How Effective are Voluntary Agricultural Pesticide Use Reduction Programs?

A Study of Pesticide Use in California Almond and Walnut Production

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SUPPORTED BY A GRANT FROM
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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 growers of the same crop who were 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 cohort grower who operates the same total number of nut crop acres.

Cohort Orchards were carefully selected to match, on a pairwise basis, BIOS Orchards for both almonds and walnuts. It was found that pairs of orchards could be matched using location, orchard size, and farm size criteria. Interviews with both groups revealed that the BIOS and Cohort Orchards were also well matched in terms of tree density and age of trees. This latter finding was unintentional but highly desirable.

Pesticide use reports (PURs) for all BIOS and Cohort Orchards were obtained and examined in detail. From these individual PURs it proved possible to examine actual amounts of pesticides reportedly used on a field-by-field basis. Determinations were made of the number of orchard fields treated, the number of applications per orchard field treated, the amount of all pesticides applied in each field treated and of the amount of restricted materials applied.

This study finds that, uniformly, BIOS Orchards report a significantly lower proportion of fields treated with registered pesticides as compared with a matched group of Cohort Orchard fields. The share of all BIOS Orchard fields treated with any registered material has significantly declined throughout the period in which the BIOS programs have been implemented. In the case of almonds, this share is now less than one-half; in walnuts about one-fourth.

Second, substantially lower intensities of pesticide use are reported in BIOS Orchards than is the case for the matched Cohort Orchards. In almonds, the BIOS Orchards report a steady decrease in the intensity of pesticide use for the period 1993-95 and also in comparison with levels reported in 1990. However, in walnuts, where only a small share of all BIOS Orchards is reportedly treated, there has been no significant change in the intensity of pesticide use. However, it should be emphasized that pesticide use in BIOS walnut orchards is extremely low and very much lower than in the Cohort Orchards.

Finally, greater pesticide use is associated with obtaining pest control advice from Chemical Company Representatives, whereas lower pesticide use is associated with seeking pest control advice from Independent PCAs and members of the BIOS Management Team.

Introduction: Agricultural Pesticide Use Continues to Increase

One of the most vexing contemporary environmental issues is how to reconcile bountiful agricultural production with the on-going damage to natural resources caused by intentional application of chemical poisons to crop fields. The issue is perplexing because high crop yields are to a significant degree dependent on the widespread use of agricultural chemicals to prevent crop losses caused by pests. The depth of this conflict is reflected in use of the term "economic poison" as a synonym for pesticides by government environmental regulators. Not a few environmental advocates have pointed out that this term is surely an oxymoron.

This report describes quantitative measures of progress in reducing agricultural chemical use by farmer participants in a voluntary program whose goals include encouraging a diminished dependence on chemicals for crop protection. Of course, there are a much larger number of farmers, such as organic farmers, whose individual commitment to non-chemical pest control methods has long been reflected in their production practices. However, the voluntary programs described in this report differ in an important way from those individual initiatives. First, they are cooperative efforts that rely on shared resources and collective trial and error learning, not just individual initiatives. Second, they are intended to involve farmers who, until recently, have mostly relied on conventional, chemically oriented, pest control practices. Third, these programs have been publicly supported, either through government programs or private foundation grants, and are therefore subject to public scrutiny.

Total pesticide use in U.S. agriculture has increased in recent years. Although there is no direct quantitative measure of all agricultural pesticide use, inflation-adjusted agricultural chemical production expenditures on U.S. farms show a sharp rise in recent decades, by some 55% since 1974 even though the nation's total cropland has remained essentially constant throughout this period.[1]

Less well recognized is the fact that sharply increased U.S. acreage and production of fruits & nuts, vegetables & melons, and horticultural specialty (nursery) crops in recent years is associated with a corresponding rise in agricultural chemical use. Farm operators use a greater amount of pesticides on each acre of these crops than is used to produce extensive crops, such as cotton, grains or forage crops. Fruit & nut farms reportedly spend as much as ten times more pesticides per acre than do grain farms. One indicator of this difference is the expenditure per cropland acre for agricultural chemicals reported by different types of farms to the Agricultural census. This is shown in Table 1.

Table 1
Average Agricultural Chemical Expense per Acre of Cropland, by Type of Farm, United States, 1992

TYPE OF FARM	COST PER ACRE
Grain	$12.43
Field Crop	$25.99
Fruit & Nut	$113.24
Vegetable & Melon	$85.35
Horticultural Specialty	$83.87

Source: *Census of Agriculture 1992*

As is shown in Table 1, the average expenditure for agricultural chemicals, per acre of cropland, is nearly ten times larger on fruit & nut farms as compared with grain farms. For vegetable & melon farms, it is seven times greater than for grain farms.

The shift from extensive to FVH[2] crops has a number of significant implications for policy: greater pesticide use, increased reliance on hired labor, and a much greater reliance on market mechanisms than on government farm support programs. In quantitative terms, in just ten years the FVH share of U.S. crop production increased from one-fifth to one-third of the total, based on the value of farm sales. Since crop values depend upon both prices, which are notoriously volatile for agricultural commodities, and on the volume of production, economists prefer to measure changes in agricultural production in physical terms, such as pounds or tons, rather than sales. This is because large increases in the physical volume of crop production may cause prices to fall, if demand fails to keep up with supply. Total U.S. fruit and vegetable production, measured in tons harvested each year, has increased by 49% in just twenty years.[3] Corresponding increases in pesticide use are associated with this rise in output.

Pesticide Use in California Agriculture

Reports by California farmers demonstrate that they lead the nation in agricultural pesticide use, ranking ahead of Illinois and Iowa, respectively.[4] The state is also the most intensive user of pesticides: although it has only one-fortieth of all U.S. cropland, it accounts for one-ninth of farm pesticide production expense. In other words, the state's farmers spend an average of four and one-half times as much for pesticides per acre of cropland as does the average U.S. farmer.[5] In terms of specific types of crops, Table 2 shows agricultural chemical expenses for different categories of crop farms in California. Note especially the much higher pesticide expense per acre as compared with all U.S. farms (shown in Table 1).

Table 2
Average Agricultural Chemical Expense per Acre of Cropland, by Type of Farm, California, 1992

TYPE OF FARM	COST PER ACRE
Grain	$26.50
Field Crop	$46.98
Fruit & Nut	$119.21
Vegetable & Melon	$127.49
Horticultural Specialty	$240.19

Source: *Census of Agriculture 1992*

One factor contributing to the greater intensity of pesticide use in California agriculture as compared with the U.S. is that production in the state is far more intensive than in most other states. For example, most cropland is irrigated in California, whereas most U.S. cropland is not. Correspondingly, reported state crop yields are much greater than for other parts of the nation. The state is also the national leader in fruit & nut as well as in vegetable & melon production, and it ranks second in horticultural specialty crop production. Fully half of all U.S. fruits, nuts, vegetables and melons are grown in California.

However, the soils and climate of California are not only an ideal habitat for many crops, they are often ideal for their pests as well. The problem is sufficiently serious that state officials have imposed strict border inspections at every highway that crosses state lines. Drivers from out of state must dispose of any fresh produce or other products that might carry crop pests before being allowed to enter California.

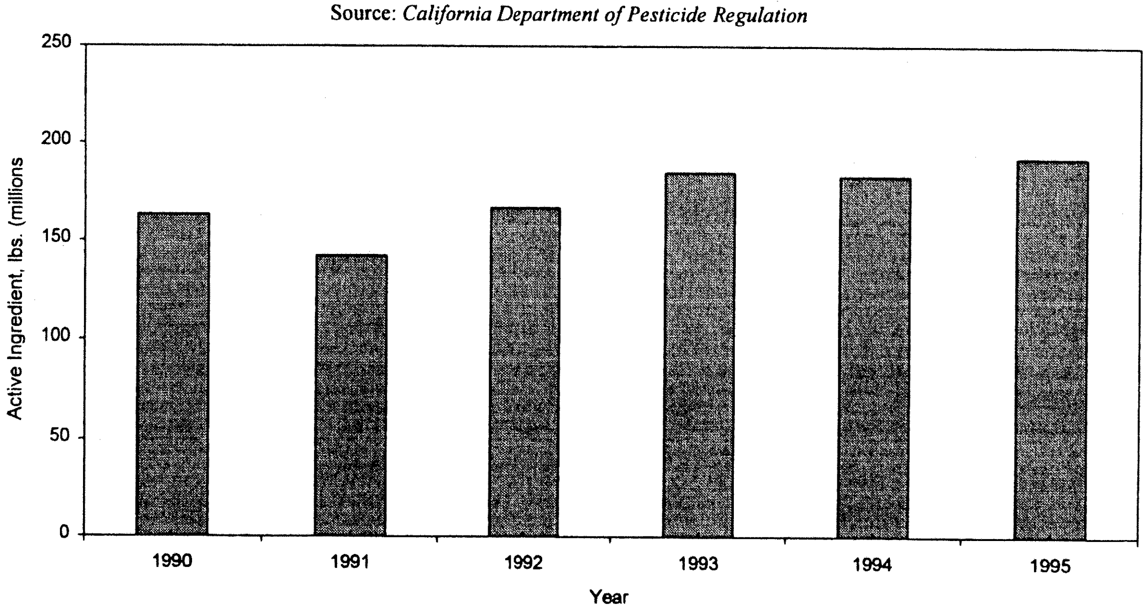
California also has the nation's most thorough, and public, system for reporting commercial pesticide use. This is due in large part due to the very great reliance of the state's farmers on agricultural chemicals. Since 1970, California has required its farmers, and certain other commercial users of "economic poisons" to report all use of *restricted* pesticides. Restricted materials are those chemicals that scientists believe are the most dangerous. Those materials thought to be relatively safe are classified as *unrestricted* materials.

Starting January 1, 1990, this requirement was expanded: all commercial use of any registered pesticide in the state must be reported. This latter requirement is termed "full use" reporting since every application of every registered material—restricted or not—is reported as part of the public record.

Full use reporting has made it possible, for the first time, to quantitatively determine reported annual pesticide use in California. State officials reported that 627.9 million pounds of pesticide active ingredients were sold in the state in 1994, of which somewhat over one-fourth was reportedly used in agricultural production. The remainder, nearly three-quarters, was presumably used in industrial or home settings, including home gardens. Figure 1 shows the reported number of pounds of

Figure 1
Reported Agricultural Pesticide Use
Active Ingredient (lbs.), California

Source: *California Department of Pesticide Regulation*



active ingredients utilized in California agricultural production for each year since full use reporting began in 1990.

While there has been some year-to-year variation in the amount of reported pesticide use, mostly owing to weather and pest population conditions, the overall trend clearly has been toward significantly increased use. By 1995, the most recent year for which full data is available, the total amount applied reached nearly 200 million pounds of active ingredients.

A determination of the amount of this increase in pesticide use that takes account of yearly variations due to weather or other similar effects involves comparing annualized averages for multi-year intervals. Thus, during the period 1990-92 an average of 157.5 million pounds per year was applied, while for 1993-95 it was 186.9 million pounds, an increase of about 19% over the earlier period. Despite using three-year intervals to attempt to take account of "normal" annual variations, it is still possible that the effects of California's most recent major drought may actually be influencing this computation. 1990-92 corresponds to the final three years of a six-year drought in the state. During those years, harvested cropland declined significantly in the Central Valley, the state's most important crop region. It is likely that the lower total of pesticide use reported for 1990-92 is partly due to the drought.

This report's finding of a 19% increase in annual average pesticide use during the period 1990-95 conflicts sharply with the finding by Liebman of a 31% increase in pesticide use between 1991 and 1995.[6] However, Liebman deliberately chose to ignore the 1990 data, arguing that it was flawed. Procedures developed by CIRS for analyzing reported pesticide use data include correcting flawed data, such as eliminating duplicate pesticide use reports and checking obvious data entry errors against primary data. For this reason we conclude that Liebman has significantly overstated, by more than half, the extent of the increase of annual pesticide use in California during this period.

The top five crops ranked according to the largest amounts of reported pesticide use in California agriculture are listed in Table 3. The top five crops are, in descending order of reported pesticide use, grapes (dried & fresh), grapes (wine), cotton, almonds and processing tomatoes (these are tomatoes that are canned or processed into paste or sauce). As was suggested above, the fruit & nut and vegetable & melon sectors dominate the list in accordance with the findings concerning the intensity of use in these crops.

Table 3
Top Five Commodities, Reported Pesticides Applied and Estimated Intensity, 1995 California, Active Ingredients

Commodity	*Amount Applied (millions pounds)*	*Estimated Intensity (lbs./acre)*
Grapes, fresh/dried	31.8	92
Grapes, wine	27.0	90
Cotton	17.7	14
Almonds	12.0	35
Tomatoes, processing	11.7	43

Source: *California Department of Pesticide Regulation*

The materials used to control pests on California farms vary greatly, from relatively benign chemicals to extremely dangerous poisons. Surprisingly, the most widely used material is sulfur, a chemical element that is effective in controlling various fungal infestations in important crops, such as grapes and deciduous tree fruits. Since sulfur is a naturally occurring substance, state agricultural authorities have approved its use by organic farmers. Table 4 shows the top five chemicals used by California farmers.

Table 4
Top Five Chemicals, Reported Pesticides Applied, 1995 California, Active Ingredients (million pounds)

Commodity	*Amount Applied*
Sulfur	69.8
Petroleum oil	19.1
Methyl bromide	17.6
Metam-sodium	15.3
Glyphosate	4.2

Source: *California Department of Pesticide Regulation*

Sulfur alone accounts for more than one-third of all chemicals used in the state's agricultural production. Together with petroleum oil and glyphosate, these are unrestricted pesticides that are considered to be relatively safe. However, public health researchers recently found that sulfur was responsible for more reported cases of acute occupational poisonings among hired farm workers in California than any other chemical.[7] It is another paradox of farming with chemicals that the material that is most widely used and that causes more acute illness among hired farm workers is both naturally occurring and is considered to be so safe that it is permitted for use by organic farmers.

Both methyl bromide and metam-sodium are restricted materials, and are among the most dangerous applied to the state's crop fields. Since they are known to be so dangerous, regulators have imposed strict conditions on how they are used. Environmental advocates have pointed out that methyl bromide, a gas pumped into soils to kill microorganisms that can cripple crop yields, is also an important factor in contributing to the destruction of the earth's ozone layer. The federal Clean Air Act will require phase-out of methyl bromide use by January 1, 2001. Recently, agricultural producers, including the Western Growers Association, have mounted a campaign to postpone the phase-out to 2005.

Voluntary pesticide use reduction in almonds and walnuts

A number of California farmers have joined with their peers to form associations whose purpose is to develop and implement sustainable farming methods. By sustainable, farmers understand planting, cultivation and other production techniques that are both environmentally friendly and economically viable. It is important to be aware that these methods refer not just to reducing pesticide use. They also include using pest resistant plant varieties, building up soil organic matter, beneficial insects, more efficient use of irrigation water and less reliance on chemical fertilizers. Some of these methods are associated with creating conditions that may result in lower pesticide use.

Among the most prominent of the voluntary farmer efforts are those in almonds, walnuts and wine grapes, although significant efforts are underway in other crops, including raisin grapes and processing tomatoes. As is evident from the preceding discussion of pesticide use in the state, both almonds and wine grapes are crops in which farmers have relied heavily on agricultural chemicals. Both almonds and wine grapes rank among the top five crops in the reported amount of annual pesticide use.

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 is to provide technical information to growers on pesticide use and management. Started in late 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 growers 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 walnut growers who are located in Central and Northern California. The focus of the work with almond growers is in Merced and Stanislaus Counties. The walnut growers are concentrated in Yolo and Solano Counties.

California's Almond and Walnut 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 almonds were relatively high in the period 1994-96, as they were for walnuts. 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, which is 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 recently planted non-bearing trees were in the ground as of 1996 and additional plantings have been added since then. This represents at least 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 then 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, 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 most recent U.S. agricultural census, some 6,230 California farms reported almond plantings, and 6,655 reported walnuts.[8] Average almond acreage in the state was 71 acres per farm and, for walnuts, it was 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 walnut 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. Several very large producers have joined as well enrolling a small portion of their acreage.

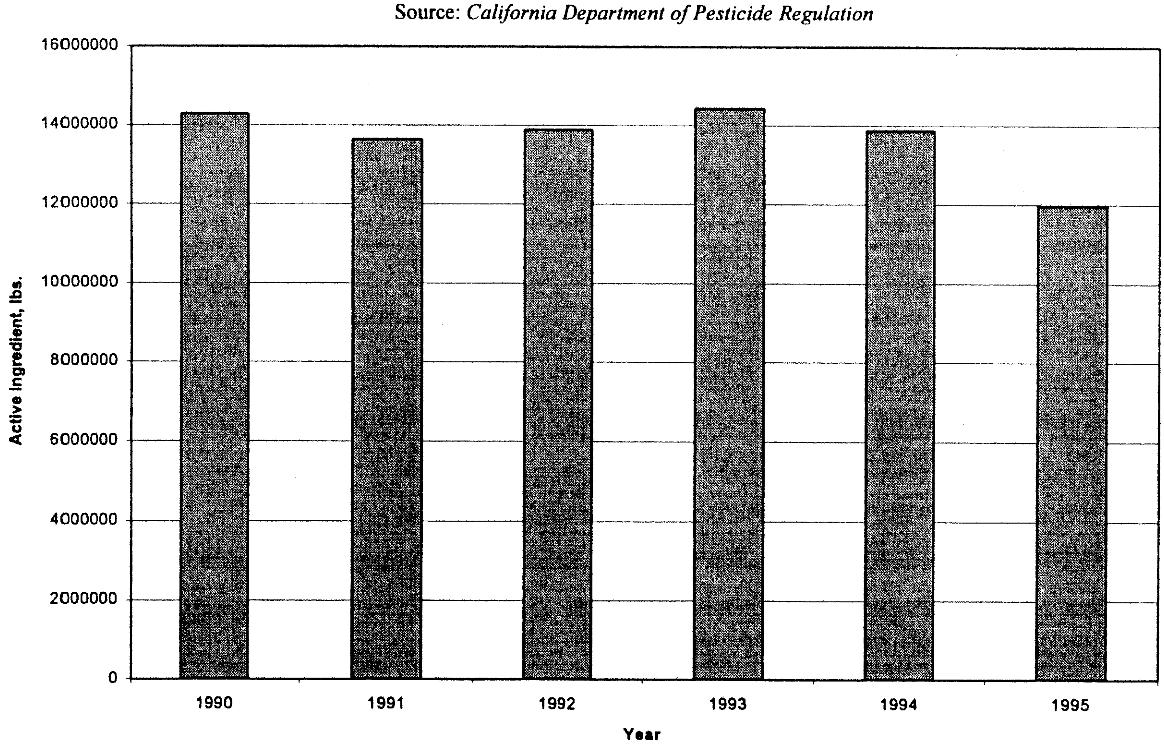
Pesticide Use in the California Almond Industry

Pesticide use in the almond industry of the state is significant. As described above, almonds ranks fourth among all crops grown in California in the total amount of pesticides applied each year. Figure 2 shows the annual amount of reported pesticide use in almond production on the state's farms. It has averaged nearly 14 million pounds per year since 1990, except for 1995.

Figure 2

Reported Pesticide Use in Almond Production
Active Ingredient (lbs.), California

Source: *California Department of Pesticide Regulation*



As is apparent in the figure, there was a significant fall-off in the reported amount of pesticide use in California almond orchards in 1995, in contrast with the five prior years. Comparing the amount reported for the three-year interval 1990-92 for the corresponding three-year interval 1993-95, there has been a decline in the annual pesticide use of about 3.6%.

County pesticide use data shows similar patterns. For Merced and Stanislaus counties, site of the BIOS initiative, pesticide use in almonds is especially important. The largest single use of agricultural chemicals in both counties is for almond production. Possibly of greater significance is the fact that, in both counties, approximately one-third of all pesticide applications is in almonds, despite the fact that almond tree plantings represent only about one-sixth of total cropland.

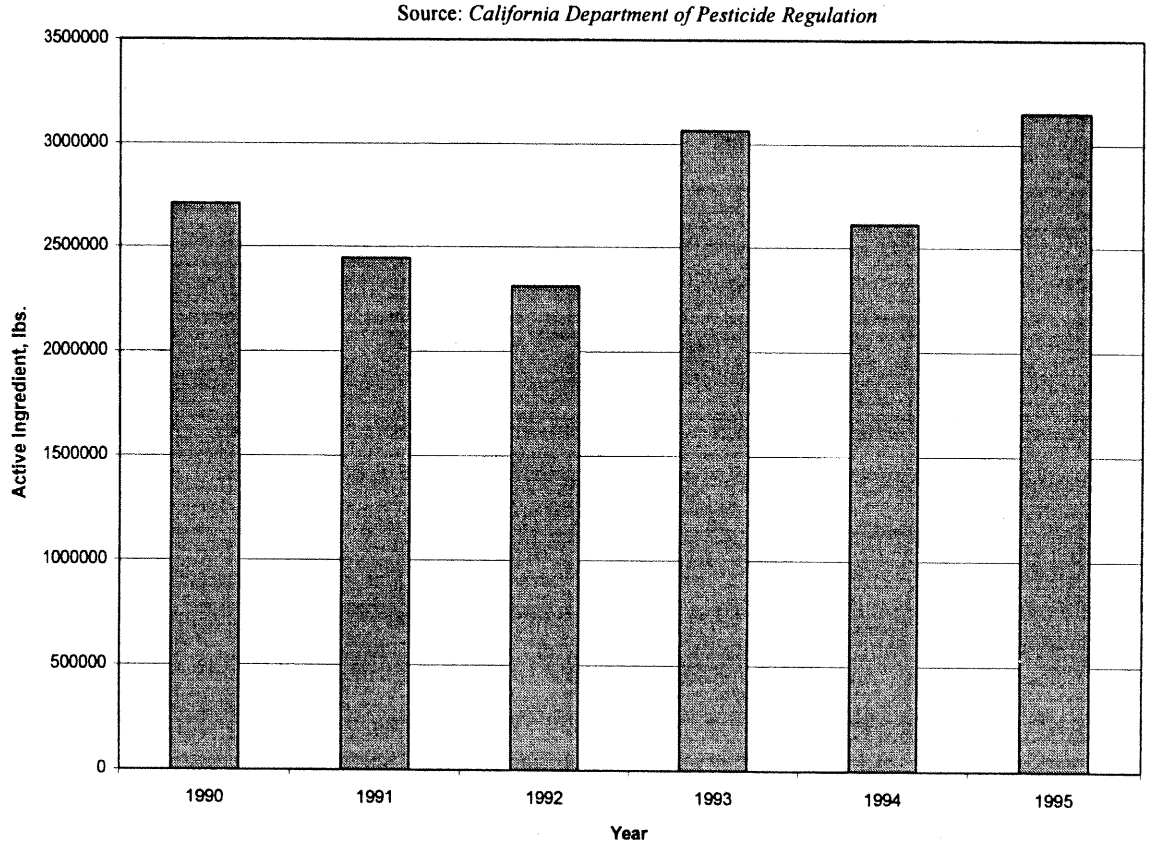
Pesticide Use in the California Walnut Industry

Pesticide use in walnuts is far less intense than for almonds. About 3.3 million pounds are applied each year on California walnut orchards, and this industry ranks fifteenth among all crops in the amount applied each year. In part, the smaller total reflects the fact that walnut acreage is less than half of almond plantings, and prevailing walnut production practices involve much lower amounts of pesticide use due to a different set of pests. Figure 3 shows the annual amount of reported pesticide use in walnut production on the state's farms.

Unlike the case of almonds, pesticide use in walnuts fluctuates quite a bit from year to year. However, comparing three-year average annual pesticide use for the period 1990-92 with that for 1993-95 shows an increase of about 18% and, despite the large annual variations, this increase in reported use is statistically significant.

For Solano and Yolo counties, site of the BIOS walnut program, annual variations in pesticide use are even larger than are found in statewide totals and exhibit no obvious pattern of annual variation. For example, in Solano County, the amount of pesticide applied in walnuts in 1994 was double that reported for 1993. In neighboring Yolo County, the amount applied in 1993 was 50% higher than in 1992. Thus, Yolo county applications were unusually high in the same year that Solano county applications were unusually low. As is discussed more thoroughly below, both counties show unusually low levels of annual pesticide use per acre of walnut cropland, so that small quantitative increases appear to be relatively large.

Figure 3
Reported Pesticide Use in WalnutProduction
Active Ingredient (lbs.), California
Source: *California Department of Pesticide Regulation*



Measuring the Effectiveness of Pesticide Use Reduction Initiatives: Methods

The goal of this study was to test the efficacy of these voluntary pesticide reduction programs. We compared two groups of tree nut growers. First, a group of growers who are members of a voluntary pesticide reduction program (BIOS); and second, a group of 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 entirely committed to 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.

Measuring changes in the amount of pesticide use on farms is challenging. First, seasonal and annual variations in climate and weather can lead to drastic changes in pest populations. Second, trees of different varieties and ages may face different types of pest problems. Third, local variations in soil types and conditions may lead to a wide range of decisions regarding effective pest control methods. Finally, different pest control advisors may provide vastly different advice regarding methods for controlling a particular pest problem.

The methods used in the present study to determine changes in pesticide use involves directly comparing almond and walnut orchard fields that have participated in the BIOS program with a carefully selected set of non-BIOS orchard fields, which serve as a cohort. For purposes of discussion these will be henceforth termed "BIOS Orchards" and "Cohort Orchards." Ideally, the BIOS and Cohort Orchards would be exactly matched, by location (to match soils and microclimate), by age of trees, by varietal mix, by tree density, by size of orchard and by total farm size. In this idealized match, the two groups would likely differ only in farm management practices in the specified orchard fields.

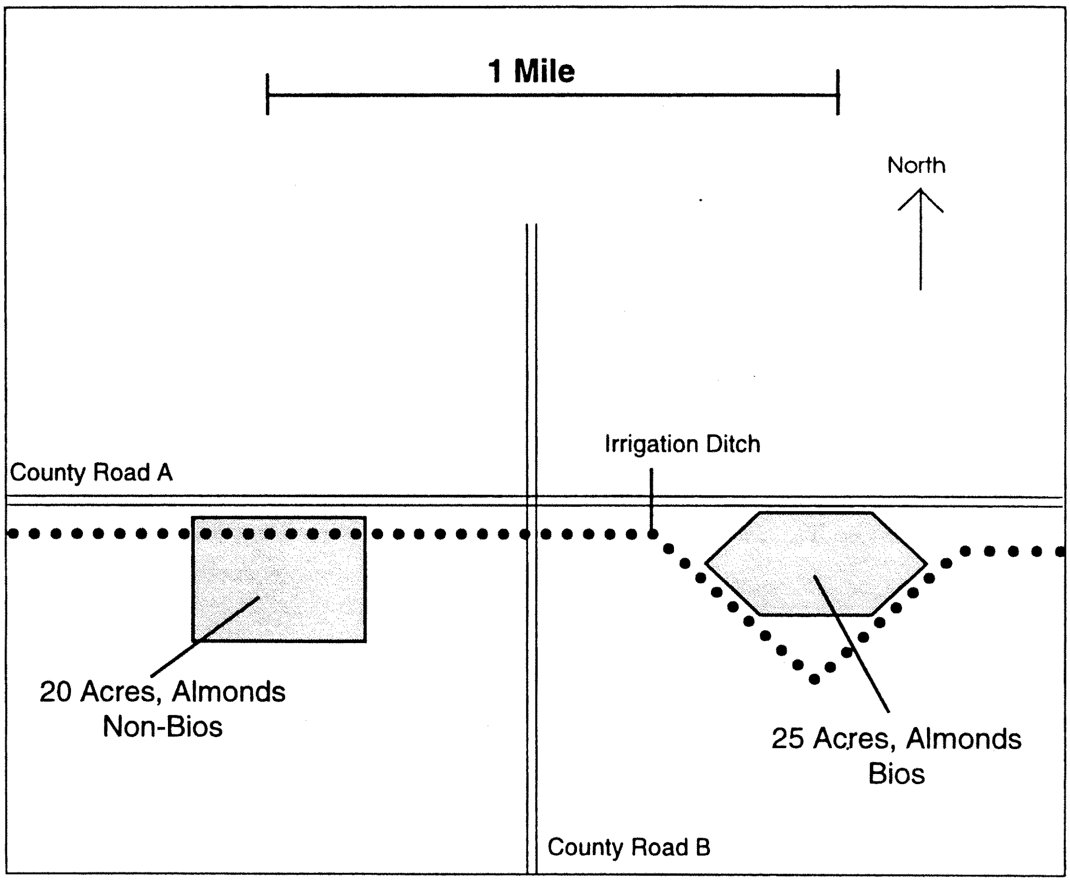
In this study it was possible to match the two groups according to many of these variables, with the exception of age of trees, tree density and varietal mix. However, as described later, personal interviews conducted by CIRS staff with both groups of farmers showed that the average age of trees as well as the average tree density of the two groups were remarkably similar.

This process of matching BIOS and Cohort Orchards was accomplished by utilizing the CIRS Farm Operator Data Base, which includes detailed crop and field information for more than 75,000 California farms. For each farm in the data base, field-by-field location and acreage information for each crop on which the operator expects to apply registered pesticides is included. Many organic farmers are also in this data base inasmuch as many use those pesticides that have been approved for organic agriculture. It is another paradox of agriculture that some registered pesticides, such as sulfur, are allowed under organic farming guidelines.

The method of matching BIOS and non-BIOS orchard fields involves three steps:

(1) precise identification of every BIOS orchard field as regards crop (almond or walnut), orchard size (measured in acres), and location (specified by

Figure 4
Location of Selected Bios and Non-Bios Cohort Almond Grower Pair, Merced County



county, USGS section, township, range);

(2) for each BIOS orchard field, determining whether non-BIOS orchard fields of the same crop could be identified in the same location and of approximately the same size;

(3) selecting at least one non-BIOS orchard field from those farm operators with location and size matched orchard fields whose total nut crop acreage was approximately equal to that of the BIOS farm operator.

This matching process assures that matched pairs of orchard fields will be no more than one mile apart (see Figure 4 above). Presumably, soil and microclimate for both members of each pair would be very similar if not identical. The size match criterion that was utilized allowed up to a 20% difference in orchard field acreage. Thus, a "match" was achieved for a 25 acre almond orchard field if the second orchard was between 15 and 20 acres in size. 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.

It was found that the very large number of almond farms in Merced and Stanislaus counties—some 856 in the former county and 1,192 in the latter—made it possible to readily identify a matching Cohort Orchard for every almond BIOS Orchard. And, in all but two cases, at least two matching non-BIOS orchard fields were identified.

For the walnut farms in Solano and Yolo counties, the matching process was more difficult. This is because there are relatively few farms producing walnuts in these two counties, just 84 in Solano and 116 in Yolo, and the vast majority of these are located in a relatively small geographic area (located in the vicinity of the town of Winters). Also, the participation of two very large walnut farm operators in the BIOS program effectively precluded finding two equally large non-participants. In these two special cases, geographically and sized matched Cohort Orchard fields were listed in descending order by size of total walnut acreage and the two largest were selected, even though they were outside the total walnut acreage criterion.

The final step in the comparison process involved obtaining all individual pesticide use reports for each farm—BIOS and Cohort—and then carefully selecting those that corresponded to the matched orchard fields. As a part of this process, a comparison was also made for all almond and walnut orchard fields for the two groups, including BIOS and non-BIOS orchards of BIOS participant growers.

In a separate, but related project, a total of thirty-six Almond growers, all located in Merced and Stanislaus Counties, were contacted and interviewed in person during summer 1997.[9] Of this total, twenty-three growers were members of the CAFF/BIOS project and thirteen were Cohort producers. The sample of Walnut growers was drawn from Solano and Yolo counties. Five were members of the CAFF/BIOS program and sixteen were Cohort growers.

Each grower was asked to provide her/his California Department of Pesticide Regulation farm and field identification number of their BIOS orchard(s), or matched orchards, 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. 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 as compared with a single year's outcome. The generous contribution of the time and effort of the participating growers is deeply appreciated.

One important component of the interview process was collecting data regarding age of trees and tree planting density, allowing further comparison of the two groups. It was found that the average year planted for the blocks was 1977 for both BIOS and Cohort almond growers, suggesting that this study's matching process resulted in a fortuitous match of orchard tree age. The average number of trees planted per acre for BIOS almond participants was 81.3 and 71.8 for Cohort growers, a relatively small difference. It was not possible to separate out differences in the varietal mix of the two groups.

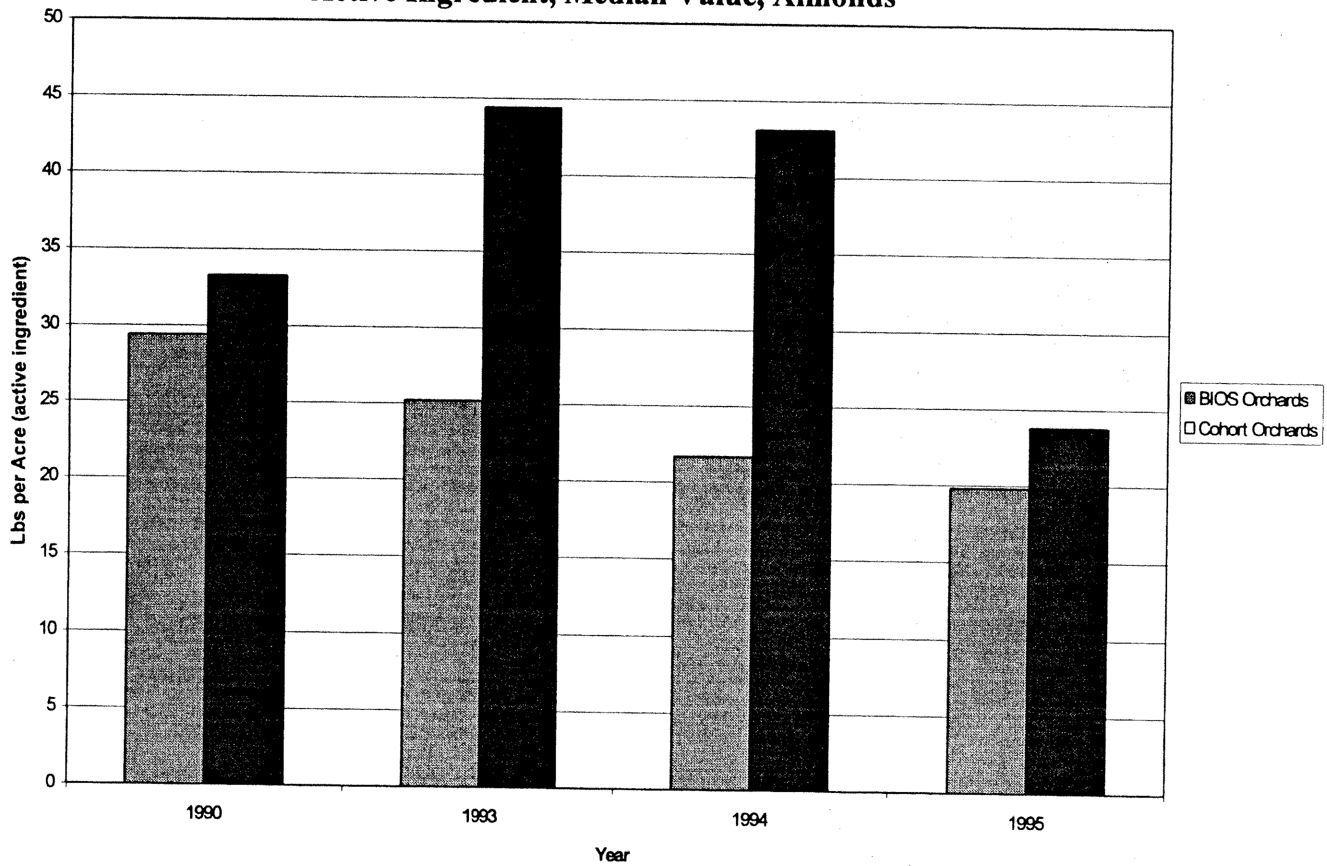
In the case of the BIOS and Cohort walnut producers, there were also few differences between the two groups regarding tree density and tree age. None of the blocks grown by BIOS participants were planted after 1988, and only two of the 16 Cohort growers' blocks were planted after 1987.

Measuring the Effectiveness of Pesticide Use Reduction Initiatives: Results

Almond Program

For almond growers, the results of the study are rather clear cut. First, BIOS Orchards reported significantly lower pesticide use than was the case for Cohort Orchards. This difference in pesticide use is best measured by the *intensity of active ingredients* applied in the matched orchard fields. Intensity refers here to the total number of pounds all chemical active ingredients per acre actually treated, not the acreage harvested. This latter distinction is important because this study finds that many pesticide applications in almonds covered only a portion of the full orchard acreage, in some case only a relatively few trees (spot treatments). Figure 5 shows

Figure 5
Intensity of Pesticide Use, Lbs. per Acres Treated
Active Ingredient, Median Value, Almonds



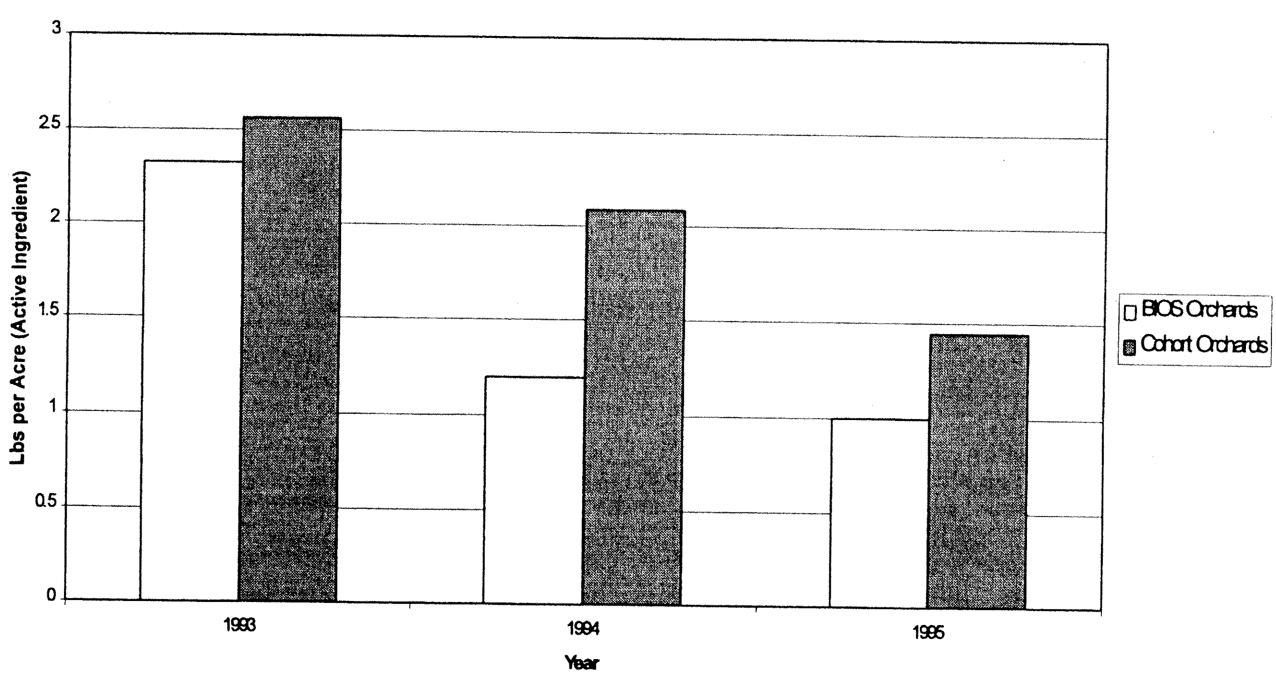
the comparison of the intensity of pesticide use for the matched BIOS and Cohort Orchards for the period 1993-95, corresponding to the immediate pre-BIOS period and its first full years, and for 1990, well before the BIOS program was initiated. What is clear from Figure 5 is that BIOS orchard fields reported a smaller intensity of pesticide use than did Cohort orchard fields, and this difference was especially great in 1993 and 1994.

Second, whereas Cohort Orchards show a substantial annual variation in the intensity of pesticide use—up some years and down in others—the intensity of pesticide use in BIOS Orchards exhibits a systematic and steady decrease throughout the entire period. Thus, the median value of Cohort Orchard pesticide use was nearly 45 pounds of active ingredients per acre treated in 1993, *up* from 33.5 pounds per acre in 1990. The corresponding values for the BIOS Orchards were 25 pounds per acre treated in 1993, *down* from nearly 30 pounds per acre in 1990. By 1995, the BIOS Orchards were reporting just under 20 pounds of active ingredients per acre treated.

Liebman reported that the intensity of pesticide use in almonds in 1995 was about 30 pounds per acre, determined by dividing all reported pesticide use for almond production by the reported total acres of almonds harvested.[10] This figure of 30 pounds per acre can not be correct and, therefore, can not be directly compared with the findings of the present study. As indicated above, many pesticide applications in almonds cover only a portion of an orchard field, not the full acreage harvested. For the BIOS and Cohort Orchards, the present study finds that the percent acreage treated was in the range of 48% to 56% for BIOS Orchards and 84% to 91% for Cohort Orchards. Thus, the statewide average figure regarding the intensity of pesticide applications determined by Liebman must be corrected. It is likely to be in the range of 33 to 36 pounds per acre under the assumption that the range of percent acreage treated found for the Cohort Orchards represents the range of values for all almond orchards in the state.

Another, independent measure of pesticide use in BIOS and Cohort Orchards is the intensity of use of restricted pesticides. These are the most dangerous materials, often requiring extreme care by handlers and applicators. Presumably, substitution of less toxic materials for the most dangerous can be understood as a form of pesticide use reduction. That is, even if the total amount of materials applied remains

Figure 6
Intensity of Restricted Pesticide Use, Lbs. per Acre Treated
Active Ingredients, Median Value, Almonds



unchanged but less dangerous chemicals are substituted for the most dangerous, it can be argued that the environmental toxic load has been reduced. Figure 6 shows a direct comparison of the intensity of restricted materials use between the matched orchard fields for the period 1993-95.

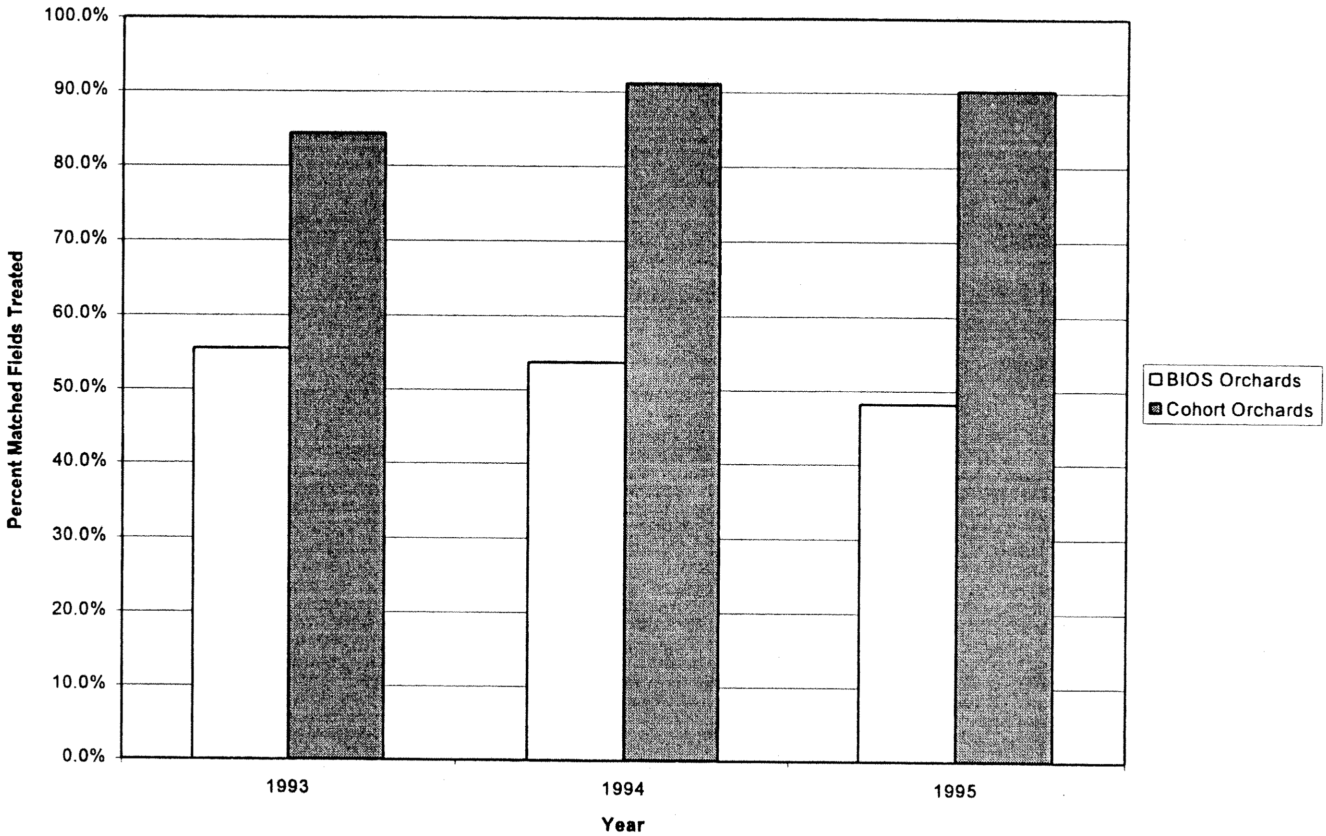
In all years the intensity of restricted materials pesticide use was lower among the BIOS Orchards than it was for the Cohort Orchards. The difference was greater after the BIOS program was initiated than in the years just prior. Of great significance is the fact that the decline of the intensity of restricted materials use in the BIOS Orchards declined by more than half (59%) in just three years. In 1993, Cohort Orchards reported 10% greater intensity of restricted materials use than did BIOS Orchards; by 1995 Cohort Orchards reported 53% greater intensity of restricted materials use, owing to the large fall-off in restricted materials by BIOS participants.

One of the most important findings regarding the difference between BIOS and Cohort Orchards is the percent of matched fields treated. That is, not all BIOS Orchards or Cohort Orchards were reported to have been treated with registered materials in a given year. In both groups there were always some orchards that were not treated. Of course, the number of applications in each field where materials have been applied is also a measure of pesticide use. However, whether a field is treated at all has great significance as well.

For all years, BIOS Orchards reported treating substantially fewer orchard fields than was the case for Cohort Orchards. Moreover, the proportion of BIOS Orchards treated with any registered pesticides fell to less than half in 1995. In contrast, the proportion of Cohort Orchards treated never fell as low as 80%. These findings are shown in Figure 7.

Especially striking in Figure 7 is the fact that the proportion of matched Cohort Orchards reportedly treated with any materials rose somewhat during 1993-95, to more than 90%. At the same time, the proportion of BIOS Orchards reported treated actually declined throughout the period, to just 48%. This is very compelling evidence of the attainment of pesticide reduction goals by the BIOS almond program.

Figure 7
Percent Matched Orchard Fields Reported Treated
All Registered Pesticides, Almonds



Comparisons were also made of the number of applications per orchard field actually treated. For all years, the median number of reported applications in BIOS Orchards was larger than was reported for Cohort Orchards: 18 vs. 15 in 1993; 16 vs. 14 in 1994; and 16 vs. 12 in 1995. This was a surprising finding: more applications per year in BIOS Orchards than in Cohort Orchards. One possible explanation is that the type of pesticides preferred by BIOS participants may require more applications. It is well established that some less toxic materials, including some approved for organic production, require two or more applications for effective treatment.

Nevertheless, the proportion of orchards treated and the intensity of pesticide use in BIOS Orchards was smaller than was the case for Cohort Orchards. Thus, despite the larger number of reported applications per orchard treated, pesticide use reduction was clearly achieved.

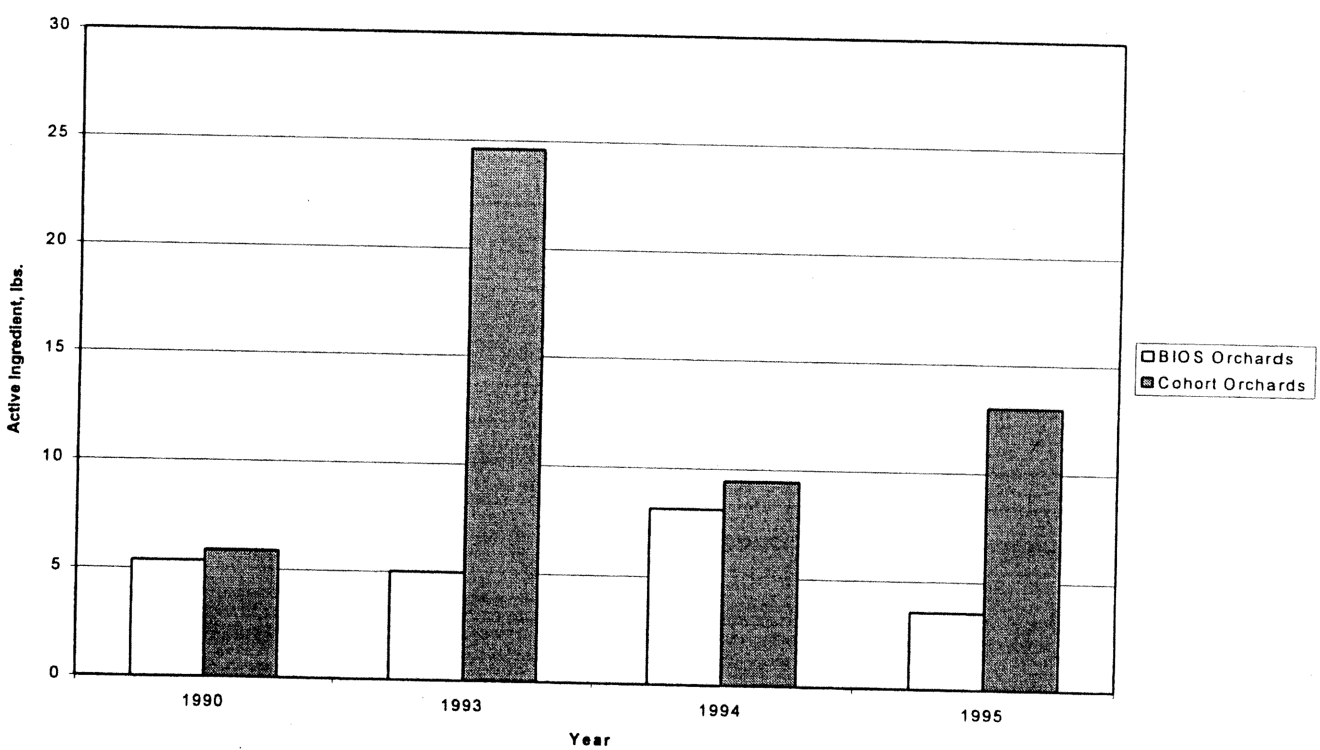
Walnut Program

The BIOS walnut program is quite a bit smaller than the BIOS almond program, involving about half as many growers. Moreover, the amount of pesticides reported used in both BIOS Orchards and Cohort Orchards was found to be very much smaller than was the case for almonds. For example, the number of pesticide applications in those walnut orchards that were actually treated was about one-third to one-half the number found in the case of almonds. In fact, there were so few applications in some years that statistical results were not meaningful. As a consequence, this study found it more difficult to obtain conclusive results. Nevertheless, all measures suggested much lower pesticide use in BIOS Orchards than in Cohort Orchards.

Figure 8 shows the comparative findings for the intensity of pesticide use in matched walnut orchards for the period 1993-95.

For all years, the reported intensity of pesticide use among Cohort Orchards was larger than was use among BIOS Orchards. However, in both 1990 and

Figure 8
Intensity of Pesticide Use, Lbs. per Acres Treated
Active Ingredient, Median Value, Walnuts



1994, pesticide use of the two groups is rather comparable. In both 1993 and 1995, use in Cohort Orchards was very much greater than in BIOS Orchards, five times as great in the former year and three times as great in the latter year. Interestingly, Cohort Orchards reported a substantial increase in the intensity of use in 1995 as compared with 1994, whereas the BIOS Orchards reported a small decline.

It is important to note that the amount of reported pesticide use in the BIOS *walnut* Orchards was in the range of 4 pounds per acre treated in the period 1993-95. This is less than one-fourth the intensity of use reported in BIOS *almond* orchards. Among the *walnut* Cohort Orchards, pesticide use averaged about 10 pounds per acre treated, a very much smaller level of use than in *almond* Cohort Orchards. Since the levels of reported pesticide use are so small, rather modest changes in the number of pounds applied may appear to signify a substantial change.

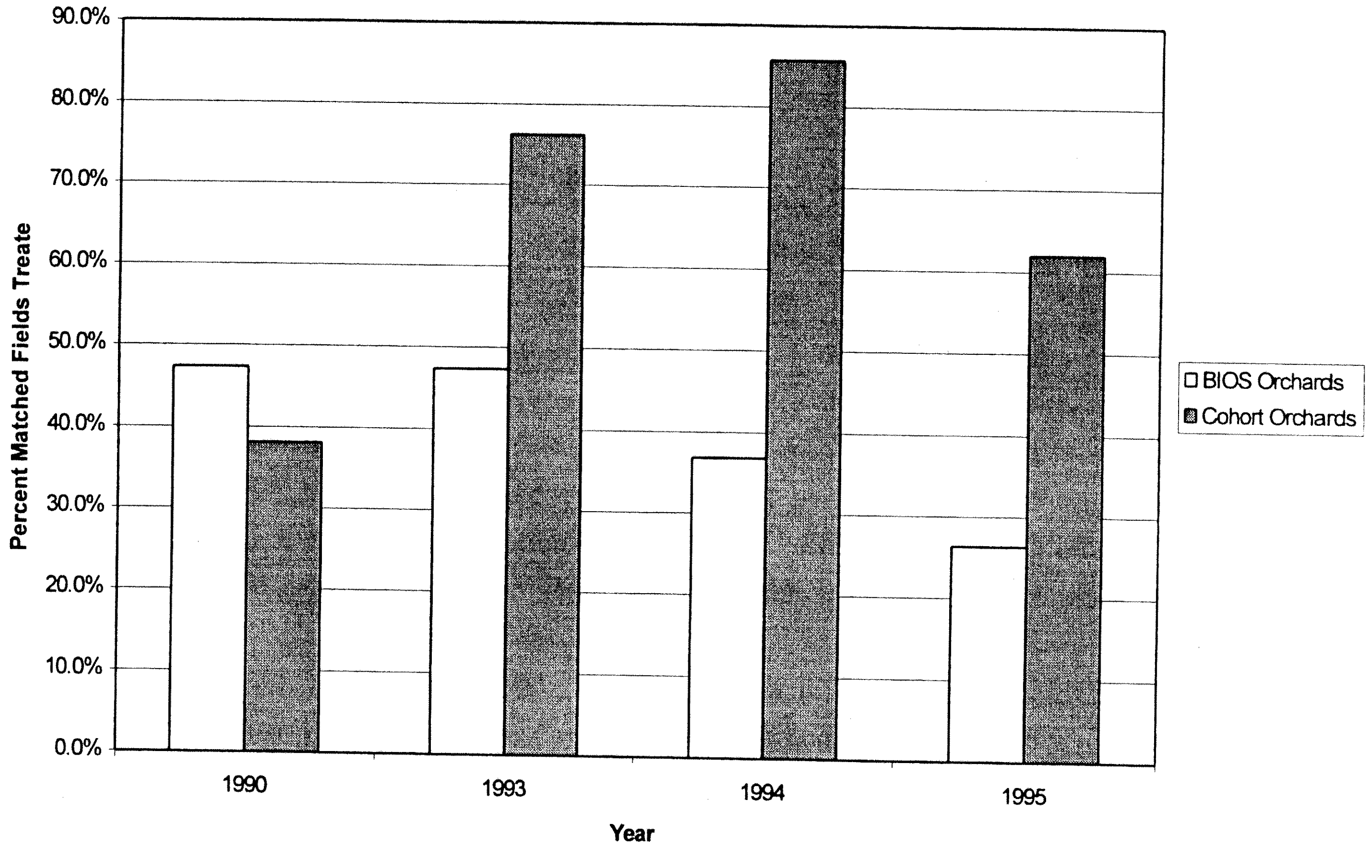
Restricted pesticide use was found to be relatively uncommon among both BIOS Orchards and Cohort walnut Orchards. For example, there was only one reported restricted materials application in all of the BIOS walnut Orchards in 1995. Among Cohort walnut Orchards there were nine applications in all. In 1994, BIOS Orchards reported a grand total of six applications of restricted materials, Cohort Orchards reported fourteen. While it should be clear that BIOS Orchards use very little restricted materials in walnuts, meaningful statistical comparisons of such small level of use may not be particularly informative.

Another measure of pesticide use in walnuts that is a helpful indicator of the effectiveness of the BIOS program is the proportion of matched walnut orchards treated with any registered pesticides. This is shown in Figure 9.

The steady decline in the proportion of walnut BIOS Orchards treated is evident, down to just one orchard out of four in 1995. In contrast, the Cohort Orchards reported a large variance in the proportion of orchard fields treated, as high as nearly two out of three in 1995.

One of the interesting findings obtained in the interviews that CIRS staff conducted among BIOS and Cohort farmers was that the two groups relied on

Figure 9
Perent Matched Orchard Fields Reported Treated
All Registered Pesticides, Walnuts



very different information sources in seeking pest control advice. The BIOS participants stated that Independent Pest Control Advisors (PCAs) were their most important information source, followed closely in preference by the BIOS Management Team.[11] Independent PCAs are licensed by the state and provide information for a fee, usually charged on a per acre basis. In striking contrast, Cohort farmers strongly preferred Chemical Company Representatives as their preferred source of pest control information.

Thus, greater pesticide use is associated with seeking advice from Chemical Company Representatives, while pesticide use reduction is associated with Independent PCAs and the BIOS Management Team.

Conclusions

Cohort Orchards were carefully selected to match, on a pairwise basis, BIOS Orchards for both almonds and walnuts. It was found that pairs of orchards could be matched using location, orchard size, and farm size criteria. Interviews with both groups revealed that the BIOS and Cohort Orchards were also well matched in terms of tree density and age of trees. This latter finding was unintentional but highly desirable.

Pesticide use reports (PURs) for all BIOS and Cohort Orchards were obtained and examined in detail. From these individual PURs it proved possible to examine actual amounts of pesticides reportedly used on a field-by-field basis. Determinations were made of the number of orchard fields treated, the number of applications per orchard field treated, the amount of all pesticides applied in each field treated and of the amount of restricted materials applied.

This study finds that, uniformly, BIOS Orchards report a significantly lower proportion of fields treated with registered pesticides as compared with a matched group of Cohort Orchard fields. The share of all BIOS Orchard fields treated with any registered material has significantly declined throughout the period in which the BIOS programs have been implemented. In the case of almonds this share is now less than one-half, in walnuts it is about one-fourth.

Second, substantially lower intensities of pesticide use are reported in BIOS Orchards than is the case for the matched Cohort Orchards. In almonds, the BIOS Orchards report a steady decrease in the intensity of pesticide use for the period 1993-95 and also in comparison with levels reported in 1990. However, in walnuts, where only a small share of all BIOS Orchards is reportedly treated, there has been no significant change in the intensity of pesticide use. It should be emphasized that pesticide use in BIOS walnut orchards is extremely low and very much lower than in the Cohort Orchards.

Third, subsequent to the inception of the BIOS almond program, participants have significantly reduced their usage of all registered materials, as compared with prior years. The reduction is especially dramatic for restricted materials usage. However, for the BIOS walnut program, there has been relatively little usage of any pesticides both before and after the program began. Thus, the intensity of pesticide use does not indicate much change. At the same time, the proportion of matched BIOS walnut orchards treated at all was actually higher than for the Cohort walnut orchards in 1990, whereas in both 1994 and 1995 the proportion was less than half. Therefore, after the BIOS program began, BIOS walnut participants did reduce the proportion of orchards treated at all. Taken together, these two indicators suggest that those walnut growers who chose to participate in the BIOS program were relatively less intensive users of pesticides before joining, but did reduce the proportion of their orchards treated once in the program.

Finally, greater pesticide use is associated with obtaining pest control advice from Chemical Company Representatives whereas lower pesticide use is associated with seeking pest control advice from Independent PCAs and members of the BIOS Management Team.

References

[1] Agricultural chemical production expenses reported in the *Census of Agriculture* have been adjusted for inflation by using USDA's Index of Prices Paid by Farmers, which takes account of price increases for chemical products.

[2] The acronym FVH will henceforth be used to refer to fruit & nut, vegetable & melon, and horticultural specialty crops.

[3] U.S. Department of Agriculture, *Agricultural Statistics. 1998*, Tables 4-1 and 5-2.

[4] According to the 1992 *Census of Agriculture*, agricultural chemical production expense for California farms totaled $694.5 million, while for Illinois it was $439.7 million and for Iowa it was $424.1 million.

[5] According to the 1992 *Census of Agriculture*, there were 10.5 million acres of cropland in the state and agricultural chemical production expense was $694.5 million, which is equivalent to $66.28 per acre; for the U.S., the corresponding figures are 435.4 million a acres of cropland, $6.134 billion in agricultural chemical expense, equivalent to $14.09 per acre.

[6] Jamie Liebman, *Rising Toxic Tide*, Pesticide Action Network, 1997.

[7] William S. Pease, Rachel A. Morello-Frosch, David S. Albright, Amy D. Kyle and James C. Robinson, *Preventing Pesticide-related Illness in California Agriculture*, California Policy Seminar, University of California, 1993, Table, pp. 8-9.

[8] Bureau of the Census, U.S. Department of Commerce, *1992 Census of Agriculture. California State and County Data*, Washington, DC, 1994.

[9] Charles V. Moore and Don Villarejo, *Information and Pesticide Management*, California Institute for Rural Studies, Davis, CA, 1998.

[10] Jamie Liebman, *Rising Toxic Tide*, Pesticide Action Network, 1997.

[11] Charles V. Moore and Don Villarejo, *Information and Pesticide Management*, California Institute for Rural Studies, Davis, CA, 1998.