Almond Culture and Orchard Management

Project No.: **10-HORT3-Connell**

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Project Cooperators and Personnel:
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5) Elizabeth Fichtner, Farm Advisor, Tulare County
6) Franz Niederholzer, Farm Advisor, Sutter and Yuba Counties

Interpretive Summary:

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.

Farm Advisor Projects:

1) Increasing the Nonpareil Percentage: Pollenizer Arrangement & Bloom Timing

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Project Cooperators and Personnel: Brian Miller, CSU Chico University Farm

Objectives:
- To determine if the Nonpareil percentage can be increased with careful placement of pollenizers and still maintain yields of a 1:1 planting.
- To determine if one mid-blooming pollenizer variety is sufficient or if two pollenizers (an early pollenizer plus a mid-blooming pollenizer) provide better production.

Materials and Methods:

The trial orchard was planted in March 2002 at the CSU 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%, an early pollenizer (Sano) at 25% and a mid-blooming pollenizer (Price) at 25%.
- Early and mid-blooming pollenizers with Nonpareil in every row and pollenizers arranged every two trees down the row with pollenizer trees in each row offset, Nonpareil at 66%, Sano at 17%, and Price at 17%.
- Nonpareil in every row and pollenizers arranged every two trees down the row with pollenizer trees in each row offset, Nonpareil at 66% and Price at 34%.

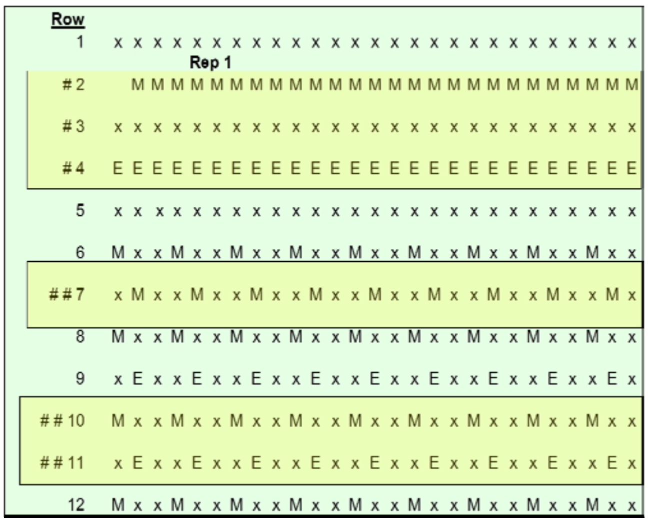


Figure 1. Schematic of replicate 1 showing the plot layout. Rows marked with the # sign are yield rows representing the three treatments.

X = Nonpareil
M = Mid-blooming Pollenizer (Price)
E = Early-blooming Pollenizer (Sano)

Rows in each replicate are 27 trees long and there are four replicates in the trial. 2010 was the orchard's 9th growing season.

Number of Trees per Acre by Variety and % of Planting

		Nonpareil	Price	Sano
Standard 1:1 Planting, 3 Varieties	Variety %	50%	25%	25%
	# Trees/acre	58	29	29
Nonpareil in Every Row, 3 Varieties	Variety %	66%	17%	17%
	# Trees/acre	76	20	20
Nonpareil in Every Row, 2 Varieties	Variety %	66%	34%	
	# Trees/acre	76	40	

Results and Discussion:

The 2010 yield per tree and yield per acre are not significantly different between treatments. 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 six 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, 2008, and 2010. The addition of an early blooming pollenizer did not enhance Nonpareil yield. The 2010 data is shown in the following table.

2010 Mean Yield per Tree & per Planted Acre by Variety Percentage

	Nonpareil		Price		Sano	
	lbs/tree	lbs/acre	lbs/tree	lbs/acre	lbs/tree	lbs/acre
Standard 1:1 Planting, 3 Varieties	17.8	1034	17.6	511	17.8	516
Nonpareil in Every Row, 3 Varieties	16.9	1287	18.8	377	15.7	314
Nonpareil in Every Row, 2 Varieties	19.2	1462	15.8	633		
	ns*		ns		ns	

*ns at bottom of column indicates no significant treatment effects at P <0.05

The numerical trend of cumulative yield per acre between 2005 and 2010 favors the higher percentage of pollenizers found in the standard 1:1 planting. Interestingly, in spite of having a higher percentage of Nonpareil in the "Nonpareil in Every Row" treatments, the differences in dollar value per acre were not significant in 2010 (Nonpareil valued at $1.70/pound, and Price and Sano valued at $1.20/pound). Even though Nonpareil has a higher value, the increased Nonpareil percentage only showed a slightly better numerical return per acre. In addition, harvest is more difficult with mixed variety rows, is undoubtedly more costly, and has the potential for mixed nut deliveries.

2) The Effects of Delaying Pruning until Early Spring in Young Almond Trees

Project Leader: Carolyn DeBuse, UC Farm Advisor, Solano/Yolo Counties, E-mail: cjdebuse@ucdavis.edu

Objective:

1) To compare the seasonal growth of second leaf trees that were pruned at three different times; dormant, after leaf bud break, during leaf expansion.
2) To compare the seasonal growth of first leaf trees that were headed at three different times after planting; at planting (dormant), after leaf break, during leaf expansion, as well as comparing branch numbers of two heading heights.

Interpretive Summary:

The traditional pruning time for young almond trees is during the dormant season after the leaves have dropped, but this is also one of wettest times of year with regular fog, rain and dew. Open wounds created by the pruning cuts are vulnerable to infection from canker causing bacterial and fungal pathogens which are transferred in wet weather. Cankers formed in the lower scaffolds or crotch of tree can reduce yield due to scaffold breakage and limb death. Pruning these lower cankers out of the tree is not practical and often not possible. Severe damage can lead to tree removal. The vulnerability of the pruning cuts to infection may be reduced if pruning is done during drier parts of the year such as late fall or early spring. A

study conducted by Wilbur Reil et al. (1989) that compared pruning timings of late fall, before leaf drop, to dormant pruning showed that pruning after October 15th but before dormancy does not reduce yield. This study investigates the possibility of pruning in early spring compared to dormant season on second leaf trees as well as the timing of heading newly planted trees. The results show no significant difference between growth measurements of first leaf diameter and height, and second leaf circumference, height and canopy size compared to control trees between any of the timings of pruning. This experiment showed that the growth of the Nonpareil almond tree was not reduced by pruning in the spring when the trees were at bud break or early leaf expansion.

Materials and Methods:

The trial was a replicated, randomized design using Nonpareil trees on Lovell rootstock in a Solano County commercial orchard. The first part of the experiment used 72 trees, planted in the winter of 2008/09, entering their second season in 2010 when pruned. The trees were pruned at three different times; dormant (Feb. 16, 2010), after leaf bud break (March 9, 2010), during leaf expansion (April 27, 2010) (**Figures 1-3**). Three pruning treatments with 6 replications of 4 trees each. The pruning was performed in the same manner as the rest of the grower's orchard; three scaffolds were selected and removal of all other branches. Selected scaffolds were left unheaded. Measurements were made on all four trees in each replicate. Circumference at 3 inches above the graft union and height of tallest branch was measured in April and November. Width of the canopy in both directions was measured in September with area of shade calculated for comparison.

The second part of the experiment used 64 trees, planted at the same location on March 19, 2010. It compared three timing treatments and two different heights of the first heading cut done on newly planted trees; heading at 36 inches at planting, 36 and 48 inches at bud break 19 days after planting, and heading 36 inches during leaf expansion 42 days after planting. Each treatment had four replicates of 4 trees each. Measurements were made on all trees with diameter measured in June and November at 18 inches above the ground, height and numbers of branches over 8 inches long counted in November.

Analysis using ANOVA Type III and Duncan's multiple range test was performed using SAS (GLM procedure).

Results and Discussion:

The results show no significant difference between growth measurements of first leaf diameter and height, and second leaf circumference, height and canopy size compared to control trees between any of the timings of pruning. Significant differences were found between the numbers of branches over eight inches long of the one year old trees. Both timing of the heading cut and the height of the heading cut showed a difference in branch number. The treatment with the heading cut at 48 inches at bud break, 19 days after planting, had 28% more branches than the control ($p < 0.05$) and 15% more than the treatment with the heading cut 36 inches at bud break (not significantly different)(**Figure 4**). The treatment with the least amount of branches was the one headed 36 inches during leaf expansion, 42 days after planting, with 12% less branches than the control ($p < 0.05$) and 31% than the treatment heading cut at 48 inches at bud break($p < 0.05$). The number of branches of the control and the heading cut at 36 inch at bud break were not significantly different from each other.

It appears that young almond trees can be pruned from late fall through early spring. These results on the different pruning timings show that pruning may be done later in the spring, even after bud break, without detrimental effects to tree growth. This allows a larger window of time to prune young trees with the idea of trying to avoid the wettest times of the year that promote pathogen dispersal and infection. Growers who are concerned with the potential spread of pathogens during winter may prune young trees after winter rains have abated.

The increased number of branches grown on the trees headed at 48 inches at bud break is significantly different but the number of trees and treatments were not large enough for any definitive conclusions to be made. The extra height alone could be the distinguishing factor that increased branch number. More noteworthy is the result that the latest pruning timing of heading at leaf expansion, 36 inches height, had significantly less branches then all other treatments. This may indicate that, even though final height and trunk diameter was not significantly different from other treatments, heading just planted trees after leaf expansion has a detrimental effect on final branch numbers. This could decrease the choices for scaffolds at the next years pruning.

References:

Reil, Wilbur; Micke, Warren; Yeager, Jim; and Langston, Charles. (1989). Improving Almond Pruning Decisions. Seventeenth Annual Almond Research Conference. Almond Board of California.

Figure 1. Dormant pruning treatment second leaf trees, Feb. 16, 2010 (left photo - before, right photo - after)

Figure 2. Pruning treatment of second leaf trees after leaf bud break, March 9, 2010 (left photo - before, right photo - after)

Figure 3. Pruning treatment of second leaf trees during leaf expansion, April 27, 2010 (left photo - before, right photo - after)

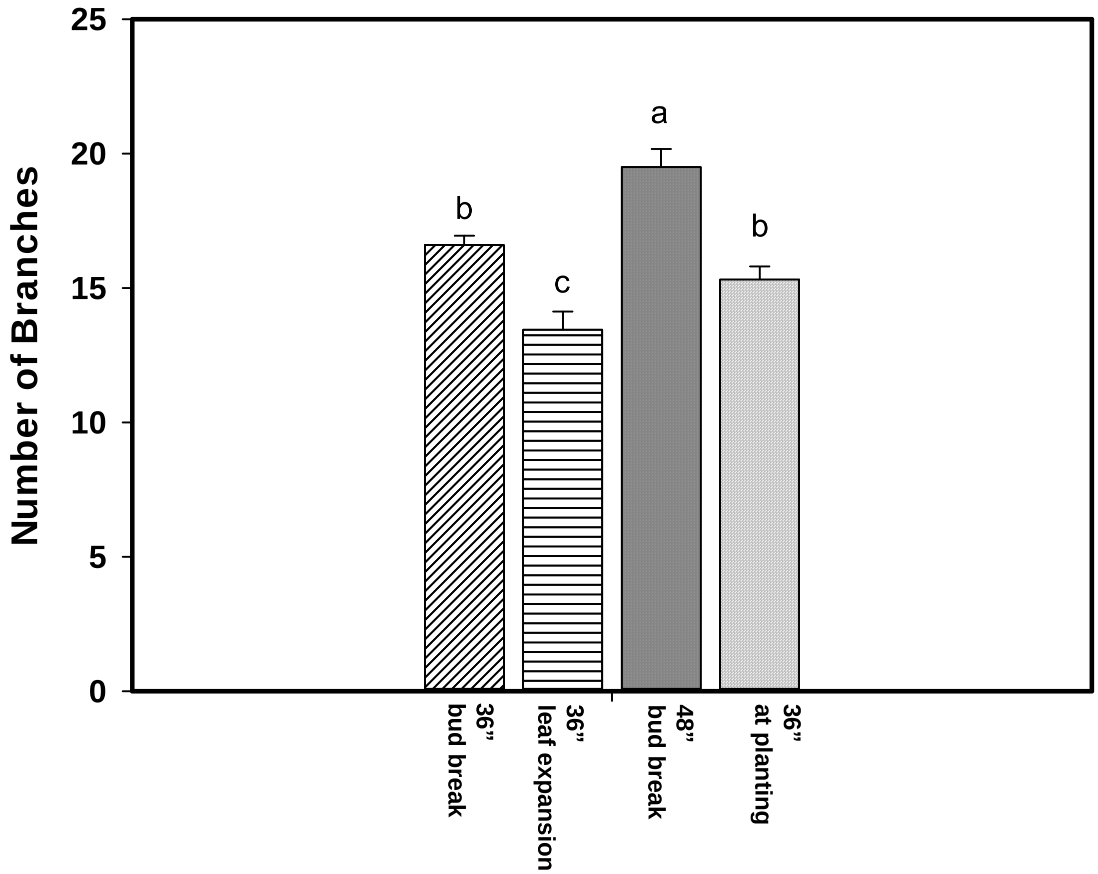


Figure 4. Comparison of number of branches over eight inches long on first leaf almond trees with different timings and heights of the heading cut after planting. (36” height at bud break, 36” height at leaf expansion, 48” at bud break, and 36” height at planting). Letters refer to statistical grouping of the Duncan’s test.

3) Performance of Six Almond Rootstocks with Long-Term Exposure to Sodium and Chloride

Project Leader: David Doll, UC Farm Advisor, Merced County, 2145 Wardrobe Avenue, Merced, CA 95341, (209) 385-7403, dadoll@ucdavis.edu

Project Cooperators and Personnel: Roger Duncan, UC Farm Advisor, Stanislaus County, Glen Arnold, Arnold Farms

Objectives:
To determine the long term effects of sodium and chloride on the yields of six rootstocks used for almond. Rootstocks include Halford peach, Lovell peach, Nemaguard peach, Red-Leafed Nemaguard peach (Nemared), Bright's #1 Hybrid, and Hanson Hybrid.

Interpretive Summary:
Increasing salinity within irrigated perennial crops is a major problem facing the longevity of the almond industry. Varying tolerance of rootstocks to sodium has been observed within field plantings, but studies have never documented the long term effects of sodium exposure. In 1989, a rootstock trial testing two peach-almond hybrid rootstocks and four peach rootstocks was established to determine the effects of sodium on almond yields.The source of sodium was the irrigation water pumped from the regional aquifer. Throughout the 20 years of the trial, the grower noted that the peach rootstocks showed increasing signs of sodium toxicity within the leaves. 20 years after trial establishment, trees grafted to peach-almond hybrid rootstocks produced higher yields than trees planted on peach rootstocks.Tissue analysis indicated that peach-almond hybrid rootstocks had lower concentrations of sodium and chloride in comparison to the peach rootstocks. Results from this study suggest that peach-almond hybrid rootstocks are more tolerant to sodium than peach rootstocks and may provide a tool for managing salinity issues in affected areas.

Materials and Methods:
A rootstock trial was established in 1989 on loamy sand soil in northern Merced County. Rootstocks were spaced 24'x24' containing two varieties, Nonpareil and Carmel. The block was irrigated with solid-set sprinklers using well water with moderately high sodium (6.35 meq/L). All rootstocks and both varieties were farmed according to the grower's standard practice.

Mid-July leaf sampling was conducted following UC recommendations. Leaves from replicate trees of the same variety and block were pooled for analysis. All samples were submitted to UC Davis Analytical Laboratory for analysis. Prior to harvest, observations of the trees expressing symptom of salt burn were made. Harvest yields were taken to allow a comparison of rootstocks 20 years post planting.

Results and Discussion:
Earlier research within this trial has demonstrated that peach x almond hybrids out-grow and out yield peach rootstocks. Peach rootstocks were smaller in size, and often lost leaves in the late season due to salt toxicity within the leaves.

Leaf tissue analysis indicated that sodium and chloride levels were significantly higher in all peach rootstocks when compared to the two P/A hybrid rootstocks (**Figures 1 and 2**). Sodium within the leaves of the P/A hybrid rootstocks was below the UC established critical/toxic value of 0.25%, while all peach rootstocks exceeded the level. Late season observations supported this finding; the majority of trees planted on peach rootstocks showed significant leaf burn due to the accumulated levels of salt (**Figure 3**).

Trees planted on P/A rootstocks yielded more kernel pounds per acre than all peach rootstocks within the Carmel variety (**Figure 4**), and more than Halford, Lovell, and Nemared rootstocks within the Nonpareil variety (**Figure 5**). Yields of Nonpareil on P/A hybrids were considered an acceptable and farmable yield by the grower. Carmel yields were lower than expected due to a frost event that occurred earlier in the spring.

The findings of this long term study indicate that there is a greater tolerance to sodium and chloride with P/A hybrids. Mechanisms of tolerance have not yet been determined, but results suggest root exclusion since sodium and chloride uptake was influenced by choice of rootstock. The use of P/A hybrids provides a management option for areas of high sodium and chloride, but the genetic tolerance should not take the place of proper irrigation and salinity management strategies.

Figure 1. Sodium content as a percentage of almond leaf tissue of six different almond rootstocks.

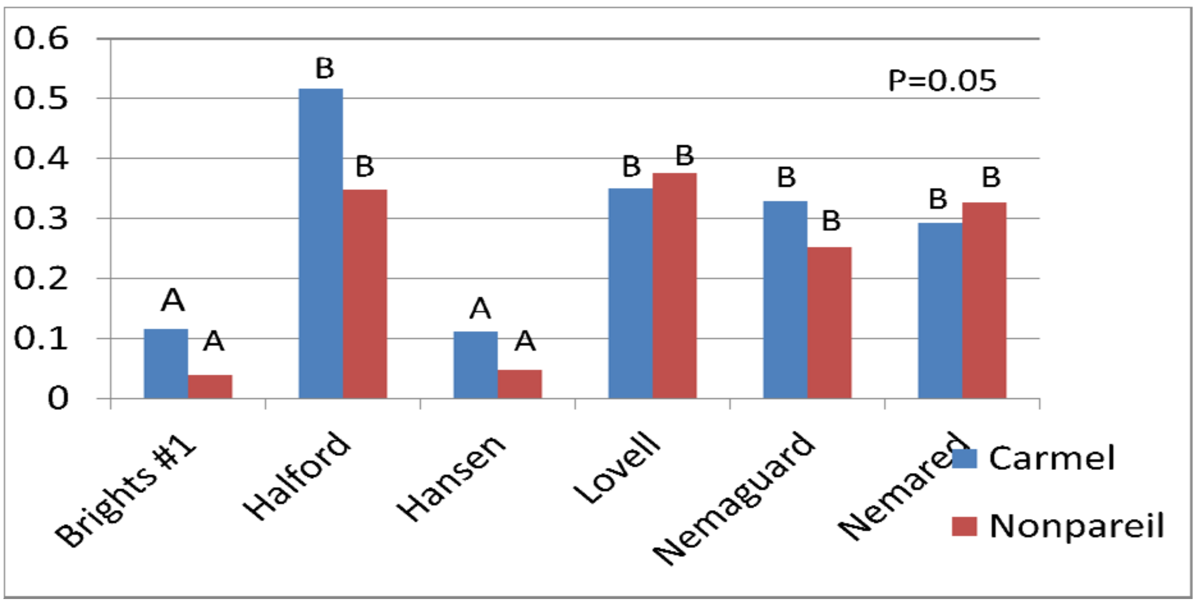


Figure 2. Chloride content as a percentage of almond leaf tissue of six different almond rootstocks.

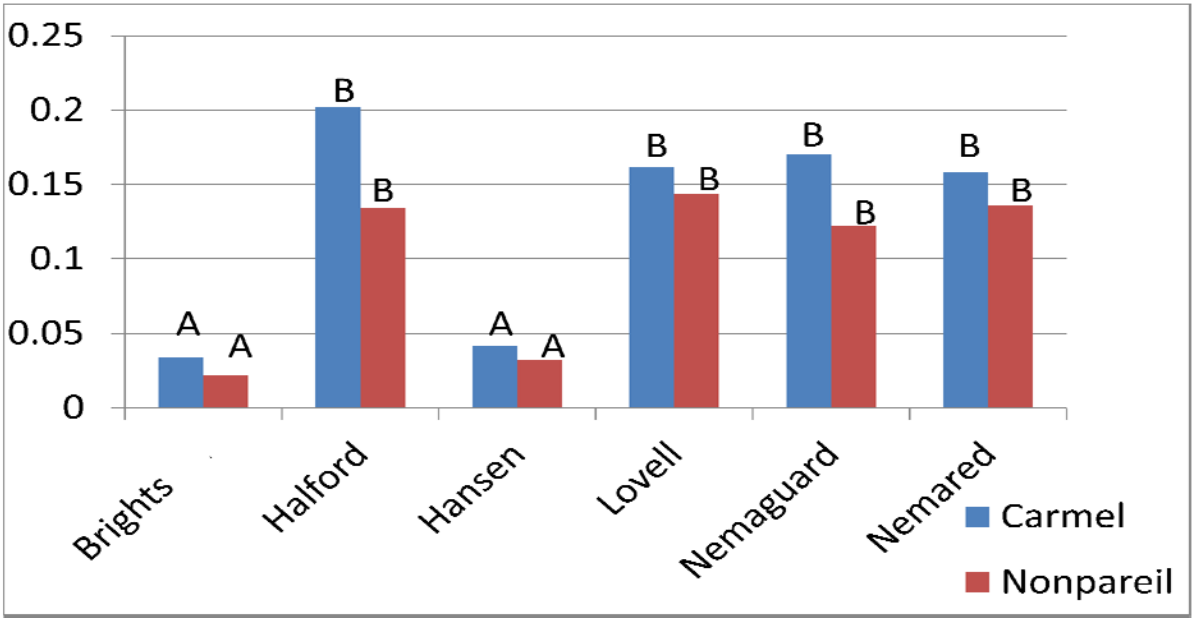


Figure 3. Percentage of trees from six different almond rootstocks showing symptoms of salt burn in late August.

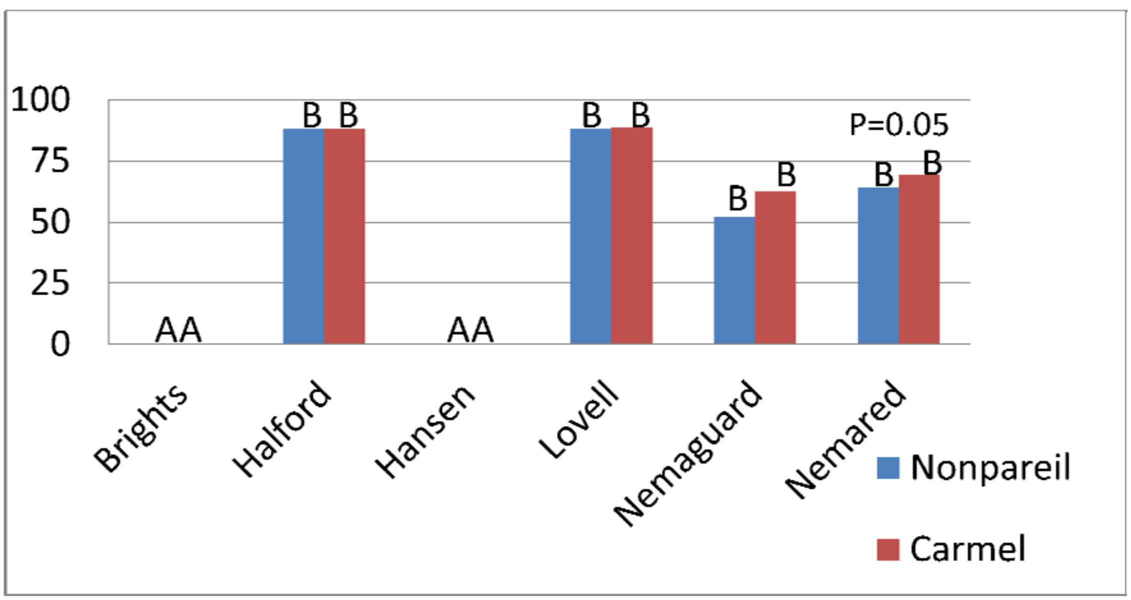


Figure 4. 2009 Carmel almond yields for six different almond rootstocks from a 20 year old orchard irrigated with water containing a high amount of sodium.

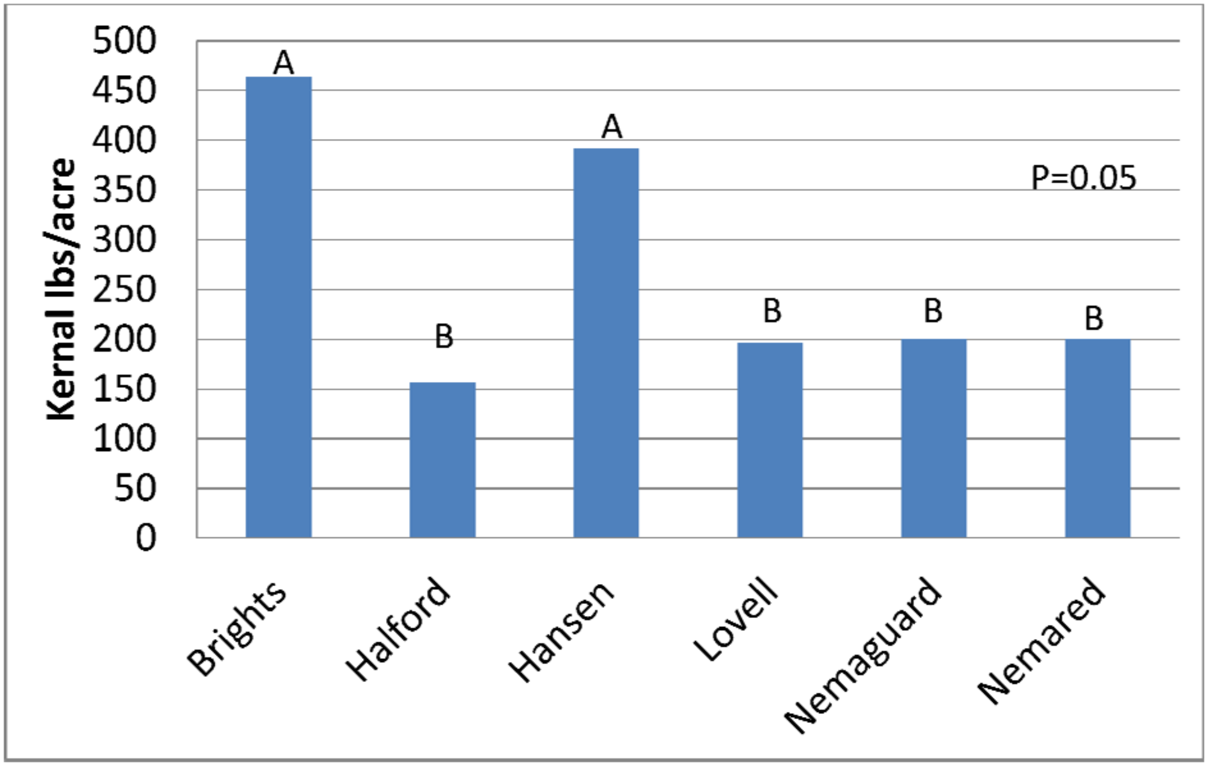
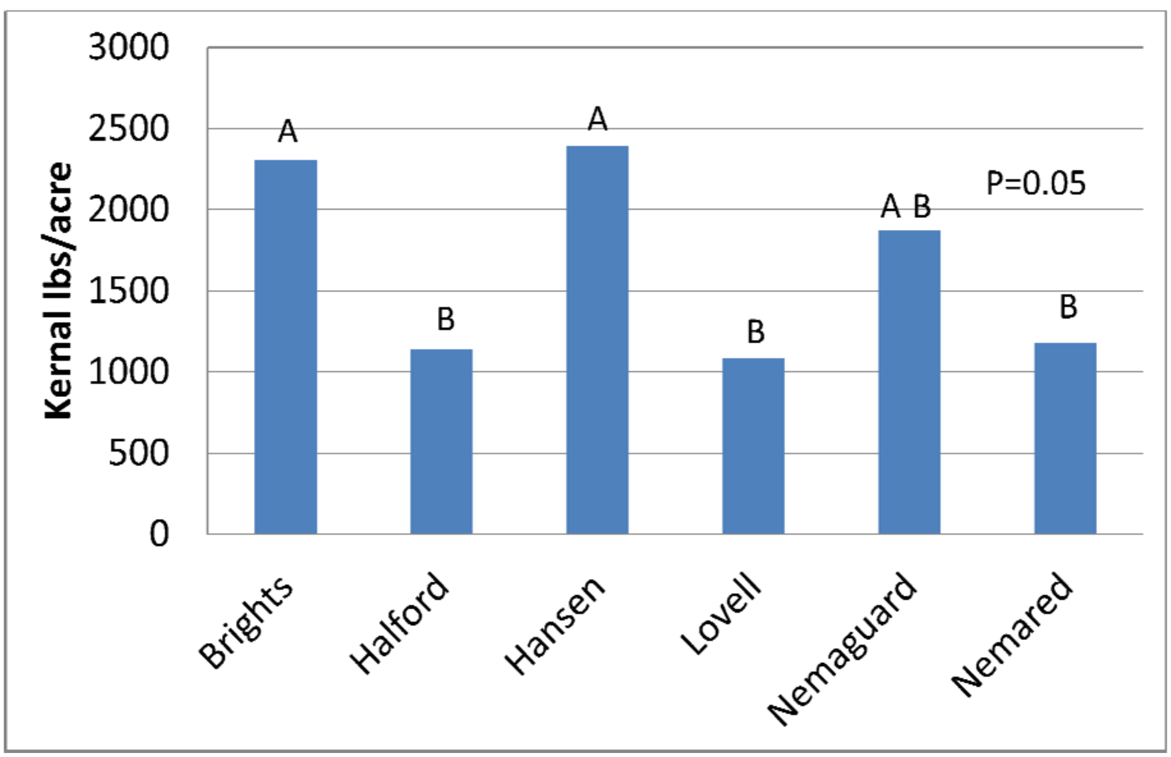


Figure 5. 2009 Nonpareil almond yields for six different almond rootstocks from a 20 year old orchard irrigated with water containing a high amount of sodium.



4) Almond Production on Raised Beds

Project Leader: John Edstrom, UC Farm Advisor Emeritus, Colusa County, jpedstrom@ucdavis.edu

Project Cooperators and Personnel: Stan Cutter, Nickels Soil Lab Orchard Manager

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

Materials and Methods:
A commercial planting was established in 2006 with Nonpareil, Monterey and Fritz varieties planted @ 16' x 22'. Prior to planting 2 berm types were formed down the entire length of 6 rows that will allow three replicates to compare Raised Beds verses Standard Berm designs. 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. Standard Berms did not receive amendments. Plots were irrigated summer/fall to stimulate weed growth/microbial activity. Each of the 2 treatments have dedicated sub-mainlines to allow differential watering schedules. All berms/beds will be instrumented with soil moisture probes to schedule irrigations to maintain uniform bed/berm moisture levels via micro-sprinklers. Tree growth and yield data will be collected. The complications of large beds to orchard operations will be assessed.

Results and Discussion:
At the end of 2010, the 5th growing season, tree measurements showed no difference in trunk circumference between the Raised Bed and Standard Berm planted trees (**Table 1**). Yield figures also fail to show any statistically valid difference in production, but, there is a numerical 200-pound per acre advantage to the Raised bed production system. Only time will tell if this is the beginning of a trend towards higher production from the larger soil volume created by the raised beds or simply a fluke. 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 rooting environment. As trees mature, higher levels of cropping will presumably put greater demand on the Lovell peach root systems and may eventually show an advantage to the raised bed system.

Additionally, the use of sizable berms/beds improves the drainage of winter rain and allows tree planting much earlier in the season than flat/level plantings. Grower experience indicates that rootstocks that sucker such as Marianna 2624 should not be planted on berms/mounds that stimulate suckering.

In this test, the large beds have not interfered significantly with the typical cultural practices of mowing and sweeping/harvesting nuts but higher capacity blowers maybe necessary. The 11' wide beds do restrict the effective width of row middles and could require machinery adjustments. This bed size (20 inches high x 11 feet wide) required adjustments to the herbicide spray boom to evenly apply herbicides in this 16’x22’ spacing. The higher gpa micro-sprinkler system that resulted in excessive runoff and failed to evenly wet the raised bed soil was replaced with a dual drip system this season and has more uniformly wetted the raised bed soil. This has allowed a better evaluation of the effects of raised beds verses the standard berms. We have not found an increase in limb breakage or tree loses as a result of the raised beds.

Table 1. Tree growth and yield on standard berms compared to raised beds.

	Trunk Circ. cm	Yield lbs/ac	Kernels/oz.
Standard Berm	45.7	1,830	21
Raised Bed	46.4 ns	2,040 ns	21 ns

Berm 8” x 5’ Raised Bed 20” x 11’

Recent Publications:

Annual Report of the Nickels Soil Laboratory, May, 2010

5) Measurement of Tenlined June Beetle Activity in Soil

Project Leader: Elizabeth J. Fichtner, UC Davis, Tulare County Farm Advisor, 4437 S. Laspina St. Suite B., Tulare, CA 93274, 559-684-3310, ejfichtner@ucdavis.edu

Project Cooperators and Personnel: Marshall Johnson, Extension Specialist, Entomology, UC Riverside

Objectives:
The overall goal of this project is to investigate the influence of soil moisture on activity of tenlined june beetle (TLJB) larvae and determine soil moisture levels that are suppressive to the larvae. Specific objectives include: i) adapt techniques for measurement of soil microbial activity (Zibilski, 1994) to assessment of tenlined june beetle larval activity and ii) compare the respiration rates of second and third instar larvae. After development of a technique for assessing TLJB respiration, future studies will be designed to assess the influence of soil matric potential on larval activity.

Interpretive Summary:
Though TLJB is an inhabitant in many orchards, it only causes damage in a fraction of infested blocks. Where TLJB damage does occur, the impact is severe. Extensive larval feeding on roots results in rapid tree decline and death. Because TLJB damage is more severe in sandy soils or sand streaks within orchards, larval activity is presumed to be enhanced by dry soil conditions. A technique was developed to assess larval respiration rates in soil as a measure of larval activity. Using this technique, the activity of 2^{nd} and 3^{rd} instar larvae was compared. Though 3^{rd} instar larvae produce more CO_2 than 2^{nd} instar larvae, their respiration rates are similar when compared per unit body mass. Consequently, either 2^{nd} or 3^{rd} instar larvae can be utilized in studies where respiration rates are employed as a measurement of larval activity. Future experiments can now be designed to address the influence of soil moisture on TLJB activity, as determined by changes in larval respiration rates.

Materials and Methods:
Larval respiration rates (ie. CO_2 evolution) were assessed as a measurement of larval activity. TLJB larvae were incubated in moist sand within large, sealed 2L Mason jars to create respiration chambers. Within each respiration chamber, CO_2 gas evolved from both larvae and the soil microbial community was trapped in a beaker containing 5 ml of 0.5M NaOH. Amount of CO_2 evolution was determined by precipitation of carbonates with 5 ml of 0.5M $BaCl_2$, and titration to a clear phenolphthalein endpoint with 0.1 N HCl. In order to differentiate between microbial respiration and larval respiration, a set of respiration chambers containing soil in the absence of larvae were included in the study.

Respiration rates were compared between 2^{nd} and 3^{rd} intar larvae incubated in sandy soil at 6% gravimetric moisture for 26 days. Five replicate respiration chambers of each instar were utilized in the experiment, and 3 replicate chambers containing soil without larvae were included to account for microbial respiration. Chambers containing 3^{rd} and 2^{nd} instar larvae contained 1 and 2 grubs per chamber, respectively. CO_2 evolution was assessed after 3, 7, 10, 14, and 28 days in respiration chambers. Larval respiration was calculated both as a measure of total quantity of CO_2 evolved per larvae, as well as total CO_2 evolution per unit larval body mass.

Results and Discussion:

A technique utilized for measurement of soil microbial activity (Zibilski, 1994) can be applied to measurement of larval activity in soil. The application of this technique to measurement of larval respiration will allow for future assessment of the impact of environmental factors or applied insecticides on TLBJ activity. Because 2^{nd} and 3^{rd} instar larvae exhibit similar levels of CO_2 evolution per unit body mass, either developmental stage of the insect can be used in future studies. Third instar larvae, however, evolve more CO_2 on an individual grub basis.

The next stage of this project will focus on determining the influence of soil water status, particularly soil matric potential, on respiration of TLJB larvae. The overall goal is to determine threshold matric potential levels suppressive to TLJB larvae for consideration of soil moisture status in management of TLJB larval damage to roots.

References Cited:

Zibilski, L.M. 1994. Carbon mineralization. Pages 835-864 in: Methods of Soil Analysis, Part 2. Microbiological and Biochemical Properties. SSA Book Series No. 5

6) Increasing Almond Tree Boron Levels in Sutter County – How Long Can it Last?

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Project Cooperators and Personnel: 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:

Fall timing of boron fertilizer applied to the soil does not increase flower boron levels at bloom the following year. Spring (May) application of 4-8 pounds actual B fertilizer to the orchard floor increased flower and hull tissue B levels the following year, although it took 7-8 pounds of actual B/acre to increase hull B levels > 100 ppm B. Increased flower B levels were measured for at least two years after a May soil treatment with B fertilizer.

Materials and Methods:
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 (60-100 flowers/tree) were taken at full bloom (March 1, 2009, February 20-23, 2010, and February 20-21, 2011). Leaf (50 count) and hull (25 count) samples were taken on July 31, 2009. Hulls (25 count) were sampled at harvest in 2010.

Results and Discussion:
Soil applied boron applied in fall did not significantly increase flower B levels at bloom the next year (see **Table 1**). Boron rates were 20 lbs/acre or 40 lbs/acre as Solubor applied in October. Similar results were obtained in 2008 following application of 10 or 20 pounds of Solubor® in October, 2007. Similar results have been reported in apple. These data suggest -- for fall application -- foliar sprays, not fertilizer application to the soil, increase flower boron for the coming crop.

Spring timing of soil applied boron did increase flower B levels for at least two years (Table 1). Fall application at a high rate also increased flower B, but in the second year after application. Soil applied boron fertilizer can increase flower B levels, but application should go out before harvest in one year to see increase in flower B the following year. A modest rate of Solubor (20 lb/acre) applied in the spring, 2009 produced the same level of flower B in 2010 and 2011 as 2x the amount (40 lbs/acre Solubor) applied in the fall, 2008 (Table 1).

Table 1. 'Nonpareil' almond flower boron concentrations (average of eight trees for each treatment) in 2009, 2010 and 2011 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	Flower Boron (ppm B) 2011
Untreated	30 a	47 a	28 a
20 lb/acre Solubor® October, 2008	36 a	52 a	39 ab
40 lb/acre Solubor® October, 2008	38 a	69 b	48 bc
20 lb/acre Solubor® May, 2009		60 ab	46 bc
40 lb/acre Solubor® May, 2009		86 c	59 c
50 lb/acre Granubor® May, 2009		90 c	56 c

Table 2. 'Nonpareil' almond summer leaf (2009) and harvest hull boron (2009 and 2010) concentrations 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 large, bold print. Treatment means followed by different letters indicate significant differences ($p \leq 0.05$) for the 2010 hull data.

Treatment	Leaf Boron (ppm) 2009	Hull Boron (ppm) 2009	Hull Boron (ppm) 2010	
Untreated	29 33 38	35 41 44	39 50 60	a
20 lb/acre Solubor® October, 2008	35 41 52	40 65 84	41 59 76	a
40 lb/acre Solubor® October, 2008	37 42 47	72 104 153	63 108 150	bc
20 lb/acre Solubor® May, 2009	30 42 55	47 54 61	55 80 100	ab
40 lb/acre Solubor® May, 2009	38 44 53	45 59 78	84 114 126	cd
50 lb/acre Granubor® May, 2009	41 43 46	60 77 94	120 138 166	d

Fall or spring applied boron fertilizer did increase leaf and/or hull boron, but the biggest increases appeared at least one year after application. Soil applied boron, as Solubor® (40 lb/acre in the fall, 2008; 20 lb/acre in spring, 2009 or 40 lb/acre in spring, 2009); or Granubor® (50 lb/acre in spring, 2009) increased hull and leaf B levels in summer, 2009 and 2010 (**Table 2**). There was poor correlation between hull and leaf B levels in 2009.

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. All flower B levels showed a trend to lower levels in 2011 compared with 2010.