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Influence of farm management style on adoption of biologically integrated farming practices in California

Sonja Brodt[1], Karen Klonsky[2,*], Laura Tourte[3], Roger Duncan[4], Lonnie Hendricks[5], Cliff Ohmart[6], and Paul Verdegaal[7]

[1]University of California Statewide Integrated Pest Management Program, Davis, CA, USA.
[2]Department of Agricultural and Resource Economics, University of California, Davis, CA, USA.
[3]UC Cooperative Extension, Santa Cruz County, Watsonville, CA, USA.
[4]UC Cooperative Extension, Stanislaus County, Modesto, CA, USA.
[5]UC Cooperative Extension, Merced County, Merced, CA, USA.
[6]Lodi-Woodbridge Winegrape Commission, Lodi, CA, USA.
[7]UC Cooperative Extension, San Joaquin County, Stockton, CA, USA.
*Corresponding author: klonsky@primal.ucdavis.edu

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Abstract

We consider the adoption of biologically integrated agricultural practices from the perspective of farm management style. Adoption decisions for farming practices must fit into a broader farm decision-making context that incorporates economic, environmental, social, family and personal considerations, as well as use of agricultural information sources. Drawing from a study of California almond and winegrape growers, we demonstrate that management styles differ substantially among farmers, these differences affect use of information sources and adoption of biologically based practices on the farm, and such adoption does not negatively affect crop performance. We used Q-methodology, a method for eliciting qualitative data using a variant of factor analysis, to identify three distinct management styles among a purposive sample of 40 growers. The Environmental Stewards' management style places higher priority on conservation of natural resources than on getting the highest possible yields or profits. Production Maximizers, with a different style, prioritize more traditional goals of producing the highest possible yields and quality and focusing resources on the farm rather than on outside concerns. Networking Entrepreneurs, on the other hand, value learning about innovative techniques in social contexts such as informational field days, evaluate new information with a business-like attitude and enjoy off-farm interests. A two-season mail survey of farming practices and information sources demonstrated that differences in management styles affect the adoption of practices. Environmental Stewards were more likely to practice biological pest control and encourage wildlife and less likely to use the most toxic chemicals. Production Maximizers had a greater tendency to use prophylactic and broad-spectrum chemicals, while Networking Entrepreneurs preferred more innovative biological pest controls but tended to avoid time-consuming cultural practices. Production Maximizers were distinguished by less use of more social forms of communication, such as attending field days and talking with other growers. Crop health and quality indicators showed that almost all growers were managing their crops very successfully, regardless of management style or choice of practices. These results hold important implications for efforts to increase the adoption of sustainable agriculture, especially by showing that contents and methods of outreach efforts must vary to accommodate diverse farm management styles.

Key words: sustainable agriculture, integrated pest management, farm management style, Q-methodology, pest control advisers (PCA), extension, adoption, almonds, winegrapes

Introduction

The term 'biologically integrated farming systems' was coined by Dr Robert Bugg (personal communication, July 2003) and is modeled after the term 'integrated farming', as commonly used in Europe. The term refers to more than just specific management practices; it implies a whole-systems approach that considers the impact of management practices on all organisms and ecological relationships in the farming system. This approach is contrasted to 'conventional farming', which we interpret here as an approach that attempts to manipulate and control single elements in order to modify the agroecosystem and to counteract or eliminate perturbations, rather than to work *with* the system in an adaptive orientation.

Since the advent of formal programs of biological pest control, integrated pest management (IPM) and soil conservation techniques, an extensive body of literature has focused on issues of adoption of such techniques. Following a tradition of research in diffusion of innovations[1], studies typically try to find correspondence between the use of certain practices and one or more categories of farmer characteristics, including demographic and socio-economic characteristics, and information sources used[2–9]. While some authors have additionally examined farmers' attitudes and perceptions, to our knowledge no previous studies have attempted to integrate these diverse factors into a holistic management style.

A focus on management style directs attention to the decision-making process itself, as management style is defined by the sum of the decisions taken by a farmer and the priorities expressed in those decisions. Ajzen and Fishbein[10] maintain that empirical studies of many different types of behavior have shown time and again that what they term 'external variables', such as demographic characteristics and personality traits, tend to have few or weak relationships with actual behavior, although they may influence attitudes. Instead, Ajzen[11] proposes a theory of planned behavior, which states that the immediate determinant of a given action is a person's intention to perform or not to perform that particular action. Intention, in turn, is a function of personal attitudes (positive or negative evaluations of behaviors) mediated by subjective norms (what a person thinks others want him or her to do) and perceived behavioral control (the belief that one has the necessary resources and capability to perform a behavior). Attitudes, in turn, are determined by beliefs, which are associations of various attributes to an object or action.

Following such an approach, this study focuses on farmers' beliefs, attitudes and goals in order to understand adoption of specific practices. From the perspective of farm management, we can interpret the work of Ajzen to imply that beliefs and attitudes affect overall management goals. These goals, which incorporate economic, environmental, social, family and personal considerations, interact with available human and material resources and lead to the formulation of adaptive strategies to meet those goals. All these adaptive strategies together constitute a management style. Finally, management style is a direct determinant of particular decisions, or intentions, to adopt or not to adopt specific farming practices. This paper draws on data from California almond and winegrape growers to explore the diversity of management styles among growers, the effects of these diverse styles on adoption of biologically integrated farming practices and use of information sources, and the impact of adoption on crop performance.

Research Methods

Study design and sample selection

For the purposes of this study, indicators of adoption of biologically integrated farming were drawn from the suites of practices recommended by two related programs: the Biologically Integrated Orchard Systems (BIOS) program of the Community Alliance with Family Farmers (CAFF), and the Biologically Integrated Farming Systems (BIFS) program of the Lodi-Woodbridge Winegrape Commission (LWWC). BIOS was launched in 1993 by CAFF, a non-profit organization based in Davis, California, to integrate the expertise of growers, researchers, University of California Cooperative Extension farm advisors and state-licensed pest control advisers (PCAs) in providing assistance and support to almond growers wishing to reduce synthetic fertilizer and pesticide use[12]. BIOS-recommended practices hinge on using a whole-systems approach to building overall orchard health and buffering orchards against pest outbreaks. They include practices such as comprehensive monitoring of pest and beneficial populations, enhancing habitat for beneficials, releasing beneficials, cover cropping, applying natural fertilizers such as compost, using selective 'soft' pesticides such as *Bacillus thuringiensis* and only when monitoring indicates they are needed, and careful mowing and irrigation management for disease control.

The BIFS program, which encompasses several crops, grew out of the success of the initial BIOS program in almonds. In 1995, the LWWC, a grower-funded commission in California Crush District 11, received a BIFS grant to establish a grower–university partnership to identify and implement among member growers a similar set of BIOS-type practices for winegrapes, with some crop-specific modifications such as leaf removal for disease control.

The study sample comprised 40 farmers growing perennial crops, including 21 almond growers and 19 winegrape growers, in California's Central Valley. Within each crop, we selected a group of farmers practicing biologically integrated farming and a group of conventional farmers, on the basis of their participation or non-participation in the BIOS (almonds) or BIFS (winegrapes) programs.

Nine almond growers in Merced and Stanislaus Counties who are enrolled in the BIOS program were selected for this study. Twelve almond growers not participating in BIOS were also selected from Merced, Stanislaus and San Joaquin Counties. In winegrapes, this study included 11 growers actively participating in the LWWC BIFS program, and eight growers further south in San Joaquin County who were not part of the LWWC nor of the BIFS program.

Identifying farmer management styles using Q-methodology

In the first phase of the project we used Q-methodology to identify distinct management styles among the growers. This methodology has been applied previously to an

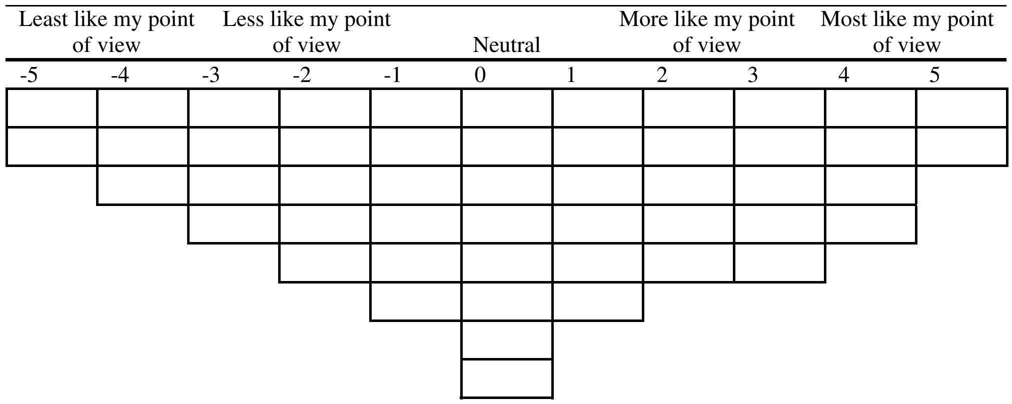

Figure 1. Statement sorting board.

agricultural context by Fairweather and Keating[13]. This approach inverts the rows and columns in a typical factor analysis. This inversion turns the focus of the analysis *towards* intercorrelations of people, based on each individual's overall pattern of all traits tested for, and *away* from intercorrelations of individual traits, based on how many people were tested for them[14,15]. By so doing, it enables the quantitative study of small sample sizes and even single cases, because the study population now becomes the set of tests or questions, rather than the set of people being tested.

The methodology also encompasses a particular method of data collection, which is designed to minimize interference from researcher bias by involving the respondent in a card-sorting exercise. In our study, each grower was given a set of cards, each printed with a goal or value statement relating to farm management. The grower then arranged the cards on a sorting board (Fig. 1) according to degree of agreement or disagreement with the selected statements. The statements were designed to test for growers' values, beliefs, attitudes and goals regarding factors ranging from economic factors (profit, stability and growth) to considerations for family, leisure, work environment, community involvement and social responsibility regarding environmental stewardship. The consequent rankings of statements from all growers were then analyzed using a Q-methodology software package, PQ Method[16], that identifies key suites of statements (or 'factors') ranked similarly by distinct groups of growers.

Farming practices and information use survey

In the second phase of the project, the same growers completed a mailed survey on information sources used, farming practices and financial and business aspects of their farms. The survey was administered twice, once after the 1998 growing season and again after the 1999 season. The over 50 items on farming practices called for simple yes/no responses to questions of whether or not the specified practices were used on any orchard or vineyard within the previous growing season. As such, the questions were designed to test for overall adoption of a practice and did not distinguish intensity or extent of use of a practice. The practices selected cover a wide range of functions, with particular emphasis on pest management (insect, mite, disease and weed), as well as fertility management, orchard/vineyard floor management, pruning/brush management, irrigation, and wildlife habitat enhancement.

The survey also asked growers to indicate their frequency of contact with various information sources. Personal contacts comprised Cooperative Extension farm advisors, crop handlers/buyers, as well as other growers/family members/neighbors. Independent and input-supplier-employed pest control advisers (PCAs) were also included. PCAs are state-licensed consultants who scout growers' fields and recommend pest control measures and, in some cases, fertilizer regimens. Input-supplier PCAs are open to conflicts of interest, since they typically recommend pesticides sold by their companies. In addition, they may have less extensive knowledge of biologically integrated approaches, as such knowledge is not currently a requirement of licensing. However, they do not charge growers directly for their services (although costs are included in the costs of the pesticides), while independent PCAs, many of whom specialize in biologically integrated pest control, contract with growers for a fee. Other media sources included manuals produced by the University of California Integrated Pest Management Program, other university publications, farm advisor newsletters, BIOS and LWWC publications, meetings/seminars/field days, Internet and trade journals.

Surveyed growers were asked to indicate weekly, monthly, annual or no frequency of use for each of 12 specified information sources. Farm-advisor members of the project team helped to standardize the raw frequency data to a three-level rating system that indicates high, moderate and low degree of use, allowing comparison of information sources that are typically available to farmers at very different frequencies (such as semi-annual field days versus a monthly publication).

Standard statistical techniques for hypothesis testing were not appropriate for our small and purposively selected sample of growers. Instead, we used Kendall's tau b, a measure of mutual association for ordered, categorical data[17]. This measure is less sensitive than others to choice of response categories, which allowed us to assess relative differences between small groups of growers over a somewhat large number of response categories. Standard statistical significance levels are not associated with tau b results. We also used correspondence analysis to explore relationships between diverse variables. Correspondence analysis uses principal components analysis to transform matrices of categorical data into a graphical format, in which relationships between variables can be observed, based on physical proximity to each other[18].

Crop performance measures

We measured crop-specific biological performance for participating farmers. In almonds, leaf nutrient analysis and nut reject levels at harvest told us about the health of the trees and the impact of pests on the final crop quality and yield. For winegrapes, the key measure was the ratio of crop yield to weight of vine prunings taken during the following dormant season (also known as vine balance), which is an indicator of vine vigor and capacity for long-term sustained yield. A ratio between four and eight is generally considered desirable; a larger value indicates that the vine is probably being stressed to produce too much for long-term health, while a lower value indicates that the vine is not producing well or is overly vigorous in vegetative growth, at the expense of fruit production. Fruit from overly vigorous vines tends to produce lower-quality wine.

Results and Discussion

Demographic characteristics

The majority of growers in the sample had at least some college education, and while their ages ranged from younger than 35 years to about 75 years, 65% were over 45 years old. Their farms ranged from 6 to 2632 ha (mean 358 ha, median 57 ha). Our sample size was too small to identify statistically significant demographic differences between the groups described below.

Farmer management styles

The Q-method procedure resulted in three groups of growers, signifying three distinct management styles, which together accounted for 48% of the total variance. We named the three groups the Environmental Stewards, the Production Maximizers and the Networking Entrepreneurs, based on the statements each group most agreed or disagreed with.

The defining characteristic of the 17 Environmental Stewards (eight almond and nine winegrape growers) was a high valuation of environmental stewardship. They placed higher priority on managing resources in cooperation with nature than on getting the highest possible yields or profits. The Environmental Stewards were the least concerned with how they compare to other farmers in their communities, except on issues of crop quality, and they considered themselves more dependent on family help on the farm compared to the other groups.

The 14 Production Maximizers (seven almond and seven winegrape growers) focused most of their resources on their farm businesses and on producing the highest possible yields and quality. They took a more industrial approach to farming, with some expressing the view that they struggle with nature to get the best possible crop. Strongly committed to their farms, they were the least interested in off-farm activities, including exchanging information with others at events such as field days.

The nine Networking Entrepreneurs (six almond and three winegrape growers) distinguished themselves by placing relatively less emphasis on earning a living from the farm and showing a correspondingly stronger interest in off-farm activities and social interaction. They also valued new, cutting-edge information and enjoyed acquiring such information in social contexts such as extension field days and conversations with other farmers. Finally, they displayed a strong business-like attitude in their decision-making style, with considerations about the benefits of new farming techniques versus their costs in time, money and crop quality figuring highly in the Entrepreneurs' approaches to farm management.

Adoption of alternative and biologically integrated practices

Most and least commonly used practices. To provide a context for highlighting key differences in the adoption of farming practices, we begin here by outlining the similarities, i.e., farming practices that tended to be used by the majority of growers across all styles, as well as those practices that very few growers used. Most growers in the study employed practices that used standard materials more efficiently or carefully, such as spot spraying herbicides and managing irrigation and fertility to meet pest control goals (Table 1). Such practices can save money and reduce environmental stresses, while not requiring fundamental changes in pre-existing patterns of farm management.

In addition, almond growers in this study were characterized by their widespread use of foliar nutrient sprays, winter orchard sanitation for insect pest control, and burning of orchard prunings. They also maintained their orchard floors by mowing resident vegetation and avoiding or reducing tillage, which can be a money-saving strategy. Most winegrape growers, on the other hand, disked for weeds and use pre-emergent herbicides.

Several practices with very low rates of adoption among the study growers are relatively new. Fewer than 20% of almond growers had adopted reduced pruning (alternate year or no pruning) or pheromone use for peach twig borer control. Winegrape growers exhibited low adoption (fewer than 20%) of beneficial insect and mite releases for pest control and low use of compost for disease and pest

Table 1. Farming practices used by 80% or more of all growers (almonds and winegrapes) in both years surveyed.

Biological Pest Control
Monitoring insect pests
Monitoring mite pests
Cultural Pest Control
Dust reduction for mite control
Irrigation management for mite control
Irrigation management for disease control
Fertility management for disease control
Spray for disease based on weather
Biologically Integrated Floor Management
Spot spraying of herbicide for weed management
Conventional Floor Management
Use of contact herbicide for weed management
Fertility Practices
Use of synthetic fertilizers

suppression. They also had little adoption of electrostatic sprayers (which help sprays reach their target and avoid drift). Of the more traditional practices, very few winegrape growers burnt prunings, which would contribute to air pollution. Instead, they tended to shred prunings. Fewer than 20% of the almond growers maintained a 'clean' or bare orchard floor, which is the less ecologically integrated approach to floor management.

In order to better conceptualize and analyze differences in the adoption of farming practices, we reduced the total number of practices by eliminating those used by 80% or more of all growers, those used by 20% or fewer of all growers, and those that were specific to only one or the other crop. We then grouped the remaining practices into the following seven functional categories: Biological Pest Control, Cultural Pest Control, Reduction in Toxic Chemicals, Prophylactic and Synthetic Chemicals, Biologically Integrated Floor Management, Conventional Floor Management and Wildlife Habitat Enhancement (Table 2).

Table 2. Grouping of farming practices into seven categories.

1. Biological Pest Control
Monitor beneficial insects
Monitor predatory mites
Cover crops for beneficial insects
Cover crops for predatory mites
2. Cultural Pest Control
Remove and destroy mummies
Compost for disease/pest suppression
3. Reduction of Toxic Chemicals
'Softer' or less toxic insecticides
Below label rate applications of insecticides
Alternate-row spraying of insecticides
Below label rate applications of miticides
Spraying 'hot spots' with miticides
Spraying for disease according to crop history
4. Biologically Integrated Floor Management
Minimum or no tillage
Hoeing, flaming or irrigation weed management
Seeded cover crop
Resident vegetation
Chip/shred/mulch prunings
5. Wildlife Habitat Enhancement
Owl/bat/bird boxes
Creating wildlife habitat
6. Prophylactic and Synthetic Chemicals
Broad-spectrum insecticide sprays
Routine spray for mites
Routine spray for disease
7. Conventional Floor Management
Pre-emergent herbicides
Disking
Maintenance of a 'clean' (bare) floor

Differences between management styles. A preliminary assessment using multiple correspondence analysis to relate categories of practices to each other and to the three management style groups, using only 1998 data, reveals a distinct pattern. To represent this relationship graphically, growers were assigned raw scores denoting how many practices they had adopted within each category. We then calculated the mean score of all growers for each category, and assigned each grower a score of 1 in each category for which the raw score was greater than or equal to the mean score for that category, and a score of 0 when the raw score was less than the mean score. We performed a multiple correspondence analysis on this set of final 1/0 scores and plotted the results (Fig. 2).

As the graph illustrates, all the biological and biologically integrated categories of practices cluster together, and the two more 'conventional' categories, namely Conventional Floor Management and Prophylactic and Synthetic Chemicals, form their own separate cluster. Categories that are clustered together indicate that individual growers who used many of the practices in one of the categories also tended to use many of the practices in the other categories of the cluster, and vice versa, those who used few in one category also used few in another category. Furthermore, we can see that the Environmental Stewards were strongly associated with the biologically integrated categories, while the Production Maximizers were most associated with the conventional and chemically oriented categories. The Networking Entrepreneurs were not strongly associated with any of the categories nor with either of the other two groups of farmers. On the horizontal scale, which suggests an environmental ranking, they are situated between the two main clusters, but closer to the biologically integrated cluster. Their vertical distance from any cluster may be a reflection of a large within-group variability that prevents the group as a whole from being placed in proximity to any one particular cluster. This variability may stem from the fact that the group was comprised of some farmers who were business-minded like Production Maximizers and others who shared some key characteristics with Environmental Stewards.

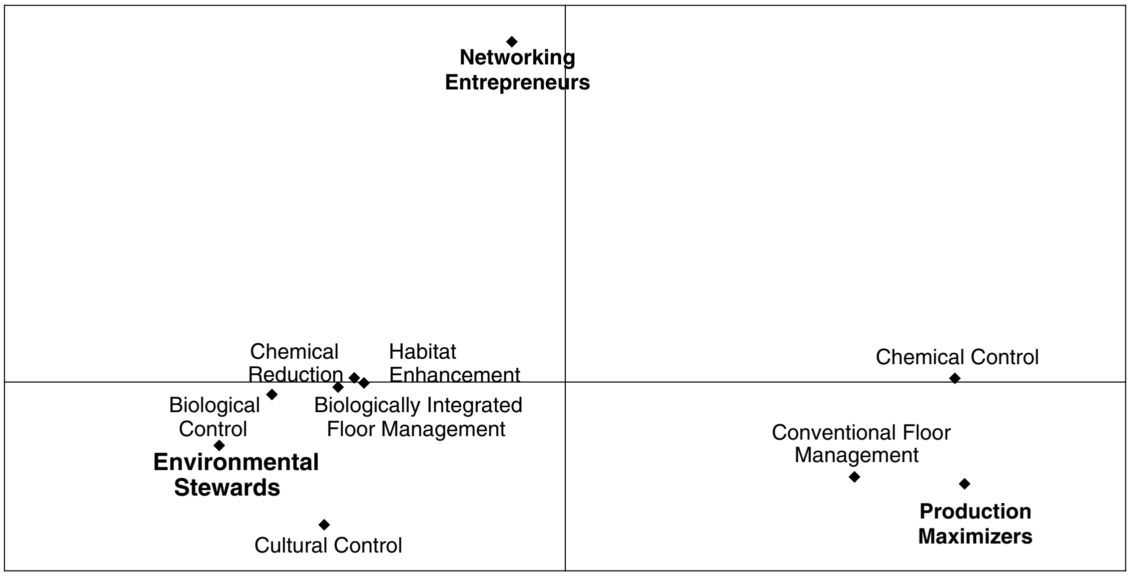

Figure 2. Correspondence analysis of management style groups and adoption of aggregated farming practices in 1998.

These preliminary suggestions of differences between management styles are corroborated by a more comprehensive analysis testing Kendall's tau b value on the aggregated data from both years of the study. The greatest differences between Q-groups were revealed for Cultural Pest Control, Prophylactic and Synthetic Chemicals, Biologically Integrated Floor Management, and Wildlife Habitat Enhancement. In each of these cases, except cultural pest control, the Environmental Stewards differed substantially from the other two groups in using more biologically integrated and environmentally benign practices and fewer synthetic pesticides. We found that the Environmental Stewards distinguished themselves most in their low use of broad-spectrum insecticides, their creation of wildlife habitat and their use of 'softer', less toxic pesticide sprays (tau $b > 0.3$). Only in the category of Cultural Pest Control did the Production Maximizers exhibit a pattern similar to that of the Environmental Stewards, while the Networking Entrepreneurs stood out most in their low adoption of these practices (Table 3).

Certain members of the Entrepreneurs group also stood out in their low use of some individual practices, including use of less-toxic insecticides (under Reduction of Toxic Chemicals) and chipping and shredding of prunings (under Biologically Integrated Floor Management). These practices, as well as several cultural control practices, could

Table 3. Categories of farming practices showing substantial differences in adoption between management styles.

Pairwise comparisons by category of practices	Tau b[1]
Cultural Pest Control	
Environmental Stewards and Production Maximizers	0.00
Networking Entrepreneurs and Environmental Stewards	0.42
Networking Entrepreneurs and Production Maximizers	0.41
Prophylactic and Synthetic Chemicals	
Environmental Stewards and Production Maximizers	0.45
Environmental Stewards and Networking Entrepreneurs	0.37
Networking Entrepreneurs and Production Maximizers	0.10
Biologically Integrated Floor Management	
Production Maximizers and Environmental Stewards	0.42
Networking Entrepreneurs and Environmental Stewards	0.32
Production Maximizers and Networking Entrepreneurs	0.02
Wildlife Habitat Enhancement	
Production Maximizers and Environmental Stewards	0.54
Networking Entrepreneurs and Environmental Stewards	0.33
Production Maximizers and Networking Entrepreneurs	0.13

[1] Tau b values range from −1 to +1, with values closer to |1| indicating greater differences between groups. Positive values indicate higher use by the second member of the pair, as listed. Conversely, negative values would indicate less use by the second member of the pair.

all impose higher costs in materials, equipment and labor than their counterpart conventional practices. This observation points to an important distinguishing characteristic of Networking Entrepreneurs, their strong off-farm interests and commitments, which may motivate them to use mainly those practices that fit best into their time and management constraints.

Differences between crops. While the two crops were almost equally represented among the Environmental Stewards and Production Maximizers, almond growers comprised almost 75% of the Networking Entrepreneurs, meaning that this group was highly influenced by its almond grower contingency. Examination of the data for individual practices reveals that almond growing Entrepreneurs were particularly unlikely to use softer or less toxic insecticidal sprays and to chip and shred their prunings. Overall, they showed lower adoption of the categories Cultural Pest Control, Reduction of Toxic Chemicals and Biologically Integrated Floor Management, compared to other almond growers (tau b ranging from 0.3 to 0.8).

Winegrape growers in the Entrepreneur group, on the other hand, did not differ as much from winegrape growers in the other two groups (tau b ranging from 0.0 to 0.5). The only noteworthy distinction was the greater tendency of those in the Networking Entrepreneur group to follow strategies to reduce the amounts of toxic pesticides used compared to winegrape growers in the other two groups (tau b = 0.3 and 0.5). Almond growing Networking Entrepreneurs, in contrast, were less likely to use such strategies (tau b = −0.3 and −0.5).

Certain types of biologically integrated practices appealed more to all winegrape growers as a group, while others appealed more to almond growers as a group, regardless of management style. Winegrape growers were less likely than almond growers to use broad-spectrum and routine pesticide applications, to grow cover crops as habitat for beneficial organisms, or to remove and destroy mummies for sanitation (tau b from 0.27 to 0.46). They were more likely to use the newer forms of less toxic pesticides (tau b = 0.28). The role of almond growers in distinguishing the Networking Entrepreneurs also suggests that almond growers in this sample exhibited a greater range of management styles overall than did the winegrape growers.

With the exception of the less toxic but more expensive pesticides, the winegrape growers' adoption pattern suggests an overall strategy of reducing input and labor costs, which is, at least in part, due to the fact that many of the winegrape growers in this study produced high-value varieties for which quality is more important, and often more lucrative, than quantity. Since high quality in winegrapes often occurs inversely to high yield, winegrape growers can afford to be relatively less concerned about many of the most prevalent insect and mite pests, since these pests mostly affect the foliage and overall vine vigor, but do not directly affect the quality of the grapes themselves. In fact, lower vine vigor could even be considered an asset rather than a liability in producing higher-quality, higher-priced grapes. The higher prices, at least at the time of this study, also meant that winegrape producers could afford to try the newer, less toxic but more expensive pesticides, because they still had a higher profit margin within which to operate than did almond growers.

On the other hand, price incentives for quality of almonds are relatively minimal, and those that are offered are based on the level of direct damage to nuts caused by insects and diseases. Since certain insects, in particular, can cause substantial damage, the price bonuses provide added incentives for growers to use routine and broad-spectrum sprays as 'insurance policies'. This pattern leaves only those almond growers most dedicated to an environmental orientation using certain practices generally perceived as more risky, such as using less toxic sprays and only spraying after pest thresholds are observed, rather than routinely. Lower prices also give almond growers an incentive to reduce costly tillage operations and allow resident vegetation on the orchard floor. Moreover, winegrape growers have more appearance concerns, relating to the growing agritourism industry in wine-producing regions, which could be contributing to a higher tendency toward 'clean' vineyard floors compared to almond growers.

Differences by program participation. The results for comparing non-program farmers with BIOS/BIFS participant farmers reveal differences that are much smaller than those between management styles (Table 4). In fact, Biologically Integrated Floor Management was the only category with a somewhat notable tau b value, of 0.36, with program participants using more of these practices than non-participants. This result is not surprising, since cover cropping is one of the practices highly promoted in the BIOS/BIFS programs. Reduction in use of prophylactic and synthetic chemicals, as well as use of biological pest controls, showed a smaller difference, as both of these were also frequently adopted by non-participants. The distribution of participants among the management style groups tells a similar story. While the Environmental Stewards group did have a larger proportion of BIOS/BIFS participants

Table 4. Differences in adoption of farming practices between BIOS/BIFS non-participants and participants.

Categories of practices	Kendall's tau b value comparing BIOS/BIFS non-participants and participants
Biological Pest Control	0.20
Cultural Pest Control	0.05
Prophylactic and Synthetic Chemicals	−0.17
Reduce Toxic Chemicals	0.24
Biologically Integrated Floor Management	0.36
Conventional Floor Management	0.09
Wildlife Habitat Enhancement	0.17

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(76% of the group) than the Production Maximizers group (29%, tau b = 0.45), our sample included four non-participants who were Environmental Stewards and four participants who were Production Maximizers. These results show that the BIOS and BIFS programs are appealing sources of information to a wide range of farmers in terms of management styles, whether or not they can immediately adopt all the recommended practices. In addition, those not officially enrolled in the programs may also be accessing the information, either directly or indirectly through other farmers, or they may be making changes in their farm operations due to broader-based environmental and regulatory influences that affect everyone.

Moreover, the lack of substantial differences between BIOS/BIFS growers and non-BIOS/BIFS growers was limited to basic *adoption* of practices, i.e., whether they had been implemented on any part of a grower's acreage. Villarejo and Moore[19] have shown that program growers do differ substantially from non-participants in the *intensity* of use of particular practices, measured in pounds of pesticides applied per acre and in percentage of acres treated.

Crop performance and its relation to farming practices

To assess whether management styles influence crop performance, we examined crop performance data from participating farmers. The mean almond nut reject level was 1.5% [standard deviation (SD) 1.4%, range 0.2–4.6%] for 15 growers from whom data could be collected in 1999. Performance did not differ significantly either between management style groups ($P = 0.28$) or between participants and non-participants of BIOS/BIFS ($P = 0.81$). Seven of the 15 growers had levels under 1%, which frequently brings a price bonus, while one grower, with organic acreage, had a reject level over 4%, which often incurs a price penalty. Leaf nutrient data revealed neither deficient nor toxic levels of any major macro- and micronutrients for the 20 growers whose orchards were tested. These results are comparable to those obtained in a 3-year comparison study of seven conventional and seven BIOS almond orchards, in which overall insect infestation rates were low and not significantly different in sprayed and unsprayed orchards[20].

The mean vine balance ratio in 2000 was 7.9 for the 12 (out of 19) winegrape growers from whom measurements could be obtained (SD 2.8, range 2.8–11.7). As mentioned previously, a ratio between 4 and 8 is an indicator of a healthy balance between vegetative growth and fruit production. Significant differences were found between the management style ($P < 0.001$) and between BIFS participant and non-participant groups ($P < 0.001$). The Production Maximizers had a much higher mean ratio (10.5) than the Environmental Stewards (7.7) and Networking Entrepreneurs (6.6), in keeping with the Production Maximizers' goals of attaining high yields.

The non-BIFS winegrape growers had a much higher mean vine balance ratio (9.8) than did the BIFS participants (6.9). While this sample is not necessarily representative of all growers, these results do point to some crucial differences among winegrape growers in this region. Growers can choose between two different production and marketing strategies—either to grow premium varieties that are used for varietal wines and command high prices, or to grow blending varieties that are marketed as commodities. Since flavor components are improved when vines are not overly vigorous and yields are smaller, wineries pay significantly more (from \$US650 to \$US800 ton^{-1} at the time of the study) for varietal grapes grown under low-input conditions. Prices for blending varieties are typically much lower (from \$US250 to \$US450 ton^{-1} at the time of the study). Growers of these blending varieties therefore tend to manage their vines to emphasize yield, reflected in higher vine balance ratios. As a general marketing strategy, the LWWC, which includes all the BIFS participants in this study and about three-quarters of the winegrape Environmental Stewards, has emphasized higher-quality varieties that can be identified with this region. The other growers, in the same county with the same growing conditions but just outside of the Lodi-Woodbridge jurisdiction, tend to grow lower-value blending varieties, which explains their higher vine balance ratios.

The distinction between winegrape varieties also made a difference in choice of pest management practices used. Growers of high-value varieties were more likely to monitor beneficial mites, to treat 'hot spots' in their fields with miticides, and to use leaf pulling to control insects and disease (tau b = 0.32, 0.40 and 0.42, respectively). These practices are management and labor intensive. High-value producers were also more likely to apply materials such as miticides at below the recommended label rates (tau b = 0.29), because they could afford to be more vigilant in monitoring and spraying hot spots when necessary.

Use of information sources

Data for frequency of information use from 12 sources was aggregated for the 1998 and 1999 growing seasons. For the sample overall, the pattern of contact frequencies suggests that pest control advisers (PCAs) tended to be the first sources to which growers turned, with almost three-quarters of growers reporting high use of input-supplier PCAs, and almost one-third reporting high use of independent PCAs. University-based information sources, including Cooperative Extension farm advisors and their newsletters, were also accessed at relatively high rates, although not as often as PCAs. In addition, 85% of the sample growers reported attending meetings and field days held by farm advisors and others, from once a year to once a month. Other growers and family members were also frequently consulted, while Internet sources were seldom consulted.

The results indicate few differences in information use between farm management styles. Almost three-quarters

Table 5. Selected information sources[1] with differences in frequency of use between management styles.

Pairwise comparisons by information source	Tau b
Independent PCA	
Production Maximizers and Environmental Stewards	0.41
Networking Entrepreneurs and Environmental Stewards	0.42
Networking Entrepreneurs and Production Maximizers	0.10
Input-supplier PCA	
Environmental Stewards and Production Maximizers	0.31
Environmental Stewards and Networking Entrepreneurs	0.43
Production Maximizers and Networking Entrepreneurs	0.26
Other growers/friends/family	
Production Maximizers and Environmental Stewards	0.32
Networking Entrepreneurs and Environmental Stewards	0.07
Production Maximizers and Networking Entrepreneurs	0.23

[1] Information sources with tau b values $>|0.3|$.

of all growers consulted BIOS and LWWC program publications relatively frequently (most between once a month and once a year). These results suggest that most growers are interested in alternative information and that print publications may constitute a relatively easy and inexpensive source of this information.

The largest difference between management styles was in the use of the various classes of PCAs, with Environmental Stewards making the most use of independent PCAs and the least use of input-supplier PCAs (Table 5). Production Maximizers used social sources, especially other growers/friends/family, less frequently than the other two groups, which is consistent with their lower preference for social interaction. Overall, however, differences in use of information sources between management styles were not as distinct as differences in use of practices. This observation supports our hypothesis that adoption of particular practices results from a complex host of farmer attitudes and goals comprising management style.

Among personal contacts, growers with all three styles, including Environmental Stewards, the highest users of independent PCAs, chose input-supplier PCAs as their most important information source. This result is consistent with complaints frequently heard in the field about a shortage of qualified independent PCAs. Farm advisors figure prominently as second and third choices. These results correspond closely to those found in two other recent studies[7,21]. It appears that PCAs tend to serve as the first line of inquiry for day-to-day concerns, while farm advisors serve as the second tier of assistance in unusual incidents and emergencies.

Notably, other growers and family members were not important sources of information for the business-minded Production Maximizers, in contrast to their second-choice standing for approximately half the growers in each of the other two groups. Consistent with the social networking emphasis in their Q-sorting results, 38% of Networking Entrepreneurs picked meetings, seminars and field days as their top choices, while the other two groups preferred print channels. Finally, one-quarter of Environmental Stewards picked BIOS and LWWC publications as their third choice. This source did not figure prominently for the other two groups.

Conclusions

Consistent with Ajzen's theory of planned behavior[11], this study shows that farmers who approach farming with different beliefs, values and goals do indeed differ in the day-to-day farm management decisions they make. The unique combination of social and entrepreneurial characteristics of Networking Entrepreneurs, for example, leads them proactively to seek out and try new and environmentally benign practices, while eschewing those biological and cultural practices that are too time-consuming or expensive. Environmental Stewards give greater priority to a larger set of environmentally benign practices, while Production Maximizers prefer practices that constitute a more traditional path to farm business success.

A relation between farm management style and adoption of practices is also supported by a study on IPM adoption by California pear growers, which observed higher rates of adoption of more complex and pro-active IPM technologies by family farmers than by more business-like, non-resident farm managers[3]. The authors postulated that the family farmers' larger interpersonal communication networks, stronger ties to the land, and more time to spend on more management-intensive technologies all contributed to these differences.

The inability of BIOS or BIFS membership to explain differences in adoption of practices reinforces the notion of looking toward management style for edification. The BIOS and BIFS programs are voluntary programs that focus on sharing and refining information, rather than on requiring the use of certain practices. The lack of distinctions between program participants and non-participants suggests that choosing to enroll in the program is more a sign of how much a grower values learning new information and participating in alternative educational formats, rather than implementing particular practices. On the other hand, the fact that the management style groups differ more substantially from one another in use of practices demonstrates that a grower's commitment and ability to implement biologically integrated practices is best predicted by a combination of personal goals, beliefs and values, and the manner in which these interface with the underlying structural and marketing context. In other words, *obtaining* new information is a distinct activity from *operationalizing* it. These results imply that merely disseminating general information about new practices is not enough; rather, the information must be presented in varied ways to demonstrate how growers can meet divergent goals by adopting the practices (for discussion of related extension issues, see Brodt et al.[22]).

The variability among the three groups' repertoires of practices suggests that growers are adopting individual practices selectively, as opposed to uniformly adopting bundled sets of practices, as also found in the pear study[3]. Because of the complexities of personal and business factors that impact decision-making, each farmer chooses a slightly different combination of practices. This observation suggests that, while scientists and policymakers might desire everyone to adopt a whole spectrum of practices, a more effective approach might be to work with growers to aggregate practices into groups that correspond with specific management goals.

Another perspective on selective adoption is that, except for two organic growers, almost none of the growers, including several Environmental Stewards, felt that they could ever rely solely on biological and cultural practices to the exclusion of any synthetic materials, because they perceived the risks to crop quality to be too great. In a related vein, we noted that several farmers in the study were *adding* IPM-like techniques, especially monitoring and cultural practices, to their set of conventional chemical practices, rather than using these techniques to *reduce* the number of chemical methods. Even the Production Maximizers distinguish themselves from the others not by their lack of use of biological practices, of which they use a fair number, but by their greater reliance on synthetic materials at the same time. These results point to the need for further research on chemical-free and biologically integrated approaches and better grower education to ensure effective implementation. They also make a case for income guarantee crop insurance programs and federal cost-share programs that could help farmers' transition to lower chemical use.

Finally, we agree with Bentley et al.[20] that it is important to continue to demonstrate the success of new management programs to farmers and pest control advisers, as the evidence from crop performance data suggests that farmers' perceptions of the high risk of biologically integrated methods may not always be justified. Most importantly, we have demonstrated that growers of high-value crops are not adverse to change but, in fact, seek it. The questions then become, what characteristics are they looking for in new farming practices, what information do they need, and which outreach format will enable them to learn the most? Answering these questions will be key to increasing adoption of biologically integrated farming systems.

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