Information and Pesticide Management

A Study of the Impact of Information Availability and Pesticide Use in California Almond and Walnut Production

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Executive Summary

This report summarizes findings of a study designed to test the efficacy of a voluntary pesticide reduction program in California almonds and walnuts. We compared two groups of tree nut growers. First, a group of growers who are participants in the Biologically Integrated Orchard Systems (BIOS) program sponsored by the Community Alliance with Family Farmers (CAFF); and second, a group of traditional growers carefully selected to serve as a cohort to the first group. The matching procedure involved identifying a producer who farms a nut orchard located within the same section of land as the BIOS grower (a section of land has an area of one square mile and contains 640 acres), and whose orchard is comparable in size to the BIOS farmer. In addition, an effort was made to match the BIOS farmer with a Traditional grower who operates the same total number of nut crop acres.

We attempted to determine if there was a significant difference between the two groups from the point of view of the pest related inputs such as information sources and uses, including technical advice, their use of in-orchard traps and attractants, chemical and biological inputs, and cultural practices. We also collected data on crop yields and processor rejection rates due to insect damage.

A total of thirty-six Almond growers, all located in Merced and Stanislaus Counties, were contacted and interviewed in person during summer 1997. Of this total, twenty-three growers were participants in the CAFF/BIOS project and thirteen were Traditional producers. The sample of walnut growers was drawn from Solano and Yolo counties. Five were participants in the CAFF/BIOS program and sixteen were Traditional growers.

Survey results demonstrated that members of the voluntary pesticide use reduction project, BIOS, as well as the Traditional growers in the sample, invested significant resources in obtaining information about orchard pests, as well as about chemical and non-chemical methods of controlling these pests, in an attempt to maximize farm income. In the use of pheromone and Navel Orange worm trapping, members of the BIOS project were much more aggressive than the Traditional growers in investing in these traps as a method of monitoring pest populations in their orchards.

Although a large majority of both Traditional and BIOS project members followed the recommended practice of removing mummies from almonds, the proportion of BIOS growers putting in a cover crop was almost triple that of the Traditional growers.

Traditional growers reported higher pest control costs than their cohort BIOS members. On the other hand, Traditional growers reported higher average yields than did the BIOS participants. Traditional growers reported lower rejection rates by processors than was the case for the BIOS members. Data from the survey indicate the average almond yield for BIOS growers was 1,275 pounds per acre, while the Traditional group averaged 1,520 pounds per acre. Secondly, the processor rejection rate for almonds averaged 2.15 percent for BIOS growers and 1.21 percent for the Traditional group. The

comparable rejection rate for walnuts was 3.9 percent for Traditional and 5.2 percent for BIOS growers.

When Pesticide Use Reports for these growers were tabulated, both groups exhibited a marked decreased use of restricted pesticides each year since 1993, as measured by pounds of active ingredients per acre treated. In addition, BIOS orchards showed significantly lower levels of all types of pesticide use as compared with cohort orchards. While BIOS members reported lower use of pesticides, they also reported a much greater use of insect and pheromone traps to monitor pest populations. Traditional growers were much more dependent on chemical company representatives for their major source of information.

Several conclusions can be drawn from this study. First, information is the least expensive, least polluting and least hazardous input to farming. Second, both those almond and walnut growers who have joined a biological/cultural pest management project and those who have not have reduced their dependency on restricted pesticides in recent years. The survey results also indicated that dissemination of information about these practices is likely occurring through informal, neighbor-to-neighbor networks that exist in every community. Finally, since this experiment has been of a relatively short duration, the lower yields and higher rejection rates of the BIOS growers should be interpreted cautiously. The question of long term economic sustainability is yet to be answered.

Introduction

In the early 1990s the nonprofit organization Community Alliance with Family Farmers (CAFF) created a series of innovative programs to assist farmers in the quest for ecological and economic sustainability. One major CAFF program provides growers with technical information on pesticide use and management. Started during summer 1993, the Biologically Integrated Orchard System (BIOS) project is an attempt to reduce grower dependency on traditional pest control and cultivation methods, such as use of restricted pesticides or chemical fertilizers, by substituting non-restricted materials and improved cultural practices. Volunteer grower participants are supplied with technical assistance on a weekly basis in monitoring their populations of orchard pests, as well as populations of beneficial insects. The BIOS Project concentrates on almond and walnuts growers located in the San Joaquin and Sacramento Valleys of California. The focus of the work with almond growers is in Merced and Stanislaus Counties. The programs' walnut growers are concentrated in Yolo and Solano Counties.

California Almond and Walnuts Industries

California is the nation's only significant producer of almonds and walnuts, with more than 99% of total U.S. output of each crop. In 1996, the two industries brought the state's farmers more than $1.3 billion in crop sales.

Export markets are especially important for both crops, representing 55% of crop revenue for almonds and 54% for walnuts in 1995. According to the California Department of Food and Agriculture, half of the world's export trade of walnuts is grown in California.

Prospects for both industries are generally quite good. Prices for both almonds and walnuts were relatively high in the period 1994-96. However, 1997 proved to be a boom year as measured by the pounds of almonds harvested. Prices fell sharply as supply grew faster than demand.

Changes in production can be measured by crop revenue, which depends upon price, and by physical volume, usually expressed in pounds. Comparing three-year average crop revenues for 1994-96 with 1987-89, the almond industry experienced a growth of about 65% in nominal dollars, but a decline of about 7% in pounds of product (shelled basis), and a decline of about 3% in bearing acreage. However, an estimated 66,100 acres of non-bearing trees were in the ground as of 1996 and additional plantings have been added since then. This represents a

potential increase of 17% in bearing acreage and pounds of product over the next several years. Non-bearing acreage has increased significantly in recent years reflecting the attractiveness of higher prices. Of course, prices may fall significantly as supplies increase. If prices fall, it is likely that there will be much smaller increases in crop revenue—and possibly even a decline in total revenue—unless suitable new market outlets can be found.

For walnuts, the three-year average crop revenues for 1994-96 as compared with 1987-89 showed an increase of 31% in nominal dollars. But production, measured in pounds, showed a decline of about 2%, and bearing acreage declined by about 4%. Although non-bearing acreage has increased somewhat in recent years—no doubt stimulated by relatively higher prices—this total is quite a bit smaller than the corresponding figure for almonds. Thus, it is likely that increases in bearing acreage and production will be relatively smaller than will be the case for almonds.

Production of both crops is highly concentrated in the Sacramento and San Joaquin Valleys. Kern County ranks first in bearing almond acreage, followed in order by Stanislaus, Merced, San Joaquin and Fresno counties. For walnuts, San Joaquin County ranks first in bearing acreage, followed by Tulare, Stanislaus, Sutter and Butte counties.

According to the *1992 Census of Agriculture*, some 6,230 California farms reported almond plantings, and 6,655 reported walnuts, bearing and nonbearing. Average almond acreage in the state was 71 acres per farm and, for walnuts, 32 acres per farm.

However, figures representing average acreage are somewhat misleading. The tree nut industries of California are an interesting mix of thousands of very small acreage growers and a small number of very large producers. In both almonds and walnuts, the relatively few large producers—those with at least 500 acres of harvested nut trees—account for a disproportionately large share of production. For almonds, the 110 farm operators reporting the largest harvested acreage (out of 5,429 farms with harvested almonds) were responsible for one-third of the entire crop. In the case of walnuts, the 116 farms with the biggest harvested acreage (out of 5,736 farms with harvested walnuts) accounted for 30% of the crop.

But there were also 2,184 farms reporting walnuts acreage smaller than five acres, and 1,004 farms reported almond acreage in this very small acreage range. Part of the reason for the large number of small farms is that, once established, a tree nut orchard requires relatively little

labor which, for a small acreage, can readily be supplied by the farmer and family members. Thus, this crop is attractive to part-time or retired farmers. Also, the harvested nut crop is a storable commodity and can be held for marketing at a time when prices appear to be favorable.

The voluntary pesticide reduction programs described herein were at least initially intended to serve small and medium scale producers. However, several very large producers have joined as well.

Objectives of this study

The goal of our study and this report was to test the efficacy of this voluntary pesticide reduction program and the sustainability of these practices. Pesticides are a major expense item in growing nut crops for market in California. Growers invest in the use of pesticide in an attempt to minimize yield and quality losses during the growing season. In some countries of the world, this practice is called "plant protection," while in this country pesticide means "kill the pest." In either case, pesticides can be viewed as insurance against economic loss.

After repeated exposure to pesticides, some pest species develop a tolerance or resistance to commercial pesticides, especially those pests that have multiple broods each season. In such cases, growers are faced with using a new but more expensive chemical, applying greater quantities of the current chemical or looking for non-chemical, cultural and/or biological means of controlling pest populations. Providing information about on-farm pest populations and possible cultural and biological means of controlling these pests is a major goal of the CAFF/BIOS Project.

Procedures

We compared two groups of tree nut growers. First, a group of growers who are participants in a voluntary pesticide reduction program (BIOS); and second, a group of traditional growers who are cohorts (i.e., similar in microclimate, orchard size and geographic location) to the first group. Participants in the BIOS program typically devoted one entire orchard, or a block of trees within an established orchard, to the voluntary pesticide reduction program. In a number of instances, the BIOS participants had just one orchard and it was enrolled in the program. In contrast, a few of the BIOS growers farmed a large number of separate nut orchards and only one of these was in the program.

The Traditional growers were carefully selected by a matching procedure that utilized the Farm Operator database maintained by the California Institute for Rural Studies. This database includes about seventy-five thousand farms and contains detailed information about field locations, crops and crop acreage. In principle, each BIOS grower was matched with a Traditional farmer who not only farms an orchard of the same size in the same microclimate and geographic location, but also operates approximately the same total nut farm acreage. The matching procedure involved identifying a producer who farms a nut orchard located within the same section of land as the BIOS grower (a section of land has an area of one square mile and contains 640 acres), and whose orchard is comparable in size to the BIOS farmer. In addition, an effort was made to match the BIOS farmer with a traditional grower who operates the same total number of nut crop acres.

We attempted to determine if there was a significant difference between the two groups from the point of view of the pest related inputs such as information sources and uses, including technical advice, their use of in-orchard traps and attractants, chemical and biological inputs, and cultural practices. We also collected data on crop yields and processor rejection rates due to insect damage.

A total of forty-eight almond and seventeen walnut growers participated in the BIOS programs at their inception and were also active in 1997. Pesticide use data for all sixty-five BIOS and for their matched Traditional growers were obtained from the Department of Pesticide Regulation. However, interviews were obtained with a sample of both groups, yielding a total of ten matched pairs for almond growers and five matched pairs of walnut growers. For the remainder of the matched pairs, interviews from both were not obtained: either the BIOS Participant or the matched Traditional grower was not able to interview at the time our interviewers were in the field. Hereafter, we will distinguish "matched pair" interviews from "unmatched " interviews where different findings for the two groups may be significant.

A total of thirty-six Almond growers, BIOS and Traditional, all located in Merced and Stanislaus Counties, were contacted and interviewed in person during summer 1997. Due to the time limitation of an early harvest, a complete matching of BIOS and Traditional growers was not possible. In our sample, twenty-three growers were enrolled in the CAFF/ BIOS project and thirteen were Traditional producers. The sample of walnut growers was drawn from Solano and Yolo counties. Five were enrolled in the CAFF/BIOS program and

sixteen were Traditional growers.

Due to the high variance in pest population and crop yields, a long-term average was judged more representative of the decisions made by growers compared with a single year's outcome. The generous contribution of the time and effort of the participating growers is deeply appreciated.

Each grower was asked to provide her/his California Department of Pesticide Regulation farm and field identification number of their BIOS orchard(s) to facilitate access to their Pesticide Use Reports (PUR), filed with the County Agricultural Commissioner. The PUR reports provided more complete and accurate data on the exact chemical, the amount applied, acres treated and the date of application over the study period 1990 to 1996.

The questionnaire used in this study was based on the handbooks *Integrated Pest Management for Almonds* and the *Integrated Pest Management for Walnuts*, published by the University of California Statewide Integrated Pest Management Project, Division of Agriculture and Natural Resources, University of California. These handbooks provide a profile of the timing of pest problems and possible actions that could be taken by growers.

A database was created from responses to these questionnaires and Pesticide Use Reports in order to summarize the results and test for significant differences between the two groups.

Results

Information sources

We found that both groups, BIOS and Traditional (non-BIOS), invested considerable time, effort and capital in seeking information concerning pests and pesticide management.

All growers, almond and walnuts, were presented with a listing of a wide range of major information sources about pest control advice. They were asked, first, to rank these sources as to their importance and, second, to report frequency of contact with these sources. The source list is as follows:

- **Chemical company representative**
- **Neighbor/friend**
- **County Farm Advisor/Extension IPM advisor**
- **Independent pest control advisor (not affiliated with a chemical company)**
- **In-house entomologist**
- **Extension Service person, other than County Farm/Extension Advisor (listed above)**
- **Agricultural scientist, other than those listed above**
- **BIOS Management Team Member**

Surprisingly, the CAFF/BIOS group ranked the BIOS advisor second in importance as a source of information. This is due to the fact that BIOS Advisors are not registered Pest Control Advisors (PCAs). The frequency of contact with the BIOS advisor was usually every week or every two weeks during the growing season (see Tables 1 and 2 below). This same group ranked Independent pest control advisors (not affiliated with a chemical company) as their most important information source. Their frequency of contact was typically every two weeks during the season. CAFF/BIOS participants reported that the UC County Farm Advisor ranked third in importance as a source of information, but that they typically only contacted the Farm Advisor about once per year.

Table 1

Ranking of Major Sources of Information
Almond and Walnuts Farm Operator Respondents, 1997

Source	Ranking			
	First	*Second*	*Third*	***Total***
Chemical Company Representative				
Traditional	19	4	2	26
BIOS Grower	0	0	0	0
Neighbor/Friend				
Traditional	2	14	6	22
BIOS Grower	3	4	6	13
UC Coop Extension				
Traditional	4	10	6	20
BIOS Grower	6	5	4	15
Independent PCA				
Traditional	4	0	0	4
BIOS Grower	14	2	1	17
BIOS Management Team Member				
Traditional	0	0	0	0
BIOS Member	9	3	1	1

Traditional growers selected chemical company representatives as their primary source of pest and pesticide management information. The modal (typical) frequency of contact was every two weeks during the growing season. These traditional growers reported that friends and neighbors were their second most important source of pest management information. They also reported that they contacted their friends and neighbors about every two weeks in a normal year. The University of California Cooperative Extension Service County Farm Advisor was ranked third in importance by these growers. However, they made personal contact with the growers only about once per year.

Table 2

Frequency of Contact with Information Source During Growing Season
Almond and Walnuts Farm Operator Respondents, 1997

Source	Frequency			
	Weekly	*Biweekly*	*Greater than Monthly*	*Less than Monthly*
Chem. Comp. Rep				
Traditional	1	9	8	4
BIOS Grower	0	0	0	1
Neighbor/Friend				
Traditional	3	8	3	4
BIOS Grower	2	5	1	0
UC Coop Extension				
Traditional	3	2	0	11
BIOS Grower	2	2	0	4
Independent PCA				
Traditional	4	0	0	0
BIOS Grower	7	1	1	1
BIOS Management Group				
BIOS Grower	5	3	2	3

It is important to note that both groups sought out and received a significant quantity of pesticide and pest management information on a weekly or biweekly basis. This underscores the importance growers place on keeping current in this highly technical and rapidly changing field.

One indicator of the value of pest and pesticide management information is the presence of independent pest control advisors (PCAs). These licensed advisors usually sell no products. They are retained only to scout the orchards for insect populations, check insect and pheromone traps, and occasionally make arrangements for purchase and application of chemical and biological controls and in some cases make irrigation and fertilizer recommendations. In addition, they make recommendations as to the cultural, chemical and biological inputs needed to control pest populations.

Typically these professional advisors are paid on a per acre basis in contrast with chemical company representatives where the cost of technical advice is included in the cost of the pesticide. After each farm visit, usually every week during the growing season, PCAs discuss alternative pest management strategies with the grower. Final decisions are made by the grower.

One portion of the survey was constructed to determine the value placed on pest management information by posing a series of questions. First, had the grower ever employed an independent pest management advisor? Second, if yes, how many years had a PCA been employed? Third, what was the total fee per acre paid to PCAs in the current year and, finally, if all PCAs raised their fees, how high could those fees go before the grower would stop using the service?

For all almond and walnuts growers in the survey, sixteen reported they were currently employing an independent PCA. Years of employment ranged from one to eighteen years, the typical response indicating four years. With respect to fees paid for PCA services, growers reported a range of $13.50 to $43.00 per acre, with $16.00 per acre being typical. The maximum willingness to pay for a PCAs services ranged from a low of $19 per acre up to $86 per acre wide range but still indicative of the value placed on information that could spell the difference between financial success and failure for growers. These data are summarized in Table 3 below.

Table 3

Independent Pest Control Advisor Fees
Almond & Walnuts Farm Operator Respondents, 1997

Number Reporting Fees Per Acre

	$10 - 20	*$21 - 35*	*$36 - 50*	*$51 or over*
Fee Paid	5	6	2	0
Maximum Willing to Pay	2	4	2	2

Almonds

Cultural Practices

Non-chemical pest management starts with cultural practices that reduce or eliminate insect hosts, reduce the reproductive capacity of pests and encourage the growth of populations of beneficial organisms that prey on these destructive insects. One major cultural practice used by almond growers for this purpose is the removal of "mummies," (unharvested nuts remaining on the tree after harvest) which harbor certain pests and allow them to survive until the next growing season. Mummy removal was practiced by about 65 percent of growers in the BIOS project and 77 percent of the non-BIOS growers during the survey period, 1990-1996.

A second important cultural practice used to encourage the production of beneficial insects in the orchard is to plant a cover crop between tree rows and to allow all or part of this crop to remain until just before harvest time. These insectories provide habitat for insects who feed on several major orchard pests. During the survey period, 43 percent of BIOS growers planted a cover crop, while only 15 percent of Traditional almond growers use this practice. See Table 4.

Table 4

Cultural Practices Reported by Growers in Period 1993-1996
Almond Farm Operator Respondents, 1997

Practice	Traditional				BIOS Growers			
	1993	1994	1995	1996	1993	1994	1995	1996
	(N= 13)				(N = 23)			
Remove Mummies	8	8	10	10	12	15	15	15
Pheromone Traps								
Peach Twig	2	2	2	2	17	18	18	15
S. J. Scale	0	0	0	0	7	8	8	6
Oriental Moth	1	1	1	1	5	5	5	3
Navel Orange Worm Egg Trap	1	1	1	1	13	13	13	11
Parasite Release	1	1	1	1	14	14	15	14
Planted Cover Crop	1	1	2	2	10	11	10	10

Growers with blocks of trees enrolled in the BIOS project made extensive use of pheromone traps to monitor populations of Peach Tree Borer, San Jose Scale, and Oriental Fruit Moth. Although BIOS project participants did not use pheromone traps every year, an average of 78 percent of them reported use of traps for Peach Twig Borer, about 35 percent for San Jose Scale and 21 percent for Oriental Fruit Moth. Traditional growers reported very little use of pheromone traps. Only two Traditional almond growers reported using pheromone traps.

Egg Traps for monitoring Navel Orange Worm populations were used by about 56 percent of BIOS Project growers, but only one out of the thirteen Traditional growers (8 percent), used these devices in his or her orchard.

Parasite/Predator releases (release of beneficial insects or biological materials that destroy almond pests) have been available in the market for some time and were used by about 60 percent of BIOS growers. Only one Traditional grower reported using this form of pest control.

Pesticide Use

Quantitative measures of pesticide treatments and costs were determined in two ways. First, after completing the section of the questionnaire on pests and pest management practices for each season and year (1990-1996), growers were asked to estimate their total cost per acre for pesticides and biological controls for each of these years. For BIOS growers, only treatment costs for those orchard blocks dedicated to the BIOS experiment were collected. Some growers provided data from their farm records but others had to rely on their best recollections. These recall data were averaged for the four-year period 1993-1996.

The estimated average pest control materials cost for BIOS growers who applied any pesticides was $211 per acre (standard deviation was $154). Ten BIOS members reported applying no pesticides during the study period. The comparable cost for Traditional growers who treated their orchards was $327 per acre (standard deviation was $123), a $116 per acre increase over BIOS participants' costs. Three Traditional growers reported applying no pesticides. The difference between Traditional growers and BIOS growers self-reported pest control materials costs of $116 should be regarded with some caution, in view of the large variance of cost values reported by respondents.

An independent estimate of pest control materials costs for the years 1993- 1996 was prepared by determining the products and amounts of each used by each grower, and then taking account of the known retail cost of each item. Utilizing the Pesticide Use Reports (PURs) filed with the local County Agricultural Commissioner, it was possible to summarize for each farm and field the yearly quantities of pesticide materials reported for these orchards. The cost estimates for these materials were based on the 1997 retail price for the most common container size or unit sold. These retail price values were provided through the generosity of a large Central Valley pesticide distributor. Using a single price for each formulation may bias the results against large-scale operators who would be able to obtain quantity discounts on large purchases. The estimated average pest control material cost per acre for growers who used pesticides, based on PURs for the Traditional almond growers was $173.75. The comparable cost when all BIOS members are considered together was $170.29 per acre for those years when pesticide was applied—only a $ 3.46 per acre difference over all. However, this is an

average of $153.42 per acre for the paired BIOS growers and $202.77 per acre for the unpaired BIOS Growers. A frequency distribution of these data is presented in Table 5.

Table 5

Average Pesticide Materials Cost per Acre for Ranches Using Pesticides Almond Farm Operator Respondents PURs, 1997

	Less than $25	$26-$50	$51-$100	$101-$150	$151-$200	$201-$400	Over $400
Traditional	1	0	3	3	2	2	1
BIOS Growers	2	1	3	7	2	2	3

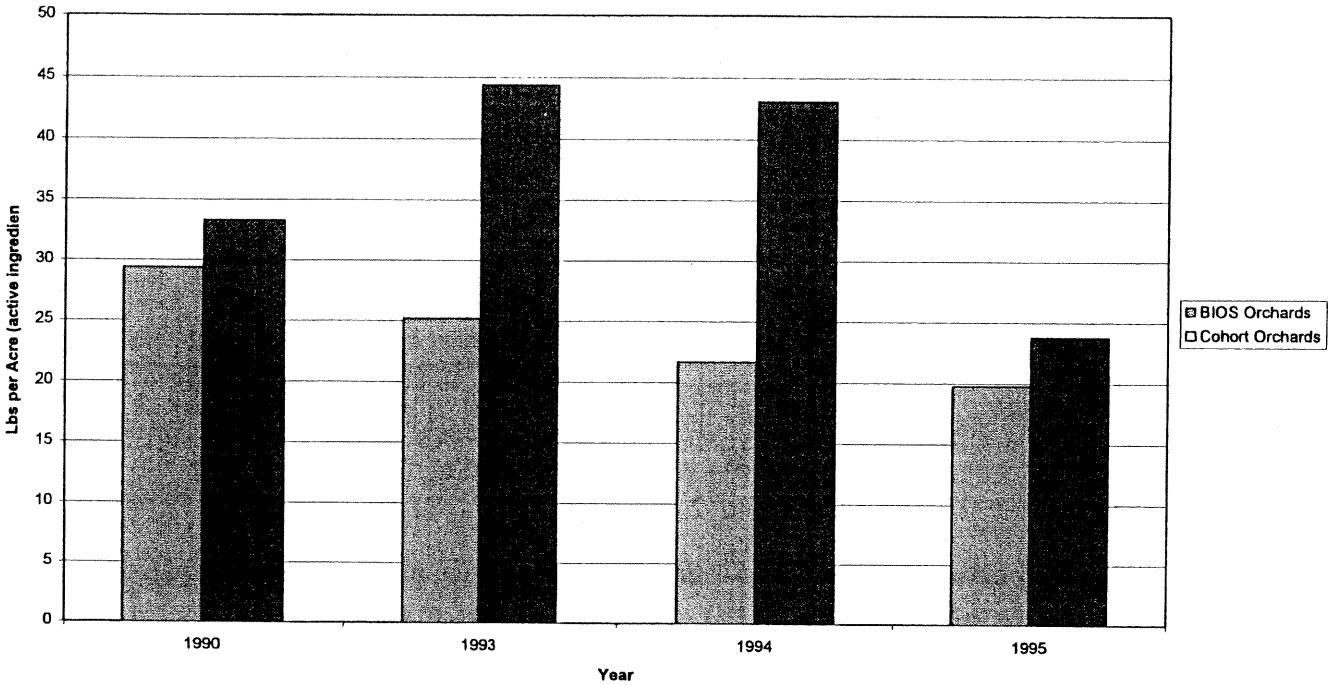
One possible explanation for the large discrepancy between the costs per acre based on grower recall compared to costs based on PURs is that, although growers were asked for materials cost only, some may have not separated out materials costs from the total cost of materials and application.

On a broader scale, the PURs for all almond growers in Merced and Stanislaus Counties for the years 1990, 1993, 1994 and 1995 were collected and analyzed. These data were separated into two groups: all BIOS participants and all non-BIOS cohorts chosen for our sample, regardless of whether they participated in survey interviews. Figure 1 presents the results showing the amount of all types of pesticides applied per acre treated for all BIOS program orchards, and the corresponding data for the matched Traditional orchards. BIOS program orchards for which no pesticide use was reported were excluded from consideration for this comparison.

As shown in Figure 1, the most important finding is the low and steadily declining pesticide use reported for BIOS program orchards, as measured by pounds of active ingredient applied per acre treated. The decline from 1990 amounts to roughly one-third less pesticide use per acre treated by 1995. In contrast, the Traditional cohort orchards show greater pesticide use for all four years, and especially greater amounts in 1993 and 1994. The BIOS almond program was initiated in Merced County during summer 1993, and expanded the following year in Stanislaus County. It is apparent that BIOS participants reported significantly lower pesticide

Figure 1

Intensity of Pesticide Use, Lbs. per Acres Treated Active Ingredient, Median Value, Almonds



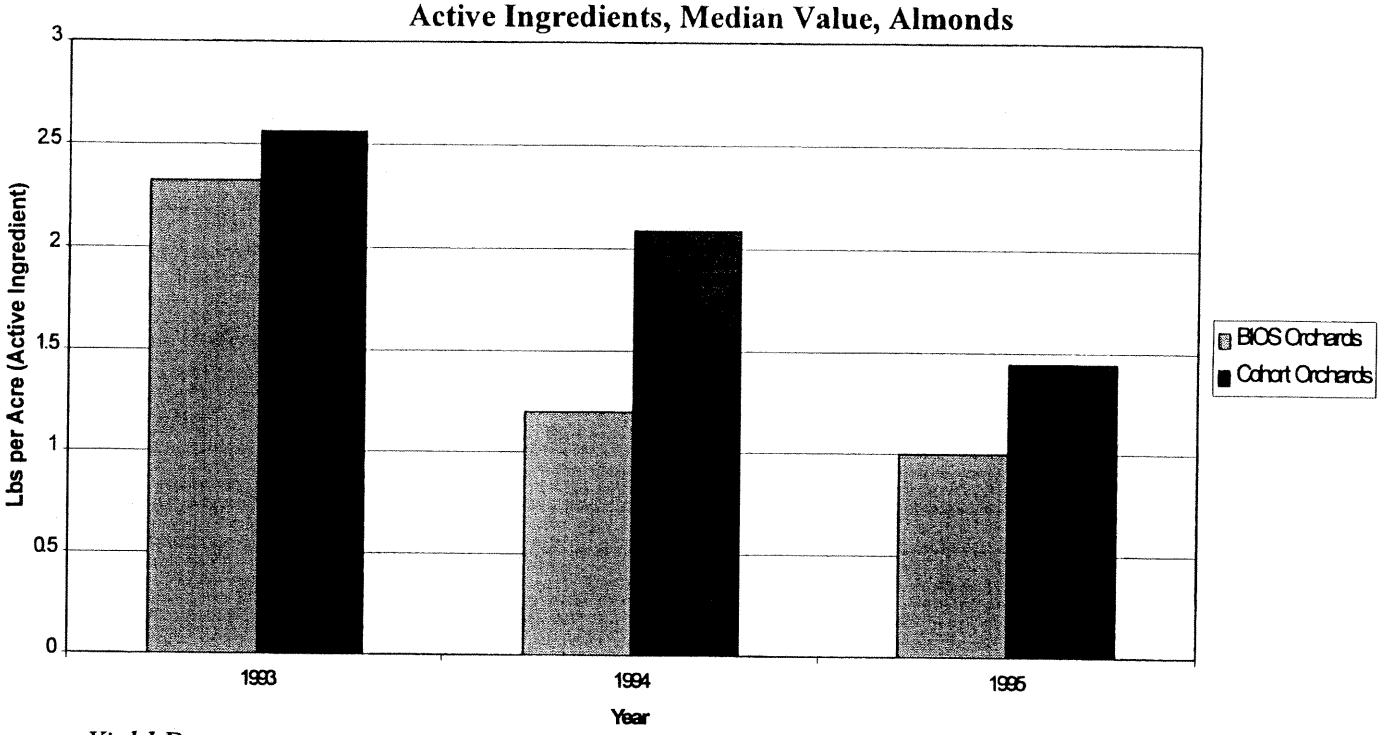
use in their program orchards during the first full year of the program (1994) and in the year following (1995) than was the case in 1990 or 1993.

A second measure of changes in pesticide use associated with the BIOS program concerns the use of restricted materials. These are pesticides which are considered to be the most dangerous, so much so that rigorous safety rules and reporting is required whenever they are used for commercial purposes in the State of California. Figure 2 presents the results when all restricted pesticides were converted into their equivalent pounds of active ingredients per acre treated, both for the BIOS orchards and the Traditional cohort orchards.

The important feature of Figure 2 is the sharp falloff in reported restricted pesticide use evident for the BIOS orchards and for the Cohort orchards as well. The conclusions to be drawn from these data are, first, BIOS growers as a group applied fewer pounds of restricted pesticides per acre treated than did Traditional cohort growers. The second conclusion from this larger sample is that both groups have decreased their restricted pesticide applications over the three-year period.

Figure 2

Intensity of Restricted Pesticide Use, Lbs. per Acre Treated Active Ingredients, Median Value, Almonds



Yield Data

Growers were asked to provide data on their yield for each year over the survey period. These data show a high variability that is a characteristic of the California Almond Industry. An analysis of variance was made of the data comparing the mean and variance of yields reported by both BIOS and Traditional growers for the period 1993-1996. The results of this analysis were first, the average reported yield for all BIOS members was 1,275 pounds per acre (standard deviation was 650 lbs./acre), and for all Traditional growers 1,520 pounds per acre (standard deviation was 663 lbs./acre). These figures compare favorably with the average of 1,036 pounds per acre for all almond farms in the two counties over the same period. Statistically these yields are significantly different at the 95 percent confidence level. When the paired BIOS growers were separated from the unpaired BIOS growers, the paired growers reported average yields of 1,173 pounds per acre and the unpaired growers reported an average yield of 1,489 pounds per acre. These last two yields were also statistically significantly different at the 95 percent confidence level. A frequency distribution of these yields is shown in Table 6.

In a test to determine if the yield data may have been affected by the age of the trees, it was found that the average year planted for the blocks reported on was 1977 for both BIOS

and Traditional growers. A second but related question was, could the yield difference be due to planting density in these same blocks? The average reported trees planted per acre for BIOS participants was 81.3 and 71.8 for Traditional growers, which suggests that differences in tree density can not account for the reported yield difference. It was not possible to separate out differences in the varietal mix of orchard blocks between the two groups.

Table 6

Distribution of Average Almond Yields in Pounds per Acre, 1993-96
Almond Farm Operator Respondents, 1997

	Less than 1,000	1,001-1,200	1201-1,400	1401-1,600	1,601-1,001	Over 1,800
Traditional	1	2	5	1	2	2
BIOS Growers	9	3	3	2	2	4

Graphically these data are shown in Figures 3 and 4.

Figure 3

Almond Yields, Traditional Growers

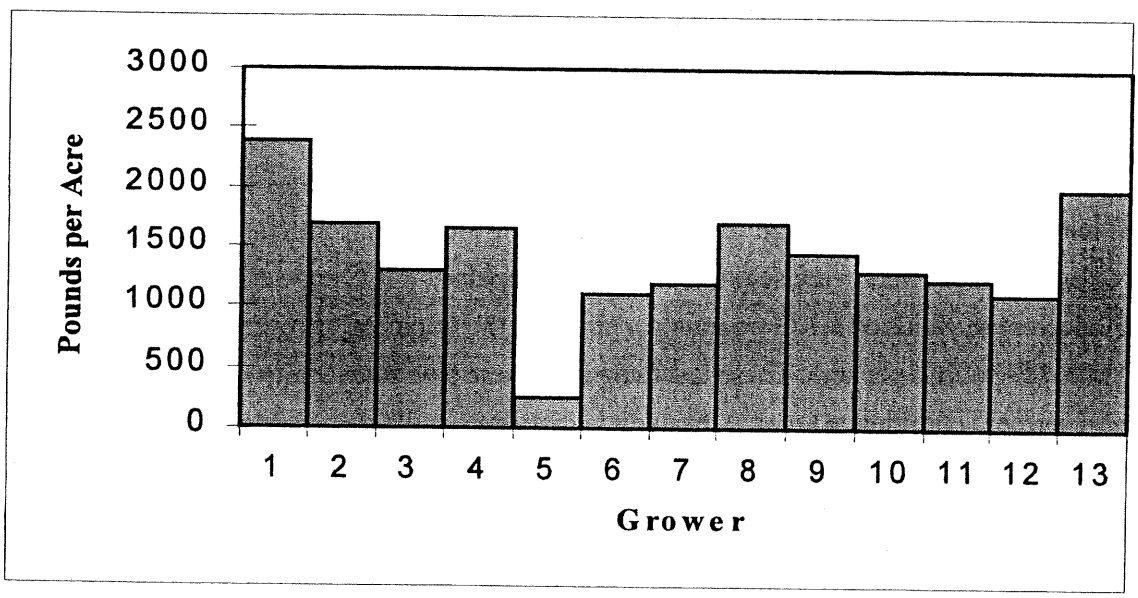
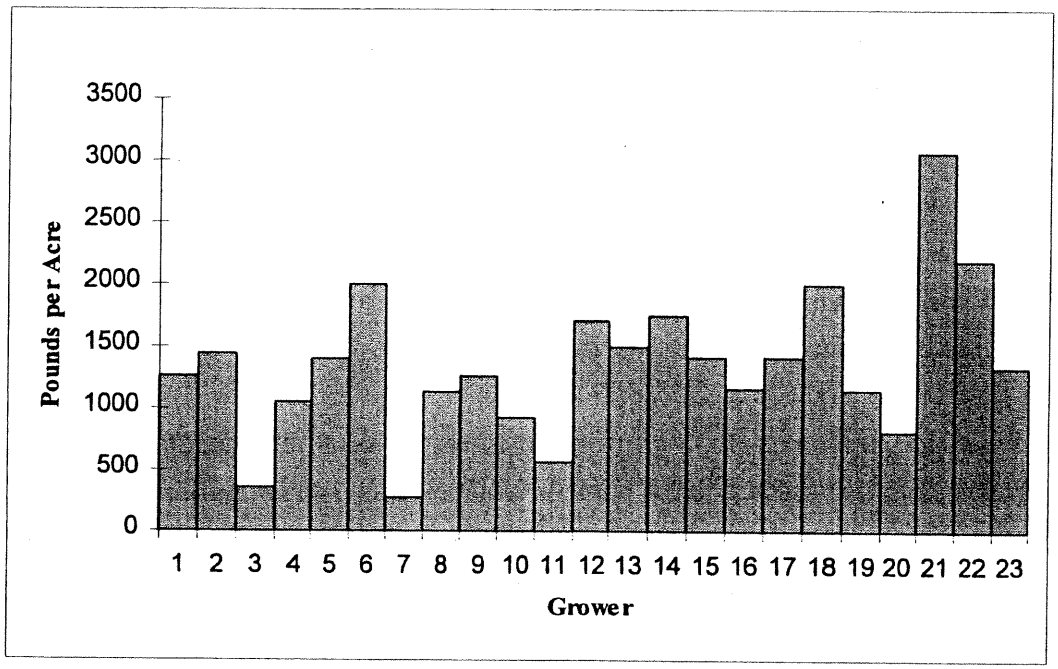


Figure 4

Almond Yields, BIOS Growers



Due to the early harvest in 1997, it was only possible to obtain ten paired matches for the traditional and BIOS growers. The correlation of yields between these ten pairs was 0.267, indicating there was only a weak relationship existed between the cohorts, but yet does show a small benefit from the matching process. Results of comparing matched pair yields show that the difference in yields (BIOS yield minus Traditional yield), were as follows:

1) Yield differences ranged from -1,000 pounds per acre to +1,000 pounds per acre.

2) In six of the cases, Traditional growers reported higher yields than their BIOS cohorts and in four cases, BIOS growers reported higher average yields than their Traditional cohorts. This relationship suggests the 10 matched BIOS cohorts are too small a sample to allow any generalization to the set of BIOS growers, or for comparison with all almond growers.

A second test was made to determine if yields reported by all thirteen Traditional growers were statistically different from all the unmatched BIOS growers in the sample. The average yield of the thirteen unmatched BIOS growers was 1,489 pounds per acre and the average yield for all thirteen Traditional growers was 1,412 pounds per acre. Statistically we are confident at

the 95% level that there is no significant difference between these two groups although reported yields of both groups exceed County average yields.

Rejection Rates

When growers deliver their nuts to processing plants the nuts are inspected for worm and insect damage, the presence of which makes the product unmarketable. Growers receive a report from the processor containing the results of this inspection. Generally these results are the average for all deliveries from an orchard. BIOS members reported their average rejection rate was 2.15 percent, while Traditional growers reported an average of 1.21 percent. A frequency distribution of these responses is shown in Table 7 below.

When the unmatched BIOS growers were separated out from the total BIOS sample, the average rejection rate increased to 2.4 percent. This rejection rate is significantly different from the rejection rate reported by the Traditional growers at the 95 percent confidence level.

Table 7

Processor Rejection Rates for Almonds, 1993-96
Almond Farm Operator Respondents, 1997

Rejection Rate Percent

	0.5 or Less	0.6-1.0	1.1-1.5	1.51-2.0	Greater than 2.1
Traditional	4	3	4	1	1
BIOS Participants	2	6	7	1	7

Walnuts

Cultural Practices

Due to the small sample size of respondent walnuts growers, we decided not to apply standard statistical analysis. This makes it more difficult to draw inferences from these data. A major information source for walnut growers is from insect counts in pheromone traps. Populations of three important pests can be monitored using these traps: Codling Moth, San Jose Scale and Husk Fly. For the period 1993-1996, the last four years covered by the survey,

eleven of the sixteen Traditional growers used traps for Codling Moth. Two of the five BIOS members used pheromone traps for this pest. Although traps can be used to monitor San Jose Scale, almost no growers, BIOS or Traditional used them. Only one out of the twenty-one growers interviewed used this technique. Pheromone Traps for Husk Fly were used by six of the sixteen Traditional growers and two of the five BIOS growers.

Pesticide Use

As with the almond growers, pesticide use data was collected both by asking growers to recall their materials and applications costs over the 1990-1996 time period, and by examining Pesticide Use Reports (PUR) from the Department of Pesticide Regulation database. For the Traditional growers, six of the sixteen respondents reported no pesticides were applied to their benchmark block of walnut trees. For the BIOS growers, two of the five respondents reported no pesticide use. For those growers who did apply pesticides, the average cost of materials for the 1993 - 1996 period was $137 per acre per year for the Traditional growers and $104 per acre for of CAFF/BIOS participants, a 24 percent difference. Based on the PURs, the average pesticide materials cost for the Traditional growers was calculated to be $97.78 per acre and zero for the BIOS growers. The latter figure of zero resulted from the fact that all five BIOS walnuts growers reported no pesticides applied on their BIOS blocks.

Yield Data

As in the almond grower interviews, participants were ask to supply yield data for the blocks of trees under consideration in this study for each of the years in question. Traditional growers reported significantly higher yields than did the BIOS growers. The Traditional growers, based on limited records and recall, reported an average of 2,844 pounds per acre yield; BIOS growers reported 1,603 pounds per acre. Average yields, as reported by the Agricultural Commissioners for the two survey counties (Yolo and Solano), were 2,020 pounds for the years 1994-1996. Age of trees does not appear to be a factor in explaining the differences in yield reflected in these data. None of the blocks managed by BIOS growers were planted after 1988, and only two of the sixteen Traditional growers' blocks were planted after 1987.

Rejection Rates

Recall data on processor rejection rates due to insect or other damage varied widely. The Traditional growers reported an average rejection rate of 3.9 percent while the BIOS growers reported a higher rejection rate of 5.2 percent. Again, due to the small sample size, especially the small number of BIOS growers who consented to an interview, these results must be viewed as tentative.

Decision Making

The final question asked of all respondents, almond and walnut growers alike, was, "Please describe your thought process and how you use this information in the decision to spray or not to spray?" All growers, BIOS and Traditional, expressed a desire for long term biological sustainability. No one indicated they sprayed on a calendar basis; rather, they acted on a basis of strong visible evidence that there was a potential for significant pest damage. No one expressed a desire to over treat their orchards in an effort to eliminate these pests. Traditional growers indicated a strong aversion to the risk of crop loss to insect pests. Taking a safety first approach, these growers appeared to be willing to invest a small monetary sum on a pesticide in order to reduce the chance of incurring a large loss due to pest damage.

Noticeable in the BIOS growers responses was one of stewardship of the land through minimizing the use of chemicals and the increased desire to use cultural and non-toxic biological agents to control pest populations. Due to the relatively recent introduction of, and demonstrated efficacy of, these methods, many of the BIOS growers appeared to be more willing to take a chance with non-chemical methods than their cohorts in the Traditional group. In addition, the BIOS growers either implicitly or explicitly expressed an aversion to the use of chemicals as part of their basic values.

Summary and Conclusions

A sample of almond and walnut growers in Stanislaus, Merced, Solano and Yolo Counties was divided into two groups. Members of the first group were participants in the CAFF/BIOS program who received extensive information on methods of monitoring pest populations in their orchards and information on biological and cultural methods of controlling these pests. Members of the second group were chosen based on their similarity of orchard size, microclimate and proximity to one member of the first group. This second group was considered the traditional growers in the industry.

A sample of growers in both groups were interviewed in the summer of 1997 and all were asked a series of questions about pest management information sources, and the practices they used on their farm. Traditional growers reported higher pest control costs than their cohort BIOS growers. On the other hand, Traditional growers reported higher average yields than did the BIOS members. Also, Traditional growers reported lower rejection rates by processors than was the case for the BIOS growers.

When Pesticide Use Reports for these growers were tabulated both groups exhibited a marked decreased in the use of restricted pesticides each year since 1993, as measured by pounds of active ingredients per acre treated. In addition, BIOS orchards showed significantly lower levels of all types of pesticide use as compared with cohort orchards. While BIOS growers reported lower use of pesticides, they also reported a much greater use of insect and pheromone traps to monitor pest populations. Traditional growers were much more dependent on chemical company representatives for their major source of information than BIOS growers.

Participants in the voluntary pesticide use reduction project, BIOS, as well as the Traditional growers in the sample, invested significant resources in obtaining information about orchard pests, as well as about chemical and non-chemical methods of controlling these pests, in an attempt to maximize farm income. In the use of pheromone and Navel Orange worm trapping, participants in the BIOS project were much more aggressive than the Traditional growers in investing in these traps as a method of monitoring pest populations in their orchards.

Although a large majority of both Traditional and BIOS project growers followed the recommended practice of removing mummies from almonds, the proportion of BIOS growers putting in a cover crop was almost triple that of the Traditional growers.

Pesticide use and costs based on grower recall were significantly higher than the estimated retail cost of the pesticides reported on Pesticide Use Reports. Pest control materials costs estimated by using the PURs for the group of matched or paired almond BIOS growers applying pesticides, was $153.42. On the other hand, when matched BIOS growers were removed, the remaining unpaired growers reported pesticide costs of $202.77 per acre. The Traditional almond growers averaged $173.75 per acre. The comparable figures for walnuts was $0.00 for BIOS members (because no program orchard reported using any pesticides), and $97.78 per acre for Traditional growers.

Important in any discussion of the efficacy of the pesticide reduction program is the effect on yields and processor rejection rates of the reduced pesticide use. Data from the survey indicate the average almond yield for BIOS growers was 1,275 pounds per acre and the Traditional group averaged 1,520 pounds per acre, however the processor rejection rate for almonds averaged 2.15 percent for BIOS growers and 1.21 percent for the Traditional group. The comparable rejection rate for Walnuts was 3.9 percent for Traditional and 5.2 percent for BIOS growers

although the sample size was quite small.

The final economic question: is the strategy of reduced pesticide use and increased pest population monitoring financially sustainable? We must state that we have insufficient information to draw any conclusion. The data indicate that overall, unpaired BIOS growers reported comparable yields, lower pesticide materials costs, but higher reject rates compared to the Traditional growers. A long-term study covering most of the life cycle of an orchard under the two different management strategies would have to be conducted in order to draw any firm conclusions.

Several conclusions can be drawn from this study. First, information is the least expensive, least polluting and least hazardous input to farming. Second, both those growers who have joined a biological/cultural pest management project and those who have not have reduced their dependency on restricted pesticides in recent years. The dissemination of information about these practices may be accelerated by the neighbor-to-neighbor networks that exist in every community where the information exchange is the local coffee shop. The University of California Cooperative Extension Service has obviously been a strong catalyst in the information flow. Finally, since this experiment has been of a relatively short duration, the lower yields and higher rejection rates of the BIOS growers should be interpreted cautiously. The question of long term ecomonic sustainablility is yet to be answered.