5	- Use commercial fertilizer only for silage corn production	- Use manure water as only nutrient source for silage corn
D6	- Commercial fertilizer and manure water to supply corn nutrient needs	- Manure water only to supply corn nutrient needs*

Dairy	*Conventional Practices*	*Improved Practices*
D7	- Apply manure water to fields, assuming that 25% of organic N is available	- Apply manure water to fields, assuming that 75% of organic N is available
D8	- Use commercial fertilizer only for silage corn production	- Use manure water as only nutrient source for silage corn
D9	- Avoid using manure on alfalfa	- Apply manure water to alfalfa at carefully monitored rates
D10	- Apply manure water during high water volume irrigation	- Apply manure water during low volume irrigation (reducing total nutrient load)
D11	- Apply manure water, assuming that 70% of organic N is available	- Same as conventional, but adjust rates to account for soil NO_3^- in spring

* At this site, commercial fertilizer was applied to the improved portion of the field due to a lack of communication between the owner and the field equipment operator. Therefore, the conventional and improved treatments reported ended up being Conventional = more manure and Improved = less manure.

Other alternative practices include the use of soil and tissue samples for decision making on commercial fertilizer and lagoon water application. Soil samples were used to assess available N, P, and K levels, following which decisions were made to reduce or eliminate P and K application, and reduce N application (in manure and/or commercial fertilizer). Tissue samples were used to evaluate the crop for potential deficiencies, and when those deficiencies were found, manure and/or commercial fertilizer was applied to meet the crop needs.

Alternative practices on alfalfa forage involved diluting manure water to reduce concern about organic matter in the manure water competing with the alfalfa crop for oxygen. Manure application rate was low enough that all nutrients applied in the manure water were removed in the alfalfa crop. Overseeding with berseem clover was used to increase nutrient uptake and crop biomass, especially in the early spring when alfalfa growth is minimal.

Results

Manure nutrient application

Manure water nutrient application was tracked on each BIFS dairy with N, P_2O_5, and K_2O applications reaching up to 828, 425, and 1044 lbs./acre, respectively, on the summer 2000 corn silage crop. Manure water nutrient application on the alfalfa crop at Dairy 9 totaled 77, 36, and 143 lbs./acre of N, P_2O_5, and K_2O, respectively.

Once nutrient application could be tracked using flow meters and manure water analysis, on-farm decision-making at participating dairies consisted of two general approaches. Those following the first approach examined data collected from an irrigation and then made decisions about subsequent manure water or commercial fertilizer applications on the field. This was especially common where flow monitoring was relatively new, and growers were mostly interested in finding out what typical applications included. Some very high applications of manure water nutrients in a single irrigation resulted (up to 550 lbs.of N/acre at one location), but these growers decided to eliminate the manure water in all or some subsequent irrigations, even though this was not their normal practice. Most growers using this method that ended up with excess nutrient application have decided to reduce flow rates as well as total applications of manure water in the coming growing season.

If the manure management system had not been tested with different irrigation and forage production practices, it might have been assumed that all dairy producers in the state (or at least all confinement dairies in the Central Valley) would be able to adopt this improved system with as much ease as some producers in Merced County. Rather, we have found other limiting factors to play a role, and

discovered that major changes to pipelines, water supply, and manure storage systems will be the norm for many California dairies wishing to implement improved manure nutrient management.

Reduction of fertilizer use and cost savings

Total commercial fertilizer use on improved BIFS fields was reduced compared to conventional practice. For example, an average of 103 lbs/acre of commercial N fertilizer was saved by implementation of the improved practices (Table 2), which was estimated to result in a $55/acre savings for participating growers. Dairies 7 and 11 are not included in the calculation of the average fertilizer savings, as they used little to no fertilizer on all BIFS land, and instead reduced manure water application for the improved treatment. Dairies 6 and 10 used the same amount of commercial fertilizer on each treatment, but reduced manure water application on the improved side. They both planned to reduce commercial fertilizer application in 2001 in order to better utilize manure water nutrients.

Table 2. Fertilizer use on silage corn at BIFS dairies, 2000 (Appears as Table 11 in Dairy BIFS Annual Report, September 2001)

	Conventional			Reduced			Fertilizer Savings		
Dairy	N (lbs/acre)	P (lbs P_2O_5/acre)	K (lbs K_2O/acre)	N (lbs/acre)	P (lbs P_2O_5/acre)	K (lbs K_2O/acre)	N (lbs/acre)	P (lbs P_2O_5/acre)	K (lbs K_2O/acre)
1	100	0	0	0	0	0	100	0	0
2	80	25	25	0	0	0	80	25	25
4	90	0	0	0	0	0	90	0	0
5	153	10	10	3	10	10	150	0	0
6	200	0	0	200	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	379	208	142	79	208	95	300	0	47
10	175	0	0	175	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0
Average (not including Dairies 7 and 11)							***103***	***4***	***10***

Changes to the current improved management practices may be needed at some dairies. For example, most calculations of nutrient application have focused on N application, mainly due to the threat of nitrate pollution in the groundwater. However, for a couple of the dairies, K is out of balance compared to N due to high K content in the manure water. These locations also tend toward extremely high available K levels in the soil. Therefore, management of manure nutrients may need to focus on setting K application rates, supplementing with commercial N fertilizer. Additionally, the dairy producers may be able to reduce K levels in manure by adjusting feed rations.

Crop yield and quality

One very important factor for growers when considering changing management practices is whether or not the new practices will affect yield and quality. Yield of silage corn (at 70 percent moisture) ranged from 20 to 35 tons/acre with no significant difference between conventional and improved treatments (Figure 1). Nutrient content (percent N, P, and K) of harvested corn silage also showed no significant differences due to treatment (data not shown).

Reduction in fertilizer or manure application did not affect nutrient removal from the field in the harvested material, which averaged 211, 96, and 305 lbs/acre of N, P_2O_5, and K_2O, respectively. Up to 279, 142, and 420 lbs/acre of N, P_2O_5, and K_2O, respectively, were harvested at specific dairies. Therefore, it is important to have a good estimate of potential nutrient utilization at each location, instead of relying on book values that don't take yield and concentration differences into account.

Winter forage, from pure wheat to oats to various forage mixtures, was all harvested for silage, and ranged in yield (70 percent moisture) from 13 to 27 tons/acre (data not shown). Nutrient removal during harvest ranged from 149 to 288 lbs N/acre, from 74 to 129 lbs P_2O_5/acre, and from 319 to 555 lbs K_2O/acre.

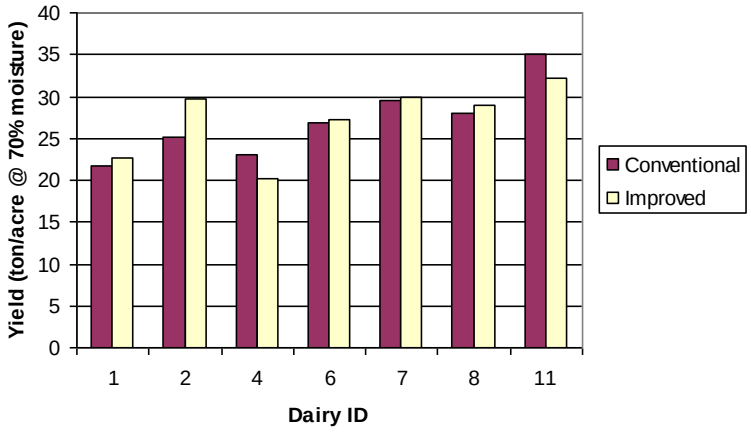

Figure 1. Silage corn yield at BIFS dairies, comparing conventional and improved manure management practices, 2000

The experiment testing berseem clover overseeding and manure water application to alfalfa at Dairy 9 took place on two different fields in 2000 and in 2001. Manure application had no significant effect on yield in either year. Neither treatment affected quality, as measured by total digestible N (TDN), which averaged 52.8 and 55.3 percent in 2000 and 2001, respectively.

Conclusion

As this part of the Dairy BIFS project comes to a close, dairy participants are considering how manure nutrient management can be extended from the BIFS field to the whole farm. For some, this means simply using the current flow meter to keep track of manure water application to the rest of their fields. For others, however, it will require installation of new pipelines and additional flow meters, plus a significant additional amount of management time.

Complex irrigation practices are the main contributing factor in these situations. These practices include irrigation of more than one field at a time and use of different irrigation water wells that pump water from different locations and in different directions through the irrigation pipelines. Although the current funding will end in March 2003, the Dairy BIFS project still hopes to collect samples from the silage corn crop of 2002.

MODIFIED EXCERPTS FROM
RICE BIFS—BIOLOGICALLY INTEGRATED FARMING SYSTEMS IN RICE
FINAL REPORT, MARCH 29, 2002

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Introduction

Rice yields in California are the highest in the world. In the past several years, yields varied between 7500-8500 lbs./acre, compared to 5000-5700 lbs./acre in the southern U.S. and about 2500 lbs./acre in Southeast Asia. This is due to adoption of cultural and chemical management practices such as use of semi-dwarf rice varieties with high harvest indexes, chemical inputs for pest and weed control, and precision land leveling (Hill et. al., 1997).

The majority of rice grown in California is cultivated in the Sacramento Valley with about 500,000 acres of rice planted in a given year. The soils in this region are typically heavy clays with an underlying hard pan. This condition makes them good for growing rice but not other crops. Therefore, most rice is continuously cropped, without systematic crop rotations. Nor are fields routinely fallowed because about 70 percent of rice ground in California is leased, and paying rent on fallow ground is not economically sound. Consequently, many of the traditional sustainable farming practices, such as crop rotation, are not readily transferable to rice farms in California.

Weed control is by far the greatest production challenge facing California rice farms. In the 1920s, rice farmers converted from a dry seeded system to a water-seeded system in order to control watergrass. Today, aquatic weeds are the key pests in California rice fields. Herbicides are applied pre- and post-planting to control a range of grass and broad leaf weed species. However, certain weed populations have developed resistance to these herbicides. One study showed that the number of resistant fields increased from four to almost 6000 between 1992 and 1995 (Hill et. al., 1997). As some compounds become less effective, others requiring multiple applications are substituted. This increases risk and drives production costs up.

Over-use of synthetic nitrogen fertilizers is also an environmental and economic issue. Nitrogen fertilizers are applied pre-planting and as a mid-season top dressing at total rates of 100-160 lbs. N/acre. Recent University of California research demonstrated that straw incorporation accompanied by winter flooding actually contributed 30 lbs./acre of crop-available nitrogen to the soil nutrient pool. Thus, it is possible to reduce the annual use of synthetic nitrogen fertilizer and still maintain yields. Similarly, winter cover-cropping with a legume may also reduce the need for fertilizer nitrogen.

These and other biological and regulatory issues significantly impact growers' economic viability. Growers look for alternative production practices that will maintain yields and reduce chemical inputs. Certain alternative practices can provide the opportunity for the timely reduction in two key chemical inputs: herbicides and N fertilizers. The rising cost of herbicides and their reduced efficacy, loss of crop subsidies, and international competition necessitate the use of cost effective, sustainable production strategies. The Biologically Integrated Farming Systems (BIFS) in Rice Project is an innovative program that combines on-farm demonstration with grower participation and outreach to assess the viability of alternative farming systems in rice. The alternative farming systems, many

based on UC research, are employed to address whole-system concerns, including long-term soil health issues, cultural control of weeds, reduction of external inputs and integration of regional rice cultivation into the larger environmental system. These alternative farming practices offer a means to protect short-term profits and promote long-term sustainability.

Goals of the BIFS in Rice project

The duration of the BIFS in Rice project was from 1999-2001. The objectives of the project were to:

1. Demonstrate alternative rice production strategies designed for the cultural control of weeds and reduction of chemical inputs in growers' fields;
2. Monitor trends in pesticide use to measure programmatic impact;
3. Evaluate the production costs per unit yield of conventional and alternative management systems;
4. Survey rice growers to determine current practices and identify constraints to and perceptions of alternative farming practices; and
5. Distribute information among grower participants and the agricultural community at large using a farmer-to-farmer extension model, newsletter, and BIFS in rice web site.

To implement these goals, a management team was formed composed of University of California personnel, private agricultural professionals and participating growers.

Goal 1. Demonstrate alternative rice production strategies designed for the cultural control of weeds and reduction of chemical inputs in growers' fields

Over the three years of the project, fifteen demonstration sites were established to showcase alternative cultural practices (Table 1) and involved 11 rice growers. Collectively, the participating growers control over 12,000 acres of farmland. Most of the demonstration sites ranged from 5 to 15 acres, with some as large as 254 acres.

Table 1. Alternative cultural practices used in the BIFS in Rice demonstration fields.
(Extracted from narrative pp. 22-23 in Rice BIFS Final Report, March 2002)

Alternative Practice	DESCRIPTION
Drill seeded	The field is cultivated in a conventional manner, except rolling (or grooving) the field is omitted. The rice seed is planted with a drill on flat beds at a row spacing of 8". The field is flash-flooded and then drained to germinate seeds. Permanent flood occurs about 30 days after planting.
Dry seeded	The field is cultivated in a conventional manner including rolling. During this final operation, the seeds are deposited into the grooves and left uncovered. The field is flash-flooded and then drained to germinate seeds. Permanent flood occurs around 30 days after planting.
Deep water	Field is prepared in a conventional manner and seeded into the water. The water depth is then raised to around 8" (as compared to 4"). Deep water is maintained until water grass dies in about 3 weeks.
Dry down	Field is prepared in a conventional manner and seeded into the water. Around 30 days after planting the field is drained. The field is dried out, sometimes severely, until the broadleaf weeds die and then re-flooded.
Reduced N	Synthetic N is typically applied to rice at a rate of about 150 LB/a. The straw following harvest is incorporated and the field flooded during the winter. The following spring N is reduced by 30 lbs./acre due to the beneficial effect of straw incorporation.
Winter cover crop	Purple vetch is planted in the fall and plowed under prior to planting the following spring.
Straw incorporation with winter flood	Straw is incorporated into the soil following harvest. The field is then flooded. The duration of the winter flood ranges from a couple of weeks to 3 months.

Reduce herbicide for broadleaf control	UC research demonstrated that rice yields are not compromised by relatively dense stands of California arrowhead. Increase plant density threshold for application.

Goal 2: Monitor trends in pesticide use to measure programmatic impact

Herbicide use. Herbicide use presents the largest challenge to the rice industry. The increase in herbicide-resistant weed populations coupled with regulatory restrictions as a result of herbicide injury to off-target crops have necessitated changes in herbicide use. On average, BIFS growers used less herbicides on their conventionally managed fields than did the rice growers in Butte County as a whole in 1999 where like compounds were used (Figure 1).

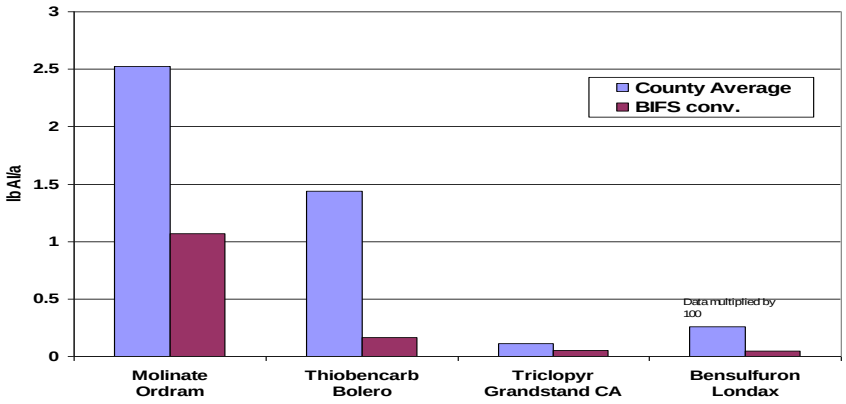

Figure 1. Comparative use of selected herbicides by participating BIFS growers in conventionally managed rice fields as compared to the Butte County average use rates. Values for bensulfuron are multiplied by 100 for display purposes. (Appears as Fig. 8 in Rice BIFS Final Report, March 2002)

Pesticide Use. Rice water weevil (*Lissorhoptrus oryzophilus*) is the principal insect pest in California rice fields and has been controlled until recently with the *highly toxic* carbamate *(www.pesticideinfo.org)* carbofuran (Furadan®). However, the EPA withdrew registration of carbofuran use in rice, effective 2000. Newly registered *and less toxic* compounds for weevil control (Dimilin® and Warrior®) first appeared in pesticide use data for the year 1998. An insecticide for weevil control is applied once per season and routinely on only 35 percent of the rice acreage in Butte County. Importantly, rice water weevil infestations in Butte County are the highest among all rice producing counties (personal communication, L. Godfrey, Entomologist, UC Davis). Consequently, insecticide used in other rice counties is often less. Compared to many other crops, rice production is a small user of insecticides.

Fungicide Use. Rice blast (*Pyricularia grisea*) was identified in California for the first time in 1996, which resulted in increased use of fungicides since 1997. Environmental conditions determine the severity of blast infections once an inoculum level is established in an area. Thus the incidence of the disease can vary dramatically between years. Since 1996, blast has spread to all of the major rice growing counties. The enlarged area of infection assures the expanded use of the *relatively low toxicity* fungicide, azoxystrobin (Quadris®), in coming years if the weather is conducive for infection. Moreover, fungal diseases have become more prevalent, because law prohibits rice growers from

burning more than 25 percent of the acres planted. Consequently, the reduction in burning may well lead to a greater use of fungicides.

It appears that rice growers attracted to BIFS projects are already making a concerted effort to reduce chemical inputs.

Goal 3: Conduct an economic analysis
A simple cost analysis was performed for each year of the project with the assistance of Richard DeMoura, Department of Agricultural Economics, UC Davis. Fixed costs were held constant and only those costs impacted by the various production techniques were considered. The analysis is based on grower provided information and should only be used for a rudimentary comparison of the various practices.

Weed control. The primary alternative treatment for weed control was the deep water, dry down treatment. All deep water treatments for weed control were in organic fields. The deep water, dry down practices increased profits on average by $140 per acre in 1999, by $264 in 2001, but decreased profits in 2000 by ($67). These figures are based on the premium pricing for organic rice. However, if the organic premium is removed from the analysis, the economic return was reduced to $121 at best and a loss of $135 at worst as compared to the conventional system. The economic return with deep water weed control was substantially better than the conventional system when an organic price advantage was considered.

Reduced nitrogen. Reduced nitrogen demonstrations consistently yielded comparable to or better than rice grown at conventional nitrogen levels. When averaged across locations and years, the reduced nitrogen fields yielded 88 cwt/acre as compared to 85 cwt/acre in the conventionally managed fields. For two of the three sites, the net return per acre was higher in the reduced nitrogen fields. The dollar advantage ranged from $18 to $49, overall. Year two showed losses, but year three showed a net gain of $46 per acre with this method.

Dry seeded. Ideally, if rice is dry-seeded, costs are reduced because less water is used, only one ground rig-applied herbicide treatment is required, and airplane costs are eliminated during planting. However, the dry seeded demonstration carried a substantial economic penalty. The grower's net return was $355 per acres, as compared to $505 in the adjacent conventional field. In other words, the grower lost $150 per acre using this technique. Due to the significant financial loss, the grower chose not to participate in 2000. Year two also showed losses, but year three showed a net gain of $46 per acre with this method.

If considered across years, deep water methods (with and without dry down) were economically advantageous when the grain was sold at organic prices. The long term economic return of the reduced nitrogen was $21 per acre. However, the highly variable results between years for the no broadleaf herbicide site resulted in a two-year net loss of $150. Substantial variability in results suggest that some factors that influence yield in these alternative cropping systems are not yet fully understood.

Goal 4: Survey Rice Growers
The Rice BIFS Principle Investigator cooperated with UC SAREP to conduct a statewide survey on growers' attitudes and practices. The survey provided evidence that attitudes toward non-herbicide methods of weed control depend on farmers' experience with these methods and the inherent risks associated with these techniques. (See Grower Practices and Attitudes section, page 60, for a report of survey results.)

Goal 5: Outreach and Education

There were two field days held during each of the three years. Field days were held at demonstration sites to discuss developments, and visiting neighboring farms to learn about promising new techniques. A poster was presented at the 1999 Annual Rice Field Day and included current demonstration activities and a summary of data gathered. Over 600 people attended. Four grower meetings were held during the first year and two each in 2000 and 2001. Topics were chosen by consensus among the participating growers or by the BIFS management team. Format was generally a round table discussion with an invited speaker to lead the discussion or a workshop presentation to teach the growers a technique, or the use of the UC leaf color chart to manage nitrogen fertility.

A BIFS in Rice newsletter entitled "The Rice Paper" was launched in August 1999. The initial copy served to introduce the BIFS project to an expanded audience. The newsletter was mailed to nearly 300 area residents that are affiliated with rice production. In 2000, the BIFS in Rice web site was established (www.buttecounty.net/BIFSinRice/bifsinrice.htm). The BIFS in Rice web site includes information from the project as well as links to other sustainable agricultural practices. It is organized in a logical progression of explanatory and exemplary items pertaining to sustainable rice production. The web site received 3403 visits as of March 2002 with over 2700 of those with in the last year.

Conclusion

The BIFS in Rice project was a novel approach to introducing concepts of sustainability to the rice farming community. The participating growers responded favorably to the concepts of the project. The information included in the outreach effort was relevant and valued as evidenced by the increasing popularity of the web site. Some of the demonstrated alternative practices are promising. However, the accomplishments were tempered by the outstanding questions that remain unanswered. Whether driven by the aquatic environment or the limitations of the underlying soil, the rice cropping system demands a long-term commitment to innovative research and education programs to develop economically sound alternative production practices.

Continued component research developed through the BIFS program

A. Area Wide Rice Water Weevil Monitoring, Principal Investigators: L. D. Godfrey and R. Lewis, University of California, Davis.
B. Field dry down for control of bulrush , Principal Investigators: Albert Fischer, University of California, Davis; R.G. Mutters, UC Cooperative Extension, J.W. Eckert, University of California, Davis.
C. Nutrient status of soil and prediction of yield, Principal Investigators: Chris van Kessel, University of California, Davis, Randall Mutters, UC Cooperative Extension, Jan-Willem van Groenigen, University of California, Davis, James Eckert, University of California, Davis.
D. Impact of irrigation water temperature on rice production, Principal Investigators: Randall Mutters, Farm Advisor, UC Cooperative Extension, Richard Plant, University of California, Davis, Alvaro Roel, University of California, Davis, James Eckert, University of California, Davis.
E. Color chart development for nitrogen fertilizer management, Principal Investigators: Randall Mutters, UC Cooperative Extension, James Eckert, University of California, Davis.
F. Alternative control of tadpole shrimp, Principal Investigators: Brian Tsukimura, California State University Fresno, Randall Mutters, UC Cooperative Extension, James Eckert, University of California, Davis.
G. Developing Strategies for Managing Herbicide Resistant Echinochloa spp. in Rice, Principal Investigators: Albert Fischer, University of California, Davis, Randall Mutters, UC Cooperative Extension, James Eckert, University of California, Davis, Jack Williams, UC Cooperative Extension.

MODIFIED EXCERPTS FROM
STRAWBERRY BIFS—FINAL REPORT – JUNE 17, 2002

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Introduction

California has the most productive strawberry fields in the world due to 50 years of research optimizing cultivars and cropping practices in the context of soil fumigation with methyl bromide and chloropicrin (MBC). Pre-plant fumigation with a mixture of MBC is an important tool in obtaining high strawberry yields in conventional production fields due to its ability to control soilborne pests and weeds. However, methyl bromide is a class I ozone depleter, and is scheduled for a 100 percent use reduction in 2005. (Regulations required a 50 percent reduction in 2001.)

In addition to the upcoming methyl bromide cancellation, strawberry growers face challenges in insect pest management. Virtually all chemicals used for two-spotted spider mite (*Tetranychus urticae*) control in strawberries have been lost due either to regulatory issues or mite resistance. In addition, many of the chemicals commonly used for control of lygus bugs (*Lygus hesperus*) are listed as carcinogenic (under California's Proposition 65) or are classified by the Cal EPA as High Priority Risk materials, and all are under review due to implementation of the Food Quality Protection Act (FQPA). Lygus bugs and spider mites are the two major arthropod pests of economic importance in Monterey Bay area strawberry production, and loss of chemical controls is certain to lead to increased pest damage and reduced yields. Additionally, fungal diseases affect strawberry production. Captan and iprodione are two of the major fungicides used on strawberries. Both are probable human carcinogens (OPP 1997); captan is also under review due to FQPA implementation.

During three years of implementation, this project worked with 15 growers to test and develop alternative production practices for strawberries. Growers donated more than 83 acres for this project representing a total investment by growers of over a million dollars. Little information was available about alternative cropping systems for strawberry production prior to this research. Rather than demonstrating integrated practices, which have already been tested, this project advanced research on alternatives to chemically based pest control. The main objectives of this research tested alternative approaches to one or more practices currently used by strawberry growers.

Objectives

1. Identify biological alternatives to methyl bromide for yield enhancement, weed and disease management
2. Enhance organic strawberry production
3. Identify biological alternatives to insecticides for control of lygus and other insect pests

Over the three years, the project tested a series of alternative practices that can be adapted to the needs of both conventional and organic strawberry growers. Alternative practices include

- Use of resistant cultivars
- Use of trap crops to attract insect pests
- Releases of parasitoids to control strawberry insect pests

- Use of vacuuming methods to manage insect pests
- Use of tarps, broccoli mulches and colored polyethelene mulches for weed suppression
- Use of mycorrhizal or other beneficial microbial inoculants for soil pathogens
- Planting of farmscaped borders and cover crops for attracting beneficial insects
- Monitoring of insects and diseases for better management decisions

Major Accomplishments

- Nine evaluations were made of a biologically integrated pest management system, which we call the BASIS below ground template, as a potential replacement for the current production system. This system gave significant control of major weeds but conditions did allow for the testing of disease control. Yield in the BASIS below ground template plots was variable when compared to MBC fumigated treatments. It is expected that this system will be optimized through continued work with growers.
- Evaluations of 20 microbial inoculants, which were commercially available or near commercialization were conducted in replicated trials. None of the inoculants demonstrated disease control or enhancement of yield. None of the microbial inoculants was selected specifically for strawberry production which indicates that an approach which uses organisms specific to the strawberry cropping system is needed.
- Three cultivars (Aromas, Pacific, and Seascape) were shown to be the top performing cultivars in organic systems.
- The presence of symphylans, *Scutigerella immaculate* was identified as a potential threat to strawberries in unfumigated ground. This arthropod pest is becoming an increasingly important soilborne pest in the central coast region and may increase problems caused by *Verticillium dahliae.*
- Corn gluten meal (CGM) was evaluated for herbicidal properties, but did not provide measurable weed control. No further evaluation of CGM is recommended.
- Ozone treatment provided some weed control but future work with ozone is not recommended as a soil disinfestant.
- Soil solarization using clear tarp, clear tarp plus broccoli residues and clear tarp plus black tarp for weed control gave moderate levels of weed control. All three tarp treatments provided good weed suppression while the tarps were in place. If soil solarization is to be a practical weed control treatment on the central coast, a means of increasing the soil temperature, or of creating an environment lethal to weed seeds must be found.
- In conventional production fields brown and green tarp provided the best weed suppression. Blue tarp provided equal or slightly less effective weed suppression than clear tarp. Red and yellow tarps appeared to stimulate weed emergence. Yields were highest in the clear tarp plots followed by blue, brown, yellow and green. Red tarp yields were the lowest.
- In certified organic production fields, weed biomass was reduced under the black, brown, green, red (on brown), white (on black) and yellow (on brown) polyethylene mulches compared to bare ground. Plant growth was enhanced by all of the colored mulches compared to bare ground. The highest production of marketable fruit came from the plots covered with black, brown, green, red (on brown), white (on black) and yellow (on brown) mulches.
- Over the three year period of this project, a trap crop was developed that accumulates 5 to 10 times more lygus bugs through the production season than does a control, and 5 to 10 times more lygus bugs than adjacent strawberries. This trap crop evolved from a single mixture of several plant species to two separate mixtures, consisting of early season and late season components. In the final year of the project the early season component functioned to give an early season alert of lygus activity, but the total number of lygus accumulated by this mixture was very small. The

late season component accumulated the vast majority of lygus, and was active for the longest period of the production season.

- Over the three years of this project, the addition of a trap crop to the edge of a strawberry field has not led to a consistent benefit in terms of pest control, either through direct reduction of lygus bug numbers or indirect reduction of pest numbers through an increase of beneficial insects.
- In 2000 and 2001, lygus bug damage to strawberries was measured during July. Damage was highest in the row adjacent to trap crops, but was not significantly different between trap cropped plots and control plots for other strawberry rows. In 2001, damage was also measured in May. Damage level was not as well correlated with distance from the trap crop, nor was it influenced as strongly by the presence of a trap crop in the field. However, total lygus numbers and overall lygus damage during May 2001 were low.
- Growers were kept informed of project progress during all three years of the project. Communication was verbal during the first year, and faxed updates were mailed to growers during the second and third years.
- In the third year of the project an experiment was conducted on the impact of vacuuming trap crops on lygus and other insect population sizes and movement into strawberries. A single pass with a tractor-mounted insect vacuum was found to reduce lygus and natural enemy numbers significantly. Vacuuming every two weeks did not have a strong long-term effect on the abundance of lygus or natural enemies in the trap crops or in adjacent strawberry fields.
- An experiment looking at releases of *Anaphes iole*, planned for the third year of the project, was terminated after two releases because of lack of availability of the parasitoid. Recovery of parasitized lygus eggs following parasitoid release was highest in the trap crop, dropping off to no recovery by the eighth strawberry row away from the trap crop.
- In the third year of the project two releases of the lygus nymphal parasitoid *Peristinus* spp. were conducted successfully. No parasitoids were recovered during two subsequent samples of the release site; however, sampling conditions were less than ideal. The project was terminated due to lack of the long-term funds necessary to make this work successful.
- The project established an early season template for insect pest management in organic production fields.
- The project established a working group to produce an Organic Strawberry Production Manual from the template and replicated experiments.

Conclusion

This project has identified cultivars that are better adapted to non-chemical conditions and has initiated a process to use available scientific literature and grower experience to design a biologically based strawberry production system with optimum performance.

MODIFIED EXCERPTS FROM
WINEGRAPE BIFS (CCVT)—2002 ANNUAL REPORT, NOVEMBER 1, 2002

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Note: This report reflects the first six months of project activities from April 1, 2002 through October 31, 2002.

Introduction

The Central Coast Vineyard Team is a private non-profit corporation comprised of farmers and winery professionals from throughout San Benito, Monterey, San Luis Obispo, Santa Cruz and Santa Barbara counties. The mission of CCVT is to promote the adoption of sustainable vineyard practices through the Positive Points System, a grower self-assessment questionnaire that quantifies the extent of sustainable farming techniques used in vineyards.

This project uses the Positive Points System to increase adoption of integrated farming techniques to reduce the use and toxicity of agricultural pesticides. A collaborative effort by project staff, project management team, enrolled growers, and University and Extension produced successful implementation of BIFS practices at Project sites during the summer of 2002. Information collected during 2002 will be used during the winter to develop improved Action Plans for 2003.

In addition to assessing their current integrated farming system with the Positive Points System and monitoring for key pests, the BIFS Project growers agreed to adopt additional new practice(s) and agreed to allow CCVT to track the impacts on pest pressure, pesticide use, and the PPS. Types of BIFS practices being incorporated include beneficial insect releases, use of reduced risk materials, cover cropping for gopher exclusion, improved canopy management, and compost amendments (Table 1).

Table 1. Description of biologically based practices compared to conventional practices.
(Appears as Table 1 in the Annual Report)

BIFS Practice	Conventional Practice
• Reduce materials used for control of mealybug • Use of ant bait stations • Use monitoring for treatment decisions • Map insect pest damage at harvest to make treatment decisions following season • Release parasitoid wasps	• Treat all acres for mealybug regardless of damage to crop or presence of pest with most toxic material possible
• Release green lacewing eggs for leafhopper control	• Treat at low leafhopper nymph populations with traditional insecticides
• Release predacious spider mites in area of heavy mite pressure • Use of reduced risk miticide, treatment based on monitoring	• Treat with traditional miticides • Treat all parts of the block regardless of damage or presence of pest • No attempt at dust control • Reliance on Sulfur dust
• Plant cover crop for exclusion of gophers in otherwise clean cultivated vineyard • Use least toxic baits	• Clean cultivated floor • Strychnine bait

BIFS Practice	Conventional Practice
♦ Trapping	
♦ Measure change in pest levels during introduction of sustainable techniques ♦ Use monitoring to make treatment decisions ♦ Use reduced risk materials ♦ Eliminate sulfur dust ♦ Map insect pest damage at harvest to make treatment decisions following season	♦ Treat at low Leafhopper nymph populations with traditional insecticides ♦ Treat all acres of the block for pests with traditional materials ♦ Reliance on Sulfur dust

Pest Monitoring

At all sites, the first new practice implemented is weekly monitoring of pest, disease, and weeds and recordi*ng* this information. Improved and detailed monitoring data is used to help growers make more informed treatment and farming decisions. The experience of the Central Coast Vineyard Team is that growers are starved for technical information to help them make improved decisions. A big gap for many growers is thorough knowledge of pest, disease, and weed issues and the lack of recorded historical monitoring information. Implementing aggressive monitoring techniques and recording the information is a critical foundation for integrated farming approaches and is believed to be a major factor in reducing toxic materials and increasing the efficacy of materials that are applied. In several cases, data collected by project data collectors was used in making treatment decisions. Hot spots were identified. Thresholds were determined using both pest population numbers and observed pest damage. In several cases, data collected by project data collectors was used in making treatment decisions. Growers reported that the field checking reports were timely and useful in helping to make decisions.

For most pests, the University of California has published guidelines and techniques for monitoring, but in many cases these techniques are too time consuming for consultants to utilize. To address this difficulty, the Project Coordinator developed two indices based on this research: one for canopy status to predict powdery mildew infections and another to quantify mealybug infestations. These indices were developed using the latest University research (Geiger/Daane 2001, Daane 2000) and the personal field experiences of the Project Coordinator. Correlation of damage at harvest and earlier in the season field observations will be used to evaluate the effectiveness of these indices as tools.

Reduced Risk

Risks have already been reduced at project sites by reducing the amount of material used, using less dangerous materials, and implementing techniques other than pesticides to treat pests. In addition, reduced risk materials were applied for the first time this year by some growers because they were confident that with the project supported monitoring a failure of the material would be caught quickly. And indeed, this was the case at one project site where a reduced risk material was chosen for leafhopper control. This site is converting to organic growing techniques for eventual certification. Project data was used to make the final decision to treat. The growers chose Pyganic, a pyrethroid recently approved by the EPA for use on grapes because it is registered for organic grape growing. The material was applied, but pest levels and damage were almost unchanged. Based on this data the grower was prepared to make another treatment when it was discovered that not all of the material had been applied. A second application was made bringing the total amount of material applied up to the recommended label rate. Pest levels dropped to zero immediately.

At another site, Nexter, a formulation of pyridaben (Cat. II) which is reported “softer” and “safer” than traditional miticides (propargite-Cat.I) was applied for the first time as a miticide. Mite levels were monitored before and after the application. Numbers of both Willamette Spider Mite adults and

eggs were reduced to zero, but gradually reappeared as the season progressed. The mite population and damage did not return to treatment levels, however.

Arthropod Predator/Parasitoid Releases
Green lacewing eggs were released at Castoro's Stone's Throw Vineyard before the start of the Project. BIFS data collectors were trained to look for green lacewing larvae during regular data collection visits and leaves were examined in the laboratory for evidence of green lacewing eggs and larvae. None were observed during the season, but leafhopper populations and damage never reached levels requiring treatment.

Mealybug
Controlling ant populations is crucial for the success of parasites on mealybugs (Daane 2000). The Argentine ant (*Linepithema humile*) is an exotic pest to California agriculture which actively "farms" mealybugs for the sweet honeydew they excrete. Argentine ants interfere with parasite success by removing parasitized bodies from the vine and otherwise harassing parasitoid activities. Project staff spent a day with UC Biocontrol Specialist Dr. Kent Daane visiting sites in the Edna Valley where Dr. Daane previously released parasitoid wasps *Leptomastix Epona* and *Pseudaphycus Flavidulus* in conjunction with ant bait stations for control of obscure mealybug (*Pseudococcus viburni*) (Daane 2000). Less than sixty days passed from Dr. Daane's first visit to a project site and to the project release. Growers reported increased confidence in UC research and extension activities as a result of Dr. Daane's continued monitoring of sites that had shown little or no improvement in the past. Grower interest in future research and experimentation is growing as a result of these experiences.

Spider Mite
Willamette spider mites are another area of study due to grower concerns about the biological disruption caused by both conventional miticides and materials used for mealybug control. Monitoring is improving by using the Mite Brushing Machine manufactured by Leedom Enterprises to identify Willamette spider mite hot spots more accurately and also provide a better picture of predacious mite populations. The Action Plan will include changes to several cultural practices next year to address dust, mite predator refuges, other pesticides used and vine status. The project is collecting data and implementing a post-harvest predator mite release at certain sites. Growers are very interested in the Mite Brushing Machine data and the potential to reduce overwintering Willamette spider mite populations.

Gophers
In many cases strychnine used for gopher control is the most toxic material used in vineyards. Many growers expressed an interest in finding ways to reduce the economic impact of gophers without the use of poisonous baits. Despite laborious research efforts, project staff was unable to find an established protocol for measuring gopher activity that is practical for this project. Observations of gopher activity were made to compare historical gopher activity during the next two seasons. In the future, growers intend to experiment with non-toxic gopher control methods including the use of exclusionary cover crops, mechanical disruption, and trapping. Trapping is the most earth-friendly method because it does not involve pesticides or soil disruption, but it can be very expensive ($300 per acre per year). The floor of this site is currently clean cultivated (mechanical disruption of gophers), but this technique affects the soil and water management.

Orange Tortrix
Orange Tortrix (*Argyrotaenia Citrana*) is a significant economic pest in Monterey County. Efforts to find effective sustainable means of controlling the pest and reducing damage have proven to be unsuccessful. The incidence of both *Botrytis Cinerea* mold and direct evidence of Orange Tortrix were mapped this fall. This information will be used in making treatment decisions next season.

Additional research by project staff will be required to develop an action plan for this pest at this organic conversion site.

Outreach and Extension

CCVT has a history of utilizing public-private partnerships for sharing and disseminating information regarding biologically based farming systems. CCVT is a private non-profit corporation comprised of farmers and winery professionals from throughout the Central Coast. CCVT growers have various experiences with successfully implementing practices that promote biological systems and reduce reliance on toxic materials. Through public funding sources and technical information from Cal Poly, San Luis Obispo and University of California Cooperative Extension, CCVT is able to extend information from individual growers to a broader audience. Technical input from University and Cooperative Extension builds on CCVT's grower-to-grower approach. Seventeen "tailgate meetings" were coordinated and conducted for this period. Attendees numbered 360 people, representing 5,000 to 21,000 acres per meeting topic. Of the total attendees, 233 attendees were Spanish speakers. Ten Spanish language tailgate meetings were conducted this year to discuss sulfur management, irrigation troubleshooting, and pest identification. The sulfur meetings were conducted by bilingual PCAs and managers and addressed issues of canopy management, drift, and worker safety. Future educational meetings will be held regarding particular pests or practices at BIFS Project sites.

CCVT's Executive Director prepared a quarterly newsletter that was distributed to the entire CCVT mailing list (900) in May and September. Issues presented included: an onsite organic composting program that returns organic material to the vineyard, promoting biological diversity, winter preparedness, a summary of the new Biologically Integrated Farming System Grant, a summary of the Finding the Right Blend II conference, and a summary of CCVT's tailgate meetings. CCVT also contributed information and writing that resulted in 11 articles during the first year of the project that appeared in *The Tribune*, *Wines & Vines*, *Biocycle*, *Vintages*, and *The Californian* among others.

BIFS Coordinator presented a summary of the BIFS project to the Central Coast Vineyard Team Board of Directors on June 6, 2002. CCVT Executive Director met with growers from the Clarksburg Growers Association to discuss the importance of proactive, grass roots programs. Dana Merrill, grower and CCVT President gave a presentation at the Paso Robles Vintners and Growers Association Water Symposium regarding water issues in Monterey County. In addition, CCVT had a presence at several industry events. Participation involved formal presentations, educational tables, and/or panel participation.

Documentation and Evaluation

A Data Collection Protocol (DCP) has been developed by the BIFS Project Coordinator based on the data collection practices of Cliff Ohmart for the Lodi-Woodbridge Winegrape Commission. The DCP measures leaf hopper nymph populations, measures both pest and predator mite populations, rates powdery mildew pressure, rates weed pressure, and where appropriate evaluates mealybug and gopher activity. Data collection began during the week of June 17, 2002 and continued until veraison or harvest.

One premise of this project is that immediate and detailed information will improve the management decisions. In addition, this project assumes that improved monitoring will improve the application timing and therefore improve efficacy. In the case of mealybugs in particular, the effectiveness of both insecticidal sprays and predator releases can be greatly increased when applied using monitoring data (Geiger 2001).

Growers will report irrigation, fertilization, labor performed in the field, and pesticide usage at the end of the year in response to a short questionnaire sent by the BIFS Project Coordinator. Yield and

quality results will be reported voluntarily by growers and costs will be described as the grower sees fit. Evaluating wine quality is difficult and expensive. Conclusions regarding yields in winegrapes are deceptive unless a long timeframe is examined due to dramatic seasonal variation. Accurately applying the cost of a fuel, labor, insurance, or tax bill to a particular acre of vineyard land is difficult. Costs, yields, and quality of fruit particular to the identified BIFS practice implemented will be demonstrated as much as possible.

Strengths and Challenges

The greatest strength of the project is the enthusiasm and dedication of the enrolled growers. Enrolled growers are motivated to implement new practices, but many have found the "nuts and bolts" of implementation daunting and spending money on a practice that is not proven in the grower's mind is difficult. However, project growers have shown an incredible openness and willingness to experiment. The timing of the project has also provided an unforeseen boost to enrolled grower commitment due to economics of the winegrape market, which is entering a period of oversupply. Wineries become more selective in their purchases and growers are looking for ways to set themselves apart from their neighbors and maintain premium prices.

The greatest challenge faced by the project is a perceived lack of funds in vineyard production budgets for experimentation. Spending an additional $50 more per acre for a new practice compared to an older conventional solution to a pest problem is difficult for growers. Most sustainable vineyard practices require significant amounts of a manager's time to implement initially, adding to the cost in a grower's mind. Extensive, regular, personal communication between enrolled growers and project staff, other growers, PCAs, and University staff helps to reduce the perception of both cost and risk. More work needs to be done to demonstrate the true cost/benefit ratios associated with sustainable vineyard practices.

Another challenge is that agro-ecosystems are complicated and conducting applied research where multiply factors are being evaluated means conclusions are rarely clean and clear. By countering negative anecdotes with positive ones and reinforcing the "research" aspect of the project, some enrolled growers have overcome their initial reluctance to let a pest outbreak develop beyond their own traditional "threshold" for treatment. This allowed recently released beneficial insects a chance to do their work.

Vineyards along the Central Coast often face challenges due to the changing nature of the California landscape. Vineyard sites are often surrounded by residential development putting a social and political pressure on growers when making treatment decisions due to neighbor concerns about pesticides and drift. This "ag/urban interface" is a significant challenge facing several project growers. The project addresses this challenge by reducing the amount and toxicity of materials used and promoting the positive activities of growers in local newspapers and general interest publications.

MEASURING IMPACTS OF BIFS ON CALIFORNIA AGRICULTURE

In addition to the BIFS Board assessments of the annual and final reports of the BIFS projects, UC SAREP has worked closely with the BIFS projects, the BIFS Program Advisory Review Board, and with other researchers and consultants to evaluate the impacts of the program. This has involved staff collecting information over the life of the program on acreage under BIFS management, subcontracting with specialists in survey design and implementation as well as in analysis of the California Pesticide Use Report database, and compiling information on publications that have resulted from the BIFS projects. We review here some of the preliminary results of this work. The BIFS projects set ambitious goals of changing grower behavior and attempting to measure and assess any changes through surveys and pesticide use analysis. Even though each project is supported for at least three years, many have come to recognize that more time—about five to ten years—is needed to have the statewide impact desired. Therefore, program impact analysis is still in the preliminary stages but some interesting data has come to light and will be reported here.

ACREAGE UNDER MANAGEMENT BY BIFS FARMERS

One indicator of the impact of the BIFS program is the number of acres managed by enrolled BIFS farmers (Table 4). Enrolled BIFS farmers demonstrate BIFS practices on their land and lead by example. Typically, enrolled BIFS farmers use BIFS practices on a portion of their acreage, fine-tuning them before converting the entire farm. By taking risks on their own land, talking with friends and neighbors, and sharing information, enrolled BIFS farmers are leading the way to economically sound reduced-chemical farming practices. In many cases, BIFS farmers (and/or PCAs and consultants who work with them) also farm in other commodities, meaning that commodity specific BIFS projects may be having impacts beyond the specific crop. For example, the total acres farmed by BIFS prune farmers is 21,871, representing 12,560 acres over and above the prune acres. Similarly, Citrus BIFS farmers farm 22,449 total, almost 18,000 acres more than citrus alone. Many other farmers attend field days and receive BIFS newsletters but are not enrolled in the BIFS projects. It is unknown how many acres they have or the adoption rate of BIFS practices on these farms. During 2001-2002, UC SAREP conducted surveys in two BIFS crops, rice and walnuts, to determine adoption rates for non-enrolled farmers (see Grower Practices and Attitudes Surveys section below).

By 2025, we predict that at least 20 percent (and perhaps as much as 60 percent) of California cropland will be under alternative BIFS or organic production systems (Swezey & Broome 2000). In 2000, we found approximately 7.1 percent of California commodity acreage had the direct potential to be served by BIFS if participating growers adopted their practices on all their acreage. In 2002, with acreage increases in most participating commodities such as winegrapes, almonds, walnuts, and a few acreage reductions in commodities such as apples, we find that still 7.1 percent of the acres are linked through participating growers with BIFS practices. Greater adoption may in fact be occurring and further survey work will confirm or deny this.

Table 4. Total cumulative acreage served by the BIFS projects from 1996—2002.

BIFS Project	Acres in BIFS and BIFS-like alternative practices demonstrations	Acres farmed by BIFS farmers in the commodity	Total bearing acres in California**	Percent acreage impacted by BIFS†
Almonds* (from BIOS for Almonds project 1993)	**19,277**	**33,820**	**525,000**	**6.4%**
Walnuts* BIOS for Walnuts (1994) BIFS (from Final Report 3/02)	**510** **407**	**900** **3,009**	**196,000**	**2.0%**
Winegrapes* (from LWWC Final Report 12/98) (from CCVT Annual Report 11/02)	**2,370** (Lodi-Woodbridge) **5,147** (Central Coast VT)	**30,000** (Lodi-Woodbridge) **21,000** (CCVT)	**458,000**	**11.1%**
Cotton (from BIFS Westside Project Final Report 3/99)	**1,653**	**90,000**	**846,150**	**10.6%**
Prunes* (from Final Report, 3/02)	**874** (total IPFP/BIFS)	**9,311**	**86,000**	**10.8%**
Rice (from Final Report, 3/02)	**3,323**	**12,200**	**550,000**	**2.2%**
Citrus (from Final Report 8/02)	**223**	**4,669**	**194,500**	**2.4%**
Strawberries (from Final Report 6/02)	**39**	**700**	**27,600**	**2.5%**
Dairy/Forage crops (from Semi-Annual Report 5/02)	**510**	**8,449**	Data not available	----
Apples* (from Final Report 10/01)	**653** (total IAP/BIFS)	**1,540**	**31,000**	**5.0%**
SUBTOTAL ACRES	**34,986**	**207,149** (excl. dairy)	**2,914,250**	**7.1%**

* Indicates combined project funding from UC SAREP/BIFS and other granting agencies.
** From: California Agriculture Statistics Resource Directory 2001: cdfa.ca.gov/docs.ResourceDirectory01.pdf (2000 statistics)
† Calculated by dividing "Acres farmed by BIFS farmers in the commodity" by "Total bearing acres in California"

GROWER ATTITUDES AND PRACTICES SURVEYS

UC SAREP has conducted two grower surveys to measure the impact of BIFS projects on grower practices (including agricultural chemical use as well as cultural practices) and attitudes about alternative practices. The Lodi-Woodbridge Winegrape Commission (LWWC) conducted a similar grower survey at the completion of their BIFS project in 1998 (Dlott 1998). These surveys have evaluated participating growers as well as regional or commodity-wide target audiences of growers on their level of adoption of these alternative farming systems. The results of these surveys also identify opportunities for further outreach efforts and inform the direction of current BIFS projects. It is likely that there will be further adoption of the alternative practices demonstrated in BIFS projects after the projects' end. The data gathered in these surveys can be used as a baseline against which further progress can be measured.

To date, three large-scale studies of the broader target audience of growers have been conducted, in rice over eight counties, in walnuts in San Joaquin County, and earlier with winegrapes in San Joaquin County (Table 5). Results of the winegrape survey were included in past reports. In this report, we present results of the rice and walnut surveys. UC SAREP has begun the development of statewide surveys of prune growers and dairy producers to be conducted in 2003.

Table 5. Status of BIFS mail-out grower surveys as of November 2002

Project	Date	# sent out	Response rate
Winegrape BIFS	1998	608	47%
Rice BIFS	2001	900	25%
Walnut BIFS	2002	722	51%
Prune BIFS	2003	Survey in design & pre-testing phase	
Dairy BIFS	2003	Survey in design phase	

RICE GROWERS SURVEY

(The following summary is based on an article printed in the UC SAREP Newsletter (October 2001) by Barzman, Mutters, Eckert, & Broome. See Attachment C for the full article.)

California rice growers were surveyed in the winter of 2001. A four-page questionnaire was mailed to 900 rice growers in nine counties. Of those, 213 valid responses were received. Short telephone interviews with 53 non-respondents showed that non-respondents were not statistically different from the 213 respondents in their age or farm size distribution. A comparison of the location of survey respondents to acreage figures from the California Agricultural Statistics Service (2000) showed that our sample was geographically representative of the state's rice growing population.

Weed management

Nearly all California rice growers depend on herbicides. The extent of this dependence is evident in the results where 98 percent of respondents use herbicides. The respondents use herbicides on an average of 95 percent of their acreage. Even though most growers do not find herbicides affordable (68 percent), most find them reliable (71 percent). The 29 percent of growers who do not find herbicides reliable may reflect the increased problems with weed resistance to herbicides. Pesticide inputs account for 15 percent to 20 percent of production costs and most of these costs are from herbicides. The large percentage of growers who do not find herbicides affordable indicates that there are opportunities to promote cheaper reliable alternatives should they become available. However, the study results show that most growers consider non-herbicide weed control methods neither affordable (72 percent) nor reliable (88 percent).

UC trials demonstrated that watergrass was effectively controlled with increased water depth (Williams et al., 1990). The BIFS project demonstrated in several field trials that deeper water often controlled weeds often without affecting yields. As reported in the BIFS in rice 2000 annual report, long-term deepwater control of watergrass will select for biotypes capable of emerging through 8 to 10 inches of water. Thus, alternative nonchemical control tactics will lose their efficacy if continually employed as sole control measures.

In addition to deep water/dry down, other non-herbicide weed management methods are available. Even though they may not be appropriate to all farming systems, the study found a number of growers using these methods on some of their acreage. Respondents reported practicing crop rotation (24 percent), summer fallow flood then plow down (9 percent), and drill or dry seed with dry down (4 percent).

Straw management coupled with reduced nitrogen input

Straw management is a long-standing challenge for California rice growers. In 1991, due to air quality concerns, the California Legislature enacted the Rice Straw Burning Reduction Act, which mandated a scheduled phase-down in rice straw burning. The California Air Resources Board (2001) reports that the rice acreage burned in the Sacramento Valley has decreased from 303,000 acres in 1992 to 139,000 acres in 2000. The study showed that in the 2000 season at least 44 percent of respondents burned straw over an average of 36 percent of their acreage (Table 6). Starting in 2001,

rice growers complied with a straw burning limit of 25 percent of each individual grower's fields with a cumulative total of 125,000 acres basinwide. Burning is permitted only if the disease levels in the field are determined by inspection to reduce yields.

Incorporating straw into the soil is the most common alternative to burning, even though the cost of this practice is estimated at $43 per acre, compared to approximately $3 per acre for burning (California Air Resource Board, 2001). In the study, a large majority (89 percent) reported incorporating straw during the 2000 season on an average of 80 percent of their rice acreage, while only 11 percent did not incorporate any straw (Table 6).

Table 6. Straw management techniques used by study respondents.

Technique practiced by grower on at least some acreage	Total number of valid responses for this question	Percent of respondents in this category	Of those who used this method, avg. % of acres on which they used the method
Burning	213	44 %	36 %
Straw incorporation	204	89 %	80 %
Straw incorporation with winter flooding	204	78 %	59 %
Straw incorporation without winter flooding	193	12 %	46 %
No straw incorporation	193	11 %	N/A
Straw incorporation + reduced-nitrogen application	196	33 %	61 %
Straw incorporation + reduced-nitrogen application in past, but did not repeat in 2000 season	131	11 %	N/A

A large percentage of respondents (78 percent) reported following soil incorporation with winter flooding on at least some of their acreage, while 12 percent reported not flooding any of their acreage after soil incorporation, and 11 percent reported not incorporating any straw. Among other benefits, flooding rice fields during the winter creates habitat for wildlife. The University of California has encouraged this practice for at least 10 years (Brouder & Hill, 1995). In this study, 73 percent of growers reported using winter flooding as a way to enhance wildlife habitat.

The majority of respondents (i.e., the 78 percent who incorporate straw and flood) have the potential to reduce synthetic nitrogen input. This benefit may be realized after three to four years of continuous straw incorporation with winter flood. During the 2000 season, 33 percent of respondents reported reducing their nitrogen application on at least some of their acreage in combination with incorporating straw and flooding. A few respondents (11 percent) reported having used this practice in the past but chose not to repeat it this last season.

Only 12 percent and 7 percent of the respondents considered stem rot and aggregate sheath spot, respectively, to be major disease problems, while 68 percent and 65 percent of the respondents indicated that stem rot and aggregate sheath spot were a concern. The grower community in large part felt that the phase out of straw burning would lead to extreme level of disease. It should be noted that during the first year of the field inspections (2001) for conditional burn permits, virtually all of the inspected fields qualified. Essentially without exception, inspected fields had disease levels that would be expected to reduce yields.

WALNUT GROWERS SURVEY

(The following summary is based on an article printed in the UC SAREP Newsletter (Fall 2002) by Ransom, Grant & Broome. See Attachment D for the complete article.)

San Joaquin County walnut growers were surveyed in the winter of 2002. A nine-page questionnaire was mailed to all 722 county walnut growers. Growers received the questionnaires in early January 2002. Of those mailed, 322 completed questionnaires were received, representing a 51 percent response rate after deleting growers from the original list who reported not growing walnuts in 2001. Brief telephone interviews with 24 randomly selected non-respondents showed that non-respondents were not statistically different from the 322 respondents in their age or answers to seven questions on crop practices. However, the non-respondents did tend to have significantly fewer walnut acres than the respondents, indicating that growers with fewer walnut acres may have been less likely to participate in this survey than growers with larger walnut acreage. In comparing survey data to figures from the California Agricultural Statistics Service (Nelson, 2002) it was determined that survey respondents farm a total of 21,245 acres of bearing walnuts, which is 74 percent of the total bearing walnut acres in the county.

Orchard floor management and fertility practices

Reducing supplemental nitrogen fertilizer applications to levels more consistent with actual demand would save walnut growers money and reduce the potential for leaching and groundwater degradation. BIFS project growers demonstrated that they were able to use less nitrogen fertilizer yet maintain good soil fertility by using leaf tissue analysis to monitor nitrogen status, and calculating a "nitrogen budget" to estimate fertilizer needs. Almost 40 percent of respondents said that they used the concept of nitrogen budgeting to estimate fertilizer needs, and 35 percent of respondents said they used leaf analysis (Table 7). Other alternative practices demonstrated in the BIFS project, such as chipping or shredding orchard prunings in field and the use of compost or manure for fertilizer, were used by a small percentage of growers (17 percent and 8 percent respectively).

Table 7. Orchard floor management and fertility practices used on bearing walnut acres in 2001. (n ranges from 294 to 311)

PRACTICE	Number of Respondents	Percent of Respondents
Nitrogen management		
Calculation of a "nitrogen budget" to estimate fertilizer needs	120	39%
Leaf analysis for nitrogen	106	35%
Chipping or shredding orchard prunings in field	52	17%
Use of compost or manure for fertilizer	23	8%
Cover Crops		
Cover crops (either new planting or self-reseeded)	63	21%
Weed Control and Tree Rows		
Use of RoundUp or Paraquat	289	95%
Use of pre-emergence herbicides (for example Surflan, Simazine, Karmex)	195	63%
Use of spot treating only around trees	107	36%

Pest management practices
BIFS project growers managed codling moth, the key insect pest for walnut growers, by experimenting with the use of pheromone mating disruption and reduced risk pesticides. They also conducted frequent monitoring for pests and beneficial insects. Survey results show that the use of pheromone mating disruption as an alternative method to control codling moth in walnuts is in its infancy. Although 80 percent of respondents reported that they had heard of using mating disruption to control codling moth in walnuts, only 32 percent reported knowing how to use it. Only 18 respondents (6 percent) used mating disruption in 2001; 11 of these were BIFS growers (Table 8).

Survey results confirmed that BIFS growers found that mating disruption works: 100 percent of BIFS project growers agreed with the statement: "The use of mating disruption is effective to control codling moth." However, 70 percent of all other respondents responded "Don't know" to this statement, pointing to the importance of, and opportunities for, future outreach efforts to inform walnut growers about the effectiveness of pheromone mating disruption in walnuts.

Several BIFS project growers demonstrated habitat restoration and enhancement practices including setting up owl or bat nesting boxes and insectary plantings along farm borders or waste areas. Although 21 percent of respondents reported using owl boxes or bat houses, only 2 percent used insectary hedgerow plantings to attract beneficial insects. Space limitations and a general lack of perceived potential benefits of insectary plantings may limit growers' interest in planting insectary hedgerows (Table 8).

Table 8. Pest management practices used on bearing walnut acres in 2001. (n ranges from 291 to 304)

PRACTICE	Number of Respondents	Percent of Respondents
Organophosphate insecticide sprays (for example Guthion, Lorsban, Imidan) to control codling moth	201	67%
Miticide spray to control mites	181	61%
Relied only on beneficial insects to control mites	64	22%
Use of owl boxes or bat houses	63	21%
Pheromone mating disruption (Isomate C+ or Checkmate) for codling moth	18	6%
Insectary hedgerow plantings to attract beneficial insects	7	2%

Attitudes
The survey questionnaire included several statements that growers were asked to state their level of agreement with. Fifty-seven percent of respondents agreed (either strongly or somewhat) that "It's worth using practices that reduce my overall chemical and fertilizer use even when it might take a little more time or expense" showing that a majority of growers are willing to go to some effort or cost to reduce their agricultural chemical use. Sixty-four percent of respondents reported they *did* try to reduce their use of pesticides during the 2001 walnut-growing season. As might be expected, 71 percent of these respondents reported that "cost" was the most important reason for their efforts to reduce the use of pesticides. Environmental concerns, health concerns, and protecting beneficial insects were also frequently mentioned as one of, if not the most important, reason to reduce pesticide use.

Forty-six percent of respondents reported they were interested in experimenting with new management practices. BIFS projects provide the funding for many growers to experiment and demonstrate the use of alternative practices and then, through organized field days and other events, show what they have learned to other growers.

Project outreach and key sources of information

A key element of the Walnut BIFS project was outreach to other walnut growers in the region. Survey results show that almost half of the survey respondents were exposed to the project in some way. Twelve respondents (4 percent) were enrolled as BIFS growers in the project. Excluding these BIFS growers, 53 percent of survey respondents reported that they had "heard of the Walnut BIFS program;" 39 percent had read the Walnut BIFS project newsletter; 21 percent had talked with a BIFS grower or project management team member; and 15 percent had attended at least one Walnut BIFS field day.

Respondents were asked to identify the three most important sources of information from a list of 19 different choices. PCAs were most often identified as one of the three most important information sources (53 percent). This highlights the importance of the involvement of PCAs in BIFS projects. "Results of monitoring/inspecting orchard" was identified as one of the three most important information sources by 38 percent of respondents. Many BIFS projects support intensive monitoring, recognizing the information intensive nature of biologically integrated farming. And finally, "other walnut farmers" were identified by 32 percent of respondents as one of the three most important information sources. Results from a similar survey of Lodi-Woodbridge winegrape growers, conducted at the conclusion of a three-year BIFS project, also found that PCAs and other growers were most often identified as important information sources (Dlott & Haley, 1998). BIFS projects frequently provide many opportunities for growers to share their experience with other growers as well as researchers.

Conclusion

In addition to serving as baseline data for future studies, the results of this survey help to identify opportunities for further extension efforts geared toward enhancing and extending the impact of the walnut BIOS project. In summary, these results indicate that of the walnut growers who participated in this survey, the majority:

- want to reduce their chemical and fertilizer use
- are primarily motivated to reduce agriculture chemical use by the desire to save money
- are also motivated by concerns for health and the environment
- highly value pest control advisers and the results of monitoring/inspecting the orchard as important sources of information for farm management decisions
- do not know that mating disruption can be effective to control codling moth and do not know how to use it
- are not using BIFS practices that may help them to reduce their ag chemical use, including:
  - nitrogen budgeting to more accurately estimate fertilizer needs
  - replacing pre-emergence herbicides with other strategies such as spot treating and narrow strip spraying of post-emergence herbicides
  - establishing cover crops
  - using pheromone mating disruption.

PESTICIDE USE ANALYSIS OF BIFS COMMODITIES AND PROJECTS

In California, we have access to the most complete pesticide use information in the world, through the Pesticide Use Reporting (PUR) system (http://www.cdpr.ca.gov/docs/pur/purmain.htm). Farmers in California are required to report all pesticide applications. This data is compiled by the State and is made available for analysis. UC SAREP has contracted with Dr. Minghua Zhang, UC Davis Department of Land, Air, and Water Resources Agricultural GIS lab to conduct pesticide use report (PUR) analysis of BIFS project crops. We will present preliminary analyses of the PUR:

- determine baseline (pre- and early-project) state trends of targeted pesticides over time, and
- compare BIFS farm pesticide usage to the rest of the county or region if appropriate.

The most recent data available, 2001, was just released in October. As a result, some of this analysis runs through 2001 and for other commodities only through 2000. Most of the projects started in 1999. Therefore, it is still early to expect to see any major influences due to project activities. However, we can look at county trends prior to the projects and early into the projects. In addition, we can look at how BIFS growers' pre-project to early-project years may relate to the rest of the county. Most of the funding for this analysis has been provided by US-EPA (Region 9) Agricultural Initiative as well as some funds from the University of California BIFS workgroup. This analysis is still preliminary and will undergo further work. In this report we present the results for prunes, walnuts, rice, and apples.

Each project working with UC SAREP provided a list of active ingredients of interest, either because the project was trying to reduce the use of this material, it was an alternative material to one that was being targeted for use reduction, or it was a material that might be considered a reduced risk replacement for the material of concern. The projects also supplied the unique grower identification (ID) number and the unique site location ID number for the particular fields involved in the demonstration project. However, the PUR in general does not allow us to distinguish the BIFS alternative treatment plots from their side-by-side comparison conventionally managed plots. BIFS alternative and conventional plots might be 20-40 acres in size, which is large by grower standards in terms of showing meaningful real world comparisons, but the PUR is not able to distinguish between them. Therefore, the comparisons using the PUR of BIFS growers may not show as great a difference as might actually exist. In addition, other acreage outside the BIFS program entirely may also be included in the reported site usage.

The UC Davis researchers searched the PUR database and extracted total pounds applied, acres treated, acres planted, and the number of applications for each active ingredient of interest for the years 1992-2000 (2001). Then they calculated three additional variables that enable better comparisons by grower category or by region which show the percent of acres treated with this material and also the amount used per acre, that is, variables that show better the degree of reliance on particular materials. These calculated variables include: cumulative acres treated (all acres treated multiple times/acres planted), maximum acres treated (maximum of the acres treated/acres planted), and intensity (pounds of active ingredient per acre planted). We will present most of the data in the following pages as total pounds of active ingredient applied, followed by the percent of maximum acres treated to allow, which controls for increases in acreage that might influence use trends if we only looked at total pounds applied.

Use of the PUR, however, is complex and interpretation of the data must be conducted with caution. Especially when attempting to look for project impacts these may be overshadowed by larger influences of weather, prices for agricultural chemicals, prices for commodities, pest pressure, etc.

Walnut BIOS Project

The key pest for this project is codling moth. County use trends from 1992 through 2001 show that chloropyrifos (Lorsban®) and phosmet (Imidan®) use has been decreasing over the past nine and five years, respectively. Methyl parathion (Penncap-M®), which was only re-registered in 1996 in California, appears to be replacing those materials (Figure 1). The mating disruption material E, E-8, 10 (CheckMate®, Isomate®) is not being used much by the San Joaquin County walnut growers to date. This demonstration project was established to evaluate its potential use in walnut orchards. It should be noted that the BIFS growers were using a Research Authorization product of this active ingredient, not yet registered, so their use does not show up in the PUR at all.

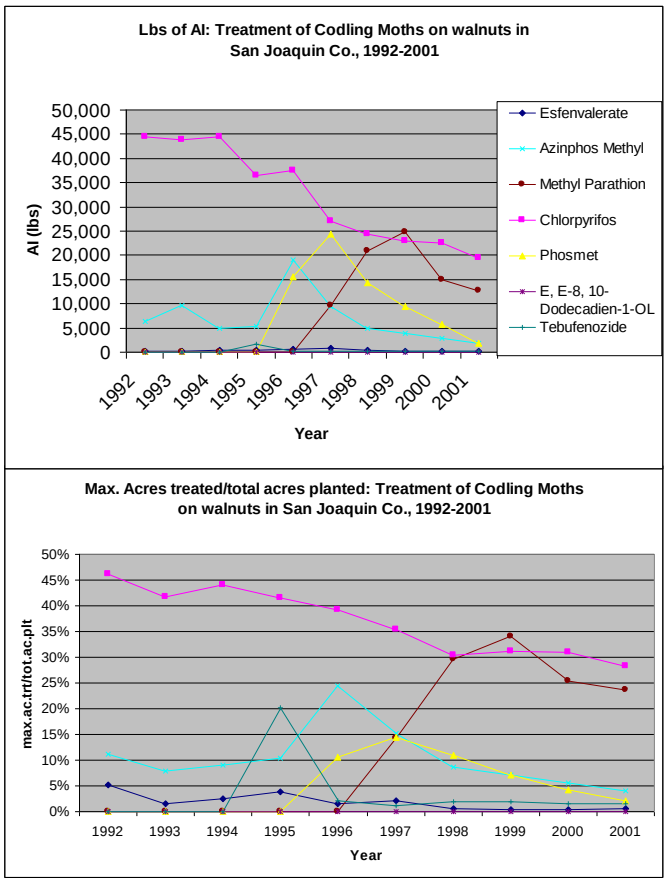

Figure 1. Total pounds applied of active ingredient and the percent of acres treated (max.) with insecticides use to control codling moth on walnuts in San Joaquin County from 1992-2001. (1999 was the first year of the project.)

After looking at the whole county use trends, we compared cooperating BIFS growers use of some codling moth insecticides of environmental or human health concern and compared this use to the rest of the country growers (Figure 2 a, b, c). It must be noted that the project was initiated in 1999 so much of the use shown in these figures is prior to project initiation. Methyl parathion is applied to

only as much as 10 percent of BIFS acreage whereas up to 35 percent the rest of the county walnut acres are receiving applications of this insecticide. BIFS growers prior to the project initiation in 1999 had been using azinphos methyl (Guthion®) on just over 40 percent of their acreage in 1997, more than the rest of the county growers, but since then their use along with that of the rest of the county has dropped down significantly and its use eliminated in 2001 by BIFS growers and the rest of the county was at 5 percent. In addition, chloropyrifos (Lorsban®) was used on about 60 percent of BIFS growers acreage in 1992 and 1994 but is now being applied to only 30 percent, the rest of the county acreage is being similarly treated.

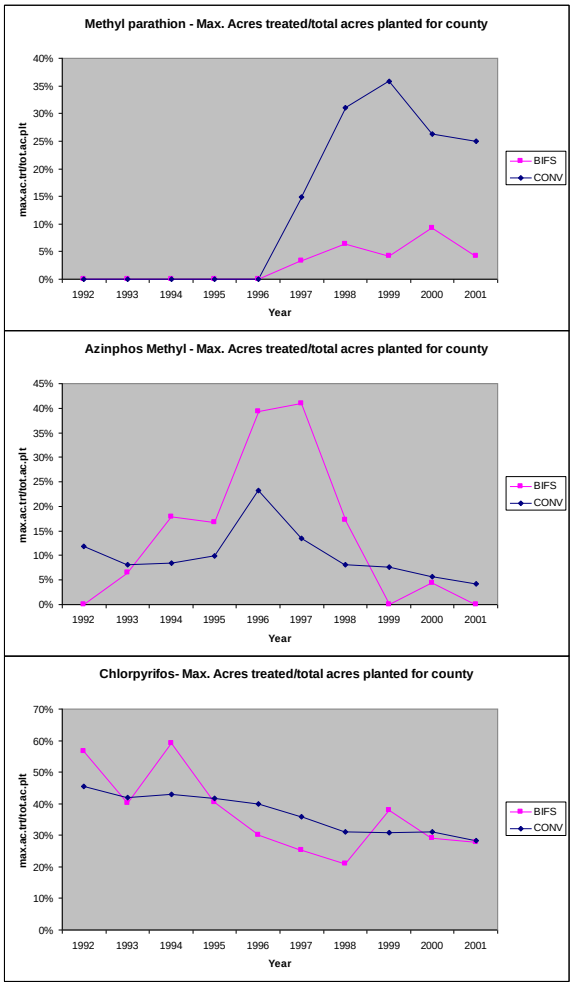

Figure 2 a, b, c. Organophosphate insecticides used for codling moth control on walnuts in San Joaquin County from 1992 through 2001 by BIFS growers (n=9) as compared to the rest of the county growers (n=489). (1999 was the first year of the project.)

The overall county use trends for some important acaricides (pesticides against mites) shows that propargite (Omite®) is the most heavily used in this commodity (and in many others) and that other newer materials have not been that readily adopted (Figure 3). BIFS growers however are using less of this material – approximately 15 percent of their acreage is treated with it compared to 40 percent of the rest of the county acreage (Figure 3). The BIFS project promoted the use of cover crops in walnuts as well as releases of beneficial organisms. The Walnut BIFS project did not find a statistically significant difference in mite pressure but there were trends in that direction, it is thought that using cover crops and fewer broad-spectrum pesticides may contribute to lower mite pressure. The BIFS fields were not treated with hardly any of these disruptive materials. More analysis is needed to understand these complex interactions.

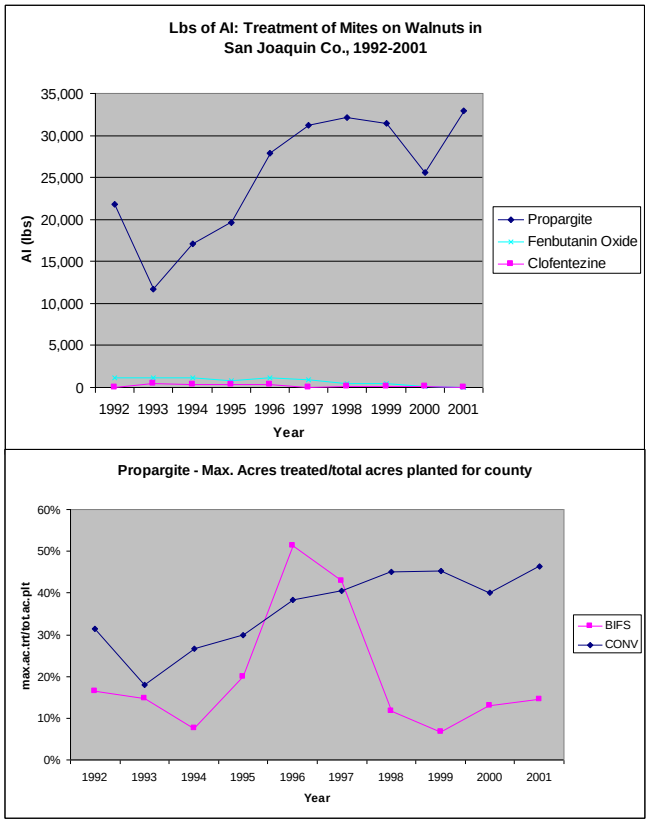

Figure 3 a and b. Key acaricides (against mites) used in walnuts in San Joaquin County from 1992 through 2001: a) whole county trends, and b) by BIFS growers (n=9) as compared to the rest of the county growers (n=489). (1999 was the first year of the project.)

Butte County Rice BIFS
Modified excerpt from the BIFS in rice final report, Objective III. Documentation and evaluation.

Total rice production in Butte County fluctuates between 80,000 to 95,000 acres depending on the year. An increase in herbicide-resistant weed populations accounted for the recent downward trend in use of molinate (Figure 4). The associated loss of efficacy, consequently, contributed to the increased use of another grass herbicide, thiobencarb (Bolero®), during the same period. Herbicide resistance has been documented in broadleaf species, as well, resulting in a decline in the use of bensulfuron (Londax®). The rise in use of new herbicides (e.g., triclopyr, Grandstand®) attests to the growers' efforts to replace those chemicals, which are becoming ineffectual due to herbicide resistance (Figures 4). Phenoxy compounds were once a mainstay of broadleaf control in rice and have also declined in use. Because herbicide injury to off-target crops in recent years resulted in application restrictions and a loss of availability due to legal concerns. Thus, the decline in their use (Figure 4) will continue as the quantities of phenoxy compounds in storage dwindle. Pesticide use trends on Butte County rice farms for grass and broadleaf herbicides parallels valley wide use. Molinate use peaked in 1996 followed by a subsequent decline with a parallel increase in propanil and thiobencarb use to combat herbicide resistant water grass (Figure 4). Comparatively, herbicide resistant broadleaf weeds resulted in less use of bensulfuran and an associated increase in triclopyr in Butte County (Figure 4).

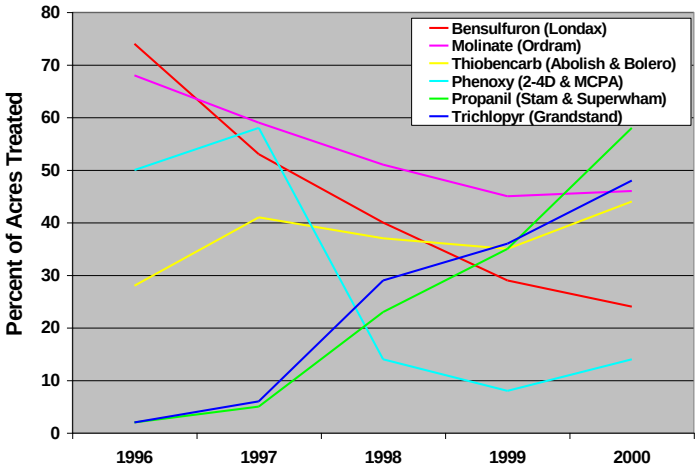

Figure 4. Percent of acres treated with various herbicides in the rice growing counties of the Sacramento Valley. Source: DPR Pesticide Use Reporting database. (Appears at Figure 4 in Rice BIFS Final Report, March 2002)

Rice water weevil (*Lissorhoptrus oryzophilus*) is the principal insect pest in California rice fields and has been controlled until recently with carbofuran (Furadan®). However, the EPA withdrew registration of carbofuran use in rice, effective in 2000. The small number of acres treated with carbofuran in 2000 reflects the growers using remaining inventory. Newly registered compounds for weevil control (Dimilin® and Warrior®) first appeared in pesticide use data for the year 1998 (Figure 5). An insecticide for weevil control is applied once per season and routinely on only 35 percent of the rice acreage in Butte County. Importantly, rice water weevil infestations in Butte County are the

highest among all rice producing counties (personal communication, L. Godfrey, Entomologist, UCD). Consequently, insecticide use in other rice counties is often less. Compared to many other crops, rice production is a small user of insecticides.

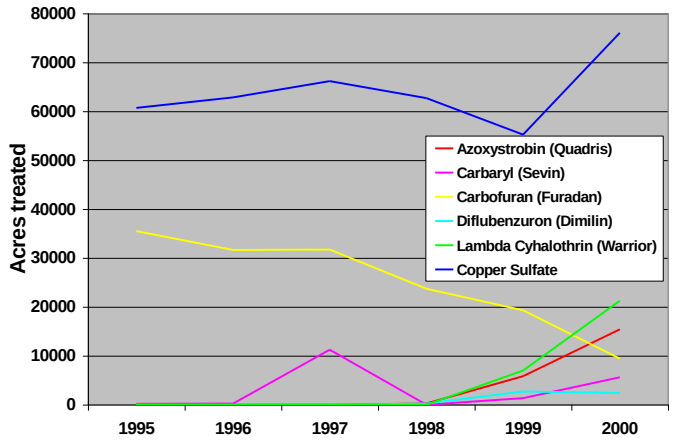

Figure 5. Acres of rice in Butte County treated with insecticides and fungicides from 1995 to 2000. (Appears at Figure 7 in Rice BIFS Final Report, March 2002)

Copper sulfate is used to control algae and tadpole shrimp. It is routinely applied on over 60 percent of the rice fields (Figure 5). The use rate is typical for much of the Sacramento Valley. Noteworthy, copper sulfate is registered for use and is widely used in organic rice fields.

Rice blast (*Pyricularia grisea*) was identified in California for the first time in 1996, which resulted in increased use of fungicides since 1997 (Figure 5). Environmental conditions determine the severity of blast infections once an inoculum level is established in an area. Thus the incidence of the disease can vary dramatically between years. Since 1996, blast has spread to all of the major rice growing counties. The enlarged area of infection assures the expanded use of azoxystrobin (Quadris®) in coming years if the weather is conducive for infection. Moreover, fungal diseases have become more prevalent, because law prohibits rice growers from burning more than 25 percent of the acres planted. Consequently, the reduction in burning may well lead to a greater use of fungicides.

While pesticide use numbers (referencing grower and location) may apply to an area larger than an individual field (some of which may be in two different sections), and may not relate to the on-farm field designation used by the grower, we were able to distinguish use patterns on some key herbicides of environmental concern. It appears that BIFS growers are using less of propanil and molinate than the rest of the county growers (Figure 6).

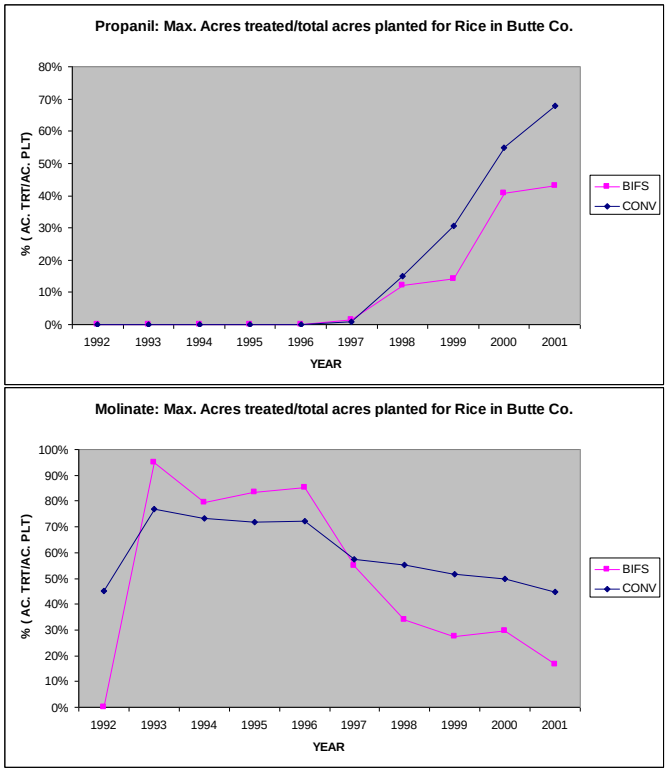

Figure 6. Percent acres treated by propanil and molinate use on BIFS fields (n=14-20) as compared to the rest of the county (n=1000).

Contra Costa County Apple BIFS.
This project focused on the key pest of apples, codling moth through the demonstration and subsidizing of mating disruption materials. Overall county use trends for major insecticides used on apples show 80 to 90 percent of the acreage being treated with azinphos methyl (Guthion) from 1992-1997 but then a major drop in use in 1998 followed by an increase back to this material. Methyl parathion use suddenly increased around 1998 potentially replacing the azinphos methyl use and then falling back down. Phosmet (Imidan) use appears to fluctuate between about 20 and 60 percent of the acres being treated. The use of mating disruption in the county as a whole peaked in 1999, the first year of the BIFS project, but then appears to have remained at about 20 percent of the acres being treated (Figure 7). However, BIFS growers since 1999 are using the mating disruption material on as much as 70 percent of their acres in 2000 which has dropped back down by 2001 to about 40 percent. The rest of the county growers are only treating about 10 percent of their acres (Figure 8).

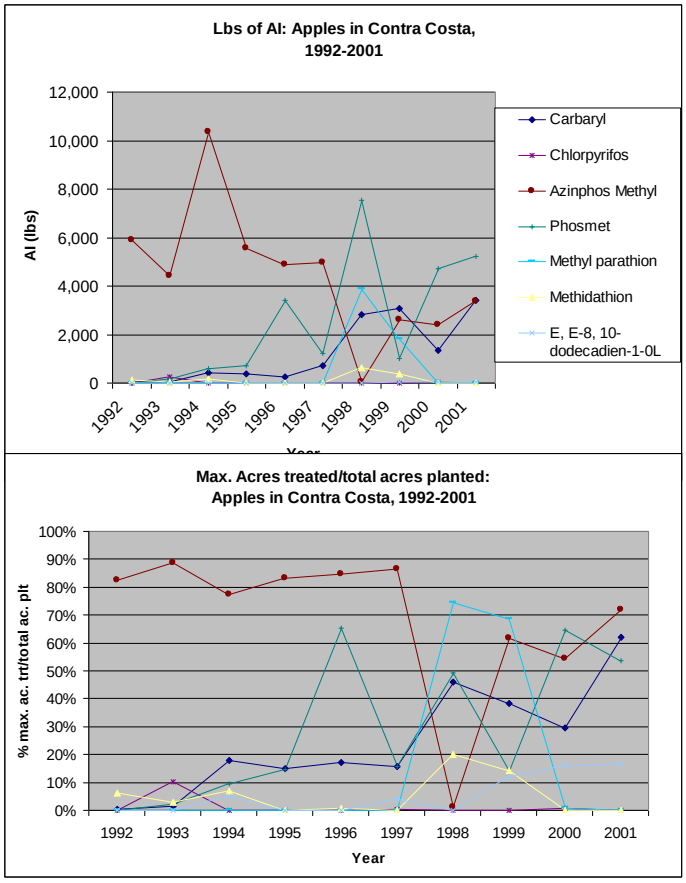

Figure 7. Total Pounds of active ingredient applied and the percent of acres treated (max.) for key insecticides in apples in Contra Costa County 1992-2001. (2000 was the first year of the BIFS project.)

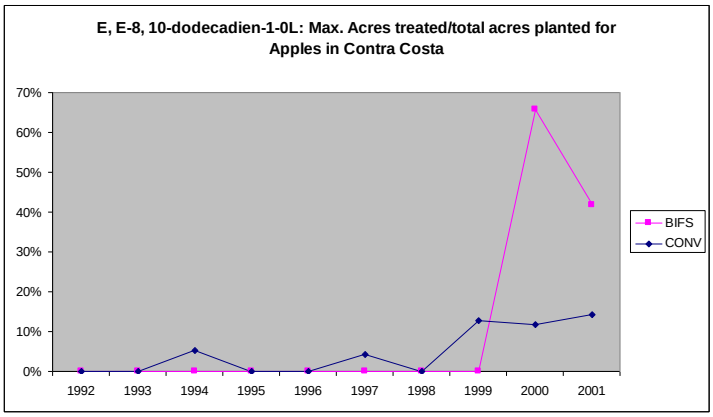

Figure 8. Mating disruption active ingredient used for codling moth control on apples in Contra Costa County 1992 through 2001 by BIFS growers (n=12) as compared to the rest of the county growers (n=52). (2000 was the first year of the BIFS project.)

Prunes (Dried Plums) in California

This project's main environmental challenge is dormant season use of organophosphate insecticides to control peach twig borer and the additional control that practice provides for control of secondary pests like aphids and mites. In addition, the project has developed several protocols for fungal disease management, specifically for brown rot and rust. The project is active in eight counties. However, we will only present results from one of the top counties in terms of pesticide use, Sutter County, due to the preliminary nature of the data analysis and space limitations. Overall county use trends show that diazinon use has been reduced since 1992; however, still about 30 percent of the acres are receiving an application of this surface water contaminating insecticide (Figure 9). The fungicides captan and iprodione are also being applied on about 20 to 40 percent of the prune acres (Figure 9).

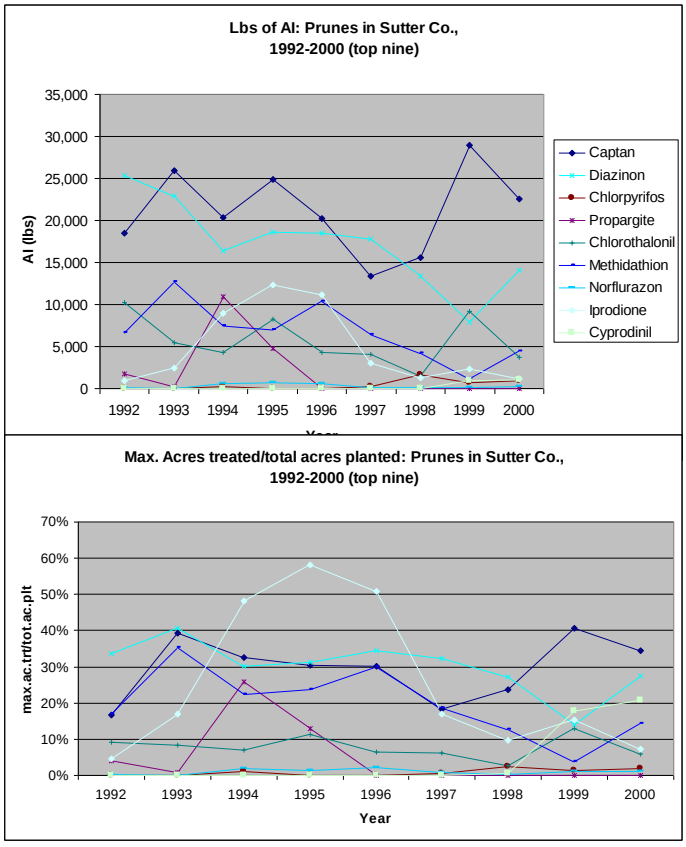

Figure 9. Total pounds applied of active ingredient and the percent of acres treated (max.) with this active ingredient of selected pesticides on prunes in Sutter County from 1992-2001. (1999 was the first year of the project.)

The use of surface water contaminating organophosphate insecticides by Prune BIFS growers is actually much less. In fact by 2000, only about three percent of their acreage was being treated with diazinon (Figure 10), whereas 30 percent of the rest of the county orchards received an application of this material. However, earlier in the decade, BIFS growers were much more reliant on this material treating 45 percent of their acreage.

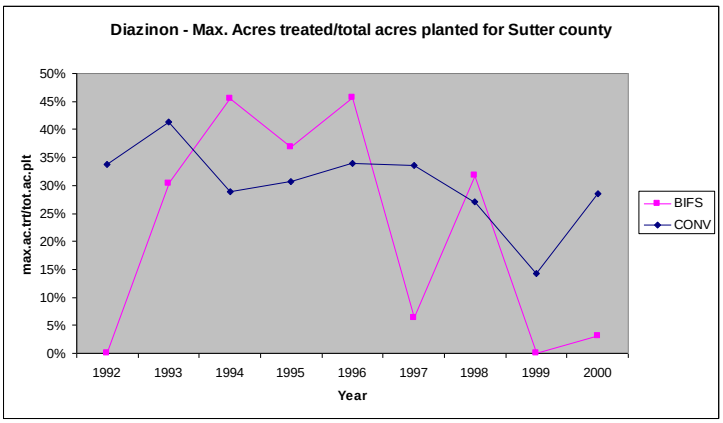

Figure 10. Diazinon used for peach twig borer, aphids, and mites on prunes from 1992-2001 by BIFS growers (n=11) in Sutter County as compared to the rest of the county growers (n=460). (1999 was the first year of the BIFS project.)

The Prune BIFS project developed several protocols for testing for presence of fungal pathogens and promoted using fungicides only when thresholds were reached. The brown rot model, ONFIT, used testing of young fruit for incipient infections and using this information in later treatment decisions. And the prune rust model tested for presence of the rust and date relative to harvest to determine if treatments were needed. The use of iprodione (Rovral®) and captan appear to differ between the BIFS orchards and the rest of the county (Figure 11). Between 30 and 40 percent of the county are treating using captan whereas only 5 to 10 percent of the BIFS plots were treated. From 10 to15 percent of the county treated with iprodione, whereas during the years of the project almost no iprodione was used (Figure 11).

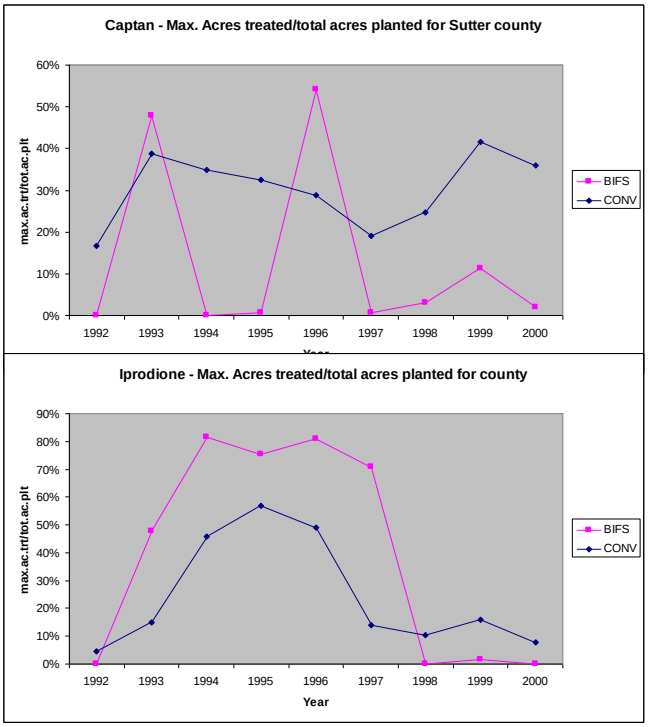

Figure 11. Captan and iprodione used for brown rot control on prunes from 1992 through 2001 by BIFS growers (n=11) as compared to the rest of the county growers (n= 460). (1999 was the first year of the BIFS project.)

PUBLICATIONS FROM BIFS PROJECTS

The BIFS program is mainly focused on changing grower practices in the field through on-farm demonstrations and outreach and educational activities geared towards growers and consultants. However, many of the projects do not have a complete system developed and include important research on either the whole farming system or components of it. Once research is conducted it must be peer-reviewed and then published so that others can learn about the results and adapt relevant results to their farm or new research efforts. Nine peer reviewed publications, eleven abstracts, and several conference proceedings have been published that present results of BIFS projects or related research. Publications have ranged from Andrews et al. 2002, a landmark study in cotton that describes the development of a soil quality index for use by researchers, educators and growers to understand how on-farm practices effect soil quality and yields (see attachment E) to the (in press) paper by Grant et al. 2003 that outlines the pest management practices and achievements of the walnut BIFS project.

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NEXT STEPS IN THE BIFS PROGRAM

1. Continued support by the U.S.EPA Region 9 Regional Initiative for the Food Quality Protection Act (FQPA) has enabled the continuation of the UC SAREP BIFS competitive grants program. Funds have been provided since 1995 through 2002 that total $961,000. Continued funding support to UC SAREP from U.S. EPA Region 9 is anticipated. Ideally this would result in a call for proposals in 2004 for funding BIFS projects beginning in 2005.

2. California Specialty Crop Block Grant. UC SAREP's BIFS program has been awarded a California Specialty Crops block grant in the amount of $100,000 for two years (2002-2003) for a project titled "Increasing the Adoption of Biologically Integrated Farming Systems (BIFS) in California Specialty Crops: Farmer-to-Farmer Outreach of Environmentally Sound and Economically Viable Practices." The goal of the project is to assist California producers of prunes, walnut, citrus and forage crops in adopting selected economically and environmentally sound agricultural practices through three main objectives: 1) implement a farmer-to-farmer outreach initiative that relies on the experience of a core group of farmers in biologically integrated farming system practices; 2) create and refine key educational tools and documents that will facilitate the farmer-to-farmer outreach program; and 3) improve outreach efforts based on results of walnut, dairy, and dried plum grower surveys.

3. Consortium for On Farm Conservation Biology and Restoration Ecology. The expansion of agriculture has often been at the expense of wildlands, native plants, and wildlife, yet farms and ranches can be managed in such a way that the impact is lessened, both in fields and on edges. California comprises 99,822,720 acres, of which 27,800,000 acres (28 percent) are devoted to agriculture. By contrast, 14,400,000 acres are wilderness, and 32,600,000 are forest, with some overlap between these two categories. Only 54,720 acres are included in National Wildlife Reserves. These numbers indicate the potential value of incorporating on-farm conservation and restoration strategies and wildlife-friendly farming practices, because a large proportion of California's land surface, about 28 percent, would be addressed. Our review of the literature, as well as first hand research experience, indicates that strategies and tactics for accomplishing this are still in the formative stage and lack a strong scientific foundation. Based on this strategic overview, UC SAREP personnel decided to facilitate a multi-researcher planning process and proposals on this theme. It was decided that winegrape vineyards would be the first farming system addressed as winegrape vineyards present both challenges and opportunities so far as conservation biology and restoration ecology are concerned. The winegrape industry in California has expanded rapidly in the past decade, and vineyards have replaced oak woodland, rangeland, orchards, and field crops in many areas. Vineyard expansion has been blamed for destruction of vernal pools, loss of connectivity of native vegetation, for destruction of native riparian vegetation in the name of disease reduction, and for increased run-off and sedimentation in streams, putting native fish, including anadromous species, at risk. However, opportunities arise in that winegrapes can be grown with a wide range of cover cropping options, including the use of native perennial bunch grasses and wildflowers. This raises the possibility of using such plants to sustain wildlife while stabilizing soils. Many winegrape vineyards have irrigation water impoundments (farm ponds) that could be managed for native plant and wildlife enhancement. All these options will require research to ensure that conservation and restoration efforts are on the best footing. Fifteen individuals have participated in research planning sessions including USDA ARS scientists, faculty from the University of California and from California State University. We intend to submit a multi-state proposal (involving Oregon and Washington) to the USDA Initiative for Future Agricultural and Farming Systems (IFAFS) and to approach philanthropic foundations interested in California environmental research and conservation work.

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ATTACHMENTS

A. California Assembly Bill 3383 (AB 3383)

B. California Assembly Bill 1998 (AB 1998)

C. *Walnut BIOS Notes*, Newsletter of the Walnut BIOS Projects in San Joaquin and Stanislaus Counties, UC ANR, UCCE and CAFF, April/May 2001.

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