Almond Board of California
Annual Report
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Project No. 94-BF3- Almond Culture and Orchard Management

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Objectives:

1. To compare the benefits of various covercrops, and to determine the adaptability of each to almond orchards. Comparisons of soil fertility, organic matter content, and biological activity will be made. A second objective is education. The covercrop comparison planting is an excellent location for farmer field tours to demonstrate the benefits and associated problems of various covers.

2. To implement a dormant and spring organic fungicide program to control bloom and foliage diseases. Also, to implement cultural weed control strategies, in an attempt to manage Johnson and Bermuda grass problems in a young orchard where the tree canopy is not large enough to shade-out the weeds around the base of the tree.

3. To compare two types of drip irrigation systems (above ground and buried) in a 6-year-old almond orchard and to determine the effects of irrigation strategies on hull rot which has become a problem in this orchard. An additional objective is to study the effect of high boron levels on nut removal at harvest. Preliminary data suggests excess boron may cause increased mummies at harvest.

4. To (1) evaluate the effect of annual fall applications of Enzone® on ring nematode populations; (2) evaluate subsequent incidence of bacterial canker as related to Enzone® application and nematode control; and (3) determine any significant effects of Enzone® application on tree growth and crop yield.

5. To determine the influence of shaker damage to tree trunks of young trees on productivity and its impact on hull split and insect damage in nuts. The information from this project will not only help evaluate the productive life of damaged orchards but will also help in the management of insect pests.

6. To compare three low-volume irrigation systems, microject, surface drip, and subsurface drip, for their effect on tree growth and productivity.

7. To further investigate the damaging effects on almond leaves from the apple leafhopper, *Empoasca maligna,* and to work on control measures for this pest.

Procedures, Results and Discussion: See Attached

ALMOND BOARD OF CALIFORNIA 1994 ANNUAL REPORT ABSTRACT

DATE: DECEMBER 22, 1994

PROJECT TITLE: SOIL-BUILDING WITH COVER CROPS IN CALIFORNIA ALMOND ORCHARDS

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Abstract. A covercrop trial comparing ten covercrop mixes replicated twice, was planted in fall 1992. Comparisons were also made in 5 orchards with established covercrops. Organic matter (OM) was moderate for all planted species. The two highest OM levels are in the Beneficial Blend and the Insectary Mix. In the Arnold orchard, established resident vegetation had the highest OM level. OM levels were very high in 1993 and 1994 in the established orchards. Ladybird beetles were abundant in the established vetch+clover covercrops and in the Beneficial blend, Insectary mix, vetch and clovers. Numbers were low in the resident vegetation, Blando brome, Zorro fesque, and in the sparce bur medic. Parasitic wasps numbers were highly variable. Earthworms were found in high numbers in the established covers, a few in the Takhar orchard, and none in the Arnold Farms. NOW survival was very low in all of the heavily cover cropped, non sprayed orchards.

ALMOND BOARD OF CALIFORNIA 1994 ANNUAL REPORT

DATE: DECEMBER 21, 1994

PROJECT TITLE: **SOIL-BUILDING WITH COVER CROPS IN CALIFORNIA ALMOND ORCHARDS**

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METHODS AND ACTIVITIES:

A cover crop trial comparing ten cover crop mixes was planted November 9, 1992 at the Arnold Family orchard on Cressey Way, Atwater. Each plot is 2 middles wide by 14 trees long, replicated twice, with the Nonpareil row in the center. Comparisons are also being made in 5 orchards with established covercrops.

The following covercrops are being compared at Arnold's:

Annual grasses: Blando brome, Zorro fesque

Annual legumes: Cahaba white vetch, sub clover mix, Rose clover, non-til clover, bur medic, annual clover mix

Mixed species: resident vegetation, Beneficial Blend, Insectary Mix

Measurements have been made for organic matter (OM) monthly in spring and summer. Leaf samples for nutrient analysis were collected in mid-June from the Nonpareil row in each cover crop plot and from each orchard. The cover crop and trees were surveyed periodically for insect, mite and spider activity. Both PTB and NOW traps were maintained to monitor these pests. Covercrop height was measured periodically, and mowings were recorded for each cover.

Tours were held April 21, 27, and May 5, 1993, and April 15, 1994 for growers, researchers, and farm advisors.

RESULTS AND DISCUSSION:

Samples show moderate OM levels for all cover crop species in the newly planted cover crop trial. See Table 1. The two highest OM levels are in the Beneficial Blend and the Insectary Mix. Both of these have a wide variety of plant species which grow over a long time period. The resident vegetation which has been established several years, shows the highest OM level in the Arnold orchard. The lowest OM levels are in the annual grass plots; Blando brome and Zorro fesque. In the five established orchards, the OM levels are very high for sandy soils in the Central Valley. The top OM averages are in the long-established vetch covers in the Ray Eck and Glenn Anderson orchards and in the resident vegetation in the Ron Anderson orchard. The young vetch and clover cover in the Lashbrook orchard and the new BIOS "rich mix" cover in the Takhar orchard have intermediate OM levels.

Leaf samples for nutrient analysis are collected in mid-June from the Nonpareil row in each cover crop plot and from each orchard. These samples show normal levels in all orchards. Ron Anderson continues to have a borderline high 0.38% chloride. Glenn Anderson's N has increased from 1.9% N in 1993 to 2.4% in 1994. Zinc is still somewhat low at 17 ppm. Cindy Lashbrook has reduced the high sodium and chloride of 0.4% in 1993 to 0.3% each in 1994. It is interesting that the certified organic orchards of Eck and Lashbrook have very high N levels, and very good K and Zn levels as well.

The cover crop and trees were surveyed periodically for insect, mite and spider activity. See Table 2. The numbers of ladybird beetles were high in the established vetch/clover and tall resident vegetation cover crops during April and May. Ladybird beetle levels were very high in the Takhar orchard in 1994. This orchard had the BIOS "rich mix" this year. In the Arnold test planting there were high Ladybird beetle numbers in the Beneficial Blend, Insectary mix, vetch and clovers. Numbers were low in the resident vegetation, Blando brome, Zorro fesque, and in the bur medic. These results are very similar to 1993. The ladybird beetle numbers were lower in the Rose clover in 1994 than in 1993.

The numbers of beneficial, parasitic wasps are highly variable, but appear to be in lower numbers in the resident vegetation and higher in the planted covers.

Table 3 lists the numbers of earthworms per counting ring in both 1993 and 1994. High earthworm numbers indicate good soil health and viability. The highest numbers of earthworms were the Glenn and Ron Anderson orchards and in the Eck orchard. Moderate numbers were found in the Lashbrook orchard and they increased later in the summer (personal communication). Few earthworms have been found in the Takhar orchard. No earthworms have been found in the Arnold Farms. This orchard was "seeded" with earthworms from the Ray Eck orchard in mid-April.

There were very few mites in the Arnold block. The Eck and Lashbrook orchards had few 2-spotted mites and very high levels of the predator mite, *M. occidentalis*. Both Anderson orchards had a brief surge of 2-spotted mites in the heat of August 1994, but the high levels of *M. occidentalis* quickly brought these under control. Measurement over the past seven years consistently show that 2-spotted spider mites are very seldom an economic problem in heavily cover cropped, unsprayed almond orchards. The Western orchard predator mite, *M. occidentalis* can very effectively hold the 2-spotted mite to less than economic injury levels.

During the 1993 and 1994 growing seasons no insecticides were applied to the five innovative orchards, except for the Toki Takhar orchard. In the Takhar orchard a dormant spray of diazinon plus oil and copper, and a hullsplit spray of Lorsban were used.

Traps were maintained to monitor PTB and NOW. PTB catches were high in both 1993 and 1994. In 1993 damage was high statewide, but in 1994, rejects are low. High reject levels from PTB damage do not necessarily follow high PTB trap catches.

NOW egg numbers were extremely low in both '93 and '94, and damage was also very low both years. NOW survival is very low in heavily cover cropped orchards with high levels of undisrupted beneficials. The insect damage counts are tabulated in Table 4. In 1994, the Eck orchard had the lowest reject levels of the five orchards. Only the Ron Anderson orchard had reject levels higher than 1993. These were almost entirely PTB.

Covercrop height was measured periodically, and number of mowings, and timing were recorded for each cover. There is no single, "best" method of cover crop management. The following are typical timings for mowings:

COVER	JAN/FEB	MAR	APR	MAY	JUNE	JULY
RESIDENT VEGETATION:	1"	1"	1"	1"	<1"	<1"
RESIDENT INSECTARY:	2"	4"*	4"*	4"*	4"*	<1"
VETCH & CLOVER MIX:	6"				4"	<1"
CLOVERS	4"				4"	<1"
BROME & FESQUE:	4"				1"	<1"

* Alternate rows

CONCLUSIONS:

The top soil OM averages are in the long-established vetch covers in the Ray Eck and Glenn Anderson orchards and in the resident vegetation in the Ron Anderson orchard. These orchards also have the top earthworm counts. In the Arnold Farms block, the highest OM levels are in the established resident vegetation, the Beneficial Blend and the Insectary mix. The lowest OM levels are in the annual grass plots; Blando brome and Zorro fesque. In the five established orchards, the OM levels are very high for sandy soils in the Central Valley.

Nutrient levels are adequate in all orchards and cover crops. It is very interesting that the certified organic orchards of Eck and Lashbrook have very high N levels, and very good K and Zn levels as well. Using certified organic methods does not need to result in low fertility.

Ladybird beetle numbers are highest in dense, diverse covers such as the Beneficial Blend, the Insectary mix, vetches and clovers. These are covers in which plentiful supplies of prey insects flourish. Numbers were low in the resident vegetation, Blando brome, Zorro fesque, and in the poor stand of bur medic which support fewer prey insects. The numbers of beneficial, parasitic wasps are highly variable, but appear to be in lower numbers in the resident vegetation and higher in the planted covers.

High earthworm numbers indicate good soil health and viability. The highest numbers of earthworms were the Glenn and Ron Anderson orchards and in the Eck orchard where soil organic matter levels are high.

Again in 1994, it was confirmed that high reject levels from PTB damage do not necessarily follow high PTB trap catches. NOW egg numbers were extremely low in the test orchards in both '93 and '94, and damage was also very low both years. NOW survival is very low in heavily cover cropped orchards with high levels of beneficials.

Table 1. Average seasonal organic matter in surface six inches.

ORGANIC MATTER MEASUREMENTS-INNOVATIVE GROWERS		
	ORGANIC MATTER CONTENT	
GROWER, LOCATION, CULTURE	1993	1994
GA, HILMAR, VETCH, ORGANIC	1.46	1.44
RA, HILMAR, RES VEG, STANDARD	1.53	1.61
RE, HILMAR, VETCH+CLOVER, ORGANIC	1.46	1.18
PC, ATWATER, VETCH+CLOV, ORGANIC	0.96	0.89
TT, HILMAR, VETCH+CLOV, STANDARD	0.96	0.93
ARNOLD FARMS, TEST BLOCK	1993	1994
RESIDENT VEGETATION	1.10	0.88
BENEFICIAL BLEND	0.80	0.65
INSECTARY MIX	0.86	0.71
CAHABA WHITE VETCH	0.71	0.61
ZORRO FESQUE	0.62	0.53
NONTILLAGE CLOVER MIX	0.67	0.62
BLANDO BROME	0.65	0.53
BUR MEDIC (POOR STAND 1993)	0.68	0.59
SUBCLOVER MIX	0.55	0.61
ANNUAL CLOVER MIX	0.61	0.53
ROSE CLOVER	0.54	0.63
CLEAN TREE STRIPS	0.54	0.32

Table 2. Ladybird beetle larvae and adults per 25 sweeps.

GROWER, LOCATION, CULTURE	1993*	1994*
GA, HILMAR, VETCH, ORGANIC	34	37
RA, HILMAR, RES VEG, STANDARD	10	77
RE, HILMAR, VETCH+CLOVER, ORGANIC	26	34
PC, ATWATER, VETCH+CLOV, ORGANIC	29	44
TT, HILMAR, VETCH+CLOV, STANDARD	13	60
ARNOLD FARMS, TEST BLOCK	1993*	1994*
RESIDENT VEGETATION	10	25
BENEFICIAL BLEND	65	51
INSECTARY MIX	62	34
CAHABA WHITE VETCH	34	40
ZORRO FESQUE	6	25
NONTILLAGE CLOVER MIX	51	39
BLANDO BROME	18	29
BUR MEDIC (POOR STAND 1993)	8	25
SUBCLOVER MIX	34	39
ANNUAL CLOVER MIX	35	41
ROSE CLOVER	42	28

*Totals for 6 dates in 1993 and 7 dates in 1994.

Table 3. Earthworm counts per ring.

GROWER	1993 DATE			1994 DATE	
	5/15	6/7	7/12	4/25	5/9
GA HILMAR VETCH	9	15	8	6	12
RA HILMAR RESID	0	28	9	20	14
RE HILMAR VET/C	6	IRRIG	14	23	12
PC ATW VET/CLOV	0	6	0	2	4
TT HILMAR RES/C	0	0	0	.7	.3
COVER CROP TEST ATWATER SAND	0	0	0	0	0

Table 4. Almond kernel rejects due to NOW and PTB damage.

REJECTS DUE TO WORMS							
ORCHARD/CULTURE	1988	1989	1990	1991	1992	1993	1994
GA:VETCH/NO SPRAY	2.8	1.1	0.4	0.2	1.8	2.1	0.7
RA:NATIVE/NO SPRAY	2.7[a]	1.8[a]	2.9	0.6	1.6	2.7	3.4
TT:NATIVE/DORM+HSPLT		9.5[b]	6.5[b]	0.4	4.3	2.2[b]	1.7[b]
PC:VETCH/Bt+Goniozus				3.9	3.9	2.2	2.1
RE:VETCH/NO SPRAY						4.1	0.6
a: RA dormant spray 1988 and 1989 only. b: TT annual dormant plus hullsplit, BIOS 1994.							

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Reduced Input Management Practices To Control Diseases and Perennial Weeds

Wesley K. Asai, U.C. Farm Advisor, Stanislaus County

Objective: Two experiments were conducted to study the impact of reduced chemical inputs for control of almond scab and perennial weeds in a local almond orchard. In the weed study, a pilot project using White Chinese young and adult geese, and Brown African adult geese were used in a local organic orchard in an attempt to control thick stands of Bermuda and Johnson grass.

In the scab study, the orchard used had a severe scab infestation and defoliation the previous year. With grower interest in the use of reduced chemical inputs, a study using organically approved fungicides was tried.

Procedure: Young White Chinese goslings were put into fenced areas of the orchard in early May. The White Chinese and Brown African adults were added to their respective pens in mid-May. The geese were given only water and relied on the weeds present for food. Evaluations were made on their abilities to control thick stands of Bermuda and Johnson grass, in and around the almond trees. This is only a non-replicated pilot study to test the effectiveness of geese in a situation where herbicides cannot be used.

In the scab study, the organically approved fungicides dormant liquid lime-sulfur (DLLS), delayed-dormant copper hydroxide (DDCu), and spring wettable sulfur (SS) were used at various timings and combinations:

Treatment	
1	Untreated Check
2	DLLS
3	DLLS + DDCu
4	DLLS + DDCu + SS
5	DDCu + SS
6	SS

A severe spring frost destroyed the entire crop so evaluations were only made on scab incidence on the leaves and it's effect on defoliation.

Results: The young goslings were effective on the Bermuda and other small grasses, but the Johnson grass was too aggressive before the goslings could control it. Part of the limitations of using goslings was their unavailability until late spring from the hatcheries. By the time they are large enough to put out, the Johnson grass is already too large and aggressive. The adults were effective in controlling both grasses, but the economics of purchasing large numbers of adults may be prohibitive. Starting with large numbers of goslings and raising them to reproducing adults for subsequent years is a more feasible alternative.

In the scab study, the entire crop was lost to a spring frost so only leaf symptoms could be evaluated. There were no significant differences in the incidence and severity of scab between the untreated checks and any of the treatments. Even the most intense treatment (#4) received a dormant liquid lime-sulfur, a delayed-dormant copper hydroxide and multiple spring wettable-sulfur, and had the same scab damage as untreated checks. All of the treatments provided unacceptable control.

COMPARISON OF ALMOND TREE GROWTH, PRODUCTION AND HULL ROT UNDER VARIOUS DRIP IRRIGATION MANAGEMENT

Wilbur Reil, Yolo/Solano Farm Advisor

Objectives

Farmers continue to strive to improve irrigation efficiency because of both the increasing cost of water and power and the availability of only limited amounts of water. Drip irrigation is increasingly becoming popular. Most drip systems use single hoses with 4 to 6 point sources for water emission. Also, buried drip irrigation systems are now being suggested and limitedly used with perhaps even higher efficiency. This trial is designed to compare two types of drip irrigation systems (above ground and buried) in a uniform almond orchard. Hull rot has also become a problem in this same orchard so water management will also be evaluated during July-August. In Yolo County, boron is present in excess quantities in the irrigation water. Observations show that nuts are hard to knock with many nuts remaining after shaking.

Plans and Procedures

Three irrigation systems were installed in a 6 year-old almond orchard on the Nonpareil rows (every other row). The systems are (1) above ground drip of a single hose designed to apply 100% ET until first hull split then be reduced to 50% ET for one to four weeks; (2) buried drip with a hose buried on each side of the tree 5 feet from the tree row and 12 inches deep to apply the same amount of water as treatment 1; and (3) an above ground drip to apply the same water as 1 and 2 until early hull split, then apply twice the water or 100% ET of the other two systems. Additionally, extra boron has been added to three trees of four different varieties to determine its effect on number of mummies left after harvest. A total of 1.9 pounds solubor was applied per tree under the emitters. Counts were made at harvest on the number of nuts remaining on trees after harvest and the number of dead shoots per tree killed by hull rot.

Results

Data for 1992 was primarily to get the system up and running and to obtain preliminary hull rot data. While treatment 1 and 2 are applying the same amount of water the buried drip system has no surface moisture and no evaporation, therefore, more of the water is available to the tree than in treatment 1 and it is estimated at approximately 60 to 65% ET rather than 50%.

Table 1 shows the results of reduced water applications in July on nuts remaining of the tree after shaking and the number of nuts killed by hull rot.

Table 1. Evaluation of Nonpareil nuts remaining on tree after shaking under three irrigation management systems. The same quantity of water was applied to trees until 1% hull split when different rates were then applied.

Type System: Irrig. Rate: Year	Surface 100% ET	Surface 50%* ET	Buried 50%* ET
1994	312	63	44
1993	118	28	16
1992	683	282	205

*For at least 2 weeks at early hull split.

Table 2. Nonpariel Shoots killed by hull rot under three drip irrigation management systems at early hull split. The same quantity of water was applied to trees until 1% hull split when different rates were then applied.

Type System:	Surface	Surface	Buried
Irrig. Rate:	100% ET	50% ET	50% ET
Year			
1994	8.2	1.7	0.9
1993	3.6	0.5	0.5
1992	12.2	0	1.8

Table 3 shows the number of nuts remaining after shaking in the trial where additional boron was added (+ boron) compared to no additional boron (no boron). The irrigation water does contain over 1 ppm boron. While higher than desirable this was not considered to be a problem on almonds. The almond trees are planted on Nemaguard rootstock.

Table 3. Almond nuts left on tree after shaking in 1993 and 1994 when added boron was applied (+B) compared to no additional boron (-B).

	1993		1994	
	+B	-B	+B	-B
Nonpareil	604	29	575	42
Price	226	84	244	37
Butte	295	180	540	198
Padre	465	110	518	85
Average	498	101	469	91

The results show that adding boron caused a major increase in nuts left on the trees after shaking in all four varieties tested. No excess gum was visible on the attachment on hull and nut to the peduncle. The average of all four varieties was 498 with the high boron compared to 101 with no added boron or a 4.9 fold or 490% increase in 1993. The same trees without adding any additional boron averaged 469 with high boron compared to 91 with no added boron or a 5.2 fold or 515% increase in 1994.

Conclusions:

These data suggest reduced moisture in the tree during the hull split period may reduce the incidence of hull rot and improve nut removal at harvest. Both the above ground drip that had the water reduced to 50% ET at early hull split and the buried drip that also had the amount of water reduced in half had less nuts remaining on the tree after shaking than the trees maintained at 100% ET. Trees under adequate or luxurious moisture status such as the 100% ET during hull split had a much higher amount of hull rot in 1992 and 1994, and higher hull rot in 1993. While the soil surface was wet around individual drippers in this system it was run only the same length of time as the other two systems with twice the number of emitters. The surface was wet approximately the same length of time as the 50% ET treatment. The humidity in the tree canopy was low in all systems suggesting that humidity may not affect hull rot whereas the moisture status within the tree itself may be the cause.

The higher number of nuts left on the tree after shaking in the system receiving 100% ET throughout hull split also suggests that nut abscission may be enhanced by some stress during the maturation process. Some moisture is needed to stimulate hull split but perhaps intermediate or approximately 50% ET may provide sufficient moisture for proper hull split while enhancing nut removal.

Adding boron to an excess level caused a major increase in the nuts left on the trees after shaking in the four varieties. There was approximately a 500% increase in nuts left on trees with added boron when compared to trees not receiving additional boron. Excess boron appears to increase the number of nuts remaining on trees after shaking.

These data suggest that perhaps tree water status at early hull split and excess boron may both cause nuts to be harder to shake from the tree.

CONTROL OF RING NEMATODE/BACTERIAL CANKER IN ALMONDS WITH ENZONE® APPLIED THROUGH A MICRO SPRINKLER SYSTEM - Paul S. Verdegaal, UC Farm Advisor in San Joaquin County

Introduction

Nematode infestations can reduce tree vigor through root damage from direct feeding and by placing trees under stress which predisposes them to other diseases. A good example of this type of disease interaction is ring nematode and bacterial canker which can kill various species of fruit trees. Typical symptoms of nematode infestations consist of a general reduction in vigor and weakening of trees. Lower yields, poor growth, and greater sensitivity to stress will often accompany nematode attacks. Since above ground symptoms are rather vague, nematode infestations are often misdiagnosed as water stress of nutrient deficiencies. Microscopic examination of the soil or roots is required for an accurate diagnosis of a nematode problem. There are several species of nematodes that have been identified as important pathogens on deciduous fruit trees which would include the following:

1. Ring nematodes (Criconemella xenoplax)

2. Lesion nematodes Pratylenchus spp.)

3. Dagger nematodes (Xiphinema spp.)

4. Pin nematodes (Paratylenchus spp.)

5. Root-knot nematodes (Meloidogyne spp.)

Of these species ring nematodes (C. xenoplax) has been associated with increased problems of Bacterial Canker caused by Psendomonis syringae. This Enzone™ field trial was aimed at controlling ring nematode. Control of bacterial canker was also measured as it would possibly be affected.

Studies to evaluate Enzone™ for nematode control on deciduous fruit trees have been ongoing since 1985. The purpose of this study was to determine whether Enzone™, when applied at economically acceptable rates, could significantly reduce plant parasitic nematode populations. Since Enzone™ (sodium tetrathis carbonate) is distributed in the soil by irrigation water, a significant factor in determining the potential for nematode control is the efficiency of the irrigation system. Enzone™ is neither systemic in the tree nor persistent in the soil and therefore requires that the pathogen receive direct exposure to the treated irrigation solution. Uniform distribution for the irrigation water containing Enzone™ is essential for effective treatment of the root zone. Areas outside the wetted treatment zone will remain infested.

Materials and Methods

A young (1983) Carmel and Monterey orchard on Nemaguard rootstock was selected for evaluation. Ring nematode populations had built up considerably since replanting and several trees were lost due to bacterial canker. The orchard was micro sprinkler irrigated.

Enzone™ was applied through the irrigation system at a rate of 21 gallons per acre. The concentration in the irrigation water was 1445 ppm A.I. with a treatment time 8 hours. The treatment was timed to coincide with periods of nematode population growth. Enzone™ was injected with metering pumps into the appropriate irrigation lines and, after calibration, pumps were checked and adjusted at regular intervals during the treatment to ensure that proper concentrations were being maintained. The soil within the treatment areas was at or near field capacity (moisture level) at the time of application to facilitate uniform water movement and Enzone™ distribution. The water was turned off 4 hours after treatment in order to clean irrigation lines and facilitate movement of the Enzone™ solution into the soil.

The trial was a randomized complete block design with 10 replications per treatment. The Enzone™ treatment was compared to an untreated control.

The primary criterion for evaluating the efficacy of nematode control was actual counts of nematodes per unit of soil. Oakfield probes were used to collect soil cores from individual replicates for analysis. Each soil core was about 3/4 inch in diameter and 18 inches in depth. A minimum of 5 cores from different vines were combined from within each replicate in order to overcome inherent variability in nematode population counts.

The samples were analyzed by using one or more of the appropriate nematode extraction techniques, usually the sugar flotation technique, for a given nematode species. All nematode counts have been converted to a standard 500 cc. sample due to differences in individual laboratory techniques. Soil samples were taken over time to follow the dynamics of the population and evaluate long-term effects compared to similar untreated populations. Fruit production was also measured.

Results

After initial Enzone® treatment in 1991, ring nematode numbers were reduced by 40%. Average counts for 500 cc of soil were 660 for the untreated control versus 392 for treated plots. In 1993, nematode counts increased slightly to approximately 900 ring nematode per 1000 cc of soil. Harvest yields were not significantly different in 1992, averaging approximately 34 meat pounds per tree, for both treated and untreated trees. Yields were again not significantly different in 1993, averaging 37.2 meat pounds per tree for both treatments. In 1994, trunk circumferences were again not significantly different. Nontreated trees increased from an average of 57.6 cm to 63.7 cm. For treated trees, average circumferences increased from 59.7 cm to 63.7 cm.

Enzone® did reduce nematode populations and did not adversely affect tree growth, but yields were not increased in the three years of this trial. Bacterial canker symptoms are not evident and the trees are doing well, while the ring nematode population is moderate. This situation may have the trees are doing well, while the ring nematode population is moderate. This situation may have been helped by the uniform and efficient micro sprinkler irrigation system reducing tree stress. Yields were not taken in 1994. The critical period for tree loss due to Bacterial Canker, years 1 through 7, has passed and appears not to be a continuing problem for this orchard. At this point the trial will be terminated due to lack of bacterial canker disease.

March 27, 1995

TRUNK DAMAGE ON YOUNG ALMOND TREES

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PROBLEM AND OBJECTIVES: Trunk damage is a common problem in Kern County almond orchards. It can be found in both mature and young orchards. Trunk damage on young trees can occur during the first harvest by shakers. This usually takes place when the trees are four years old.

To study the effect of bark damage on young trees, a five year old orchard was selected in 1994. The bark on the trunks of these trees had been damaged during the 1993 harvest season by a malfunctioning shaker. The objectives were the following: 1) To determine the amount of bark damage, 2) to determine the effect of bark damage on hullsplit, 3) to determine the amount of healing of the damaged area in subsequent years, 4) to determine **Ceratocystis** canker infection on damaged trunks and 5) to determine tree mortality. There were 107 trees damaged in four blocks which will be called A, B, C, and D.

RESULTS: Four trees died as a result of bark damage. This represents 4% of the damaged trees. Table 1 shows trunk circumference, the percent of damaged and undamaged bark, and the percent of healing of the damaged area. Healing refers to the amount of newly laid bark on the periphery of the damaged area of the trunk. The table shows that the amount of bark damage to the trunk circumference varies from 19% in block D to 56% in block A. However, the most surprising figure is the amount of healing taking place in the damaged area. The amount of healing varies from 22% in block D to 89% in block A. At this time, none of the injured areas have shown any evidence of **Ceratocystis** canker infection.

The effect of bark damage on hullsplit was determined by weekly nut samples from 10 damaged and 10 healthy trees. The damaged trees were selected on the basis of leaf symptoms due to bark damage on tree trunks. The average circumference of these trees was 50 cm. The percent of bark damage was 81% of which 26% was healing and 74% was not healing. The effect of bark damage on hullsplit can be seen in Figure 1. This graph shows that hullsplit is significantly affected by bark damage. The onset of hullsplit on trees with damaged bark took place on June 30, while on healthy trees, the onset of hullsplit was on July 14. This means that hullsplit on damaged bark trees was two weeks ahead of the normal trees.

Table 1. Tree size (trunk circumference) and the percent of bark damaged and undamaged by the trunk shaker. Also the amount of healing taking place in the damaged area.

CIRCUMFERENCE		*TRUNK CONDITION*		
Block	(cm)	Damaged(%)	Undamaged(%)	Healing(%)
A	59	56	44	89
B	60	46	54	60
C	62	31	69	63
D	55	19	81	22

Figure 2 shows kernel weight from trees whose trunk bark has been damaged and from trees whose trunk bark was not damaged. This figure shows that there was no kernel weight differences between these two types of trees.

DISCUSSION: The amount of bark damage on the trunk circumference was variable. It varied from 19% to 56%, and in some trees, it was up to 81%. However, the worst effect of bark damage was the immediate death of the tree. This is significant because it represents yield loss and replacement costs. In this study, we lost 4% of the trees soon after the trees were damaged. However, it appears that additional trees will be lost in the future.

When the tree doesn't die due to bark injury, it will have the onset of hullsplit, ahead of a normal tree. The onset of hullsplit on trees whose bark circumference was damaged 81% was two weeks ahead of normal trees. Bark damage has an impact on the timing of hullsplit sprays for NOW control. If a hullsplit spray is timed at the onset of hullsplit of a damaged tree, the nuts on a normal tree will be left unprotected. The reason being that the onset of hullsplit in a damaged tree occurs two weeks earlier than the normal tree.

The most pleasant surprise was the evidence of new bark on the damaged area. It was called "healing" because of the presence of new bark around the periphery of the injured area. The amount of healing taking place in the injured area varies from 22% to 89%. The healing may be due to tree-seal that was applied by the orchard supervisor. The tree-seal was applied immediately after the injury occurred and it was repeated as cracking appeared on the treated surface.

Fig 1. Percent of hullsplit from damaged and undamaged trees whose circumference was 81% damaged.

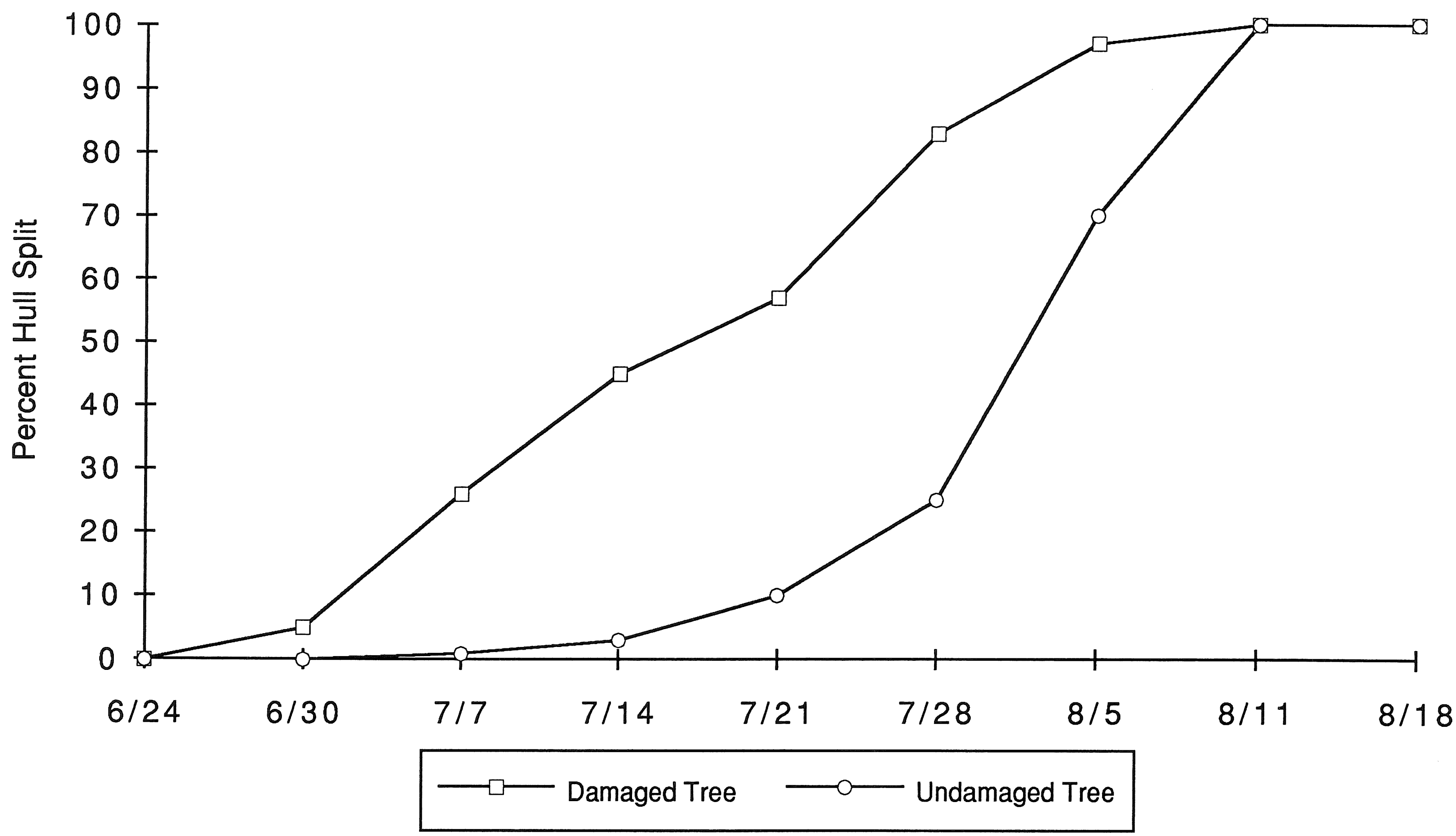
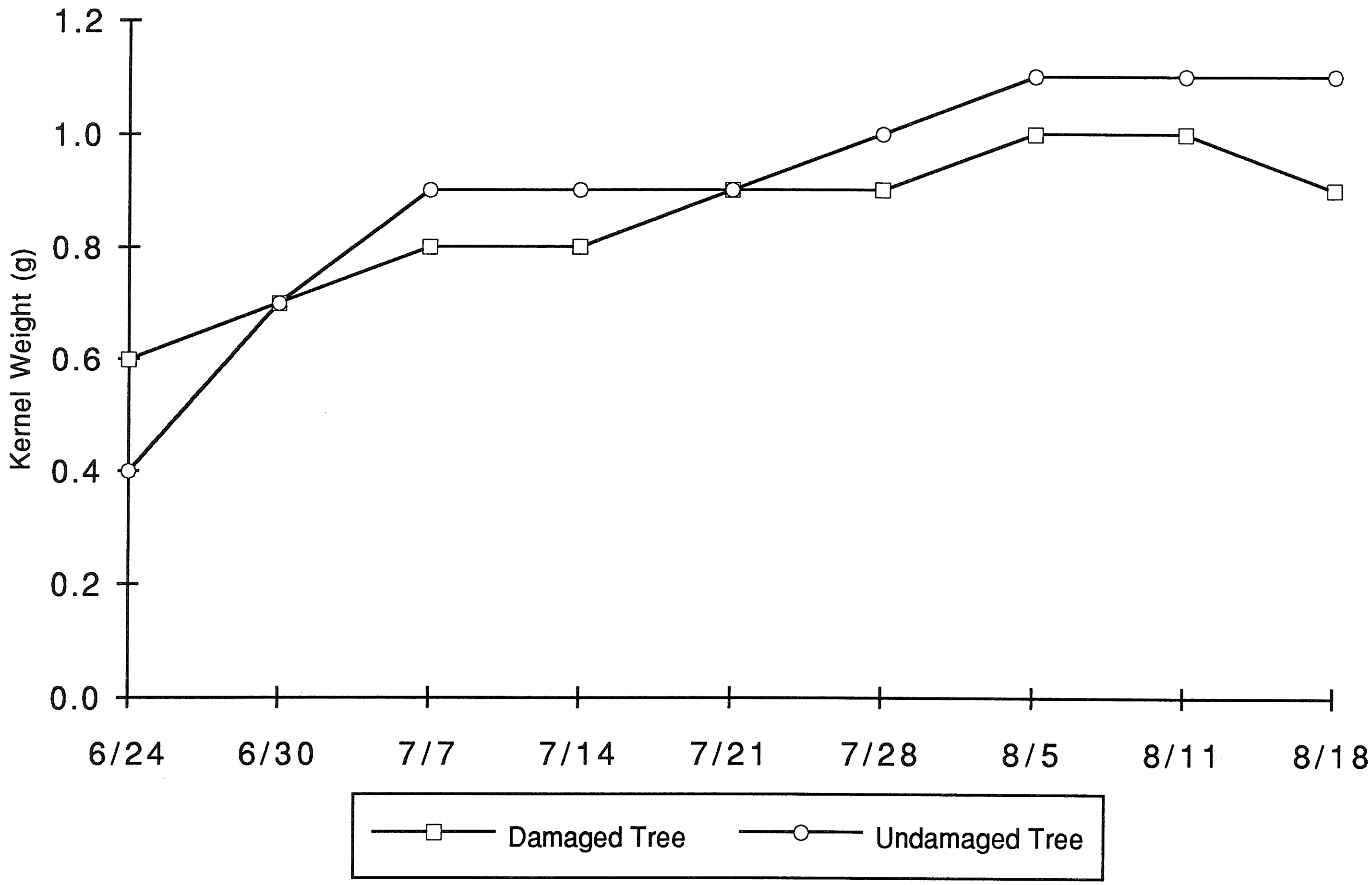


Fig 2. Kernel weight from damaged and undamaged trees whose circumference was 81% damaged.



Comparison of Low Volume Irrigation Systems for Almonds

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As the scarcity and competition for water grows in California, agriculture is under increasing pressure to improve its water use efficiency. Many tree crop growers have traditionally used flood or sprinkler irrigation to satisfy tree water demands, but advantages, (such as increased water use efficiency and improved crop yields,) of low volume irrigation systems have heightened interest in their use and paved the way for widespread adoption. Growers considering a new installation or conversion to drip or micro-sprinklers have numerous questions regarding design, management, and operation of these low volume irrigation systems.

A 22-acre field demonstration site was established in 1990 to evaluate the merits of various low volume irrigation systems for almonds. This site will allow simulation of commercial production conditions and allow practical field demonstration for growers. Various tree growth, yield and quality parameters are measured, in addition to system evaluations for water application efficiency and uniformity, system maintenance and operation requirements.

Four almond varieties, Nonpareil, Butte, Carmel, and Monterey are being grown with each of the following four irrigation systems:

1. Surface drip - single hose
2. Micro-sprinkler - one per tree
3. Subsurface drip - single hose, 2 ft. from tree row
4. Subsurface drip - double hose, 4 ft. from each side of tree row

Subsurface drip treatments were established the first year with surface drip systems and early in the second growing season converted to subsurface drip with the subsurface drip tubing installed to a depth of 15 inches.

Irrigation System Evaluations

Extensive work evaluating the irrigation systems at the Nickels Estate has been completed since the last report. These evaluations included measuring discharge rates from numerous emitters from within each of 36 plots , calculating average emitter discharge rates and Distribution Uniformity for each plot. Table 1 summarizes the results of the evaluations on the surface drip and micro-sprinkler plots.

Table 1. Summary of average emitter discharge rates and Distribution uniformity for the surface drip and micro-sprinkler plots.

Plot No.	Irrigation System	Avg. Emitter Discharge Rate (gph)	Distribution Uniformity (%)
1	Surface drip	1.04	91.1
6	Surface drip	1.05	94.3
7	Surface drip	1.07	88.8
12	Surface drip	1.12	87.7
14	Surface drip	1.09	90.1
17	Surface drip	1.20	84.0
21	Surface drip	1.13	84.4
24	Surface drip	1.05	88.7
27	Surface drip	1.07	90.5
29	Surface drip	1.06	92.4
31	Surface drip	1.07	91.8
36	Surface drip	1.11	90.8
2	Micro-sprinklers	10.07	90.0
4	Micro-sprinklers	11.12	91.6
8	Micro sprinklers	10.82	92.8
10	Micro-sprinklers	10.18	94.2
15	Micro-sprinklers	10.04	80.2
18	Micro-sprinklers	10.54	88.4
20	Micro-sprinklers	9.79	94.3
23	Micro-sprinklers	9.73	93.6
25	Micro-sprinklers	10.78	88.6
30	Micro-sprinklers	10.44	90.1
32	Micro-sprinklers	9.91	91.6
35	Micro-sprinklers	11.45	96.5

The above are excellent uniformities, particularly considering that the irrigation systems are now 4 to 5 years old. From these evaluations, there does not appear to be any significant clogging of the irrigation systems occurring. From the evaluations of the subsurface drip systems there does not appear to be any root intrusion problems occurring. All three irrigation systems continued to function properly except for one aspect of the subsurface system. One claimed benefit of subsurface drip is a dry soil surface. However, in this trial the buried system continues to wet the surface soil in 6" to 18" diameter spots directly above emitters, despite being buried 15" below the soil surface.

Root Development

A number of backhoe pits were excavated to evaluate root development in the surface drip and micro-sprinkler plots. The pit in the micro-sprinkler irrigated plot was excavated to depth of 6 to 7 feet. A constraining clay layer was evident at about 4 feet. This clay layer restricts extensive root development below that depth, and as was evident from the soil moisture measurements, also restricts water movement. In fact, tensiometer measurements indicated that following irrigation, water would move down to the clay layer, pond and saturate the soil, and as the soil above it dried actually form an upward gradient in water potential. Lateral root development showed the tree roots extending out approximately 6 feet from the centerline of the tree row. This corresponds with the wetted area of the micro-sprinklers.

The backhoe pit in the surface drip irrigated plot was excavated to a depth of approximately 4 feet. This pit was in an area of the orchard with shallower soil and the confining clay layer was found at a depth of 2 to 2.5 feet. As in the micro-sprinkler plot, root development was confined by the clay layer. The lateral root development in the surface drip plot was only 3 feet out from the centerline of the tree row - significantly less than in the micro-sprinkler plot.

Trunk Diameters

Extensive trunk diameter measurements were taken for each of the four almond varieties (Carmel, Butte, Monterey, and Nonpareil) growing under each of the irrigations systems (surface drip, micro-sprinklers, and subsurface drip). The statistical analysis of these measurements is contained in Table 2. In summary:

- The trunk diameter of the Carmel, Butte, and Nonpariel micro-sprinklers irrigated trees were greater than drip irrigated trees of the same varieties.
- The trunk diameters of the Monterey micro-sprinkler irrigated trees were equal to the Monterey drip irrigated trees.
- The trunk size of Nonpareil subsurface irrigated trees was greater than Nonpareils on surface drip.
- For the drip irrigated trees, the Carmel variety trees had a smaller mean trunk diameter than that of the Butte, Monterey, or Nonpareil trees.
- For the drip irrigated trees, the Butte variety trees had a greater mean trunk diameter than the Carmel, Monterey, or Nonpareil varieties.
- For the micro-sprinkler irrigated trees, the Carmel variety trees had a smaller mean trunk diameter than that of the Butte, Monterey, or Nonpareil trees.
- For the micro-sprinkler irrigated trees, the Butte trees had a greater mean trunk diameter than the Carmel or Monterey varieties.
- For the micro-sprinkler irrigated trees, the Butte trees and the Nonpareil trees had statistically the same average trunk diameters.

Table 2. Trunk Diameter - cm - 1994

	CARMEL	BUTTE	MONTEREY	NONPAREIL
Drip	12.04 b	13.49 b	13.17 a	12.91 b
micro	12.62 a	14.10 a	13.36 a	14.21 a
Single RAM	11.99 b	13.61 b	13.25 a	13.15 b
double RAM	11.16 b	13.46 b	13.28 a	13.28 a
double GeoFlow	12.55 a	14.52 a	13.11 a	13.48 a
All Subsurface	11.89 b	13.86 a	13.21 a	13.30 a

Values followed by same letter not significantly different .05 level.

Yield

The almond yield was measured on the Nonpareil and Butte varieties for the first time in 1994. While other trees measurements, such as trunk diameter and pruning weights may indicate growth, yield is the most useful measure of the effect of the different irrigation systems. Table 3 summarizes the 1994 yields for the Nonpareil and Butte varieties.

Table 3. Nonpareil and Butte variety yields (lbs./acre) for the 1994 season.

VARIETY	IRRIGATION TREATMENT	YIELD (LBS/AC)
Nonpareil	Surface drip	1055
Nonpareil	Micro-sprinklers	1535
Nonpareil	Subsurface drip	1237
Butte	Surface drip	1039
Butte	Micro-sprinklers	1551
Butte	Subsurface drip	1233

It is evident that the yield from the Nonpareil and Butte trees irrigated with micro-sprinklers is greater (20-30%) than the surface drip or subsurface drip irrigated trees. It should be emphasized that all irrigation treatments received the same amount of water during the season. At this early stage, it would seem that there is an advantage to growing the trees under micro-sprinklers versus the two drip methods. Possible explanations include: (1) the timing of the irrigations (irrigate more frequently with the drip systems vs. the micro-sprinklers) affects the yield, or (2) the different root development fostered by the different irrigation systems (root development more expansive with the micro-sprinklers vs. the drip systems) affects trees development and yield, (3) the micro-sprinkler trees capture a greater proportion of applied water than drip trees (applied water may leach below drip root systems). Work in future years will be very useful in determining if this trend continues.

Investigation and Control of Apple Leafhopper
Mark Freeman and Rich Coviello, Farm Advisors, Fresno County
Report on Research Done During 1994

During previous years, we reported on the type of damage that apple leafhopper causes on almond leaves. During 1994, we conducted three efforts: comparing the control given by four different chemicals, comparing the damage levels within different areas of an almond tree, and noting which varieties showed the necrotic leaf spots.

I. A plot was established to compare the control given by different chemicals on the populations of apple leafhopper. All four chemicals were applied via a hand gun on five single tree replications (of the Carmel variety) along with five trees left untreated. The trees were about 15 feet high. Before the treatments were applied, it was observed that all trees had high levels of immature leafhoppers present. The treatments were applied to coincide with a spring spray for peach twig borer control. This was done because the characteristic necrotic spotting seems to occur about that time each year and to avoid an extra insecticide spray if growers would apply a peach twig borer spray. The Diazinon, Omite, and Lorsban were applied at half label rates, and the Volck Oil was applied at the rate of one gallon/100 gallons of water. About three gallons of spray were applied per tree.

The data is reported in Table 1. All four chemicals significantly reduced the population of immature leafhoppers versus the unsprayed control. Significant differences between treatments are noted by the different letters which follow the counts. This observation agrees with previous observations that the leafhoppers are relatively easy to control with chemical sprays.

Table 1. The Use of Chemical Sprays to Control Apple Leafhopper on Carmel Almonds

Chemical	# of Immature*
Diazinon	6 A
Omite	5 A
Lorsban	2 A
Volck Oil	12 A
Control	87 B

* The number of immature leafhopper represent the number of third, fourth, and fifth instars that were found on 100 leaves from one tree. Each number represents the average number found from five Carmel trees that were sampled.

II. Mission variety trees were used in another orchard to determine the location within the tree where damage occurred. Leaves were sampled from ten trees after the characteristic necrotic leaf spots occurred . One hundred leaves were sampled from the four directional quadrants and from the tree's interior and exterior at four and eight feet in height. The number of leaves in each 100 leaf sample showing necrotic spots were then tabulated. There was not any significant difference between affected leaf levels of the four directional quadrants (such as north, south, west, or east sides of trees) as shown in Table 2a. There were more damaged leaves located in the lower heights of the tree as noted in Table 2b. The amount of leaf drop (by June) and numbers of immature leafhoppers found on those leaves (in late April) were also measured from those ten Mission variety trees. There was not a good correlation noted, possibly because the amount of leaf drop was quite low in this plot during 1994. (Statistical significance noted by different alphabetical letters following the data)

Table 2a. Location Within Tree Where Damage Occurs

Tree Location	# Leaves*
North Quadrant	22 A
South Quadrant	25 A
West Quadrant	18 A
East Quadrant	15 A

Table 2b. Location Within Tree Where Damage Occurs

Tree Location	# Leaves*
Tree Interior (4 Feet High)	31 A
Tree Interior (8 Feet High)	18 B
Tree Exterior (4 Feet High)	26 A
Tree Exterior (8 Feet High)	12 B

* The number of leaves represents the leaf number showing necrotic (brown) spots larger than 1/8 inch in diameter. One hundred leaves were sampled from ten trees and the number shown in the chart above was the average number of leaves per tree showing necrosis. Leaves were sampled in early June, 1994.

III. In the CSU Fresno almond variety block, we noted which almond varieties exhibited the necrotic leaf spotting versus the chlorotic spotting which appears similar to mite feeding. The Carmel, Monterey, Ruby, Mission, and LeGrand varieties showed the necrotic leaf spotting. All other varieties showed varying amounts of chlorotic leaf spotting.

IV. During the next six months, we plan to finish the project by comparing the results from different monitoring (or sampling) methods such as a "timed search" versus a specific number of leaves sampled. We also plan to compile pictures and text showing the appearance of different stages and types of leafhoppers found in almond orchards.