Almond Culture and Orchard Management

Project No.: 11-HORT3-Niederholzer

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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) <u>Increasing the Nonpareil Percentage: Pollenizer Arrangement and Bloom Timing</u>

Project Leader: Joe Connell, UC Farm Advisor, Butte County

Project Cooperators: Jeff Boles, CSUC 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.

Methods:

The trial orchard was planted in March 2002 at the CSU Chico farm at an 18 x 21 foot tree spacing with 116 trees per acre.

A schematic showing the treatment design and plot layout is shown in **Figure 1**. The three treatments in the trial are as follows:

- A 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%.

The percentage of each variety in each treatment and the number of trees of each variety per acre are shown in **Table 1**.

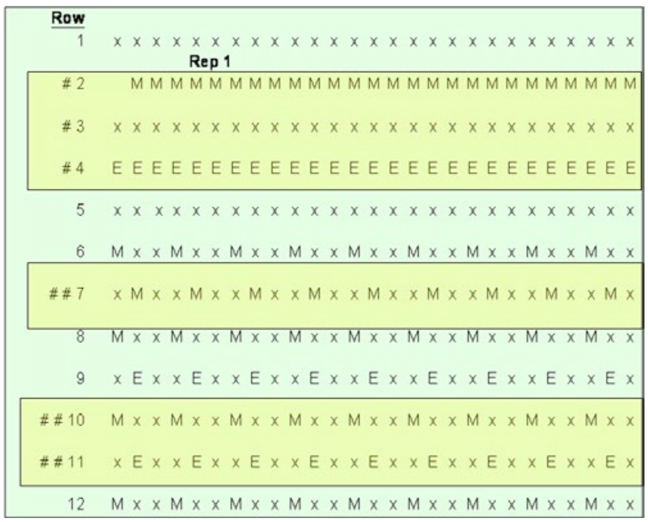

Figure 1. Schematic of replicate 1 showing the plot layout. Rows marked with the # sign are yield rows representing the three treatments.

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. 2011 was the orchard's 10th growing season.

Table 1. 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 2011 yield per tree and yield per acre are not significantly different between treatments (**Table 2**). 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 seven 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, 2010, and 2011. The addition of an early blooming pollenizer enhanced Nonpareil yield numerically but not significantly (**Table 3**).

Table 2. 2011 Mean Yield/Tree & Yield per Acre by # Trees/Ac per Variety.

	Nonpareil		Price		Sano		Total
	lbs/tree	lbs/acre	lbs/tree	lbs/acre	lbs/tree	lbs/acre	lbs/acre
Standard 1:1 Planting, 3 Varieties	23.2	1348	10.5	304	17.2	499	2150
Nonpareil in Every Row, 3 Varieties	22.3	1694	11.2	224	13.5	270	2188
Nonpareil in Every Row, 2 Varieties	20.4	1553	10.4	418			1971
	ns*		ns		ns		ns

*ns at bottom of column indicate no significant treatment effects at P < _0.05.

The numerical trend of cumulative yield per acre between 2005 and 2011 favors the higher percentage of pollenizers found in the standard 1:1 planting by a few hundred pounds per acre over the seven years (**Table 3**).

Table 3. 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		2010 lbs/acre	2011 lbs/acre	2005-2011 Cumulative Yield lbs/acre
Standard 1:1 Planting, 3 Varieties	547	797	2372	1752	2266	a	2061	2150	11945
Nonpareil in Every Row, 3 Varieties	493	902	2394	1689	2048	b	1978	2188	11692
Nonpareil in Every Row, 2 Varieties	481	987	2411	1462	2109	b	2095	1971	11515
	ns	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 ≤ 0.05.

Interestingly, in spite of having a higher percentage of Nonpareils in the “Nonpareil in Every Row” treatments, the differences in dollar value per acre were not significant between treatments in individual years or cumulatively. In **Table 4**, Nonpareil’s value was calculated using an average of $1.95/pound, and Price and Sano were calculated at $1.43/pound. This assumes early and mid-blooming pollenizer nuts may potentially be worth 52 cents per pound less than Nonpareil. These values go up and down from year to year as does the differential between Nonpareil and other varieties. No empirical difference is implied by these calculations since prices are strictly market driven.

Table 4. Yield and Dollars per acre calculated at the variety percentage in each treatment.

			2005	2006	2007	2008	2009	2010	2011	2005-2011 Total $/ac	
Standard 1:1 Planting, 3 Varieties	**Nonpareil**	lbs/ac	283	476	1505	947	1318	1034	1348		
		$/ac	**$ 552**	**$ 928**	**$2,935**	**$1,847**	**$2,570**	**$ 2,016**	**$2,629**	**$ 13,476**	
	Price	lbs/ac	132	148	442	348	384	511	304		
		$/ac	**$ 189**	**$ 212**	**$ 632**	**$ 498**	**$ 549**	**$ 731**	**$ 435**	**$ 3,245**	
	Sano	lbs/ac	132	172.0	425	457	565	516	499		
		$/ac	**$ 189**	**$ 246**	**$ 608**	**$ 654**	**$ 808**	**$ 738**	**$ 714**	**$ 3,955**	
		Total	$ 929	$1,386	$4,175	$2,998	$3,927	$ 3,485	$3,777	**$ 20,677**	
Nonpareil in Every Row, 3 Varieties	**Nonpareil**	lbs/ac	328	680	1859	1193	1458	1287	1694		
		$/ac	**$ 640**	**$1,326**	**$3,625**	**$2,326**	**$2,843**	**$ 2,510**	**$3,303**	**$ 16,573**	**Total**
	Price	lbs/ac	76	96	262	187	277	377	224		**Gain**
		$/ac	**$ 109**	**$ 137**	**$ 375**	**$ 267**	**$ 396**	**$ 539**	**$ 320**	**$ 2,144**	**Over**
	Sano	lbs/ac	89	126	274	310	313	314	270		**7**
		$/ac	**$ 127**	**$ 180**	**$ 392**	**$ 443**	**$ 448**	**$ 449**	**$ 386**	**$ 2,425**	**Years**
		Total	$ 876	$1,643	$4,392	$3,037	$3,687	$ 3,498	$4,010	**$ 21,142**	**$ 465**
Nonpareil in Every Row, 2 Varieties	**Nonpareil**	lbs/ac	353	823	1842	1063	1637	1462	1553		**Total**
		$/ac	**$ 688**	**$1,605**	**$3,592**	**$2,073**	**$3,192**	**$ 2,851**	**$3,028**	**$ 17,029**	**Gain**
	Price	lbs/ac	128	164	569	398	472	633	418		**Over**
		$/ac	**$ 183**	**$ 235**	**$ 814**	**$ 569**	**$ 675**	**$ 905**	**$ 598**	**$ 3,978**	**7**
		Total	$ 871	$1,839	$4,406	$2,642	$3,867	$ 3,756	$3,626	**$ 21,008**	**Years**
											$ 331

Dollars / acre are calculated with Nonpareil valued at $1.95/lb. and Mid/Early pollinators at $1.43/lb.

Even though Nonpareil often has a higher value per pound and the calculations in **Table 4** reflect that reality, both "Nonpareil in Every Row" treatments (an increased Nonpareil percentage) only showed a better numerical dollar return per acre in 2006, 2007, and 2010. The "Standard 1:1 planting", even with fewer Nonpareil trees, had the best numerical dollar return per acre in 2005 and 2009. In 2008 and 2011 the "Standard 1:1 planting" dollar return per acre was still better than the "Nonpareil in Every Row, 2 Varieties" treatment, again with fewer Nonpareil trees. It appears that two pollenizers in northern California's bloom weather show a general trend of providing better production than just one pollenizer (**Table 3**). The "Nonpareil in Every Row, 3 Varieties" treatment had a slightly better numerical dollar return per acre in five of the seven years compared to the "Standard 1:1 planting" without considering other costs (**Table 4**).

After ten growing seasons and 7 years of yield data collection, it appears that the increased pollen availability of 1:1 plantings did provide a generally better numerical yield potential than was achieved with a higher percentage of Nonpareil even with careful placement of pollenizers (**Table 3**). In the early 1980s, the almond industry moved away from 2:1 plantings of Nonpareil because of demonstrated yield improvements in 1:1 plantings. It appears it is a mistake to conclude that increasing the Nonpareil percentage back to 66% of a planting will result in 66% of the production having a higher value.

Finally, harvest is much more difficult with mixed variety rows. It is undoubtedly more costly, and has the potential for mixed nut deliveries. These drawbacks and expenses have not been factored in to the returns per acre calculated in **Table 4** and they are likely to erase the meager and insignificant gains accumulated over the seven years.

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

Project Leader: Carolyn DeBuse, Farm Advisor, UCCE Solano/Yolo Counties

Objective:

To compare tree growth of second and third year almond trees pruned at three different times; dormant, leaf bud break, during leaf expansion.

Part 1: To repeat last year's pruning treatments on one year old trees and expanding the trial to include three varieties; Nonpareil, Winters, Monterey. The one year old trees were pruned at three different times; dormant, leaf bud break, and during leaf expansion. The pruning was done in the same manner as the rest of the grower's orchard. The objective was to compare second year tree size of the dormant pruned trees to the other two spring pruning times.

Part 2: Compare the growth of the third year experimental Nonpareil trees pruned at three different treatment timings in 2010. Additional light pruning was done in 2011 following the same pruning timings.

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 15^{th} but before dormancy does not reduce yield. This trial looks at the effects of pruning young almonds in early spring compared to the dormant season. Results from last year's trial found no significant differences in trees size after one growing season. This year the trial replicated the pruning timings on one year old trees in a new block expanding the trial to include three varieties; Nonpareil, Winters, Monterey. Treatment timings were dormant, leaf bud break, and during leaf expansion. The 2010 experimental trees were pruned again at the same treatment timing. Trunk circumference and tree height were measured for both experiments. Results showed no differences between the treatments in the third year trees which had been pruned for two years in a row. In the second year trees, Nonpareil showed significant differences between all treatments for the circumference. Height of the Nonpareil trees pruned during leaf expansion was significantly smaller compared to the other two treatments. The Monterey and the Winters varieties showed no significant differences in circumferences for any treatment. Monterey variety was significantly shorter in the dormant pruning but this result is questionable because of the number of trees removed from the study due to wind and Verticillium wilt. This year's experiments showed that there may be a loss in growth for Nonpareil if the trees are pruned in spring when the leaves are expanding. If spring pruning is used to help avoid pathogens it is recommended to be done up to and including bud break but not later.

Methods:

Part 1 of the trial used Nonpareil, Monterey and Winters almond trees on Lovell rootstock in a Solano County commercial orchard planted March 19, 2010. The trees were pruned at three different times; dormant (Feb. 4, 2011), after leaf bud break (March 9, 2011), during leaf expansion (April 2, 2011). Replicated, randomized experimental design was used for each variety. Nonpareil had 8 replications per treatment with each plot containing 4 trees. Winters and Monterey had 5 reps. for spring pruning treatments and 4 reps. of the dormant pruned treatment. The pruning was performed in the same manner as the rest of the grower's orchard; three scaffolds were selected removing all other branches. Selected scaffolds were left unheaded.

Part 2 of the trial was a continuation of the 2010 pruning trial using the same trees and implementing the same treatments. This part of the experiment used 72 Nonpareil trees, planted in the winter of 2008/09, entering their third season in 2011 when pruned. Three pruning treatments with 6 replications of 4 trees each. The trees were pruned at three different times; dormant (Feb. 4, 2011), after leaf bud break (March 9, 2011), during leaf expansion (April 2, 2011). Pruning removed lower branches that were in the way of farm operations and one or two interior branches.

Circumferences were measured at 3 inches above the graft union in April and October. Height was measured in October.

Statistics on both years and all varieties were separately analyzed due to the lack of replication of varieties within multiple blocks. Analysis using ANOVA Type III and Duncan's multiple range tests were performed using SAS (GLM procedure).

Results and Discussion:

A number of two year old trees were hit by Verticillium wilt (*Verticillium dahlia)* and wind damage. Trees were removed from the trial if they showed severe signs of disease or had lost 2 or more scaffolds from wind damage. One tree of Monterey, 4 trees of Winters, and 4 trees of Nonpareil were removed from the trial on account of severe Verticillium wilt. Eighteen trees of Monterey and 3 trees of Nonpareil were taken out of the trial due to wind damage.

Second year trees
Table 1 shows the second year trees average measurements for circumference and height taken for each variety with the standard error.

In the Nonpareil variety ANOVA analysis showed no significant difference in the spring circumferences but there were significant differences found in both measurements taken in fall; circumference ($p < 0.0001$) and height ($p < 0.0211$). The trees pruned at leaf-expansion were significantly smaller in circumference and height from trees pruned dormant. Circumferences of the trees pruned at leaf-bud break were significantly smaller than the dormant pruned trees but their height showed no differences.

The results of the Monterey variety were compromised by wind damage and Verticillium wilt. The results from remaining undamaged trees show that the trees were unequal in circumference at the start of the trial with the dormant pruning having the smallest average. The circumference measured in the fall was not significantly different among the treatments. The average height of the dormant pruned trees was significantly smaller than the trees pruned at leaf-expansion. These results are questionable due to the number of trees removed from the experiment and should be repeated.

The Winters variety showed no significant differences between treatments for any measurement.

<u>Third year trees</u>

The pruning done on the trees entering their third year was minor compared to the previous year pruning. Only a little interior wood was taken out and the trees were skirted for ease of farm operations. No significant differences were found in any of measurements between treatments (**Table 2**)

Conclusions:

The third year Nonpareil trees did not show any significant differences in either year between pruning timings; dormant, leaf bud break, or leaf expansion. In the second year trees, Winters variety showed no differences between treatments. Nonpareil showed that the time of pruning affected the average growth. In the Nonpareil, pruning later in the spring reduced the final tree size. The conclusions are mixed. Weather may influence the tree growth from year to year. The size differences measured this year in Nonpareil may disappear in following years but caution should be used when delaying pruning. This study shows that in wet years it may be safe to delay pruning until leaf bud break but no later.

Table 1. 2011 Second year almond trees average growth measurements following three pruning treatments having different timings; dormant (2/4/11), leaf bud break (3/9/11), and leaf expansion(4/2/11) (± standard deviation). Letters indicate the significant differences between treatment means at the level p≤ 0.05 using Duncan's multiple range test.

	Circumference (cm) April 2011				**Circumference (cm) Oct 2011**				**Percent increase**	**Height (M) Oct 2011**			
Nonpareil													
'dormant'	12.57	±	0.14	a	25.04	±	0.22	a	99%	3.21	±	0.04	a
'leaf bud break'	12.30	±	0.12	a	24.34	±	0.21	b	98%	3.12	±	0.03	ab
'leaf expansion'	12.34	±	0.13	a	23.64	±	0.23	c	92%	3.08	±	0.03	b
Monterey*													
'dormant'	10.95	±	0.47	b	24.52	±	0.97	a	124%	2.66	±	0.10	b
'leaf bud break'	11.94	±	0.19	a	24.84	±	0.44	a	108%	2.74	±	0.05	ab
'leaf expansion'	12.14	±	0.20	a	24.84	±	0.35	a	105%	2.85	±	0.03	a
Winters													
'dormant'	12.11	±	0.18	a	24.07	±	0.39	a	99%	2.92	±	0.06	a
'leaf bud break'	11.92	±	0.21	a	24.72	±	0.32	a	107%	2.82	±	0.03	a
'leaf expansion'	12.23	±	0.17	a	24.33	±	0.23	a	99%	2.97	±	0.04	a

*Monterey variety had extensive wind breakage and Verticillium wilt. Results may not be reliable.

Table 2. 2011 Third year almond trees average growth measurements following three pruning treatments having different timings; dormant (2/4/11), leaf bud break(3/9/11), and leaf expansion(4/2/11) (± standard deviation). No significant differences were found between treatments.

	Circumference (cm) Oct 2011			Height (M) Oct 2011		
Pruning 'dormant'	35.78	±	0.42	4.37	±	0.05
Pruning 'leaf bud break'	36.90	±	0.27	4.39	±	0.06
Pruning 'leaf expansion'	36.57	±	0.35	4.43	±	0.07

3) Fertilizing One Year Old Almond Trees: Does Source of Nitrogen Matter?

Project Leader: David Doll, Farm Advisor, Merced County UCCE

Project Cooperator: Andrew Ray, Technician, Merced County UCCE

Objectives:

Growers have realized the benefits of fertilizer applications to one year old trees. These include increased vegetative growth, shorter time to first harvest, and larger crop loads on young trees. With this increased use of fertilizers for non-bearing trees, there are questions in regards to what source of nitrogen will provide the strongest growth response. Many growers consider the use of nitrate based fertilizers to be the best choice for young trees, but there is no data that suggests that the different nitrogen sources, which include urea, ammonium, and nitrate, have differing impacts on growth.

With the application of granular based fertilizers, there is also an interest in controlled release fertilizers for young trees. Since the root system is small and has a limited ability for nutrient uptake, slow release fertilizers may maintain nutrients within the establish rootzone of the tree longer than regular fertilizers. This may increase tree growth or cause a reduction in applied fertilizer due to an increase in nutrient use efficiency. These fertilizers are more expensive, and it is unknown if they are economical for young trees.

Methods:

This study was established in two newly planted orchards located on differing soil types in Merced County. Fertilizer applications included ammonium sulfate (AS), calcium nitrate (CaNO3), a 15-15-15 NPK blend created with urea (triple 15), and a controlled release 13-5-13 NPK blend created with a polymer coated urea (CR). One ounce of actual nitrogen was applied six times to each location from late April through mid-September. The slow release was applied three times, but with double the rate to ensure the same amount of nitrogen was applied. This was done to see if there could be a labor reduction in using slow release fertilizer types. At trial two, the treatments of potassium nitrate (KNO3) and a 50% calcium nitrate: 50% potassium nitrate blend (50/50) was added to determine if there was a benefit of providing both calcium and potassium to young trees. Leaves were sampled from treatments in late-July following standard protocol, and tissue nutrient concentration was determined by each tested elements standard operating procedure at the UC Davis analytical laboratory. Preliminary tree measurements were made before leaf-out, and final measurements were taken in December.

Results:

Trial one: The application of triple 15, AS, and the CR performed equally. Trees fertilized with the triple 15 blend were larger than trees fertilized with CaNO3 (**Figure 1**). Leaf nitrogen levels were higher in the triple 15, AS, and CR fertilizers than CaNO3. Potassium leaf levels were the highest in the triple 15 treatments. There was no difference in phosphorous levels. Micronutrient leaf concentrations varied by fertilizer treatment: CaNO3 had the highest percentage of calcium (**Figure 2**), AS had the highest concentration of zinc, CR had the highest concentration of boron, and CaNO3 had the lowest concentration of manganese (**Figure 2**). There were no treatment differences in leaf concentrations of magnesium, copper, iron, and sulfur (data not shown)

Trial two: Tree growth was the same for all fertilizers applied (**Figure 4**). Nitrogen and phosphorous levels were the same for all fertilizers applied (**Figure 5**). Potassium leaf levels were the highest in the triple 15, but were not statistically different than AS, KNO3, 50/50, and CR. Micronutrient leaf concentrations varied by fertilizer treatment: CaNO3 had the highest percentage of calcium (**Figure 5**), triple 15 and CR had the lowest concentration of zinc, and CaNO3, KNO3, and 50/50 had the lowest concentration of manganese (**Figure 6**). There were no treatment differences in leaf concentrations of magnesium, copper, iron, and sulfur (data not shown).

Tree growth at both trial locations was not affected by the reduced fertilizer frequency of using the CR in comparison to the other treatments (**Figures 1, 4**).

Discussion:

Tree growth response varied by trial location. In trial one, a sandy soil with low exchange capacity, the urea and ammonium based fertilizers outperformed the nitrate based fertilizer. This difference may be due to the observed increase in leaf nitrogen concentration, leaching of nitrate out of the rootzone (which would become unavailable to the plant), or the other nutrients within the fertilizer. In trial two, a sandy loam soil with a higher exchange capacity, no differences were found between nitrogen treatments. This lack of difference may be due to an increase in the holding capacity of the soil which would maintain more nitrogen within the rootzone since leaching is less likely to occur.

The various fertilizers affected the minerals concentrations detected within the leaves. Fertilizers that contained a specific mineral increased the concentration of that mineral within the leaf. The exception to this was phosphorous. Fertilizers containing phosphorous did not affect the leaf concentrations, which suggests that phosphorous may not be a limiting nutrient within the soil for first leaf almonds.

The economics of using controlled release fertilizers is still unclear. Although we did not see an increase in tree size, we were able to reduce the frequency of fertilizer applications. Assuming that it takes about 20 minutes to hand fertilize an acre, the use of a controlled release fertilizer saved an hour of time per acre within this study. This may compensate for the added costs. Future studies testing different controlled release fertilizers will be conducted to refine these findings.

Overall, there appears to be a slight benefit of using non-nitrate based fertilizers for young tree development. This supports the current University of California recommendation of using an NPK urea based blend for fertilizing young trees. Maintaining nitrogen within the rootzone of young trees may be more critical than fertilizer source, and studies are needed to determine proper timing and rates of applications to maximize tree growth.

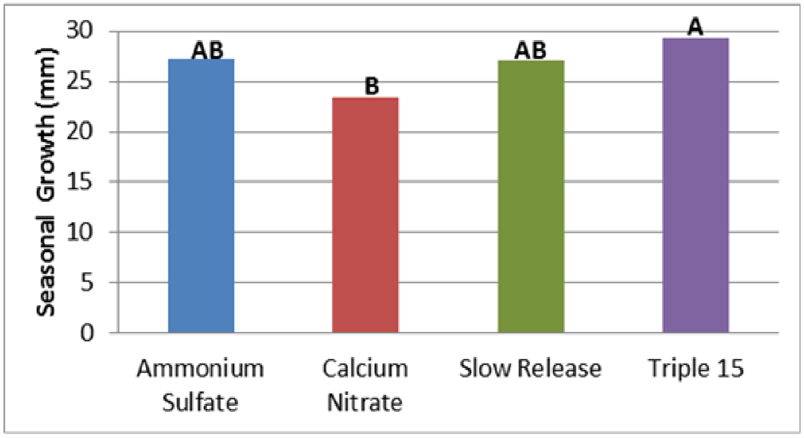

Figure 1: The effect of various fertilizers on seasonal growth of one year old almond trees planted in a sandy soil near Ballico, CA (Trial 1). Different letters indicate significance at p<0.05 using Tukey-Kramer range test.

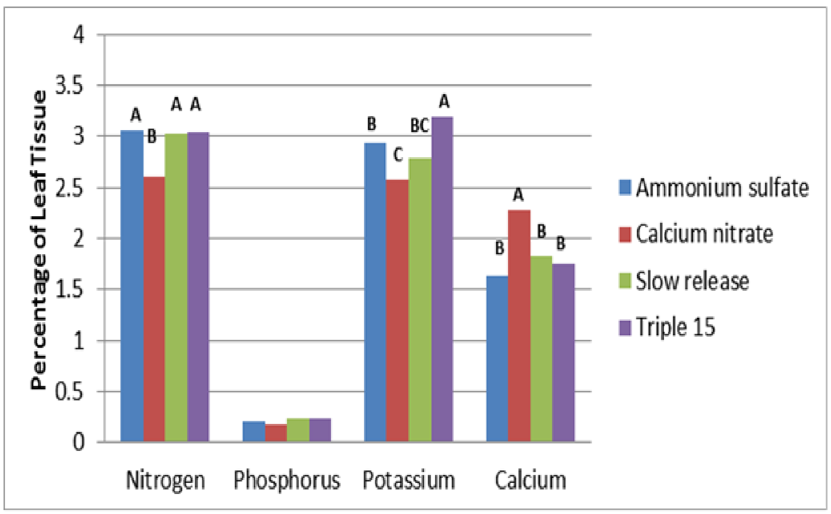

Figure 2: The effect of various fertilizers on the percentage of leaf tissue nutrient levels of three major and one minor elements within one year old almond trees planted in a sandy soil near Ballico, CA (Trial 1). Different letters indicate significance at p<0.05 using Tukey-Kramer range test.

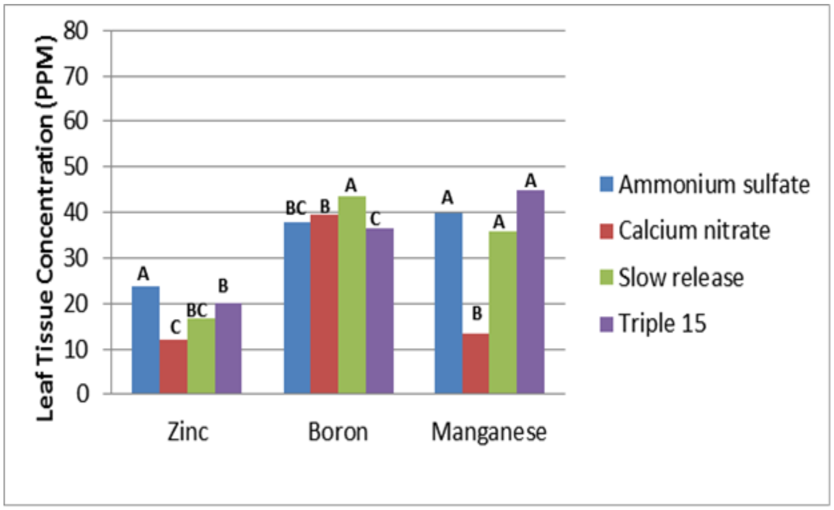

Figure 3: The effect of various fertilizers on the percentage of leaf tissue nutrient levels of three minor elements within one year old almond trees planted in a sandy soil near Ballico, CA (Trial 1). Different letters indicate significance at p<0.05 using Tukey-Kramer range test.

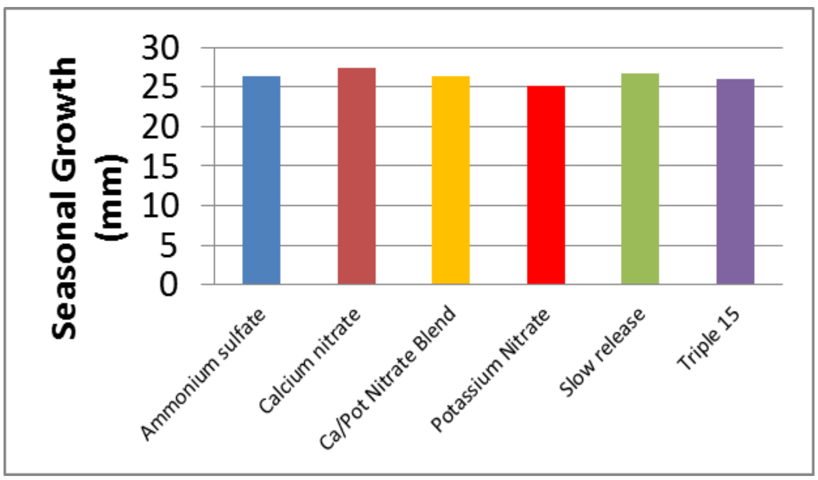

Figure 4: The effect of various fertilizers on seasonal growth of one year old almond trees planted in a sandy loam soil near Merced, CA (Trial 2).

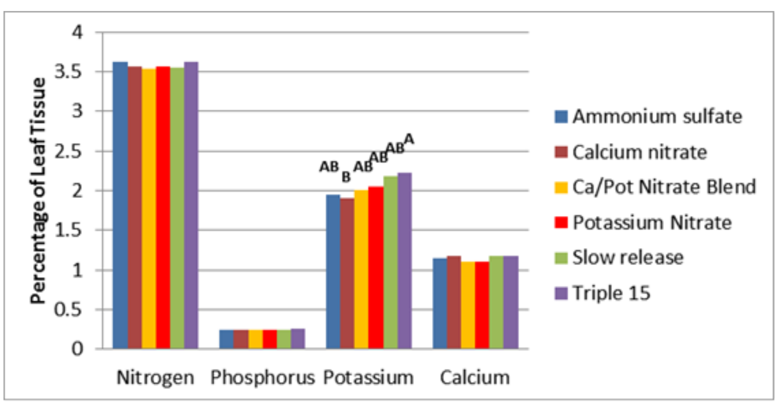

Figure 5: The effect of various fertilizers on the percentage of leaf tissue nutrient levels of three major and one minor element within one year old almond trees planted in a sandy loam soil near Merced, CA (Trial 2). Different letters indicate significance at p<0.05 using Tukey-Kramer range test.

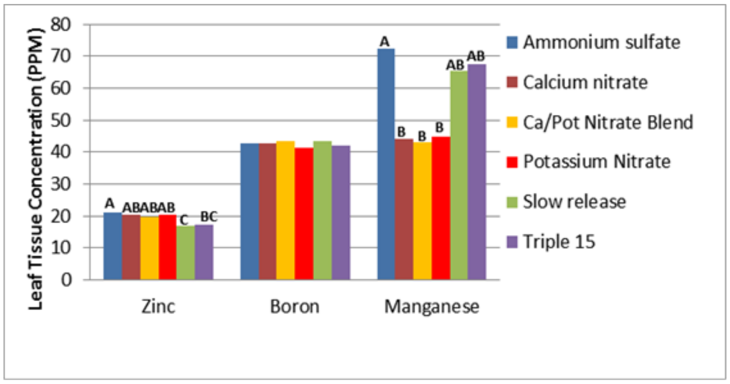

Figure 6: The effect of various fertilizers on the percentage of leaf tissue nutrient levels of three major and one minor element within one year old almond trees planted in a sandy loam soil near Merced, CA (Trial 2). Different letters indicate significance at $p<0.05$ using Tukey-Kramer range test.

4) 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. In 2010, a technique was developed to measure larval respiration rates in sand. In an experiment conducted in 2011, this technique was employed to determine the influence of soil moisture potential (Ψ_m) on larval respiration.

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 may be 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 adapted from soil microbiology protocols (Zibilski, 1994) to assess larval respiration rates in sand as a measure of larval activity. Larvae were incubated in sand at matric potentials (Ψ_m) ranging from 0 to $^-$20.0 kPa and larval respiration was assessed at each Ψ_m. Gravimetric soil water content was determined for each Ψ_m to determine the moisture content at which larval activity is suppressed in this system. Larval activity increased with decreasing Ψ_m values (ie. more dry), and larval activity was lowest under flooding conditions. These results suggest that soil water levels may be managed to suppress TLJB larval activity in orchards.

Materials and Methods:

Using hanging water columns, a 4:1 mixture of sand and soil (v/v) was equilibrated for 24 h at the following Ψ_m levels: 0 kPa, $^{-}$2.5 kPa, $^{-}$5.0 kPa, $^{-}$10.0 kPa, and $^{-}$20.0 kPa. After equilibration, subsamples of the sand/soil matrix were weighed and then incubated at 105^{o}C for 48 h to determine dry weights and estimate gravimetric water content for each experimental Ψ_m level. Sand/soil samples at each Ψ_m level were combined into a single plastic bag and homogenized before distribution into respiration chambers.

Larval respiration rates (CO_2 production) were assessed as a measurement of larval activity. Using 2L mason jars to serve as respiration chambers, 3st instar TLJB larvae were incubated for 24 h in sand/soil matrix equilibrated at the 5 Ψ_m levels, with 5 replicate mason jars per treatment. Within each respiration chamber, CO_2 gas evolved from both larvae and the 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 sand/soil matrix in the absence of larvae were included in the study.

A soil moisture release curve was generated to illustrate the relationship between Ψ_m and soil moisture content in the sand/soil matrix utilized in the study. Additionally, microbial respiration and larval respiration rates at each Ψ_m were individually determined by averaging the values from each replicate respiration chamber.

Results and Discussion:

Gravimetric soil moisture content in the sand:soil matrix ranged from 14.7% to 3.5% at saturation (0 kPa) and $^{-}$20.0 kPa, respectively (**Figure 1**). Soil microbial respiration was greatest at $^{-}$2.5 kPa Ψ_m, and declined at decreasing water potentials (data not shown). Larval respiration, however, was positively associated with declining Ψ_m, with higher larval activity observed under the driest conditions (ie. $^{-}$20.0 kPa) (**Figure 2**).

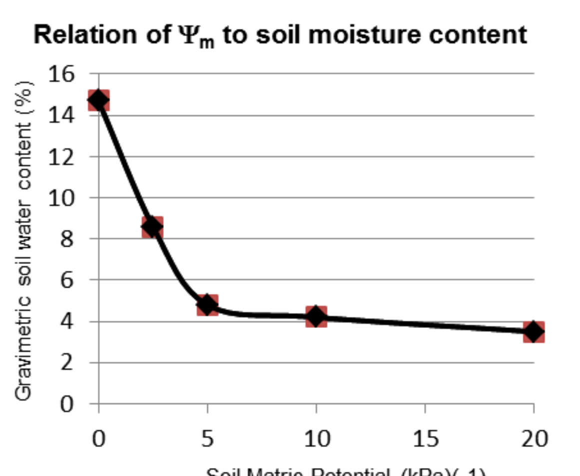

Figure 1

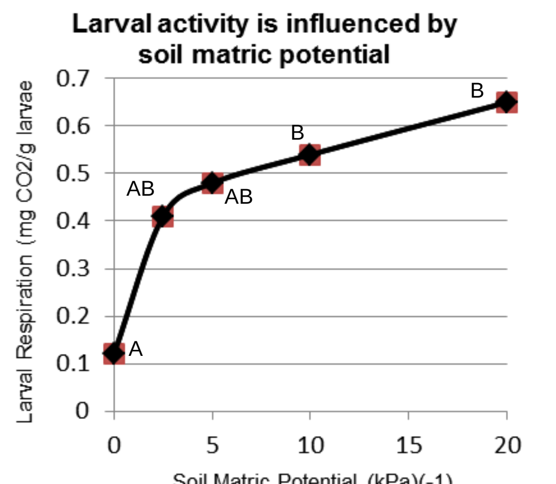

Figure 2

In the sand:soil matrix utilized in this system, soil moisture content remained relatively stable (~ 4%) between $^{-}5.0$ and $^{-}20$ kPa. In a sandy system, the soil matrix is composed of mostly large pores that drain under minimal pressure, hence the rapid decrease in soil moisture content at Ψ_m levels ranging from 0- $^{-}5.0$ kPa. Though soil moisture content decreased dramatically between $^{-}2.5$ kPa and $^{-}5.0$ kPa Ψ_m (8.6% and 3.5%, respectively) (**Figure 1**), there was no significant difference in larval respiration between these two Ψ_m levels. Conversely, microbial activity dropped 68% when Ψ_m was dropped from $^{-}2.5$ kPa to $^{-}5.0$ kPa (data not shown).

Larval activity varies in response to soil matric potential, with higher Ψ_m values (less negative) suppressing larval activity in soil. In this experimental system, the greatest suppression of larval activity was observed at 0 kPa Ψ_m, which represents flooded conditions. Prior studies have demonstrated that 2nd and 3rd instar larvae respire at similar rates per unit body mass; therefore, we infer that the trends observed with 3rd instar larvae in this study will similarly affect 2nd instar larvae. In the subsequent year, we plan to repeat this experiment and also observe the relationship between larval respiration and Ψ_m in different soil textural classes. But studying respiration in different soil textures, we can determine the soil moisture contents associated with suppressive Ψ_m levels in different soil types.

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

5) Increasing Almond Tree Boron Levels in Sutter County – How Long Can It Last?

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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, February 20-21, 2011, and February 22, 2012). Hull (25 count) samples were taken at harvest in 2009, 2010, and 2011.

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 harvest hull boron (2009, 2010 and 2011) 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 ($p \le 0.05$) for the 2010 and 2011 hull data.

Treatment	Hull Boron (ppm) 2009	Hull Boron (ppm) 2010	Hull Boron (ppm) 2011
Untreated	35 **41** 44	39 **50** 60 a	30 **37** 40 a
20 lb/acre Solubor® October, 2008	40 **65** 84	41 **59** 76 a	37 **46** 56 b
40 lb/acre Solubor® October, 2008	72 **104** 153	63 **108** 150 bc	46 **65** 80 c
20 lb/acre Solubor® May, 2009	47 **54** 61	55 **80** 100 ab	43 **48** 50 b
40 lb/acre Solubor® May, 2009	45 **59** 78	84 **114** 126 cd	53 **63** 69 c
50 lb/acre Granubor® May, 2009	60 **77** 94	120 **138** 166 d	68 **78** 92 d

Fall or spring applied boron fertilize increased hull boron for at least two years after application, but levels declined over time **(Table 2).**