Mechanical Hedging to Manage Mature Almond Orchards

Project No.: **14-HORT19-Lampinen**

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2014 Objectives:

- Objective 1. Measure impact of hedging treatments on midday stem water potential, midday canopy light interception and yield
- Objective 2. Analyze data from light bar data set to determine impacts of planting configurations on productivity

Interpretive Summary:

Density of California almond planting has been increasing in a linear fashion from about 80 trees per acre in the early 1980s to 112 trees per acre in 2012. 112 trees per acre correspond to a spacing of approximately 15 x 21 feet. However, when you consider that there are still many traditional planted orchards embedded in those statistics, the average new orchard is likely being planted at even higher densities than 15 x 21 feet. Although orchards at these close spacings tend to come into production earlier than those at more traditional spacings, there are often problems with lower canopy shading and difficulty with getting adequate sunlight to the orchard floor to dry the nuts at harvest as they mature. These likely results in increasing food safety risk suggesting there is a tradeoff between maximum production and food safety risk in almond. Recent recommendations from the author suggest that orchard photosynthetically active radiation interception at maturity should not be above 80%. This should still result in a yield potential of about 4000 kernel pounds per acre. This is substantially higher than the statewide average per acre yield of about 2500 kernel pounds per acre in 2012. This suggests that crowding related issues will continue to increase in the years ahead as average tree density continues to increase.

Preliminary light interception data showed light interception levels collected in July 2013 were just below 80% and that there were no significant differences across the orchard before treatments were imposed (**Table 2**). Simulated hedging was done over the winter of 2013-14 to predict impacts of the hedging treatments on yield. The actual levels of midday canopy light interception were greater than the predicted levels based on the simulated hedging. A likely cause for this is the sagging of limbs along the edge of the hedging cut.

There were no significant treatments impacts on midday stem water potential, perhaps due to the sagging of branches along the hedging cuts into the row leading to less of a loss of light interception than was predicted by the simulated hedging.

There were no significant treatment related impacts on water relations, overall yield or yield per unit light intercepted. Hedging did lead to increased center of row orchard floor temperatures which should result in decreased food safety risk and improved ability to dry nuts on the orchard floor. Based on the results of this study, it does not appear that hedging cuts of 28” to 48” were detrimental under the conditions of this study.

Higher density orchard plantings in and of themselves do not necessarily result in decreased long term yields compared to wider spacings. This is particularly true when you consider our current recommendations to not exceed 80% canopy light interception due to food safety concerns.

Materials and Methods:

A 13 year old almond orchard in Kern County was chosen for the hedging trial. The orchard has 50% Monterey, 25% Nonpareil and 25% Wood Colony and tree spacing is 24’ between rows and 21’ down the tree row. The orchard was hedged one time about 3 years previously to the initiation of the trial.

Preliminary measurements of midday canopy light interception and yield were done in the trial during the 2013 season before treatments were imposed.

The experiment was set up as a randomized complete block design with 12 replications of each of the four hedging treatments. The experiment is designed to be modified to have 6 replications of each of two different hedging regimes if that appears to be necessary later in the trial. Hedging treatments were imposed on December 10-11, 2013. The widths of hedging treatments were an unhedged control as well as 28”, 38”, and 48” hedging cuts. The hedging cuts were vertical and were imposed on all three varieties in each replication but yield data described above was only collected on the Nonpareil variety.

Weight of fresh prunings was collected by picking up all of the prunings in the row middles between 3 trees in the Monterey and Nonpareil as well as between the Wood Colony and Nonpareil.

Midday stem water potential was measured on one tree in each replication for all three treatments (total of 12 trees per treatment) approximately every two weeks during the 2014 season to assess if pruning treatments had an impact on midday stem water potential due to the changes in canopy light interception.

Midday canopy light interception was taken in the row middles on either side of the Nonpareil rows at 4 times during the 2014 season.

More light hitting the orchard floor at midday results in higher soil temperatures and these temperatures may help to mitigate food safety risk (Danyluk et.al, 2007). Soil surface temperatures in the middle of the drive row and under the tree row were measured with the mobile platform light bar. Light hitting the orchard floor is also important for drying the nuts after shaking.

The Nonpareil and Monterey yields were taken in the entire data row in all replications and subsamples were taken for drying and cracking out to adjust the rough field weights to kernel weights.

Based on regrowth of the hedged rows during mid-summer, we will decide on the hedging treatments to be imposed in the winter of 2016.

Results and Discussion:

<u>2013 Preliminary</u>
An earlier study in Fresno County showed that hedging had a direct negative impact of yield and the yield loss was in line with our light bar data set (i.e. 50 kernels pounds per one percent light interception decrease; **Table 1**). It should be noted here that this trial's orchard was producing right at our optimal 50 kernel pounds per 1% PAR intercepted level.

Light interception data and yield data were collected before treatments were imposed in July 2013. There were no significant differences in midday canopy light interception, yield or yield per unit light intercepted in July 2013 (**Table 2**). This suggests that the blocking was set up such that the experimental layout should allow a good test of the treatment impacts.

Using the positional information from the mobile platform light bar collected in July 2013, we ran a simulation of how much canopy would be taken off with the 3 different hedging regimes in the current study and then predicted light interception and yield loss associated with these regimes. These data are shown in **Table 2**. The predictions were for a 9, 13 and 17% yield loss for the 28, 38 and 48" hedging regimes respectively.

<u>2014</u>
Objective 1. The prunings in the unhedged treatment were due to the grower's crew removing limbs that impeded tractor traffic or herbicide spraying in the orchard. As expected, the fresh weight of prunings increased with increasing severity of hedging. The increase in weight of fresh prunings was linearly related to the width of the hedging cut (**Figure 1**).

The loss of midday canopy light interception by the hedging treatments was significant for the 38" and 48" hedging treatments (**Table 3**) but was less than predicted by the simulated hedging (**Table 2**). This was likely because branches along the hedging cut tended to bend down into the drive row which made the loss in light interception less than would be predicted as the crop weighted the branches down (**Photo 1**). **Figure 2** shows the midday canopy PAR interception measured with the mobile platform light bar on 4 dates in the 2014 season.

Yield in the orchard overall (**Table 3**) was significantly less than our predicted yields based on the 2013 light and yield data (**Table 2**). Although we hypothesized that the increased light distribution down through the canopy with hedging might result in

Photo 1. Images taken from a GoPro camera mounted on the front of the mobile platform lightbar in July 2014. Photos show hedging treatments of (a) 0", (b) 28", (c) 38" and (d) 48".

larger nuts, the hedging treatments did not appear to have a significant effect on nut size distribution (**Figure 3**).

Since the yield per unit PAR intercepted were in the 30 range in 2013 (**Table 3**), we predicted levels above 50 in 2014 but this did not occur (levels were again in the range of 30). This may have been related to the fairly extreme level of stress seen early in the 2014 season due to drought related water limitations imposed by the grower (**Figure 4**). These levels of midday stem water potential below -15 bars in early April are very unusual and could likely have led to yield limitations due to abortion of nutlets. As the season progressed, the midday stem water potentials tended to run closer to the baseline on most dates since the grower was able to allocate more water to the plots. There were no significant impacts of hedging treatments on midday stem water potential for any of the varieties on any date (**Figure 4**). There was however a significant difference among varieties (Monterey was more stressed) on the last sampling date, likely because Monterey had not been shaken yet (many leaves are lost during shaking and trees often recover in water potential).

Although there was a trend towards lower yields with hedging for the Nonpareil, there were no significant treatment effects on either yield or yield per unit PAR intercepted (**Table 3**). However, interestingly, for the Monterey there was a significant increase in the yield for the 48" hedge treatment compared to the unhedged control (**Table 3**). This may because the Nonpareil tended to be taller and hence the hedging led to more light striking the shorter Monterey. When yield and PAR data are summed for both varieties, there are no significant treatment differences (**Table 3**).

Soil surface temperature data from the mobile platform showed that the hedging treatments led to an increase in the center of row soil surface temperature. This is desirable from a nut drying and food safety perspective. **Figure 5** shows a transect of soil surface temperature along a 50 meter (164 foot) long section of one replication of each treatment. Note that the temperatures for the 48" hedged section (red line in **Figure 5**) is consistently up in the 60-65°C range while the temperatures for the unhedged control (green line) range from 30-65°C. We know from previous work on food safety that the cooler orchard floor temperatures are associated with higher food safety risk (Danyluk et.al, 2007). **Figure 6** shows the average center of row soil surface for all of the replications of all treatments on two dates during the 2014 season. It is clear that decreasing midday canopy PAR interception leads to increased center of row soil surface temperature. For the 07/09/14 date, there was a 17°C drop in center of drive row temperature as canopy cover increased from 60 to 80% (**Figure 6**).

Objective 2. This objective aimed to analyze data from the mobile platform light bar to investigate the relationship between planting density (trees/acre) and productivity. The purpose is to see if planting at higher densities leads to less production per unit light intercepted due to the hedging.

Figure 7 shows the relationship between planting density (expressed as trees per acre) and the productivity per unit light intercepted. For the overall data set, there does not seem to be a relationship. This is likely because even though higher density planting result in stimulation of vegetative growth in response to the hedging, this response is not particularly strong since the orchard is planted at high density and hence limited amounts of light are available to promote excessive vegetative growth.

Figure 8 shows the relationship between planting density and yield expressed as kernel pounds per acre. There does appear to be a slight increase in yield with increasing tree density. The average yield per acre for the orchards in our light bar study is higher than the state average. This is likely due to the selection of orchards in the study generally being younger orchards at higher density plantings. Our research tends to study in orchards with average trees per acre higher than the statewide average of about 112 trees per acre.

Some of the explanation for the large variability in yield for a given density of planting is variability due to different varieties (see annual report for Development and Testing of a Mobile Platform for Measuring Canopy Light Interception and Water Stress in Almond; 14-HORT14-Lampinen) for light bar project for details). Another major factor is likely water management-related but we do not have data on this for the majority of orchards in the study. The exception to this is the three water production function orchards. For details on this, see the Almond Water Production Function project annual report (14-HORT17-Shackel).

Preliminary Conclusions:

The actual loss in midday canopy light interception due to the hedging (2014 data in **Table 2**) was less than predicted from the simulated hedging (second column of **Table 3**). This may be because the branches in the row middle on the hedged treatment trees tended to sag down (and regrow) into the open space left by the hedging. There were no significant treatments impacts on midday stem water potential, perhaps due to the sagging of branches along the hedging cuts into the row leading to less of a loss of light interception than was predicted by the simulated hedging.

There were no significant treatment related impacts on water relations, overall yield or yield per unit light intercepted. However, hedging did lead to increased center of row orchard floor temperatures which should result in decreased food safety risk and improved ability to dry nuts on the orchard floor. Based on the results of this study, it does not appear that hedging cuts of 28” to 48” were detrimental under the conditions of this study and may be beneficial in reducing food safety risk and improving ability to dry nuts on the orchard floor at the time of harvest.

It does not look like higher density tree spacings in and of themselves necessarily result in decreased long term yields. This is particularly true when you consider our current recommendations to not exceed 80% canopy light interception due to food safety concerns.

References cited:

Danyluk, M.D., M. Nozawa-Inoue, K.R. Hristova, K.M. Scow, B. Lampinen, and L.J. Harris. 2007. Survival and growth of *Salmonella* Enteritidis PT 30 in almond orchard soils. J. Appl. Microbiol. 104: 1391-1399

Lampinen, B., G. Browne, S. Upadhyaya, V. Udompetaikul, D. Slaughter, S. Metcalf, R. Duncan, J. Edstrom, B. Holtz, B. Krueger, and F. Niederholzer. 2011. Development and testing of a mobile platform for measuring canopy light interception and water stress in almonds. Almond Board of California Annual Project Report 2010-2011. pp. 1-11.

Acknowledgements:

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Tables:

Table 1. Photosynthetically active radiation (PAR) interception before and after hedging treatments were imposed in earlier hedging trial in Fresno County. Yield is from the harvest for the season that hedging was imposed. Yield per unit PAR intercepted is the yield divided by the PAR after hedging. A value of 50 indicates good production based on our light bar study. Tree spacing in this orchard was 12’ x 24’ (151 trees per acre).

Treatment	PAR before treatment	PAR after treatment	Yield (kernel lbs/ac)	Yield/PAR
Unhedged	82.7 a	89.0 a	4505 a	50.6 a
6’ hedge	82.5 a	88.4 a	4472 a	50.6 a
8’ hedge	79.4 a	84.6 a	4334 a	51.2 a

Table 2. Simulation of loss in photosynthetically active radiation (PAR) interception and predicted yield for 2014 season for current hedging trial. 2014 yield estimate is based on 8.7 lower than optimum yield per unit PAR intercepted in 2013 becoming an 8.7 percent increase from optimum in 2014 as well as using predicted PAR interception based on hedging cut width. For unhedged example predicted yield = ((78.8 x 50) x 1.087).

Treatment	2013 Midday PAR int. (%)	Predicted PAR int. for 2014	Predicted yield in 2014 (kernel lb/ac)	Predicted percent loss in yield
Unhedged	78.8 a	78.8	4283	0
28” hedge	78.9 a	71.6	3891	9
38” hedge	78.1 a	68.3	3712	13
48” hedge	77.5 a	65.2	3544	17

Table 3. Midday canopy photosynthetically active radiation (PAR) interception, kernel pounds per acre yield, and yield per unit PAR intercepted for current trial before treatments were imposed in 2013 and after one year of treatment imposition in 2014.

Treatment	2013 PAR interception (%)	2013 yield (kernel lbs/ac)	2013 yield per unit PAR intercepted	2014 PAR interception (%)	2014 yield (kernel lbs/ac)	2014 yield per unit PAR intercepted
Nonpareil						
No hedge	78.8 a	3226 a	40.9 a	76.7 a	2414 a	31.6 a
28" hedge	78.9 a	3178 a	40.3 a	74.9 ab	2274 a	30.6 a
38" hedge	78.1 a	3351 a	42.9 a	73.5 b	2287 a	31.2 a
48" hedge	77.5 a	3192 a	41.2 a	72.9 b	2337 a	32.1 a
Monterey						
No hedge				72.7 a	2277 b	31.3 b
28" hedge				71.0 ab	2457 ab	34.7 a
38" hedge				71.2 ab	2408 ab	33.8 ab
48" hedge				70.5 b	2526 a	35.8 a
Both varieties combined						
No hedge				72.0 a	2346 a	31.4 a
28" hedge				70.5 ab	2369 a	32.7 a
38" hedge				69.9 ab	2347 a	32.5 a
48" hedge				69.1 b	2432 a	34.0 a

Figures:

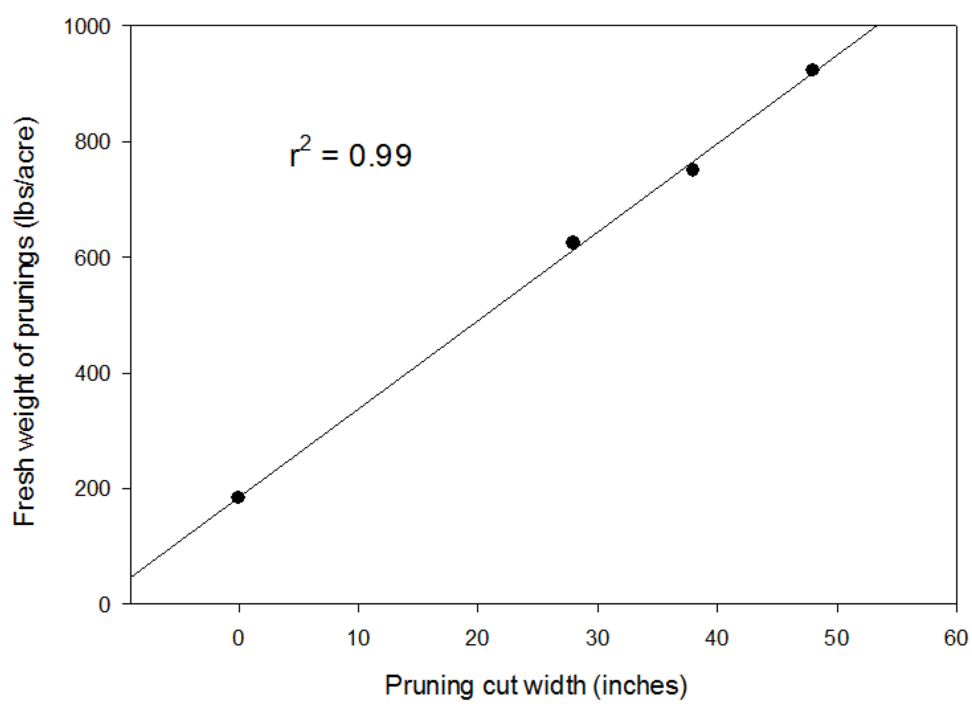

Figure 1. Pruning cut width versus fresh weight of prunings.

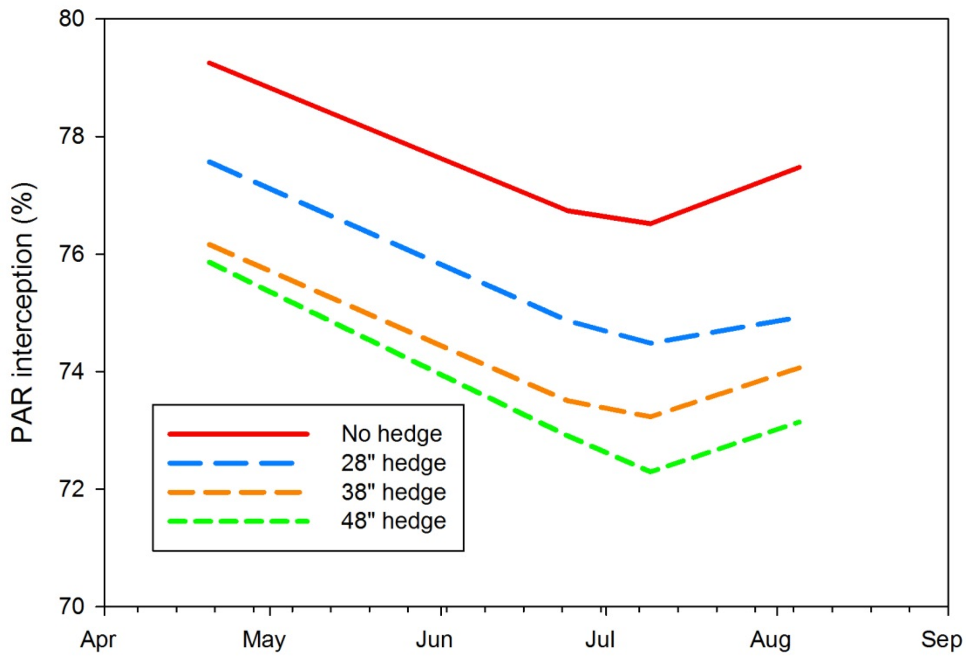

Figure 2. Midday canopy photosynthetically active radiation (PAR) interception over the 2014 season by hedging treatment.

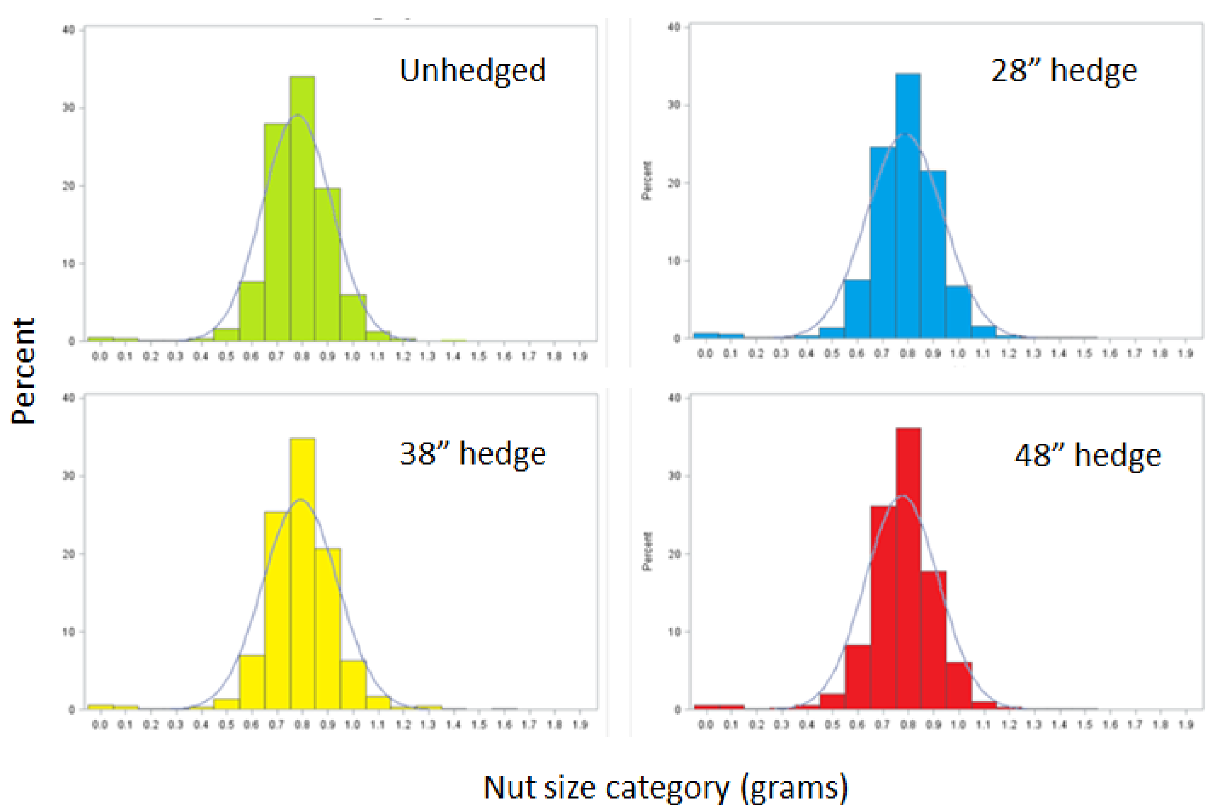

Figure 3. Nut size distribution for 200 nut sample from each replication for the 2014 harvest. There were no significant treatment differences.

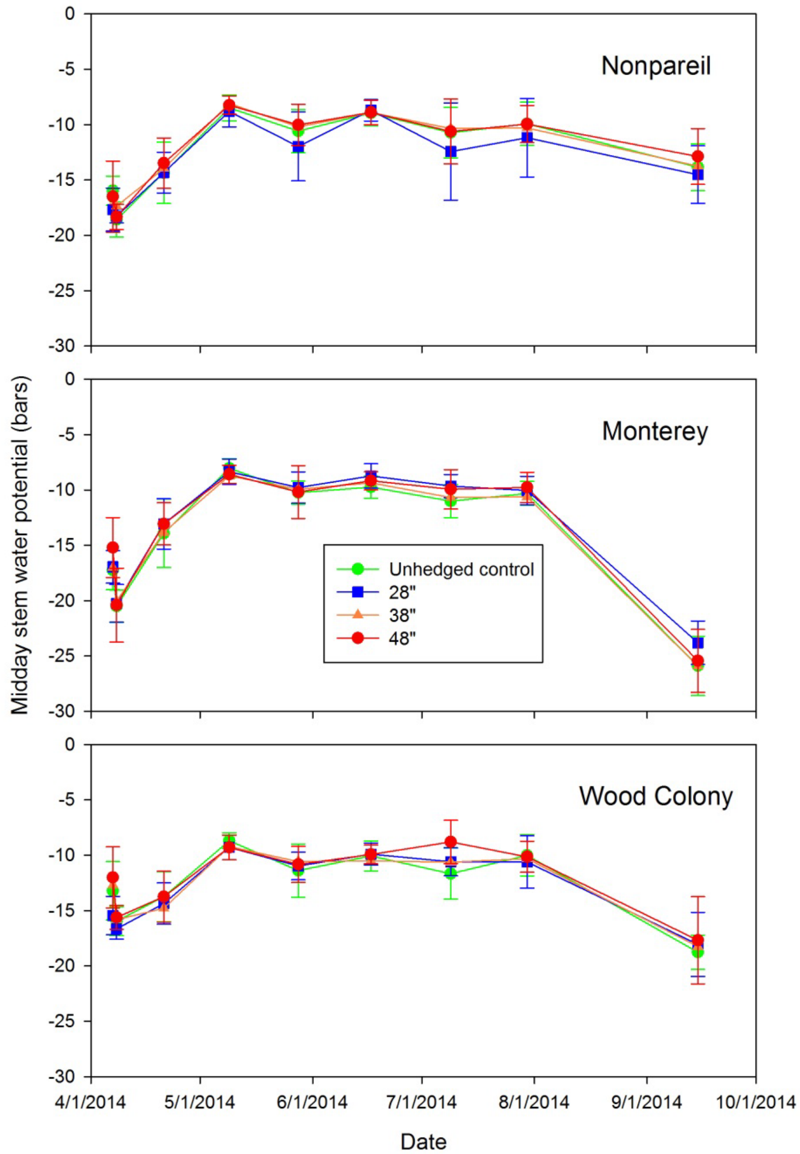

Figure 4. Midday stem water potential by hedging treatment over the 2014 season for Nonpareil (top), Monterey (middle) and Wood Colony (bottom). There were no significant differences among treatments on any date. Monterey was significantly more stressed compared to Nonpareil and Wood Colony on the last sampling date likely because it had not yet been shaken (many leaves are lost with shaking).

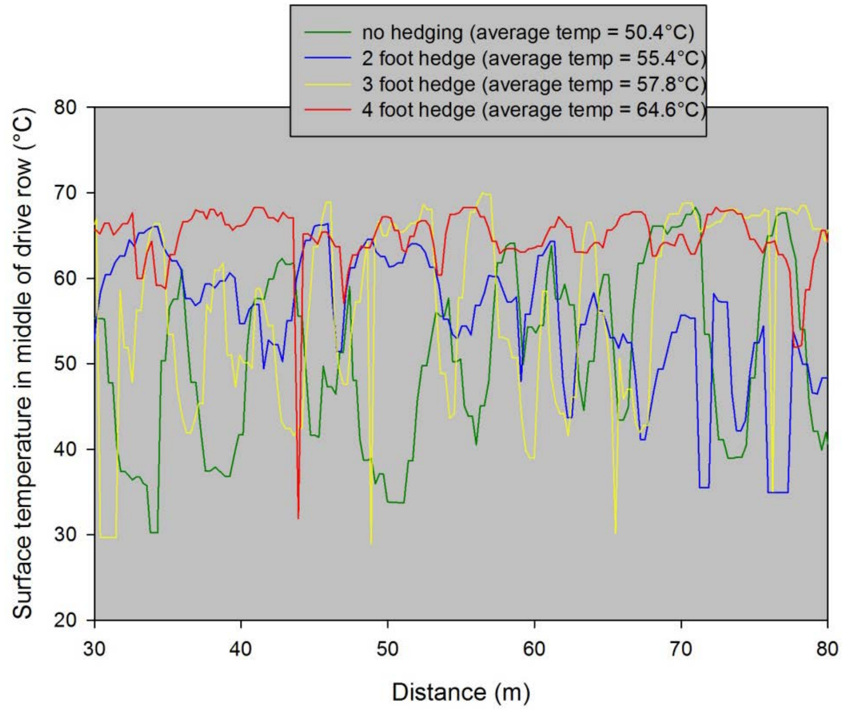

Figure 5. Soil surface temperature in the middle of the drive row at midday on July 11, 2014 by hedging treatment. 30°C is equal to 86°F and 70°C is equivalent to 158°F.

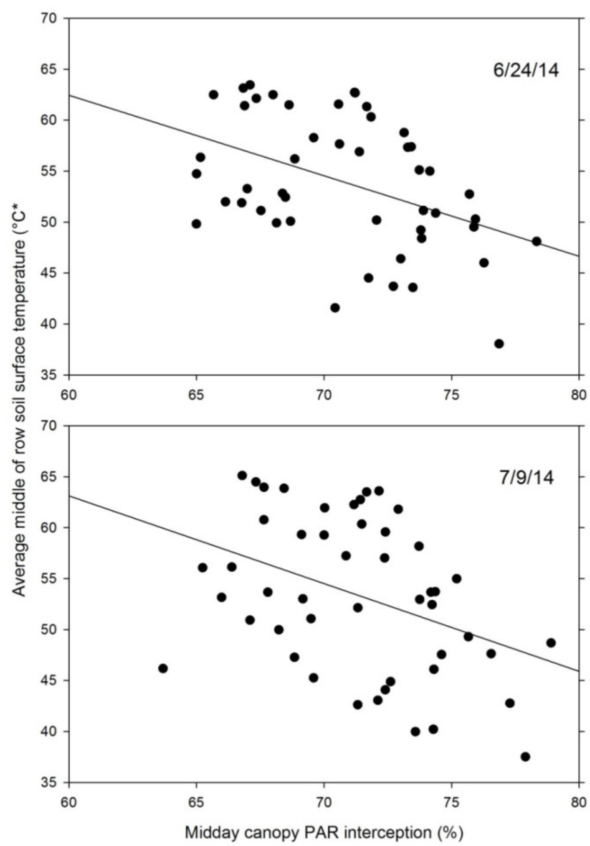

Figure 6. Midday canopy photosynthetically active radiation (PAR) interception versus soil surface temperature on two dates in 2014. Values are the average overall PAR interception and center of row soil surface temperature for an approximately 164 foot long section of each plot.

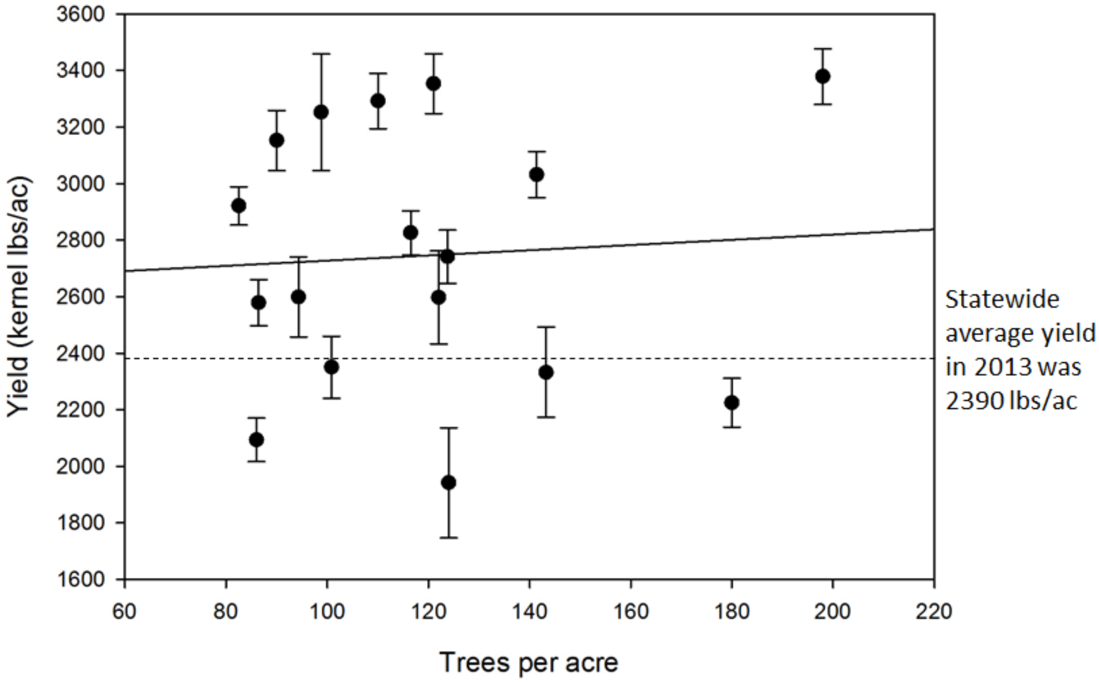

Figure 7. Trees per acre versus yield per unit PAR intercepted for 5 years of mobile platform light bar data.

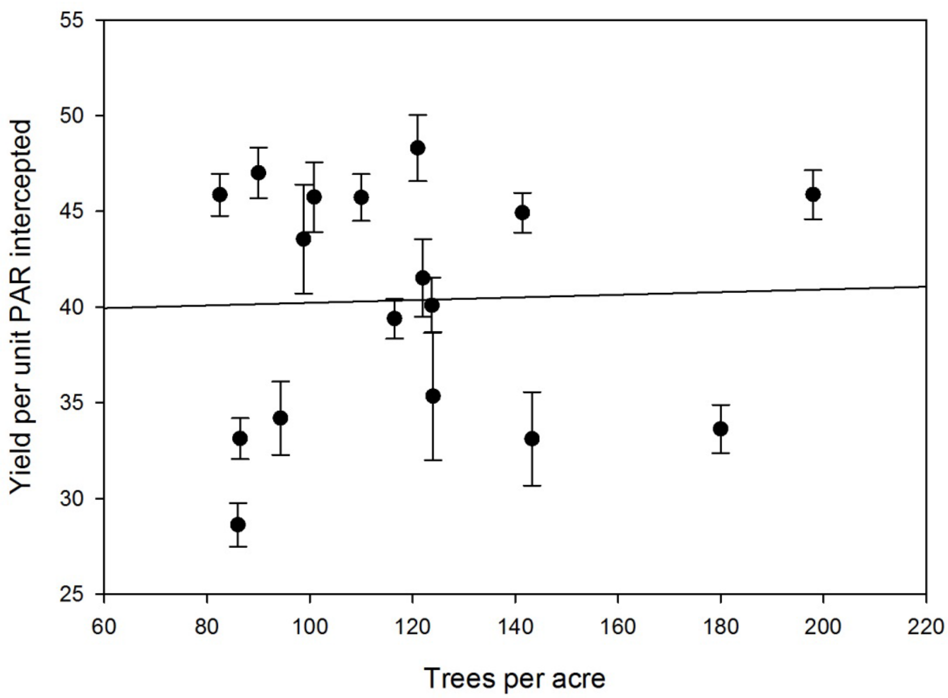

Figure 8. Trees per acre versus yield for data 5 years of mobile platform light bar data. Solid line indicates regression through all data and dashed line shows statewide average almond yield in 2013. Statewide average density is 112 trees per acre.