# Almond Culture and Orchard Management

**Project No.:** **07-HORT3-Connell**

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## Problem and its Significance:

Farm advisors conduct numerous projects addressing local issues in their counties. Many of these issues are addressed with small projects that may not require major support to conduct and complete the work. This project is designed to provide local support for county farm advisors general extension research programs related to almond production. Each advisor participating in this project highlights research results in their county from local projects they feel address an important question worthy of reporting to growers at the annual almond industry conference.

## 1) Increasing the Nonpareil Percentage: Effects of Pollenizer Arrangement and Number of Pollenizer Varieties on Yield:

**Project Cooperators:** Joe Connell, Farm Advisor, UCCE - Butte County
Joe Limberg, California State University-Chico Farm

**Interpretive Summary:**

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.

**Objectives:**

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 mid-blooming pollenizer variety is sufficient or if two pollenizers (an early pollenizer plus a mid-blooming pollenizer), provide better production is also evaluated in this trial.

**Materials and Methods:**

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 (Figure 1). The 2005 season was the 4th leaf and we conducted the first harvest in the orchard last 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.

| Row | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | | | | | Rep 1 | | | | | | | | | | | | | | | | | | | | | | |
| # 2 | | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M | M |
| # 3 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| # 4 | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E | E |
| 5 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| 6 | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x |
| # # 7 | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x |
| 8 | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x |
| 9 | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x |
| # # 10 | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x |
| # # 11 | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x | x | E | x |
| 12 | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x | M | x | x |

**Figure 1.** Schematic of replicate 1 showing the plot layout. Rows marked with the # sign are yield rows representing the three treatments.

X = Nonpareil
M = Mid-Blooming Pollenizer (Solano)
E = Early Blooming Pollenizer (Sano)
Rows in each replicate are 27 trees long and there are four replicates in the trial. 2007 was the orchard's 6th growing season.

## Results and Discussion:

Results of the first year's yield (4th leaf), in 2005 indicated that there were no significant differences between treatments in either the yield of the individual varieties or in the total yield per acre. Nonpareil yield was significantly greater in 2006 in the 2:1 planting with two varieties compared to the standard 1:1 planting with 3 varieties. In 2007, the opposite result occurred with Nonpareil yield significantly greater in the standard 1:1 planting compared to either of the 2:1 planting treatments (Table 1). Neither Solano nor Sano varieties showed significant yield differences between treatments in 2006 or 2007. The total yield in the trial averaged 895 pounds of kernel per acre in the 5th leaf and 2,392 pounds of kernel per acre in 2007 (6th leaf). Total yield per acre was not significantly different between the treatments in 2005, 2006 or 2007. We intend to continue this project for several more years to see if either significant differences between treatments or consistent trends occur in the future.

**Table 1.** Mean 2007 yield for each variety & total mean yield per acre of all varieties in each treatment.

| | Nonpareil lbs kernel/tree | Solano lbs kernel/tree | Sano lbs kernel/tree | Total Yield lbs/acre |
|---|---|---|---|---|
| Standard 1:1 Planting, 3 Varieties | 25.95a | 15.2 | 14.7 | 2372 |
| 2:1 Planting in Every Row, 3 Varieties | 24.46 b | 13.1 | 13.7 | 2394 |
| 2:1 Planting in Every Row, 2 Varieties | 24.23 b | 14.2 | | 2411 |
| | | ns | ns | ns |

* values followed by different letters are significantly different at P < 0.05
** ns at bottom of column indicates no significant treatment effects at P < 0.05

## Recent Publications:

Connell, J. H., J. Edstrom, M. Freeman, B. Holtz, F. Niederholzer, and M. Viveros. 2007. Almond culture and orchard management. p. 49-55. In: 35th Almond Industry Conference Proceedings, December 5-6, 2007, Modesto.

## 2) Evaluation of Almond Production on Raised Beds

**Project Cooperators:** John Edstrom, Farm Advisor, UCCE - Colusa Co.
Stan Cutter, Nickels Trust

### Interpretive Summary:

Major acreage on the west side of the Central Valley consists of layered hardpan or shallow soil, limiting the vigor and productivity of almonds. Shallow soils plus the widespread use of drip irrigation, that applies water to a narrow area in the tree row, greatly confines root volume and possibly tree vigor and yield capacity. A dry orchard middle, often covering a wider area than wetted by micro-irrigation, limits root development and thus underutilizes orchard soil for root growth/function.

### Objective:

Evaluate the performance and practicallity of a raised bed planting system for almonds to increase root volume and orchard productivity on the shallow soils found in many areas of the central valley.

### Materials and Methods:

Duplicating the Australian Tatura Raised Bed System, soil from the orchard “middles” was graded into large beds down the tree row. Raised beds were formed during the summer of 2005, 20 inches high X 11 feet wide, amended with 3 tons sugar beet lime and 5 tons compost per acre (equal to 6 and 10 tons per bed acre respectively). Standard berms were formed at 8 inches height x 5 ft in width. In 2006, Nonpareil, Monterey and Fritz varieties were planted at 16' x 22'. Both berm/bed treatments have dedicated sub-mainlines to allow differential watering schedules. All plots will be instrumented with soil moisture probes to schedule irrigations to maintain uniform rootzone moisture levels via micro-sprinklers. Tree growth and yield data will be collected. The consequence of large beds to orchard operations will be assessed.

**Results and Discussion:**

At the end of the 2nd growing season Nonpareil trunk circumference measurements showed no difference in tree size between the Raised bed and Standard berm planted trees. The larger volume of topsoil in the Raised beds has not yet affected tree growth. The test orchard was converted to micro-sprinklers in August that should affect root development. As trees grow in size their larger root systems may respond to the potential benefits of deeper soil profile provided by Raised beds. The typical weed control practices of mowing middles and spraying beds/ berms were not affected by bed size.

**20 inch x 11 foot Raised Bed** **Standard Berm**

## 3) Developing Evaluation Tools to Measure the Effectiveness of Extension Efforts

**Project Cooperators:** Mark Freeman, Farm Advisor, UCCE - Fresno County
Karen Klonsky, UCCE Specialist, Ag Economics, Davis
Kris Lynn-Patterson, GIS Academic Coordinator, KAC

**Objectives:**

More CE programs are using evaluation tools such as questionnaires and surveys to measure the effectiveness of the extension outreach. Clientele are using several different methods to access information, from "personal contacts" to digital teaching and access to information.  We will use current extension programs, such as the Ag. Means Business (UCCE cost studies), classes and the NRCS/UC soil survey outreach, to assist this project.  Our goal is to determine if certain groups of clientele respond more favorably to specific types of outreach; and if certain extension efforts will have more impact on those groups.  Some of the evaluation tools we plan to use include written and web based questionnaires and surveys; and interactive list-serves on the Internet.

**Results and Discussion:**

The "Agriculture Means Business" meeting was conducted in a computer lab, with three night sessions each lasting two hours.  This course featured the use of MS *Excel* and Intuit's *QuickBooks* to demonstrate the use of UCCE cost studies, cash flow, forecasting profitability and record keeping.  Each participant received a program template that contained sample data, and was encouraged to customize the document with their own information.

A second "Soils to Go" meeting featured the use of soil survey data that is available from the Internet.  Both courses received highly favorable ratings and we received feedback on improving outreach methods.  We are now contracting with a statistical service to design more effective surveys, and adapt the teaching methods as needed.

## 4) Processed-Kaolin Particle Film on Almond

**Project Cooperators:** Brent A. Holtz, Farm Advisor, and Tome Martin-Duvall, Staff Research Associate, UCCE, 328 Madera Avenue, Madera, CA 93637

**Interpretive Summary:**

Surround white clay like processed-Kaolin particle film, can easily be dissolved into suspension and sprayed onto trees (Figure 1).  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.

**Figure 1.** Surround particulate sprays have been applied to increase foliage reflectivity and reduce heat stress on plants with some increases in productivity reported in the literature.

## Objectives:

From 2002-2007 four applications of Kaolin (25 lbs/100 gallons water), were made each season to Carmel and Nonpareil 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.

## Materials and Methods:

An almond orchard in Madera with 16 Carmel and Nonpareil rows was divided into a replicated design where 8 rows of each variety received four Kaolin applications each year, while the 8 other rows of each variety did not.

## Results and Discussion:

From 2003-2007 mid-day leaf stem water potential (SWP) measurements were performed from June-September. We observed a trend where Surround treated trees had significantly less SWP in June and early July, but by late July and August there was no difference between Surround and non-treated trees. In 2003, 2004, and 2005 surround treated trees had significantly more current season shoot growth when compared to non-treated trees. In 2002 and 2006 there were no significant differences in current season shoot growth between Surround treated and untreated trees (Figure 2).

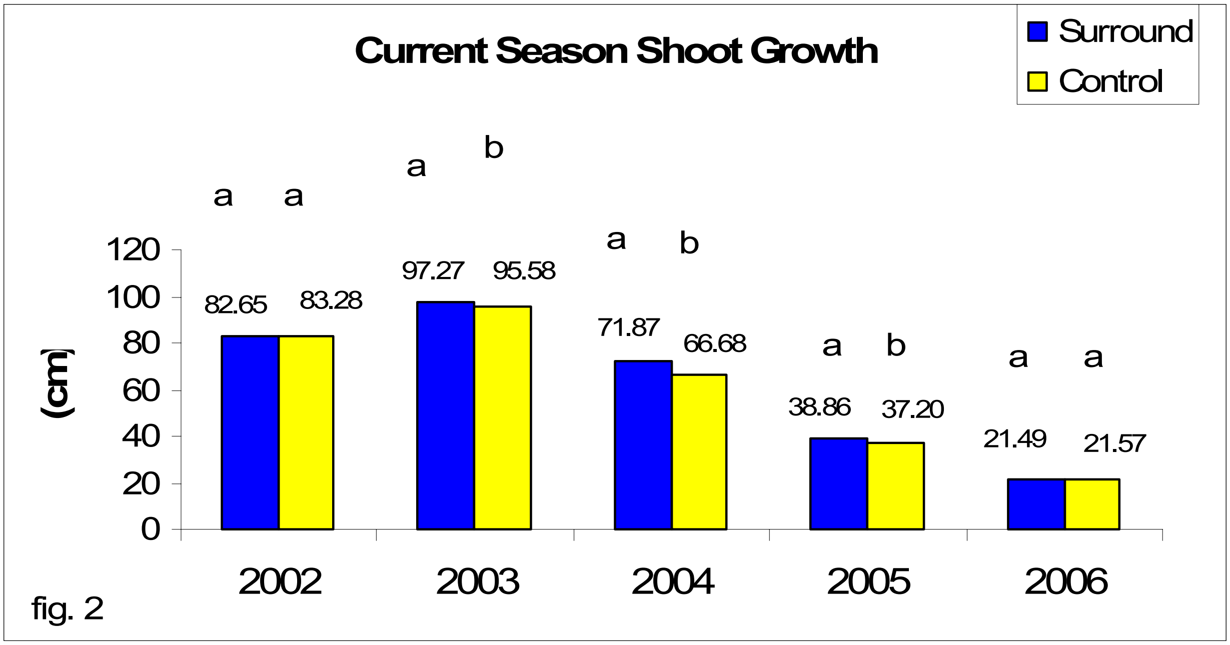


**Figure 2**. Surround effects on current season shoot growth.

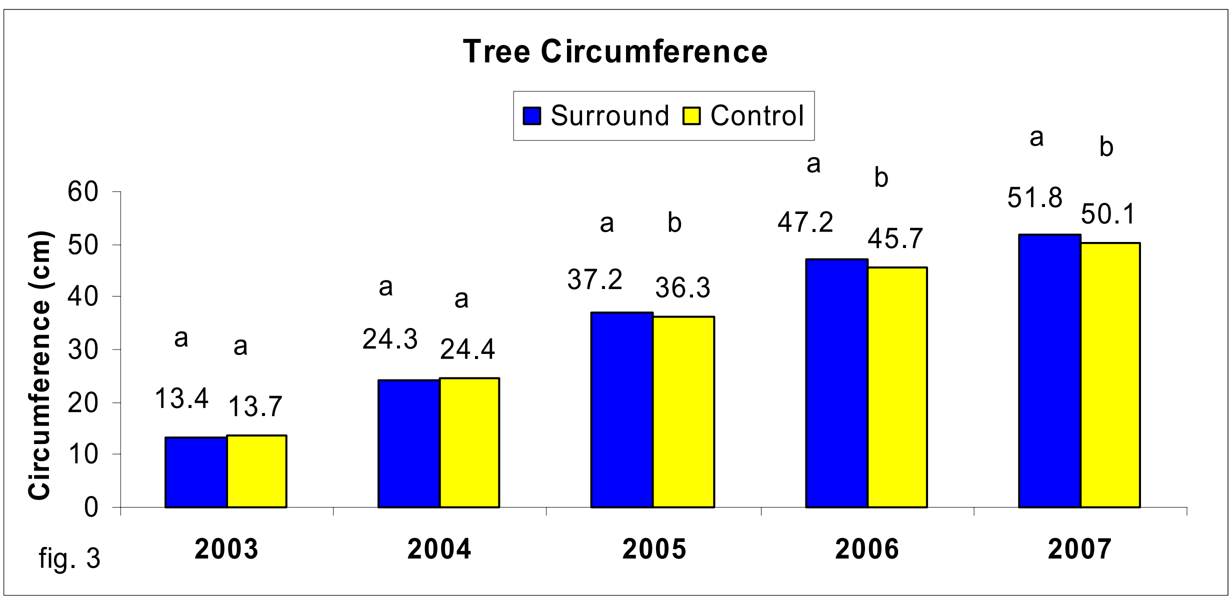


**Figure 3.** In 2005, 2006, and 2007 a significant increase in trunk circumference was observed in surround treated trees.

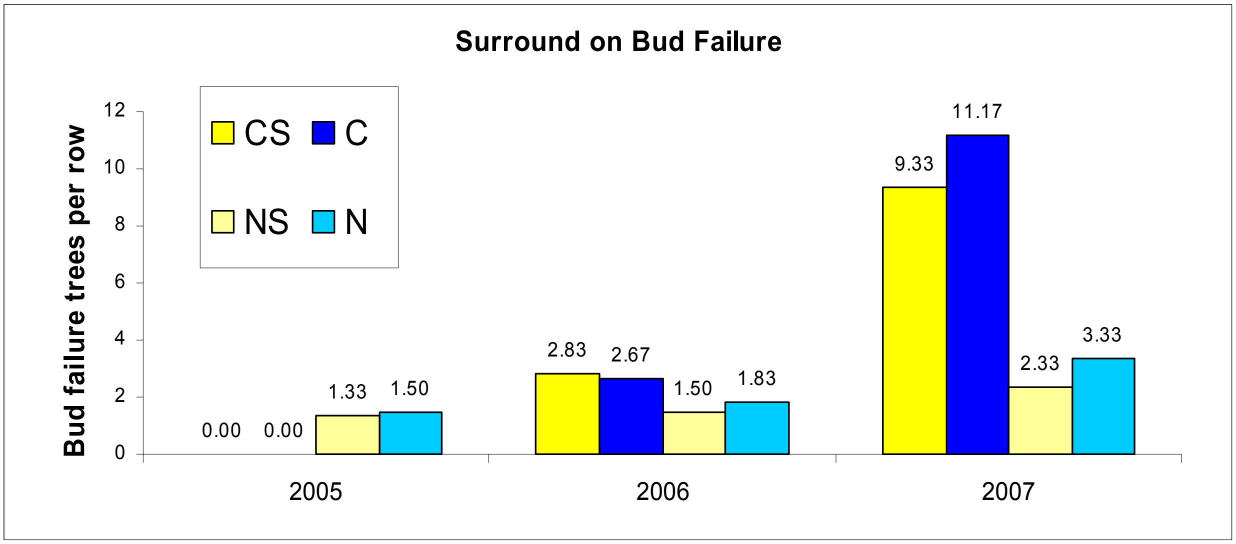


**Figure 4**. Surround effects on bud failure incidence.

In 2005 no bud failure was observed on Carmel trees in either treatment (Figure 4). In 2006 we observed bud failure in the Carmel variety but treatment differences were not significant. In 2005, 2006, and 2007 we observed less bud failure on Surround treated Nonpareil trees, but differences were not significant. In 2007 we observed less bud failure on the Surround treated Carmel ($P \leq 0.09$) trees.

In 2004 and 2005 we counted fruit on 60 trees that received Surround and 60 control trees that did not. In 2005 we found significantly more fruit on the Surround treated trees. In 2007 the Carmel treated rows had significantly greater yield when compared to the non-treated (Figure 5). There was no difference in yield between Surround treated Nonpareil tree rows when compared to untreated.

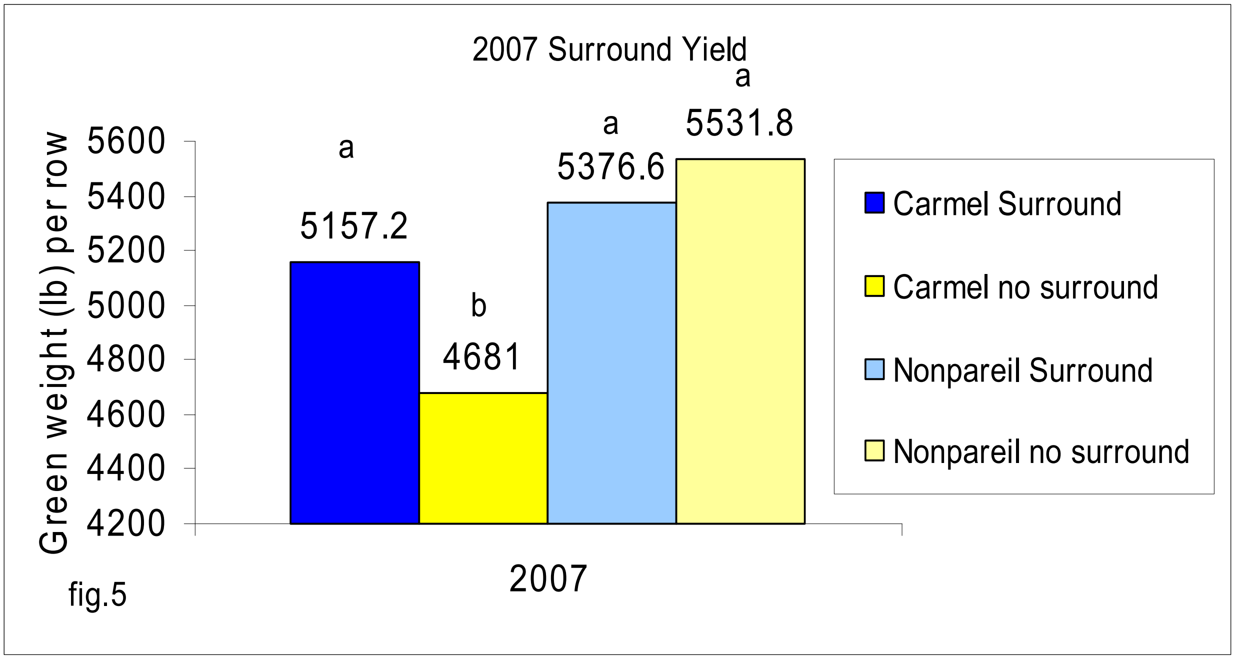


**Figure 5**. Surround effects on yield.

We will again repeat applications of Kaolin in 2008 in order to continue investigating the effect of Surround on heat stress and bud failure in both Carmel and Nonpareil almond varieties in the San Joaquin Valley of California.

## 5) Fall Spray Mixture Can Affect Bloom Boron Levels the Following Year

**Project Cooperator:** Franz Niederholzer, Farm Advisor, UCCE - Sutter/Yuba Counties

**Objectives:**

Compare bloom boron (B) levels after applying two different fall spray mixtures – 1) Solubor® + zinc sulfate or 2) Solubor® + zinc sulfate + buffer.

**Materials and Methods:**

Butte/M2624 trees (83 ppm B hull levels), were sprayed on October 27, 2006 at the rate of **1)** 2 lb. Solubor® + 20 lb zinc sulfate/acre or **2)** 2 lb. Solubor® + 20 lb zinc sulfate + 1 quart Trifol® buffer/acre. Addition of the buffer cleared virtually all of the tan haze that formed in the spray solution when the zinc sulfate and Solubor® were mixed. Spray volume was equivalent to 100 gpa. Eight trees were either individually sprayed with one treatment or left unsprayed for a total of 24 trees in the study. Flower samples (100 flowers/tree), for B analysis were taken on February 24, 2007. Bud scales were not included in the flower samples. Yield/tree and hull samples were taken at harvest.

## Results and Discussion:

A fall spray of zinc sulfate + Solubor® did not significantly increase bloom B concentration compared to unsprayed trees. Including a buffer with the zinc sulfate + Solubor® significantly increased flower B at bloom compared with flowers from unsprayed trees (Table 1). Yield was not affected by flower B concentration (data not presented). Hull sample analyses are not yet completed. To maximize bloom B levels from the combination of zinc sulfate + Solubor® in a fall spray, consider adding a buffer to the spray solution **(**Figure 1**).**

**Table 1.** 'Butte' almond flower boron concentrations (average of eight trees for each treatment), in 2007 after spray treatment on October 27, 2006. Treatments were applied with a spray volume equal to 100 gpa. There is a 95% chance that treatments are significantly different if they do not share a letter, based on Bonferroni's multiple comparison procedure.

| Treatment | Material rate/acre | Flower Boron (ppm) |
|---|---|---|
| Unsprayed | -- | 31 a |
| Zinc sulfate + Solubor® | 20 pounds + 2 pounds | 34 ab |
| Zinc sulfate + Solubor® + Trifol® | 20 pounds + 2 pounds + 2 pints | 36 b |


**Figure 1**. 2 pounds Solubor® is a common rate and is = 500 ppm B in solution.
20 pounds Zinc Sulfate (36%) is common rate for fall application to treat Zn deficiency symptoms and defoliate trees. Mixing boron with zinc sulfate in late fall seems like a good fit but, Solubor ® plus zinc sulfate don't pass the jar test. Zinc sulfate plus Solubor® plus a buffer cleared the solution and increased flower boron the following spring.

## Study trees 12 days (11/8/06) after spraying



**Trees treated with zinc sulfate defoliated rapidly, but flower boron levels were higher.**

The leaves come off fast when zinc sulfate is added to Solubor®, but flower B levels are increased over untreated – and the increase is identical to trees that were sprayed with the same rate of Solubor® without zinc.

### 6) Almond Tree Training for Catch Frame Harvester

**Project Cooperators:** Mario Viveros, Farm Advisor, UCCE - Kern County
Thomas Vetsch, Vetsch Farms
John Karlik, UCCE - Kern Co.

**Objectives/Materials and Methods:**

The test plot, which was established in 2003 on Nonpareil trees, has four objectives:
1) Train almond trees with different head heights.
2) Develop strong limb structure capable of supporting maximum crops.
3) Manage tree canopy suitable for catch frame harvesters.
4) New for 2007, evaluate the difference between drying the crop on the orchard floor and drying on a concrete surface.

**Figure 1.** At planting, trees were headed at 18” then a single trunk was headed at 62” in September. Long pruned thereafter.

**Figure 2**. At planting, trees were headed at 42 inches**.**

**Results and Discussion:**

Data from previous years show that trees headed higher than 42" need to be staked to maintain a straight trunk. Generally speaking, trees that are heavily pruned one year will have to be heavily pruned in subsequent years. Based on the present data, trees headed at 42" are significantly larger than trees headed at 62" and numerically larger than trees headed at 52". Therefore, if a tree with a 42" head can accommodate a catch frame harvester a larger more productive tree can be developed.

In 2006 there was no significant difference among treatments in both kernel weight and pounds per tree; however, numerically the 42" trees produced more pounds per acre and more pounds per tree. Yield data was not taken in 2007.

To determine the difference in drying time, nut samples were dried on concrete and on the orchard floor. After nine days, nuts dried on the orchard floor had lost 3.51 grams of moisture per nut and nuts dried on concrete had lost 4.99 grams of moisture per nut. The moisture loss from nuts dried on the orchard floor and concrete was significantly different at $p<0.05$ (LSD).