Project Name: **Almond Culture and Orchard Management**

Project Number: **05-BH-01**

Project Leader: Brent Holtz, UCCE Farm Advisor, Madera County

Project Cooperators: Joe Connell, Roger Duncan, John Edstrom, Mark Freeman, Franz Niederholzer, Mario Viveros (Farm Advisors in Butte, Stanislaus, Colusa, Fresno, Yuba-Sutter, and Kern Counties, respectively)

1) Processed-Kaolin Particle film on almond

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Surround, a white clay like processed-Kaolin particle film, can easily be dissolved into suspension and sprayed onto trees. Several research reports have been published in the Journal American Society Horticultural Science and HortTechnology describing how this reflective film can reduce heat stress, reduce solar injury, increase leaf carbon assimilation, and reduce canopy temperatures on a number of crops in several countries. In 2001 processed-Kaolin particle film was applied to 15 year old Nonpareil, Sonora, and Carmel almond trees in a preliminary experiment. Three in-season applications of Kaolin appeared to result in more return bloom, nut set, and yield on Carmel trees in 2002 when compared to non-sprayed Carmel trees (1). The Carmel trees in this orchard were showing symptoms of severe bud failure. The Sonora and Nonpareil varieties appeared unaffected by the Kaolin. Record hot temperatures were experienced in the San Joaquin Valley in May 2001 and above normal temperatures at this time have been shown to worsen the severity of bud-failure on Carmel (Dale Kester).

In 2002, 2003, 2004, and 2005 four applications of Kaolin (25 lbs/100 gallons water) were made each year to Carmel trees planted in January 2002 in order to examine if Kaolin could reduce heat stress and the onset of bud failure. We also examined the effect of Kaolin on tree water status (mid day leaf stem water potential), canopy temperatures, growth (tree circumference and current season shoot growth), and yield. An almond orchard in Madera with 16 Carmel rows was divided into a replicated design where 8 rows received four Kaolin applications each year while the 8 other rows did not.

In 2003 and 2004 mid day leaf stem water potential measurements were performed once a month from June-September. In 2003, June and July mid day leaf stem water potentials were significantly less on Surround treated trees when compared to non-treated trees. In August and September there was no difference between Surround and non-treated trees (2). In 2004, mid day leaf stem water potentials of Surround treated trees were significantly less when compared to non-treated trees in June, July, and August. By September there was no difference between Surround and non-treated trees (3). In 2005, mid day leaf stem water potentials (SWP) of Surround treated trees were significantly less in July and August (figure 1). There was no difference in SWPs between Surround and non-treated trees in June, most likely due to the relatively cool temperatures experienced in June 2005.

In 2003, 2004, and 2005 surround treated trees had significantly more current season shoot growth when compared to non-treated trees (figure 2). In 2005 there was a significant increase in trunk circumference in the surround treated trees that was not observed in 2003 and 2004 (figure 3). In 2004 and 2005 we counted fruit on 60 trees that received Surround and 60 control trees that had not. In 2005 we found significantly more fruit on the Surround treated trees (figure 4). Temperatures were significantly lower in the Surround treated trees in July but not in June in 2005 (figure 5), probably because of the unusually cool temperatures in June. In 2005 we did not observe any bud failure on the Carmel trees in either treatment. We did observe bud failure on Nonpareil trees in this experiment, but there was no significant difference between surround and non-surround treated Nonpareil trees in 2005. We will again repeat applications of Kaolin in 2006 in order to investigate the effect of Surround on heat stress and bud failure in both Carmel and Nonpareil almond varieties.

Acknowledgement: The project would not have been possible without the cooperation of George Andrews Farms in Madera, CA and the support of the Almond Board of California.

Literature:

1) Holtz, B.A. 2002. Bud failure or crazy top–the curse of the Carmel, the effect of Surround on Carmel return bloom, hull rot on almonds and field meeting, variety update. *The Pomology Post*, Vol. 37, May, 8 pages.
2) Holtz, B.A, and Hoffman, E.W. 2003. Processed-Kaolin particle film on almond, Almond Board of California, 31st Almond Industry Conference Proceedings 35-36.
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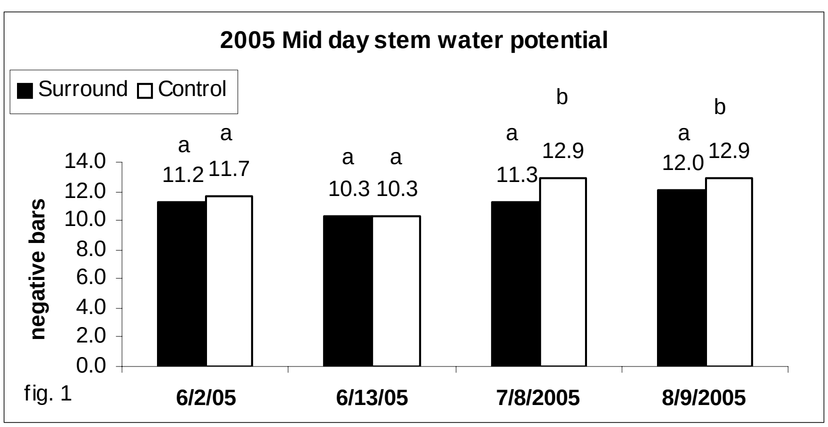

figure 1. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

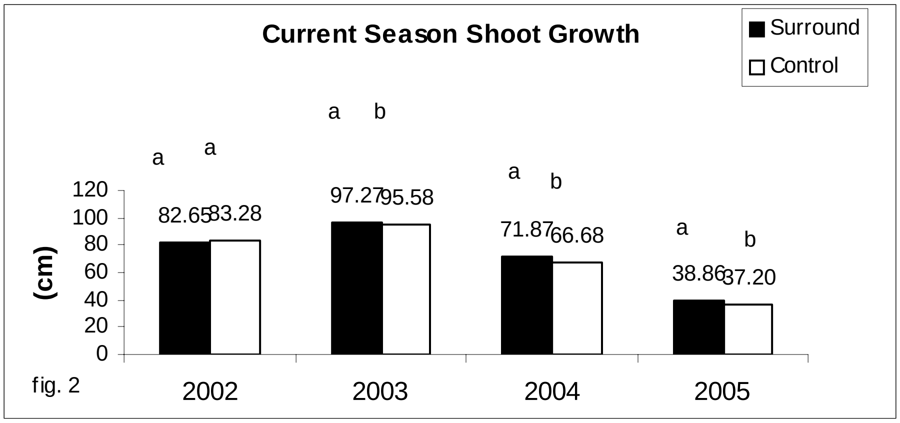

figure 2. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

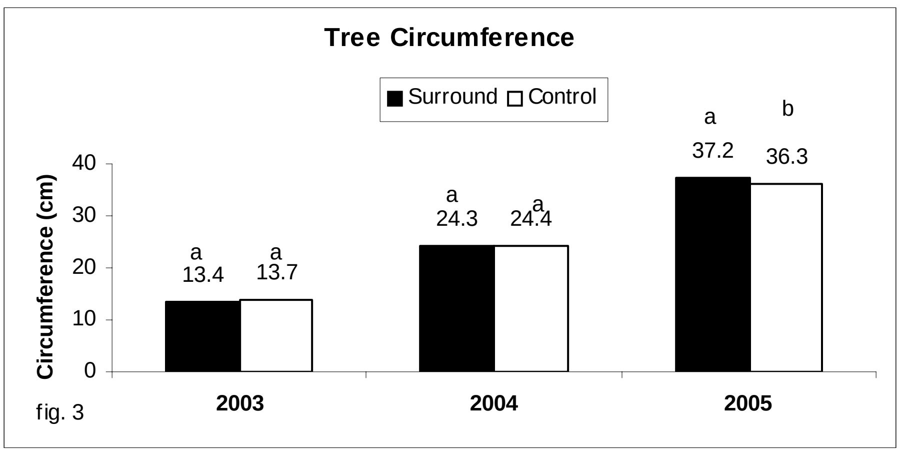

figure 3. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

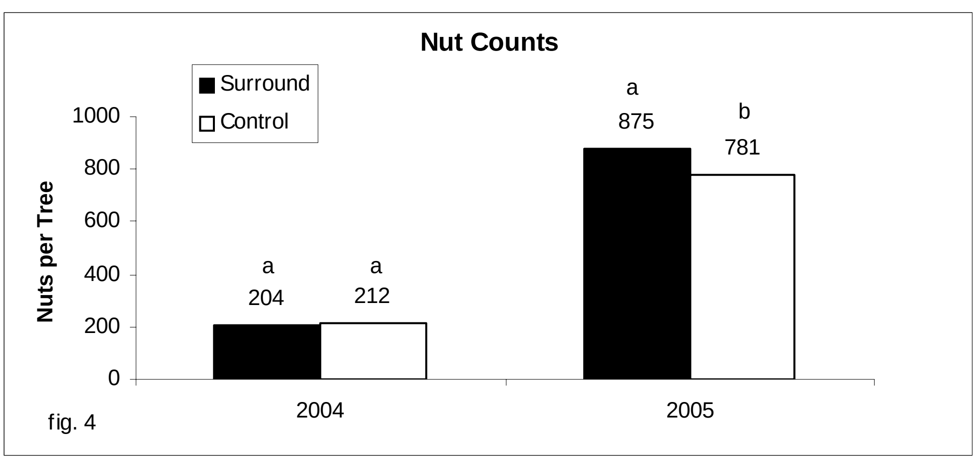

figure 4. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

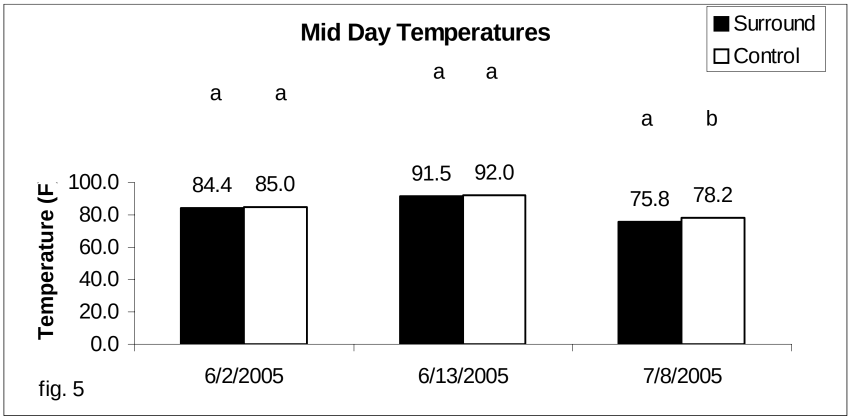

figure 5. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

2) **Increasing the Nonpareil Percentage: Pollenizer Arrangement vs. Pollen Variety**
Joe Connell, Farm Advisor, Butte Co., Bruce Lampinen, UCD, & Jim Floyd, CSUC.

Years ago when orchards were planted 2:1 with Nonpareil:pollenizer varieties we observed that yields were lower between the two Nonpareil rows. This was overcome in the industry by going to 1:1 plantings but the percentage of Nonpareil was reduced to 50% of the orchard. At the Nickels Estate in Arbuckle, trial work has indicated that alternating varieties down the row provides increased production compared to having the varieties in single rows. This trial is designed to see if the Nonpareil percentage can be increased with judicious placement of pollenizers while maintaining the yield advantages of the 1:1 planting. In addition, the question of whether one pollenizer variety is sufficient or if two pollenizers provide better production is also evaluated in this trial.

The orchard used for this evaluation was planted in March 2002 at the California State University Chico farm in Butte County at a tree spacing of approximately 18 x 21 feet resulting in 116 trees per acre. Varieties included are Nonpareil, Solano, and Sano. The 2005 season was the 4th leaf and we conducted the first harvest in the orchard this year. Yield data was collected to compare three treatments: the standard 1:1 planting with Nonpareil at 50%, Solano at 25%, and Sano at 25%; a planting with Nonpareil in every row and pollenizers arranged every two trees down the row with pollenizer trees offset between each row, Nonpareil at 66%, Solano at 17%, and Sano at 17%; and a similar treatment with Nonpareil at 66% and Solano at 34% to compare one vs. two pollenizers.

Table 1. Yield for each variety and total yield per acre of all varieties in each treatment.

Treatments	Nonpareil lbs / tree	Solano lbs / tree	Sano lbs / tree	Total Yield lbs / acre
Standard 1:1 Planting 3 Varieties	4.88	4.55	4.55	547.31
2:1 Planting in Every Row 3 Varieties	4.31	3.82	4.46ns	493.33
2:1 Planting in Every Row 2 Varieties	4.64ns	3.21ns		480.99 ns

* ns indicates no significant effects at $P \leq 0.05$.

Results this year indicate that so far there are no significant differences between treatments in either the yield of the individual varieties or in the total yield per acre (Table 1.). These trees are young and this is the first harvest in the orchard where we have documented yield. We intend to follow this project through for several years to see if significant differences between treatments or consistent trends occur in the future.

3) Identification and Management of Lower Limb Die-back Disease of Almond

Roger Duncan, Farm Advisor, Stanislaus County
Nathaniel Battig, UCCE, Stanislaus County
Themis Michailides, Plant Pathologist, UC Kearney Ag Center

Introduction. Over the past few years, many almond orchards in the North San Joaquin Valley have experienced a poorly defined lower limb die-back problem. This "disease" appears to have become more widespread in 2004 and 2005. Padre appears to be the most seriously affected variety, although symptoms in Butte can be very severe also. Nonpareil and Carmel are affected to a lesser degree. The problem seems to occur primarily in mature orchards. Surveys of affected orchards suggest that this problem is not a result of shade out, anthracnose, Alternaria leaf spot, or hull rot. The problem does not seem to be associated with any particular method of irrigation.

The die-back symptoms usually begin in weak, small shoots in the lower canopy. Eventually, limbs up to one inch in diameter may be killed several feet up into the tree. Beginning in late April, leaves on affected limbs turn yellow, then brown as the limbs slowly collapse. Limbs may die right up to the point of attachment on the scaffold. If the bark on yellowing limbs is scraped with a knife, brown spots are often visible on underlying wood. These spots are usually located under lenticels, naturally occurring openings in the bark. These spots appear to eventually coalesce to form large dead areas, primarily on the upper surface of affected limbs. The entire limb may then become girdled and collapse. Sometimes darkened cankers can be seen extending deep into the middle of the branch when cut in cross section. Sometimes the cankers are wedge-shaped, sometimes they are not. Shoots continue to collapse throughout the summer. In just a few years, the entire lower canopy of a severely affected orchard can be killed.

Orchard Surveys. In September 2004, samples of affected limbs were collected from six almond orchards in Stanislaus and Merced Counties. *Botryosphaeria dothidea* was isolated in three of the six orchards from 14%, 17% and 42% of the samples. A currently unidentified species of *Phomopsis* was isolated in all six orchards from 57%, 33%, 17%, 28%, 67% and 21% of the sampled limbs. Many samples were colonized by both fungi. In April 2005, five of the six orchards were re-sampled. On the spring sampling date, *B. dothidea* was isolated from all five orchards in 16%, 30%, 40%, 75% and 50% of the samples. *Phomopsis* was also isolated in all orchards from 50%, 80%, 60%, 25% and 100% of the samples. Spore producing structures (pycnidia) were rarely found on affected almond limb samples.

Samples of dead or dying shoots were also collected from walnut orchards and cypress trees near some affected almond orchards. A large percentage of these samples were infected with either *Botryosphaeria dothidea*, a *Phomopsis* sp. or both. In addition, spore producing structures (pycnidia) were found in abundance on these samples. Thus, affected walnut orchards and other plant species may be important sources of inoculum for almond lower limb die-back.

Fungicide trial. A fungicide trial was conducted in spring 2005 in an effort to reduce lower limb die-back in a badly affected Butte / Padre orchard in Stanislaus County. The entire orchard was treated at early bloom with iprodione (Rovral) and again at full bloom with pyraclostrobin + boscalid (Pristine). From petal fall (March 1) through June 1, experimental trees were sprayed differentially with azoxystrobin (Abound). By May 1, yellowing leaves on affected limbs began to appear in the test orchard. By the June 1 treatment date, death of lower limbs was wide spread. On June 21, the trial was rated for severity of lower limb die-back. Lower limb die-back was not reduced by any fungicide treatment. Even trees sprayed with Abound four times from petal fall through June 1 had disease levels identical to unsprayed trees. A list of treatments and the corresponding disease severity ratings are shown in Table 1 below.

Table 1. List of Application Dates of Abound Fungicide and Corresponding Disease Rating of Lower Limb Die-back.

Treatment Dates	**Disease Severity Rating (0 - 5) [1,2] June 21, 2005**
1. March 1 (petal fall)	2.5
2. April 1	2.3
3. May 1	2.4
4. June 1	2.3
5. March 1 + April 1	2.2
6. April 1 + May 1	2.5
7. May 1 + June 1	2.9
8. March 1 + April 1 + May 1 + June 1	2.7
9. Untreated	2.7

[1] Trees were rated on a scale from 0 (no affected limbs) to 5 (entire lower half of tree affected).

[2]Disease severity ratings were not significantly different at $P < 0.05$.

Conclusions.
There are many species of *Phomopsis* that cause canker diseases in grapes, figs stonefruit and other plants throughout the world. A *Phomopsis* sp. tentatively identified as *Phomopsis amygdali* was shown to be the cause of a fruit rot and associated limb dieback in a Butte County almond orchard in 1998 after an unusually wet spring. Phomopsis canker of almond, caused by *P. amygdali*, occurs in several Mediterranean countries, as well as in areas of South America and Australia. It also causes "constriction canker" of peach and apricot in Europe and the southeastern United States. A species of *Phomopsis* was the pathogen that was isolated most often from affected limbs in our survey. The species of *Phomopsis* in our isolations is yet to be identified.

The second fungus commonly isolated from affected shoots, *Botryosphaeria dothidea*, causes band canker, a fairly rare disease affecting the trunks and scaffolds of young almond trees. It is also the cause of panicle and shoot blight of pistachio, a serious disease for that industry. Recently, this fungus has been shown to cause shoot dieback in local walnut orchards. It seems feasible that one or both of these fungi are the primary pathogens of almond lower limb die-back.

In addition to the experimental Abound treatments, the grower treated the entire orchard with Pristine fungicide at full bloom. Abound and Pristine are rated very highly against both suspected pathogens. Although there were periods when even the heavily sprayed trees were unprotected with fungicide residue, the complete lack of disease control suggests that infection had already occurred prior to bloom and that it takes several months for the disease to progress and for dieback symptoms to appear.

As described in the literature, disease symptoms of Phomopsis canker in Europe and other countries sounds very similar to our lower limb die-back problem in California almonds. In Europe, most infections occur in the fall. The fungus grows very slowly during the winter and then produces a toxin in the spring. This toxin is transported through the branch to the leaves, interfering with stomatal closing. Leaves then whither, yellow and die. Affected limbs subsequently die. A fall infection period would explain the lack of effectiveness of our spring-time fungicide sprays. Local trials are currently being conducted to test the effectiveness of fall-applied fungicides.

4) Yield Benefits of Machine Hedging Almonds in a Marianna 2624 Hedgerow
John Edstrom, UC Farm Advisor and Stan Cutter, Nickels Estate

Marianna 2624 plum rootstock is the most useful rootstock for Oak Root Fungus sites, but it also shows good resistance to crown gall and has become increasingly important in the expansion of almonds onto the heavier soils. Tree size is reduced significantly with M2624 when compared to all other almond rootstocks, so maintaining vigor and productivity has been a concern. Union Mild Etch, graft union disorder with M2624 has been a problem in some orchards. Mission, Ruby and Padre varieties have shown excellent compatibility with M2624, but field performance of Butte has been erratic.

Evaluating the commercial potential of M2624 plantings requires closer spacings than typically used in almonds, resulting in more trees and higher investment expenses.
A test planting was established to check the productivity of four varieties in a close-planted hedgerow on M2624 rootstock. Butte, Mission, Ruby and Padre almonds were planted March, 1989, under drip irrigation, in single north south rows with a 10' x 20' spacing for 218 trees/acre.

A mechanical hedging program was initiated in 1999 to stimulate growth and fill in the canopies between rows. Alternate sides of alternate rows were cut each winter. A rotary saw topper made an angled cut on the shoulder of the canopy, positioned 2 feet from tree top center and angled 30 degrees down into the row middles. One side of all Ruby and Butte rows were cut the first time. The next winter all Padre and Mission rows were cut. Four winters were required to complete the hedging plan on both sides of every row in 2002-03. All varieties responded well to this operation. Of special interest were Ruby and Butte, the weakest trees in this test. Ruby trees produced 2-5 shoots at each saw cut, which grew 24-36 inches in length during the season. Buttes grew 3-6 shoots at each cut, which grew 24-48 inches. Invigoration of the Padre and Mission was somewhat greater.

Results:
Yields this year were: Butte -2169 lbs/acre on hedged trees and 1743 lbs/ac on unhedged; for Padre -3124 lbs/ac hedged and 2920 lbs/ac unhedged. (Yields for Mission and Ruby were not available at report deadline) Tree canopies in the unhedged rows filled in the 20-foot row spacing in 2002. Hedging actually delayed the canopy extension by stimulating more up-right growth that required two years of cropping to bend and touch in the middles. The hedging program stimulated growth, which formed more fruitwood. Hopefully this will result in increased production. However, so far, not much difference has been found between hedged and unhedged tree yields.

Of importance to note concerning the rootstock in this six-acre planting is the near 100% tree survival rate spanning the 17 years of this test. An adjacent orchard of the same age/same variety on Lovell peach rootstock has lost 5-10% of the trees to various maladies, while this M2624 rooted block remains solid. In this respect, Marianna 2624 rootstock exhibits a very desirable trait. Even though all Butte trees have survived on M2624, this variety continues to produce proportionately less than if grafted to Lovell.

Union mild etch has not afflicted this planting but persistent root suckers have been somewhat difficult to manage. Evaluation of the herbicide Rely® registered for sucker control shows some promise in M2624 orchards.

2005	Ave Yield	Kernel Size
Variety	Lbs/ac	gms/K
Padre	3,073	1.02
Butte	1,665	0.93
Mission	-	-
Ruby	-	-

5) Improving Almond Shell Seal with Cultural Practices to Reduce Kernel Damage by Insects

Mark Freeman, Pomology Advisor, Fresno County
Cooperating personnel: Richard Coviello, Walt Bentley, Mario Viveros,
Frank Zalom, and Tom Gradziel

The overall goal of this project is to minimize almond kernel damage due to NOW and ants by improving shell seal. We believe that cultural factors, crop load, and growth patterns can affect shell seal in-season. Also, that shell seal can be predicted before hull-split and thus assist with the decision to spray/not spray with insecticides during the summer. In 2004, a number of almond orchards with later maturing almond varieties sustained higher damage levels from NOW. Previously, it was thought that those varieties had a good shell seal. Those affected growers and PCAs now plan to apply hull-split sprays every year for NOW control.

We are working first on developing the tools needed to make quick and accurate measurements of shell seal. Several years ago, we used "spark plug gauges" to measure the widest opening of a shell split. This tool allowed quick and easy measurements, and could be used easily on the farm. We are currently developing the range of shell split or opening that Navel Orangeworm (NOW) can/can not enter into the shell.

Several factors could possibly impact the quality of shell seal, such as irrigation practices, soil type, almond variety, crop load, amount of applied fertilizer, etc. Several practices will affect the level of NOW damage in an almond orchard, such as the level of mummy nuts, date of harvest, number of insect sprays, etc. In addition, NOW moths can fly for miles from a "dirty" orchard to other host sites. We are working on developing a database with Geographical Information Systems (GIS) software. Then, we can store, compare and analyze data between orchards and within areas to look for trends of NOW damage.

6) Is there a cost effective, alternative to zinc sulfate for fall defoliation?

Franz Niederholzer, UCCE Farm Advisor, Sutter and Yuba Counties

Objective: Evaluate alternatives to high rates of Zn sulfate (36%) for fall almond orchard defoliation.

Introduction: Chemical defoliation in the late fall is one part of an integrated disease management program in almonds, and can facilitate early pruning. Zinc sulfate 36%, applied as a foliar fertilizer, often doubles as an orchard defoliant. Alternatives to zinc sulfate may be needed in the future, if regulatory scrutiny is focused on heavy metal uses in orchards. In 2003-2004, sodium chlorate, a cotton defoliant with low potential for environmental risk, effectively defoliated ‘Price’ almond nursery trees without affecting growth the next year. Encouraged by these results, and by USDA research showing that sodium chlorate reduces Salmonella bacteria populations (in anaerobic conditions), further work with sodium chlorate in almonds was conducted in 2004-2005.

Materials and methods: Sodium chlorate was applied to 5th leaf almond trees ('Non-pareil' on 'Lovell") on November 16, 2004 using a handgun sprayer at 200 psi. Spray was applied at a rate of 200 gpa. Spray water contained sodium chlorate at a rate of 18 or 6 pounds of material per 100 gallons of water. Sprayed trees were visually evaluated several times within two weeks of application to evaluate defoliation, and then in the next season to determine affect of treatments on production.

Results: Both rates of sodium chlorate resulted in rapid leaf dehydration without defoliation. Leafs were "frozen" on trees and leaf drop was actually delayed relative to untreated trees. Production the following year was almost totally eliminated in trees sprayed with sodium chlorate at the 18#/100 gallons of water, while substantial bud death occurred a the lower (6#/100 gallons) rate. Neither rate has commercial promise.

Conclusions: Obviously, the rates of sodium chlorate used in fall, 2004 were excessive. In addition, the rapid leaf dehydration after spraying may have been exacerbated by three days of dry north winds that began unexpectedly within 3 days of application.
Significantly lower rates of sodium chlorate should be used in any future work with sodium chlorate with mature almond trees, especially 'Non-pareil' variety. Mistblowers or air-blast sprayers should be used to avoid excessive application volumes. Handgun applications to runoff should be avoided. Finally, differences in leaf morphology (wax levels, etc.) between 'Price' and 'Non-pareil' and/or young nursery stock and established trees may explain the very dramatic differences in results in this work from 2003-2004 to 2004-2005.

I would like to thank the Sutter County almond grower whose patience and good nature allowed this work to be completed.

7) Almond Tree Training for Catch Frame Harvester
Project Leader: Mario Viveros, UCCE Kern County
Cooperating Personnel: Thomas Vetsch and John Karlik

Problem and Its Significance:
Air quality, due to dust and PM 10 generated by almond harvest has become an issue in the San Joaquin Valley. Of all agricultural activities, almond harvest produces the most dust. Two operations, the sweeping and picking up produces 80 to 90% of the dust. One of the ways to eliminate these operations is by using a Catch frame harvester. However, almond orchards are not only trained with a low head but also the tree canopies almost touches the ground. This makes the operation of a Catch frame harvester difficult to operate in this condition.

Objectives:
To train almond trees with different head heights.
To develop strong limb structure capable of supporting maximum crops.
To manage tree canopy suitable for Catch frame harvesters.

Plans and Procedures:

A test plot was established in February 2003 in a Nonpareil-Sonora-Carmel orchard. The experiment was established in the Nonpareil variety with four treatments and eight-tree plots replicated four times. The head height was established by a heading cut at the time of tree planting. The following treatments were established: 1) trees headed at 42 inches, 2) trees headed at 52 inches, 3) trees headed at 18 inches and 4) trees headed at 18 inches. When shoots were 4 to 6 inches long, in treatments 3 and 4, the most upright shoot was selected and tied to a stake. Later on, these shoots were headed at 62 inches. In the first dormant season; treatment 1 and 2 were long pruned, treatment 3 was short pruned and treatment 4 was long pruned. The development data such as trunk circumferences, height and pruning weights, yield data will be taken in 2006 harvest.

Results:

Observations: From the beginning it was found that some trees in the 42 inch high treatment needed to be staked to develop a straight trunk. Furthermore, all trees in both the 52 and 62 inch high treatment needed to be staked to maintain a straight trunk.

Table 1 shows that trunk circumference and tree height were significantly reduced after the first growing season (2003). The tree trunk circumference was smaller on the trees that were headed 18 inches in the spring and then headed at 62 inches in the dormant season. The decrease in trunk circumference on this treatment continues into the 2004 season. The biggest trunk circumference was on trees that were headed 42 inches. The tree height was less affected by differential in head heights. The tallest trees were those in the 52 inch head. The increase in tree height was not carried into the 2004 season.

Table 1. Trunk circumference and tree height of Nonpareil trained with 42, 52 and 62 tree head heights.

Head Height	Trunk Circumference (mm)		Tree Height (ft)	
	2003	2004	2003	2004
42 inches	176c	346b	10.4ab	12.4a
52 inches	166g	336b	10.7b	12.7a
62 inches – Short*	121a	278a	10.0a	12.4a
62 inches – Long**	126a	287a	9.9a	12.2a

*This treatment has been pruned short in both 2003 and 2004 dormant seasons (heading cuts at 36 inches)

**There were no heading cuts in this treatment. Values followed by the same letter aren’t significantly different from one another at $p<0.05$ (LSD).

Table 2 shows the amount of pruning weights taken from 42, 52, and 62 inch high heads. The effect on the amount of wood taken off at pruning time was only significant in 2003. In this year, the most pruning weights came from the 42 inch head and the least amount came from the 62 inch head.

Table 2. Pruning weights from the Nonpareil variety from the 42, 52 and 62 inch tree head heights.

Head Height	Pruning Weights (lb)	
	2003	2004
42 inches	5.6c	19.9a
52 inches	3.5b	9.4a
62 inches – Short*	3.3b	11.9a
62 inches – Long**	1.8a	10.9a

*This treatment has been pruned short in both 2003 and 2004 dormant seasons (heading cuts at 36 inches)
**There were no heading cuts in this treatment. Values followed by the same letter aren't significantly different from one another at $p<0.05$ (LSD).