Almond Culture and Orchard Management

Project No.: **09-HORT3-Connell**

Project Leader: Joseph H. Connell
UCCE – Butte County
2279-B Del Oro Ave.
Oroville, CA 95965-3315
(530) 538-7201
FAX: (530) 538-7140
E-mail: jhconnell@ucdavis.edu

Project Cooperators and Personnel:
Joe Connell, Farm Advisor, Butte County
David Doll, Farm Advisor, Merced County
John Edstrom, Farm Advisor, Colusa County
Brent Holtz, Farm Advisor, Madera County
Franz Niederholzer, Farm Advisor, Sutter and Yuba Counties

Objectives:

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, UC Farm Advisor, Butte County,
Joe Limberg, CSU Chico University Farm

Objectives:

To increase the Nonpareil percentage with judicious placement of pollenizers while hopefully maintaining the yield advantages of a standard 1:1 planting. In addition, determine if one mid-blooming pollenizer variety is sufficient or if two pollenizers (an early pollenizer plus a mid-blooming pollenizer) provide better production.

Interpretive Summary:

The trial orchard was planted in March 2002 at the California State University Chico farm at an 18 x 21 foot tree spacing with116 trees per acre. Three treatments are compared: the standard 1:1 planting with Nonpareil at 50%, Price 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 in each row offset, Nonpareil at 66%, Price at 17%, and Sano at 17%; and, a similar treatment with Nonpareil at 66% and Price at 34% to compare one vs. two pollenizers.

Since the first yield data was collected in 2005 the Price and Sano varieties have not shown any significant differences between treatments in pounds of kernel per tree. Nonpareil yields have shown significant differences between treatments in three of the first five harvests. The standard 1:1 planting had the heaviest yield per tree in 2007 and 2009, had the lightest yield per tree in 2006, and showed no significant differences between treatments in 2005 and 2008. The 2009 data is shown in **Table 1**.

Table 1. Mean yield per tree of all varieties in each treatment.

	Nonpareil	Price	Sano
	2009 lbs/tree		
Standard 1:1 Planting, 3 Varieties	22.7 a	13.2	19.5
Nonpareil in Every Row, 3 Varieties	19.2 b	13.8	15.7
Nonpareil in Every Row, 2 Varieties	21.5 a	11.8	
		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 $P \leq 0.05$

Table 2. Mean yield per acre of all varieties in each treatment.

	2005 lbs/acre	2006 lbs/acre	2007 lbs/acre	2008 lbs/acre	2009 lbs/acre	**2005-2009 Cumulative Yield lbs/acre**	**2009 $ Value per Acre**
Standard 1:1 Planting, 3 Varieties	547	797	2372	1752	2266 a	**7734**	**$ 3,632.45**
Nonpareil in Every Row, 3 Varieties	493	902	2394	1689	2048 b	**7526**	**$3,476.69**
Nonpareil in Every Row, 2 Varieties	481	987	2411	1462	2109 b	**7449**	**$ 3,699.77**
	ns	ns	ns	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 $P \leq 0.05$.

The total yield per acre was not significantly different between treatments in 2005, 2006, 2007, or 2008 (**Table 2**). In 2009 the standard 1:1 planting had a significantly greater yield per acre compared to the two treatments with Nonpareil in every row. When cumulative yield per acre between 2005 and 2009 is analyzed there are no significant differences between treatments but the numerical trend favors three over two pollenizers and also favors the higher percentage of pollenizers found in the standard 1:1 planting.

Interestingly, in spite of having a higher percentage of Nonpareil the differences in dollar value per acre were not significant in 2009 (Nonpareil valued at $1.90 per pound, Price at $1.25 per pound, and Sano at $1.15 per pound). Even though Nonpareil has a higher value, the increased Nonpareil percentage in the "Nonpareil in Every Row" treatments only showed a slightly better numerical return per acre in the "Nonpareil in Every Row, two varieties" treatment since cumulative yields are lower. In addition, harvest is more difficult with mixed variety rows and is undoubtedly more costly.

2) Survey of diseases associated with decline of almond orchards in Merced County

Project Cooperators: David Doll, UC Farm Advisor, Merced County,
Themis Michailides and Michael McKenry, UC - KAC
Florent Trouillas and Becky Westerdahl, UC Davis
Greg Browne, USDA-ARS

Objectives:

Merced County has been a major producer of almonds for over 60 years, with an estimated 88,000 bearing and 3,500 non-bearing acres. Orchards have been established on a large diversity of soil types, irrigated with varying water quality, and managed with different orchard practices. Many blocks have experienced tree loss from Phyophthora crown rot, Armillaria Root Rot, Almond Leaf Scorch, Silver Leaf, Nematodes (Root-knot, Ring, and Lesion), Crown Gall, and wood decay pathogens. These diseases, in severely affected orchard blocks, have caused the loss of many trees, shortening the production life of those orchards. This survey, which will be conducted through farm visits, will help determine abiotic and biotic causes of orchard problems, while aiding in the extension efforts between the newly hired farm advisor and county growers.

Interpretive Summary:

The survey was conducted during farm visits. Visits made for this project were requested by the orchard operator in order to help with an identified problem. A survey addressing management practices was developed and used to evaluate each orchard. Diagnoses of disease and tree problems were confirmed through tissue/soil sampling, isolation of pathogens, and discussions with advisors and consultants. In some locations where nematode problems were suspected, soil samples from 3-5 locations in the orchard were submitted to UC labs for nematode population counts.

A total of 52 orchard visits were made during the 2009 growing season and the diagnosis associated with the problems can be seen in **Table 3**. 16 (30.7%) and 36 (69.3%) orchards were diagnosed with abiotic and biotic problems, respectively. Abiotic problems included herbicide drift injury, nutrient uptake toxicity, salt burn, and water stress. Of the biotic diseases, 9 orchards (17.3%) were identified to have root problems, with four orchards being diagnosed with *Armillaria mellea* (Oak Root Fungus). 17 orchards (32.7%) displayed symptoms of scaffold diseases, which include lower limb dieback and fungal cankers associated with pruning wounds (*Eutypa* and *Botryosphaeria*). The high occurrence of scaffold diseases suggests that a review of canopy management practices should be made. Samples collected from this survey have contributed to the first isolation and identification of the fungal disease *Eutypa lata* in almond. Pathogenicity tests are currently being conducted.

Nematode sampling was performed in 12 orchards, and the population levels detected can be seen in **Table 4**. All 12 orchards were located in sand to loamy sand soils. High counts of Lesion and Ring nematode were found in 7 (58.3%) and 5 (41.6%) orchards, respectively. Orchards infested with lesion nematode often had counts above 1000 nematodes/liter (data not shown). It is important to note that genetic resistance to lesion nematode has not been identified in almond rootstocks, and should be addressed in future development.

Table 3: Identified problems from 52 orchard visits in Merced County in 2009.

Problem Type	Identified Problem	Number of Orchards
Abiotic (non-disease)	Herbicide Uptake	5
	Excess Nutrient Uptake	4
	Salt Burn (Tissue Accumulation)	4
	Lack of Water	3
Biotic (disease)	Foliar	2
	Root	9
	Scaffold	17
	Almond Leaf Scorch	2
	Nematodes	5
	Vertebrate Pests	1

Table 4: Populations of Lesion, Pin, Ring, and Rootknot nematodes from 12 sampled orchards in northern Merced County.

Population Level	**Lesion** (*Pratylenchus* sp.)	**Pin** (*Paratylenchus* sp.)	**Ring** (*Criconemella xenoplax*)	**Rootknot** (*Meloidogyne* sp.)
Low (0-50 nematodes/liter)	4	9	4	8
Medium (51-200 nematodes/liter)	1	3	3	2
High (>200 nematodes/liter)	7	0	5	2
Total Sampled:	12	12	12	12

3) Evaluation of almond production on raised beds

Project Cooperators: John P. Edstrom**,** Farm Advisor, Colusa County
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 4th growing season measurements made on Nonpareil trees (**Table 5**.) showed no difference in trunk circumference between the Raised Bed and Standard Berm planted trees. Yield figures also do not show any difference in production. The larger volume of topsoil in the Raised beds has not yet affected tree growth or productivity. In addition to the affects of deeper topsoil, raised beds in other crops are purported to increase soil temperature and oxygen levels providing a more optimal root environment. 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 and sweeping/blowing/harvesting nuts. However, adjustments to the spray boom have been required to evenly apply herbicides. Unfortunately, soil moisture probe data has shown uneven internal wetting of the Raised beds. Some of the micro-sprinkler applied water fails to penetrate/infiltrate the beds and runs down onto the flat middle. Without adequate soil moisture in the raised bed little advantage can be expected. In contrast, uniform moisture levels have been maintained in the short standard berms, thus complicating our evaluation. Adjusting the duration and frequency of irrigations has not reduced the problem in the raised beds and further improvements are needed to take full advantage of the larger soil volume created by the raised bed. A fair evaluation of the affects of raised beds can't be made until soil moisture conditions are comparable. Limited amounts of gypsum injected into the irrigation water also failed to improve water penetration. Higher amounts of continuous gypsum will be tried while a retrofit to double hode drip irrigation system was made at the end of the season to improve the rooting environment of the beds.

Table 5. Trunk circumference comparison

	Trunk Circ. cm	Yield lbs/ac	Kernels/oz.
Standard Berm	38.5	1,619	23
Raised Bed	40.1	1,525	22 ns

Berm 8"x 5' **Raised Bed 20" x 11'**

4) Processed-Kaolin particle film on almond

Project Cooperators: Brent A. Holtz, Pomology Farm Advisor, Madera County
Tome Martin-Duvall, Staff Research Associate, and Dee Haanen Laboratory Helper, UC Davis

Objectives:

Surround, 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. 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 three 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. Two applications (50 lbs/100 gallons water) were made in 2009 in an effort to reduce application costs. 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 Kaolin each year while 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 (**Figure 1**). We did not examine current season shoot growth from 2007-2009. From 2005-2009 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. 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. In 2008 we observed significantly less ($P \leq 0.02$) bud failure on the Surround treated Carmel trees. In 2005-2008 we observed less bud failure on Surround treated Nonpareil trees, but differences were not significant. In 2009 the Surround treated Carmel trees showed more bud failure while the Surround treated Nonpareil trees had less bud failure than the control trees (**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 Surround treated trees. In 2007 the Carmel treated rows had significantly ($P \leq 0.01$) greater yield when compared to the non-treated. 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, and the Surround treated Nonpareil tree rows also had significantly ($P \leq 0.04$) more yield when compared to untreated. In 2009 the Carmel treated tree rows had significantly ($P \leq 0.03$) greater yield when compared to the non-treated. The Surround treated Nonpareil tree rows had a greater yield when compared to untreated, but differences were not significant (**Figure 4**). Cumulative yields from 2007-2009 have Surround treated Carmel trees averaging 467 more dry kernel pounds per acre more than untreated Carmel trees, while Surround treated Nonpareil trees are averaging 281 more dry kernel pounds per acre more than untreated Nonpareil trees (**Figure 5**).

Acknowledgement:

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

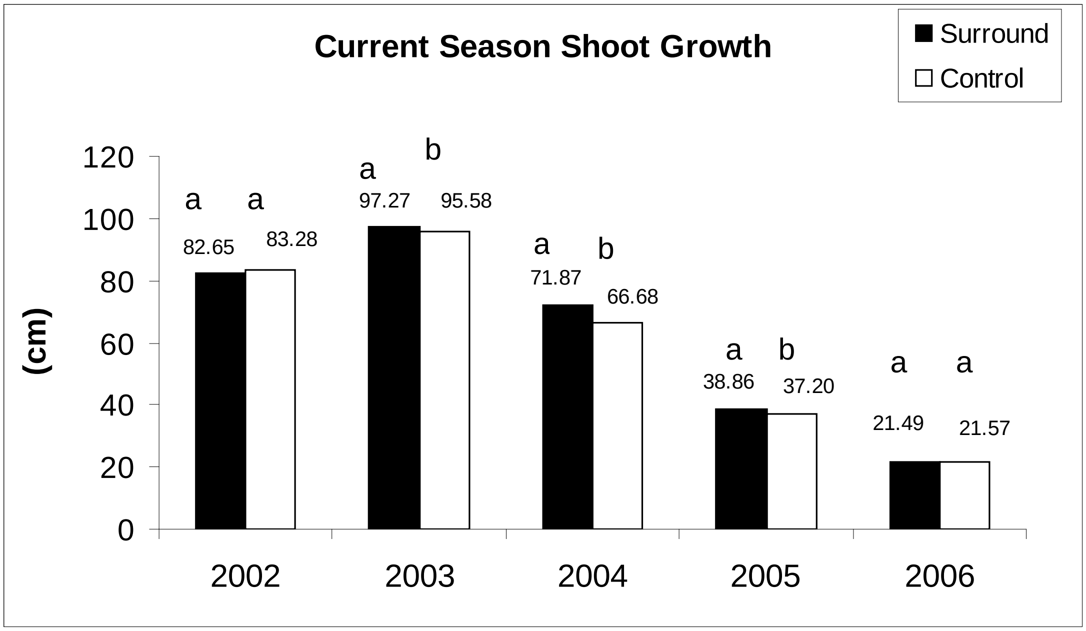

Figure 1. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

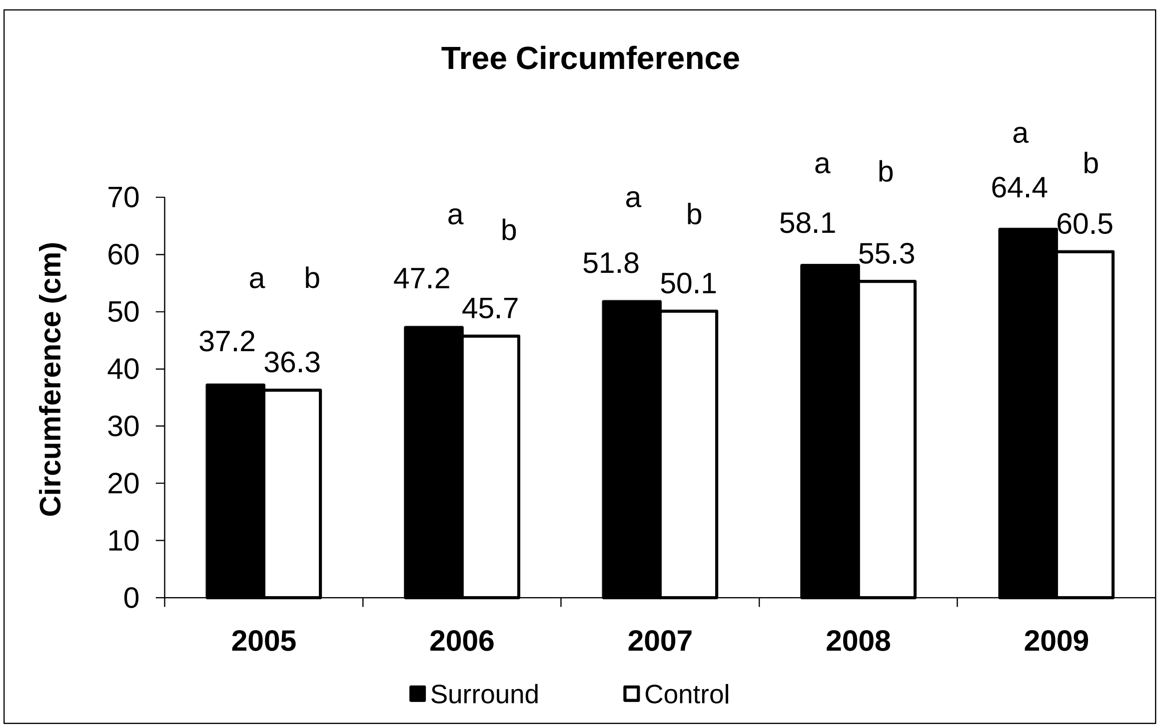

Figure 2. Paired columns with the same date with different letters were statistically different when compared in a Student's T-test (P # 0.05).

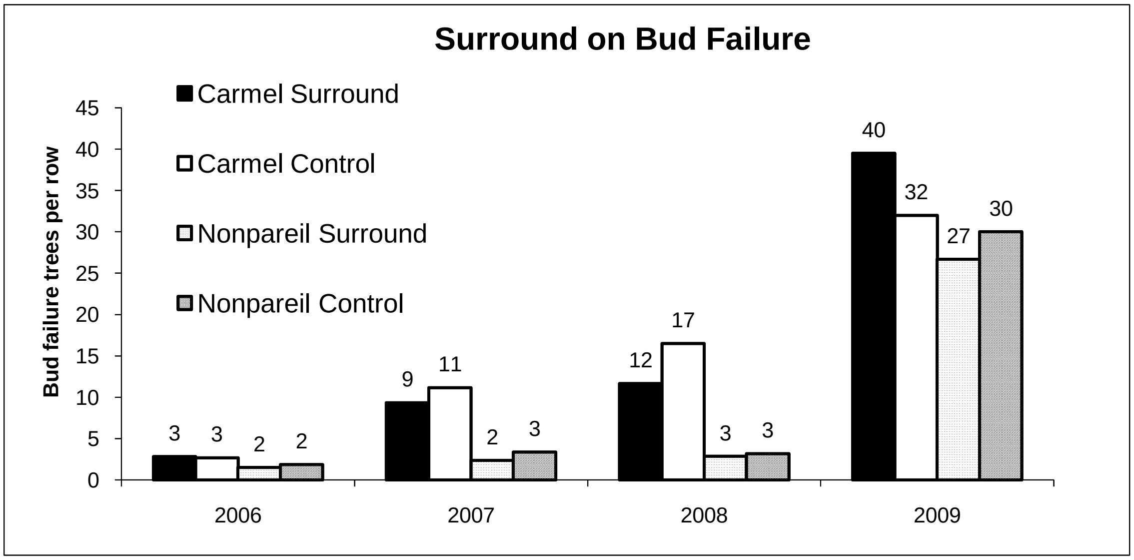

Figure 3. Carmel Surround = Carmel variety with Surround, Carmel Control = Carmel control without Surround, Nonpareil Surround = Nonpareil with Surround, Nonpareil Control = Nonpareil control.

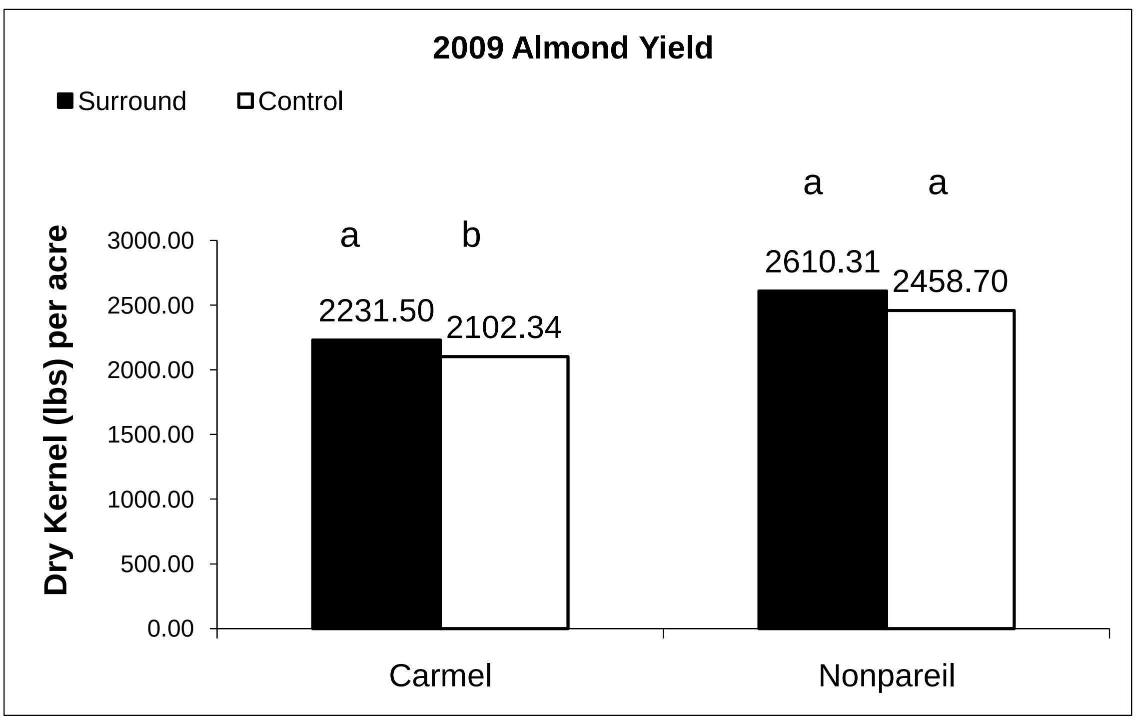

Figure 4. Paired columns of the same variety with different letters were statistically different when compared in a Student's T-test (P # 0.05).

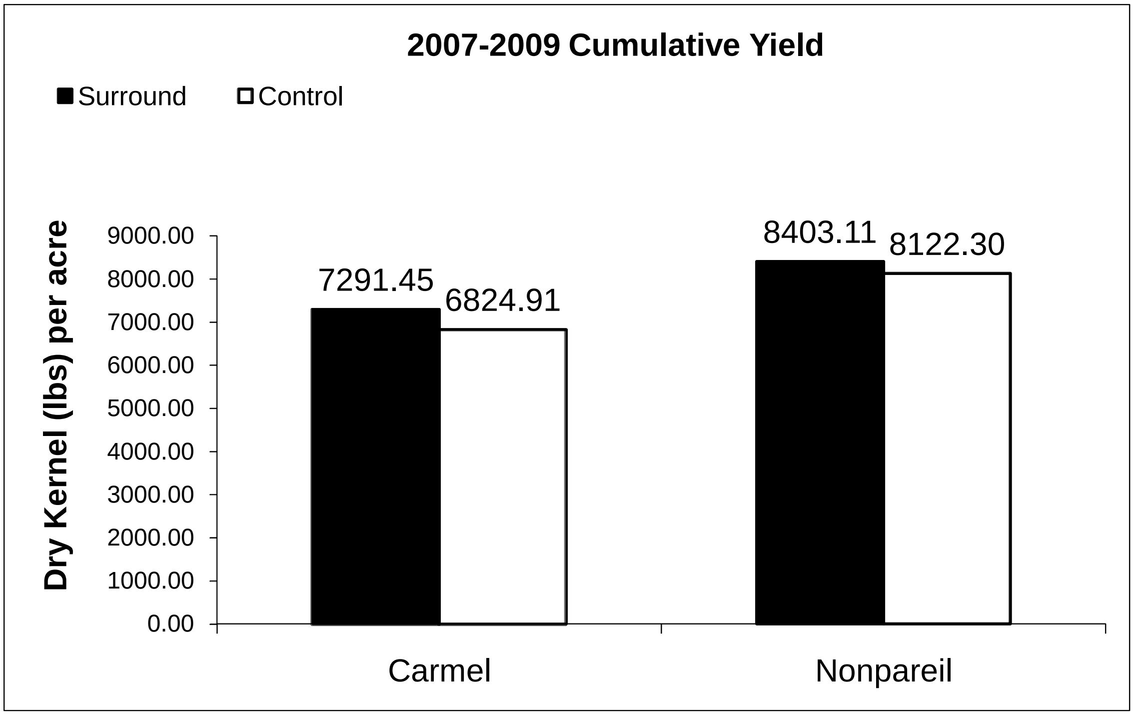

Figure 5. Paired columns of the same variety with different letters were statistically different when compared in a Student's T-test (P # 0.05).

5) Evaluating soil applied boron fertilization rates and timing in Sutter County

Project Cooperators: Franz Niederholzer, Farm Advisor, UCCE Sutter/Yuba Counties
Jed Walton, PCA, Big Valley Ag Services, Gridley, CA

Objectives:

Compare the response (in amount and persistence) of almond flower, leaf, and hull tissues to large, one-time, soil boron (B) fertilizer applications in fall, 2008 or spring, 2009. Soil applied boron fertilizer rates ranged from 4-8 pounds actual B/acre as 20 lb Solubor®/acre or 40 lb Solubor®/acre). A fifth treatment -- 50 lb Granubor®/acre, 7 lbs actual B -- was also applied in the spring. This study is being conducted at an orchard site where the unfertilized soil has very low boron levels (≤0.05 ppm B) by saturated paste extract method.

Interpretive Summary:

Nonpareil/Lovell almond trees with low B status (<50 ppm hull B at harvest, 2007) were treated with 20 or 40 lbs/acre Solubor® (20% B) on October, 2008 or late May, 2009. Granubor® (14% B) was applied at 50 lb/acre in late May, 2009. Material was applied evenly to half the distance across rows on each side of the study trees using a weed sprayer (20 gpa or hand applied with belly grinder). Soil is an Olashes sandy loam, and irrigation water is delivered by hose-pull impact sprinklers. The grower applies a liquid B equivalent to 0.6 pounds of B/acre as a foliar spray each November. Flower samples (100 flowers/tree) were taken at full bloom

(March 1, 2009 and February 20-23, 2010). Leaf (50 count) and hull (25 count) samples were taken on July 31, 2009.

Soil applied boron as 20 or 40 pounds/acre Solubor® in October, 2008 did not significantly increase flower B levels at bloom in 2009 (see **Table 6**). Similar results were obtained in 2008 following application of 10 or 20 pounds of Solubor® in October, 2007.

Soil applied boron, as Solubor® (20 or 40 lb/acre in the fall, 2008) or Granubor® (50 lb/acre in spring, 2009) increased hull and leaf B levels in summer, 2009 (**Table 7**). There was poor correlation between hull and leaf B levels (**Figure 6)**.

High rates of soil applied boron, as Solubor® (40 lb/acre in the spring, 2009) or Granubor® (50 lb/acre in spring, 2009) increased flower B levels in 2010 (**Table 7**). A lower rate of Solubor (20 lb/acre), applied at the same time, did not significantly increase flower B in 2010. Poor pollination weather produced a poor NP set across this experiment in 2010.

High levels of B were found in all flower samples in 2010, compared with 2009 and 2008. Decreases in fruit set and crop yield were measured in 'Butte' trees fertilized with foliar B where flower B levels > 60 ppm B. It is not possible – this year (2010) -- to test if high rates of soil applied B fertilizer increased or decreased yield, due to poor set across the study orchard in treated and untreated trees.

Table 6. 'Nonpareil' almond flower boron concentrations (average of eight trees for each treatment) in 2009 and 2010 following soil applied boron fertilizer in fall, 2008 or spring, 2009. There is a 95% chance that data in the same column are significantly different if they do not share a letter, based on Tukey's HSD test.

Treatment	Flower Boron (ppm B) 2009	Flower Boron (ppm B) 2010
Untreated	30 a	47 a
20 lb/acre Solubor® October, 2008	36 a	52 a
40 lb/acre Solubor® October, 2008	38 a	69 b
20 lb/acre Solubor® May, 2009		60 ab
40 lb/acre Solubor® May, 2009		86 c
50 lb/acre Granubor® May, 2009		90 c

Table 7. 'Nonpareil' almond summer leaf and harvest hull boron concentrations (low, high, and average measurement, eight individual trees sampled per treatment) in 2009 following soil applied boron fertilizer in fall, 2008 or spring, 2009. Lowest reading per treatment appears on the left of each column, the highest reading is on the right of each column. The average value appears in the middle in bold print.

Treatment	Leaf Boron (ppm) 2009	Hull Boron (ppm) 2009
Untreated	29 **33** 38	35 **41** 44
20 lb/acre Solubor® October, 2008	35 **41** 52	40 **65** 84
40 lb/acre Solubor® October, 2008	37 **42** 47	72 **104** 153
20 lb/acre Solubor® May, 2009	30 **42** 55	47 **67** 63
40 lb/acre Solubor® May, 2009	38 **44** 53	45 **59** 78
50 lb/acre Granubor® May, 2009	41 **43** 46	60 **77** 94

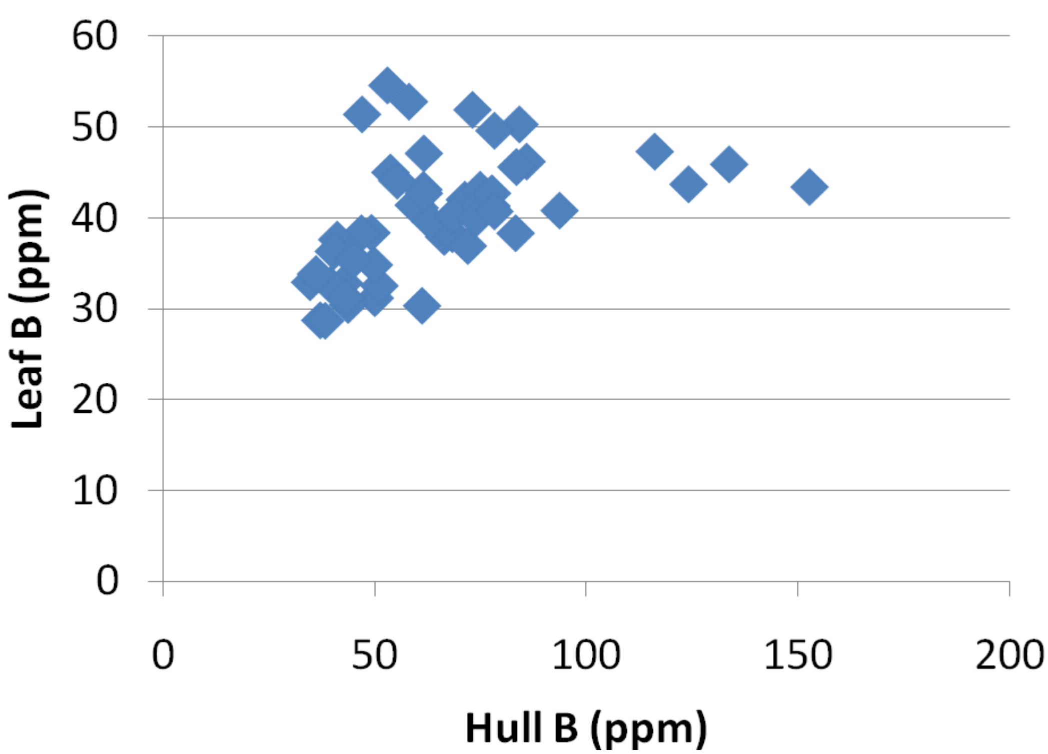

Figure 6. The relationship between hull boron and leaf boron in the study trees in 2009.