Almond Culture and Orchard Management

Project No.: **08-HORT3-Krueger**

Project Leader: William H. Krueger
University of California Cooperative Extension, Glenn County
P. O. Box 697
Orland, CA 95963
(530) 865-1152
whkrueger@ucdavis.edu

Project Cooperators: Joe Connell, Farm Advisor, University of California Cooperative Extension, Butte County
Roger Duncan, Farm Advisor, University of California Cooperative Extension, Stanislaus County
John Edstrom, Farm Advisor, University of California Cooperative Extension, Colusa County
Brent Holtz, Farm Advisor, Univeristy of California Cooperative Extension, Madera County
Franz Niederholzer, Farm Advisor, University of California Cooperative Extension, Sutter and Yuba Counties

Problems and 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, Univeristy of California Cooperative Extension, Butte County
Joe Limberg, California State University, Chico, University Farm

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. Yield data is 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.

Interpretive Summary:

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.

Results of the first year's yield (4^{th} 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 6^{th} leaf averaged 2,392 pounds of kernel per acre in 2007 and total yield per acre was not significantly different between the treatments in 2005, 2006 or 2007.

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

	Nonpareil lb kernel/tree	Solano lb kernel/tree	Sano lb kernel/tree	Total Yield lb/acre
Standard 1:1 Planting, 3 Varieties	25.95a	15.2	14.7	2372
2:1 Planting in Every Row, 3 Varieties	24.46b	13.1	13.7	2394
2:1 Planting in Every Row, 2 Varieties	24.23b	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 $P \leq 0.05$.

2) Topical Applications of a Bark Penetrant and Fungicide Mixture to Control Ceratocystis Canker Infections in Almond

Project Cooperator: Roger Duncan, University of California Cooperative Extension, Stanislaus County

Problem:

Almond trees often suffer injuries to trunks and scaffolds from shaker damage, limb tying, pruning and other orchard activities. Nitidulid beetles (*Carpophilus* spp.) and other insects carry the canker-causing pathogen, *Ceratocystis fimbriata*, from the soil or infected trees to the fresh wounds. The fungus then colonizes the damaged tissue and forms a perennial canker that can girdle and kill major scaffolds and eventually the entire tree. The accumulation of injuries and subsequent Ceratocystis infections is a major contributor to premature decline of almond orchards. Surgical removal of cankers is possible but difficult and very costly.

The pathogen is generally restricted to the bark, although it occasionally invades young xylem. Because the fungus is relatively shallow in the tree, it is possible that topically applied fungicides, when mixed with a bark penetrating surfactant, could reach the pathogen and stop progression of the disease. This would be a much easier, cheaper, and potentially more effective treatment option than surgery.

Methods:

On May 5, 2008, ten almond trees (c.v. 'Nonpareil' and 'Carmel') with trunk and/or scaffold infections of *Ceratocystis fimbriata* were treated with Pristine® (Pyraclostrobin + Boscalid) at 14.5 oz per acre, Captan® 80 WDG @ 5.66 lb. per acre or left unsprayed. Fungicides were applied in a mixture containing three ounces per gallon of Pentra-Bark® (Quest Products, Corp., Louisburg, Kansas), a bark penetrating surfactant. Materials were applied with a hand-pump backpack sprayer until areas within and at least two feet outside of the canker margins were saturated with spray (approximately 0.3 gallons of spray per tree). Cankers were re-evaluated approximately five months after treatment by measuring canker growth and observing the presence or absence of new sap at canker margins.

Results:

Fungicide treatments had no effect on growth of Ceratocystis cankers. Cankers grew an average of 25 mm, 22 mm and 28 mm for the untreated, Pristine and Captan treatments, respectively, during the five month evaluation period. All cankers appeared to still be active with newly excreted balls of sap present. The experiment will be repeated to evaluate other bark penetrating surfactants in combination with fungicides that have been shown to control *C. fimbriata* in other plant species.

3) Evaluation of Almond Production on Raised Beds

Project Coordinator: John P. Edstrom
University of California Cooperative Extension, Colusa County

Co-Investigator: Stan Cutter, Leslie J. Nickels Trust

Objectives:

Evaluate the feasibility and possible advantages of a large Raised Bed planting system in almonds to expand the potential root zone and overcome the restriction imposed to root development by shallow or layered soils.

Interpretive Summary:

At the end of the 3rd growing season measurements made on Nonpareil trees (Table 1) showed no difference in trunk circumference between the Raised Bed and Standard Berm planted trees. The larger volume of topsoil in the Raised Beds has not yet affected tree growth. As tree canopies develop, root growth may expand into the deeper soil provided by Raised Beds. In addition to the effects of deeper topsoil, Raised Beds in other crops are purported to increase soil temperature and oxygen levels providing a more optimal root environment. We do not expect to find benefits of the beds until tree size "demands" more from this shallow clay layered soil.

Heavy, reconstructive pruning following wind damage last year set back tree growth and delayed fruitwood development limiting 3rd leaf crop production. No yield difference was found between the two planting methods in 2008. High winds experienced early this season did not cause more limb breakage to trees elevated on Raised Beds.

The large beds did not affect the typical cultural practices of mowing, weed spraying beds/ berms and sweeping/blowing/harvesting nuts. However, bed shape does appear to be affecting water penetration. Soil moisture probe data has shown uneven wetting of the Raised Beds by the micro-sprinkler system. Some of the applied water runs down the slanted bed onto the flat middle. Adjusting the duration and frequency of irrigations has reduced this problem but further improvements may be needed to take full advantage of the larger soil volume created by the Raised Bed. Applications of gypsum, switching to lower gallonage micros and double irrigation sets will be attempted next season.

Table1.

	Trunk Circ. Cm	Yield lbs/plot	Kernels/oz.
Standard Berm	28.3	418	24
Raised Bed	28.7	428	23

Please visit our poster during the Almond Industry Conference for the updated 2008 yield results. We intend to follow orchard performance for several more seasons as the trees develop.

4) Processed-Kaolin Particle Film on Almond

Project Coordinator: Brent A. Holtz
Pomology Farm Advisor
University of California Cooperative Extension, Madera County

Co-Investigator: Tome Martin-Duvall
Staff Research Associate
University of California Cooperative Extension, Madera County

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 (1, 2, 3). 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 (4). 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.

From 2002 - 2008 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 (midday leaf stem water potential), canopy temperatures, growth (tree circumference and current season shoot growth), and yield. 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 did not.

In 2003 - 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 1). We did not examine current season shoot growth in 2007 and 2008. In 2005 - 2007 a significant increase in trunk circumference was observed in Surround treated trees (Figure 2). No difference in trunk circumference was observed in 2003 and 2004.

In 2005 no bud failure was observed on Carmel trees in either treatment (7). In 2006 we observed bud failure in the Carmel variety but treatment differences were not significant. In 2007 we observed less ($P \leq 0.09$) bud failure on the Surround treated Carmel trees (10). In 2008 we observed significantly less ($P \leq 0.02$) bud failure on the Surround treated Carmel trees (Figure 3). In 2005 - 2008 we observed less bud failure on Surround treated Nonpareil trees, but differences were not significant (Figure 3).

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 (7). In 2007 the treated rows in Carmel had significantly ($P \leq 0.01$) greater yield when compared to the non-treated (Figure 4). There was no difference in yield between Surround treated Nonpareil tree rows when compared to untreated. In 2008 the Carmel treated rows had significantly ($P \leq 0.02$) greater yield when compared to the non-treated (Figure 5), and the Surround treated Nonpareil tree rows also had significantly ($P \leq 0.04$) more yield when compared to untreated. We will repeat applications of Kaolin in 2009 in order to further 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.

References:

1) Glenn, D.M., Prado, E., Erez, A., Mc Ferson, J., and Puterka, G.J. 2002. A reflective, processed-Kaolin particle film affects fruit temperature, radiation reflection, and solar injury in apple. J. Amer. Soc. Hort. Sci. 127(2):188-193.

2) Glenn, D.M., Puterka, G.J., Drake, S.R., Unruh, T.R., Knight, A.L., Baherle, P., Prado, E., and Baugher, T.A. 2001. Particle film application influences apple leaf physiology, fruit yield, and fruit quality. J. Amer. Soc. Hort. Sci. 126(2):175-181.

3) Schupp, J.R., Fallahi, E., and Chun, I.J. 2002. Effect of particle film on fruit sunburn, maturity, and quality of “Fuji” and “Honeycrisp” Apples. HortTechnology 12(1):87-90.

4) 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.

5) 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.

6) Holtz, B.A, and Hoffman, E.W. 2004. Processed-Kaolin particle film on almond, Almond Board of California, 32nd Almond Industry Conference Proceedings 54-63

7) Holtz, B.A., and Hoffman, E.W. 2005. Processed Kaolin particle film on almond. Almond Board of California, 33rd Almond Industry Conference Proceedings, pages 83-86.
8) Holtz, B.A. and Martin-Duvall, T. 2006. Processed-Kaolin particle film on almond. Almond Board of California, 34th Almond Industry Conference Proceedings, pages 66-69.
9) Holtz, B.A. and Martin-Duvall, T. 2007. Processed-Kaolin particle film on almond. Almond Board of California, 35th Almond Industry Conference Proceedings, pages 52-53.
10) Holtz, B. 2008. Five year UC study demonstrates Surround crop protectant benefits in almonds. The NovaSource Reporter, Volume 1, June: pages 1-2, www.novasource.com

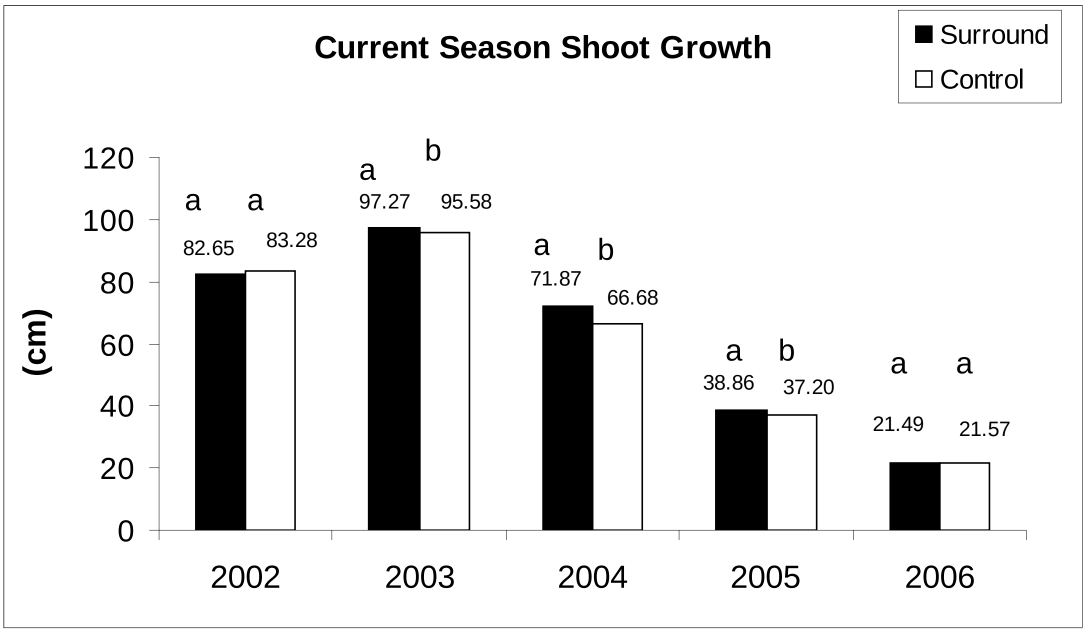

Figure 1. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

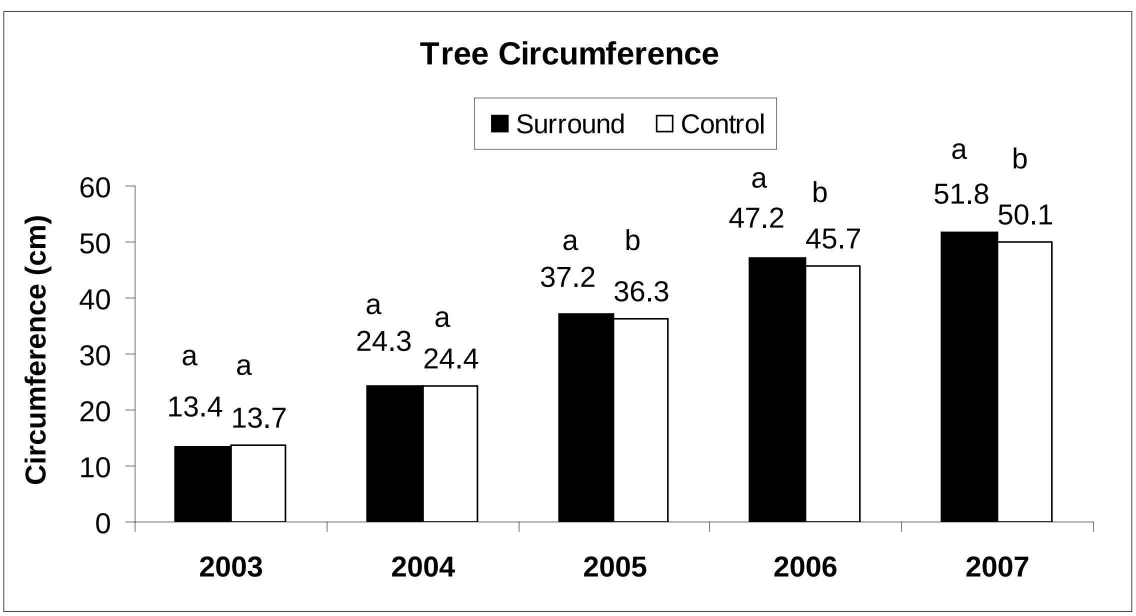

Figure 2. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

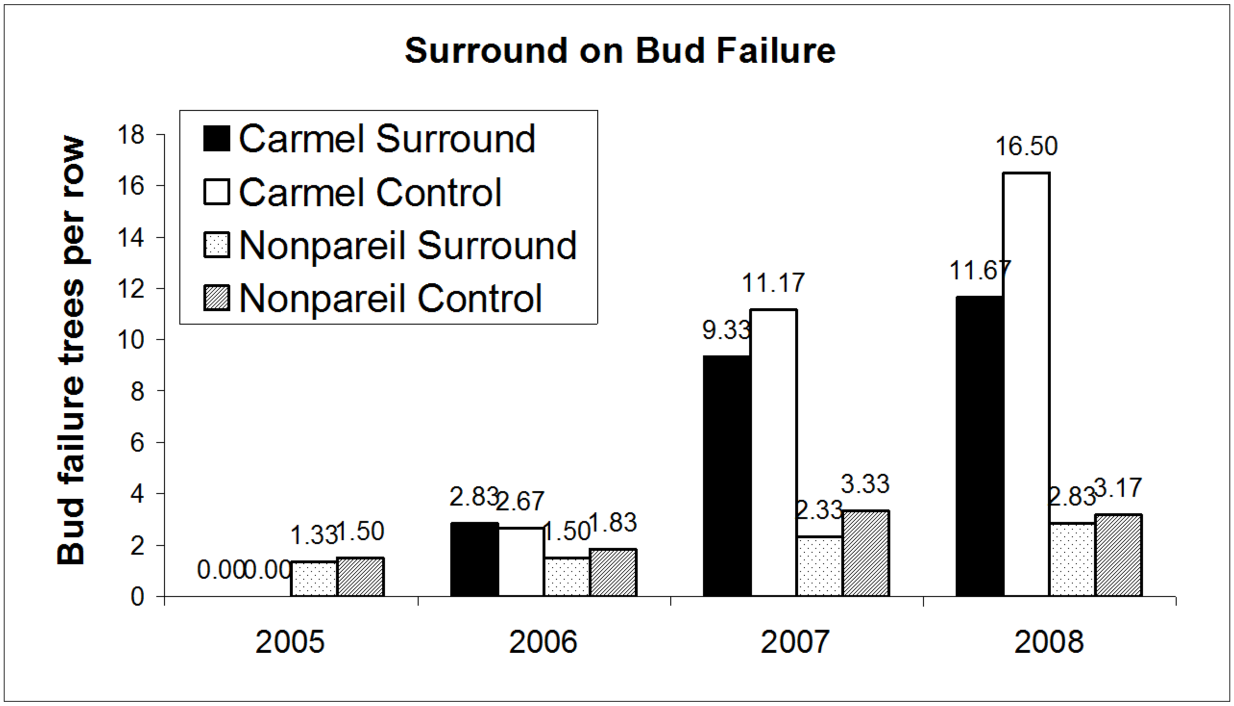

Figure 3. Carmel Surround = Carmel variety with Surround, Carmel Control = Carmel control without Surround, Nonpareil Surround = Nonpareil with Surround, Nonpareil Control = Nonpareil control. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

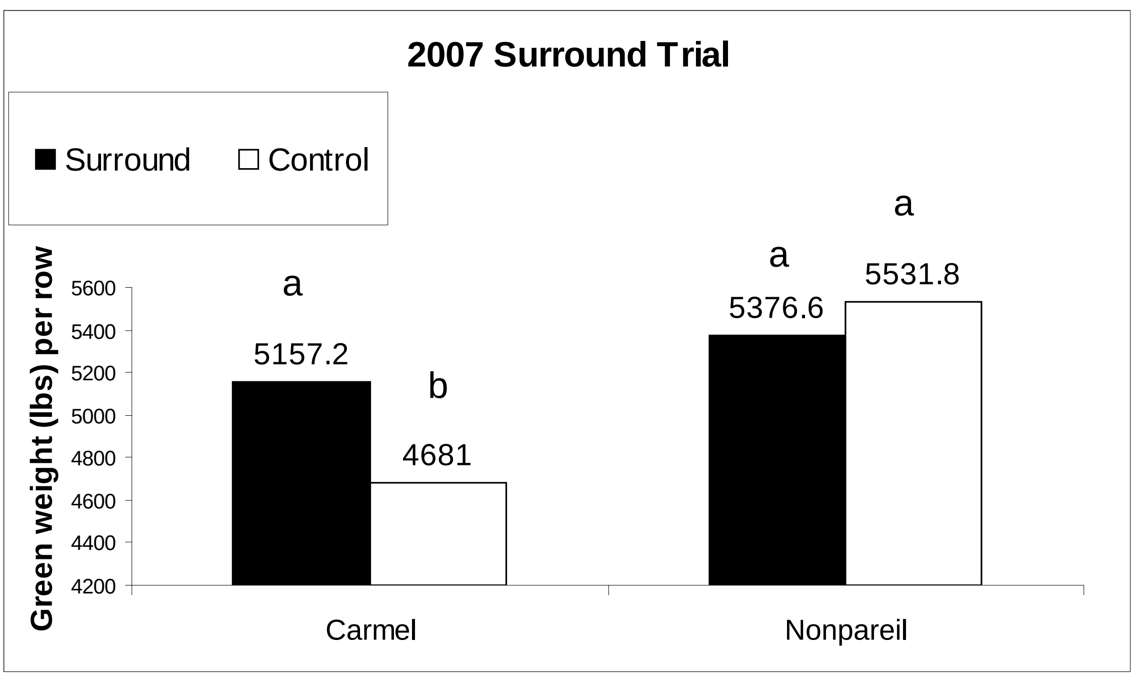

Figure 4. Paired columns of the same variety with different letters were statistically different when compared in a Student's T-test (P # 0.05).

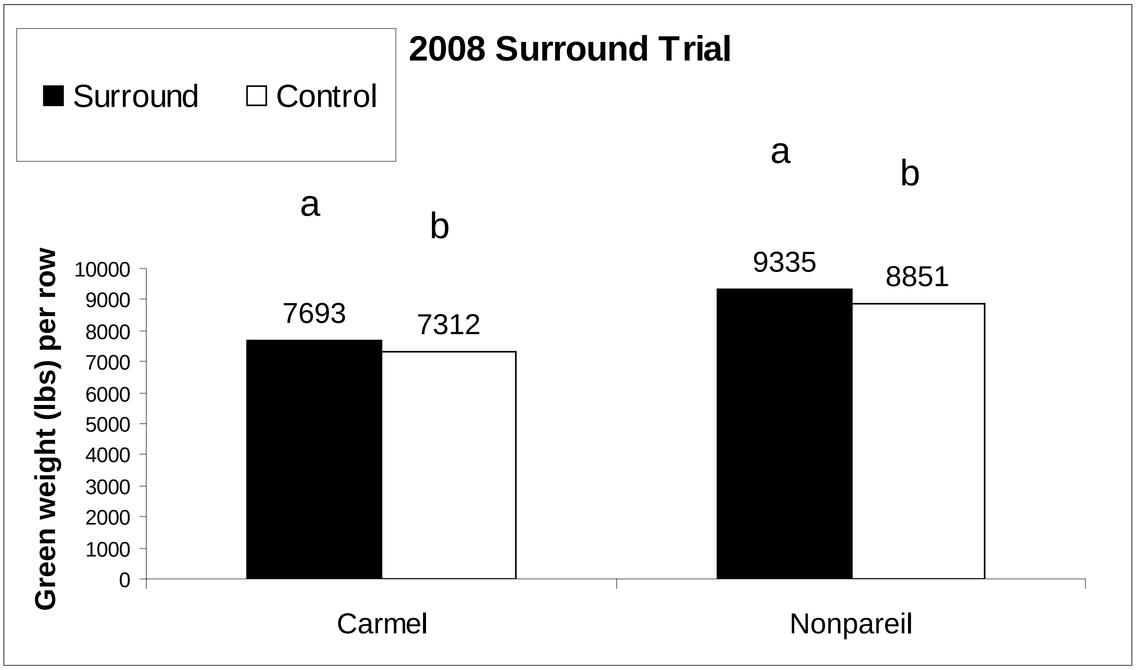

Figure 5. Paired columns of the same variety with different letters were statistically different when compared in a Student's T-test (P # 0.05).

5) Evaluating Soil Applied Boron Fertilization Rates and Timing in Sutter County

Project Cooperator: Franz Niederholzer, Farm Advisor, University of California Cooperativer Extension, Sutter/Yuba Counties

Co-Investigator: Jed Walton, PCA, Big Valley Ag Services, Gridley, CA

<u>Objectives</u>:

Compare the effect on almond flower, leaf, and hull boron (B) levels from fall vs. spring application of two rates (10 lb Solubor®/acre or 20 lb Solubor®/acre) soil-applied boron fertilizer.

<u>Interpretive Summary:</u>

Non-Pareil/Lovell (<50 ppm hull B at harvest, 2007) were treated with 10 or 20 lb/acre Solubor® (20% B) on October 12, 2007 or April 11, 2008. Material was applied evenly to half the distance across rows on each side of the study trees using a weed sprayer (20 gpa). Just under 0.45" of rain fell within a week of fertilizer application in October, 2007. A regular irrigation set (3.5" of water) was applied by the grower following treatment in April, 2008. Soil is an Olashes sandy loam, and irrigation is applied by hose-pull impact sprinklers. The grower applied a liquid boron equivalent to 0.6 pounds of boron/acre as a foliar spray in November, 2007. Flower samples (100 flowers/tree) were taken at full bloom (February 29, 2008). Leaf (50 count) and nut (10 count) samples were taken on April 11, 2008, just prior to spring fertilizer treatment. Leaf (50 count) and nut (10 count) samples were taken on August 2, 2008. Yield was not measured.

Soil applied boron as 10 or 20 lb/acre Solubor® in October did not significantly increase flower B levels in the spring following application compared to all other treatments (See Table 1). Compared to the other treatments, the fall applied 20# rate did produce statistically higher leaf B levels in April and a trend in higher leaf and hull boron levels by hull split.

We expected higher leaf and hull boron levels in trees treated with soil applied boron – at least by the harvest samples. Our rates and/or fertilizer material selection may not have been the best match for this location. Soil applications of granular ag borax (11.3% B) at 50-75 pounds per acre are recommended to improve almond boron status for 5-7 years. This is equivalent to 10-15 pounds of actual B per acre. Our Solubor® rates were equivalent to 2-4 pounds actual B/acre. At least some of the fertilizer boron in our treatments may have been leached from the root zone with winter rains and/or irrigation water. Soil sample analysis will help determine the fate of added B. Samples were taken in April 11, 2008, but have not yet been analyzed.

This research will continue using higher rates of Solubor® plus additional treatments using recommended rates of granular borax (10x less soluble than Solubor®) and repeated foliar applications.

Table 1. 'Nonpareil' almond flower, leaf, and hull boron concentrations (average of eight trees for each treatment) in 2008 after soil applied Solubor® fertilizer on October 12, 2007 or April 11, 2008. 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	Flower Boron (ppm)	Leaf Boron (ppm) April 11	Nut Boron (ppm) April 11	Leaf Boron (ppm) August 1	Hull Boron (ppm) August 1
Untreated	36 a	36 ab	25 a	32 a	43 a
10 lb/acre Solubor® October 12, 2007	33 a	33 b	25 a	31 a	39 a
20 lb/acre Solubor® October 12, 2008	36 a	37 a	26 a	36 a	50 a
10 lb/acre Solubor® April 11, 2008	36 a	34 b	27 a	31 a	43 a
20 lb/acre Solubor® April 11, 2008	38 a	34 ab	26 a	31a	47 a