Integration of Tree Spacing, Pruning and Rootstock Selection for Efficient Almond Production

Project No.: **13-HORT5-Duncan**

Project Leader: Roger Duncan
3800 Cornucopia Way, #A
Modesto, CA 95358
209.585.6800
raduncan@ucdavis.edu

Cooperating Personnel: Bruce Lampinen, Department of Plant Sciences, UC Davis

Objective:

To evaluate the interactive effects of planting density, rootstock and training / pruning techniques on tree size, structural integrity, short-term and long-term yield, and orchard longevity.

Interpretive Summary:

- After fourteen years, much of the story remains the same. Annual pruning has not increased or maintained yield in this trial. In general, the more trees have been pruned, the lower the cumulative yields have been. Cumulative yield in untrained and unpruned Nonpareil and Carmel trees are 1,378 and 3,304 kernel pounds per acre greater than annually pruned trees, respectively, through the fourteenth leaf. Annual pruning has not improved light interception within the canopy as measured by a PAR meter. Annually pruned and unpruned trees both reached their maximum light interception during years 10–12 and are now beginning to decline. Annually pruned trees appear to be declining a little faster than unpruned trees.

- Not pruning could have conservatively saved over $7,000 per acre so far compared to annual pruning when considering lost yield as well as the cost of pruning, stacking and shredding the brush every year.

- Light interception appears to be declining earliest and fastest in the most widely spaced trees. In general, the closer that trees are planted, the greater the short term and long term yields.

- So far there has been absolutely no downside to planting trees ten feet apart, even on the very vigorous Hansen rootstock. They have yielded more (especially the smaller Carmel variety), are smaller, have incurred less shaker damage, have had fewer broken scaffolds, have had far fewer replants, have fewer mummies per acre, have reduced the need to hedge down the middle to improve drying at harvest and will probably have the longest productive life.

Problem and its Significance:

It is generally desirable for almond trees to fill the space in an orchard as quickly as possible. This enables growers to bring an orchard into full production sooner and thus maximize early profits. However, after full canopy has been achieved, trees continue to grow, which may result in crowding, shade-out of lower fruiting wood and prematurely declining yields.

One could expect a significant interaction between tree spacing, pruning and rootstock. It is therefore important to examine these three farming practices in one, integrated trial. Past field trials have shown that almond trees may not require much pruning to maintain high yields. In experiments conducted by Edstrom et al., minimally pruned almond trees have had yields equal to or greater than annually pruned trees for many years – maybe the entire life of the orchard. However, trials conducted in the Sacramento Valley are under different growing conditions than in the San Joaquin Valley. Therefore, many growers in the San Joaquin Valley feel that information obtained in these northern trials may not apply to vigorous San Joaquin Valley growing conditions.

Minimal pruning of almond trees is gaining in popularity. We have established in this trial that unpruned almond trees will produce as well or better than almond trees that are annually pruned in a "conventional manner", at least for the first fourteen years. However, it is important to continue with this trial to document the long term effects of minimum pruning of almond trees.

Materials and Methods:

In the fall of 1999, a commercial almond orchard with cultivars (cvs.) 'Nonpareil', 'Carmel', and 'Sonora' was planted on virgin soil on the east side of Stanislaus County. The 37–acre field experiment was arranged in a multi-factorial design with four replications of each treatment for a total of 384 plots. There are six trees per plot. Trees on Nemaguard, Lovell or Hansen 536 rootstocks were planted at four different in-row spacings: 22 feet, 18 feet, 14 feet or 10 feet down the row. A between-row spacing of 22' was maintained constant throughout the trial. Beginning at the first dormant period, four training and pruning strategies have been employed in this trial. They are:

- "Standard" training; "standard" annual pruning. Three permanent scaffold limbs were selected during the first dormant pruning. These trees have been "moderately" pruned annually to keep centers open and eliminate crossing branches.
- Minimal training & pruning. Trees were topped twice during the first growing season to stimulate secondary branching. At the first dormant pruning, five to six permanent scaffolds were selected to maintain a full canopy with a minimally open center. These trees are pruned annually by removing a maximum of three limbs on each tree.
- "Standard" training and pruning for the first two years, then no pruning. These trees were pruned the same as in Treatment 1 above for the first two years. Other than

occasionally removing branches interfering with farming practices, these trees have not been pruned in twelve years.
- Untrained, Unpruned. No scaffold selection was made during the initial training of these trees except to remove limbs originating too low on the trunk. These trees are not pruned except to remove limbs that become problematic for cultural operations.

Professional pruning crews are hired specifically to prune this trial. Yields are calculated by harvesting nuts into nut buggies with built-in scales. Subsamples are collected from each plot and analyzed for kernel size and quality. Trees are inspected periodically throughout the growing season for other treatment effects such as disease incidence, mummies, etc.

Results and Conclusions:

- In general, annual light interception data indicate that maximum light interception in this orchard occurred from the tenth through the twelfth leaf and is now beginning to decline (**Figures 1 & 2**). These data are very similar to other data obtained in almond orchards throughout California.
- Annual pruning did not change the light interception dynamics of the orchard (**Figure 1**). Trees that have been pruned every year reached their peak light interception the same year as unpruned trees, but at a slightly lower level (about 2% - 3% less interception in annually pruned trees, representing a loss of 100 – 150 lb/acre of yield potential). Decline in light interception occurred the same year as unpruned trees, but the decline in pruned trees may be happening a little faster.
- Light interception seems to be declining earliest and fastest in the most widely spaced trees (22' x 22') and appears to be maintaining longer and at a higher level in the trees spaced 10 and 14 feet apart. The reason for this is unclear but may be related to more shaker injury and more replants in widely spaced trees.

Pruning
- In 2013, Nonpareil and Carmel yield was similar in all pruning treatments (**Table 1**).
- In most years Nonpareil yields are statistically similar in conventionally pruned, minimally pruned and unpruned trees. Cumulatively, unpruned Nonpareil trees have yielded just 1378 pounds more than conventionally trained & pruned trees through the 14th leaf.
- In most years, Carmel yields are highest in the untrained and unpruned trees. Cumulatively, untrained & unpruned Carmel trees have yielded 3304 pounds more than conventionally pruned trees.
- Conservatively, the cost of pruning, stacking brush and shredding every year, plus the value of lost yield would have cost the grower over $7,000 per acre to date.
- It does not appear that pruning leads to better nut removal at harvest (see 12-HORT5-Duncan*).
- Trees trained to multiple scaffolds are more prone to scaffold failure and tree blow over (young trees), especially in widely spaced trees.
- Pruning has not affected kernel size.

- It appears that pruning may not be necessary to improve or maintain almond yield, at least through the first half of an orchard's life.

Spacing

- In 2013, Nonpareil yield was the lowest in the widest tree spacing (22' x 22') while Carmel yield was similar at all spacings (**Table 1**).
- Cumulative yield for the Nonpareil variety is similar at all tree spacings, especially on the vigorous Hansen rootstock (**Figure 3**).
- Cumulative yield for the smaller Carmel variety is directly correlated to tree spacing – the closer the trees were planted, the higher the yield (**Figure 4**).
- Closely planted trees are smaller than widely spaced trees. As a result, more closely planted trees are easier to harvest, resulting in less shaker injury and fewer mummies per acre than widely spaced trees.
- Approximately three times as many trees have been replaced in the widest spacing (22' x 22') compared to the closest spacing (10' x 22') (**Figure 5**) resulting in more than six times more lost canopy (44,528 ft2 vs. 7,260 ft2) in the orchard (**Table 2**).
- This may mean that higher density orchards will be productive longer than low density orchards, a hypothesis counter to current assumptions.
- Currently we have not measured any disadvantage at all to closely planted trees, even Nonpareil on Hansen rootstock planted ten feet apart.

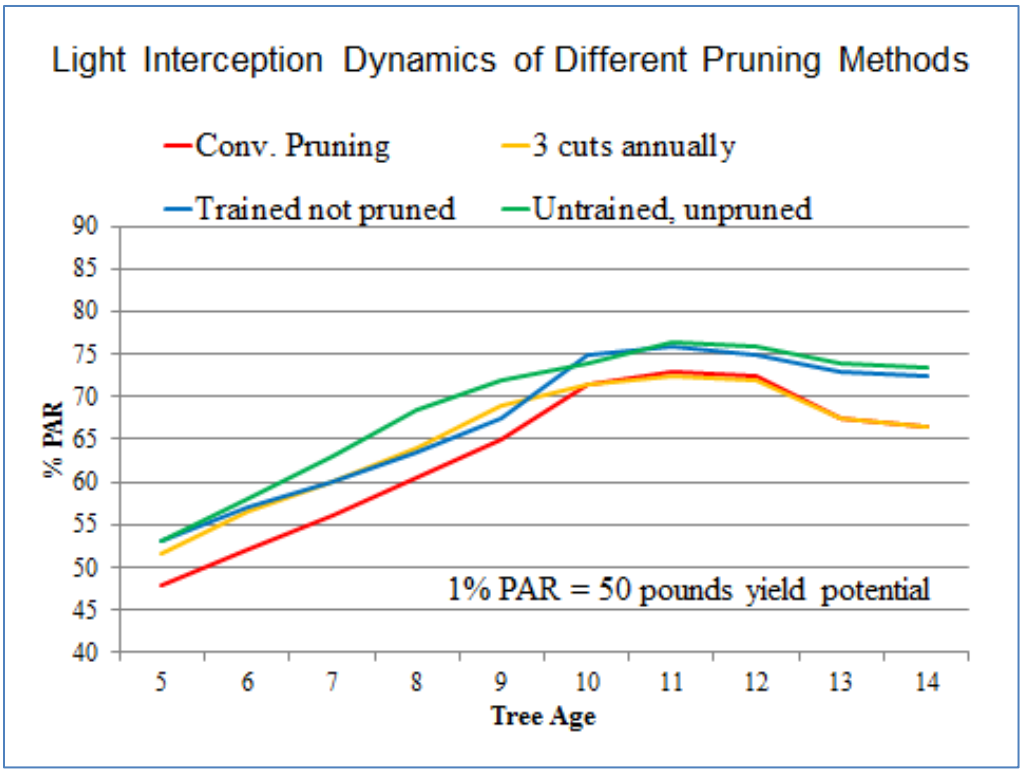

Figure 1. Light Interception Dynamics of Different Pruning Methods. Annual Light interception data indicates that the maximum light interception occurred from the tenth to twelfth leaf. Annual pruning did not change the light interception dynamics of the orchard.

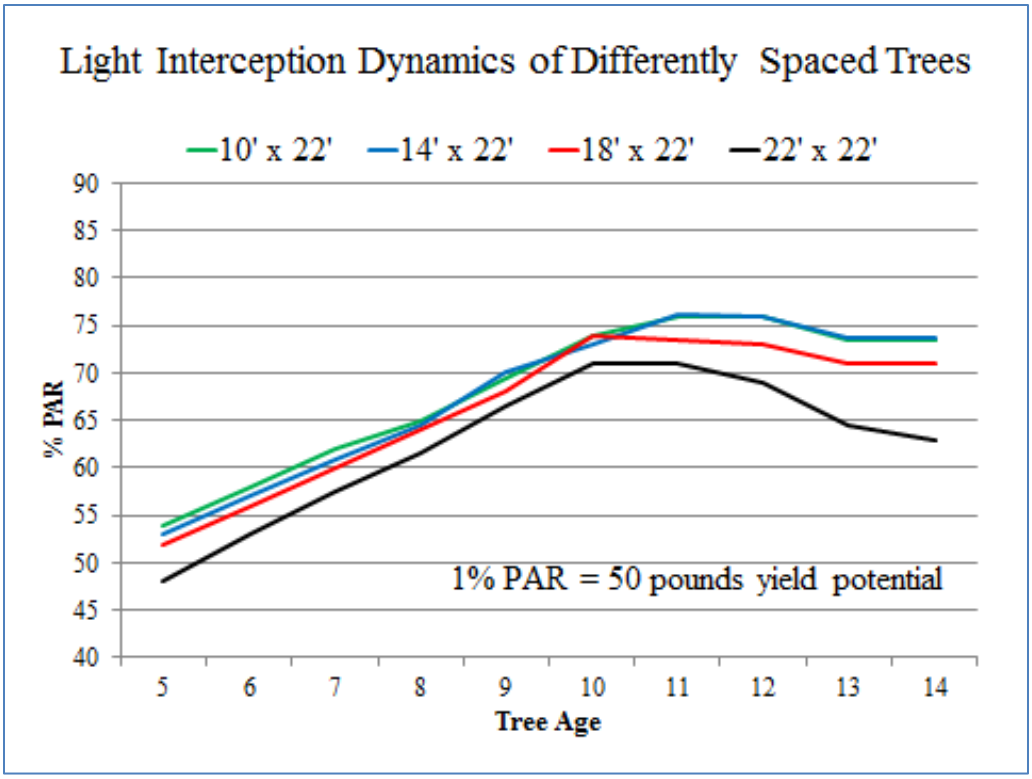

Figure 2. Light Interception Dynamics of Differently Spaced Trees. In general, annual light interception data indicates that the maximum light interception occurred from the tenth to twelfth leaf.

Table 1. The Effect of Pruning, Tree Spacing and Rootstock on Current (2013) and Cumulative (Through 14th leaf) Yield (lb. per acre)

	Nonpareil		Carmel	
	2013	Cumulative	2013	Cumulative
Training & Pruning				
Trained to 3 scaffolds; annual conventional pruning	2908 a	32,246	1995 a	27,615
Trained to 3 scaffolds; unpruned since 2nd leaf	2811 a	33,481	2029 a	29,564
Trained to multiple scaffolds; Three pruning cuts each year	2812 a	31,581	2127 a	29,207
No scaffold selection; No annual pruning	2942 a	33,624	2083 a	30,919
Tree Spacing				
10' x 22'	2922 a	32,793	2129 a	30,453
14' x 22'	2992 a	33,392	2153 a	30,387
18' x 22'	2876 a	33,004	2048 a	28,924
22' x 22'	2683 b	31,742	1905 a	27,542
Rootstock				
Hansen	3131 a	32,665	1945 a	27,086
Nemaguard	2605 b	32,800	2172 a	31,566

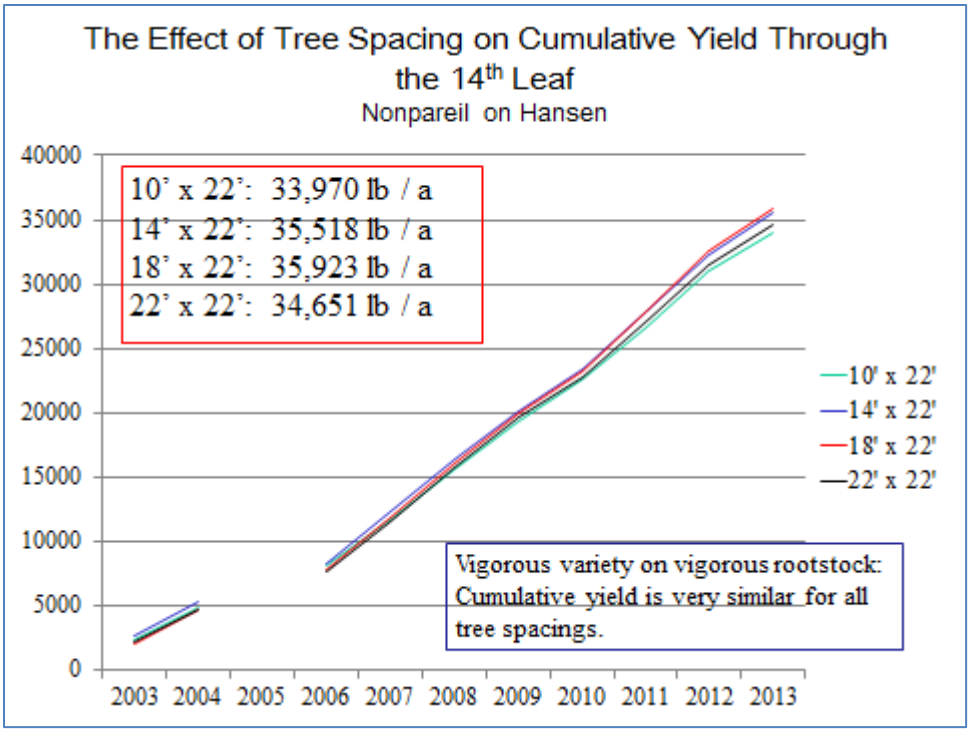

Figure 3. Indicates that there has been no significant cumulative yield difference among tree planting densities for Nonpareil on the vigorous Hansen hybrid rootstock through the 14th leaf.

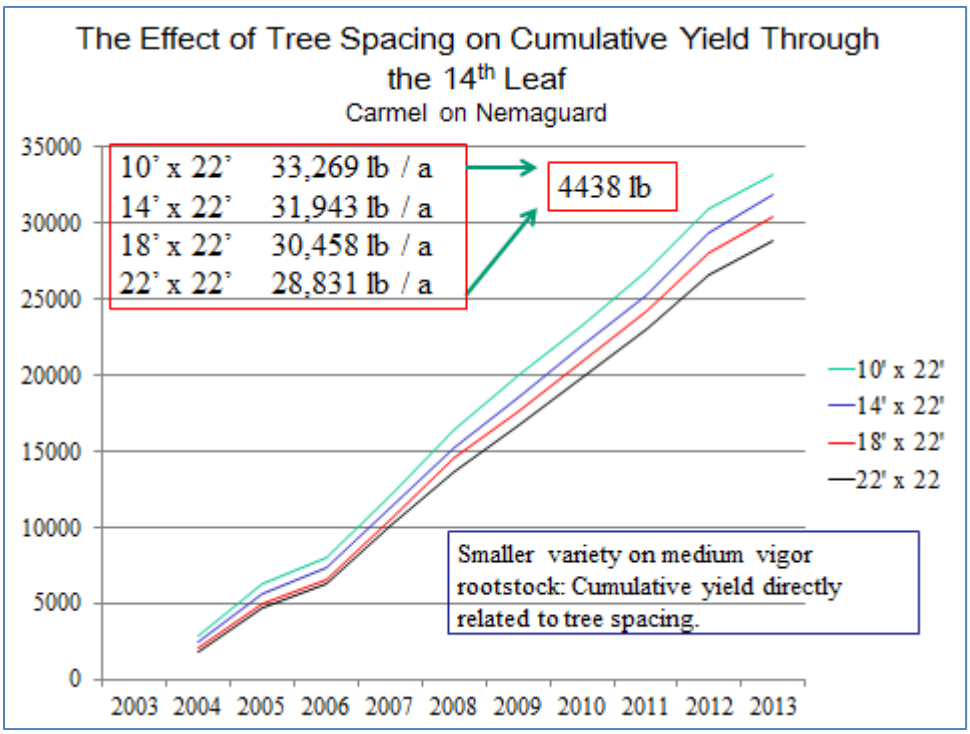

Figure 4. Indicates that the smaller Carmel variety on the intermediate vigor rootstock Nemaguard benefitted much more from closer tree spacing.

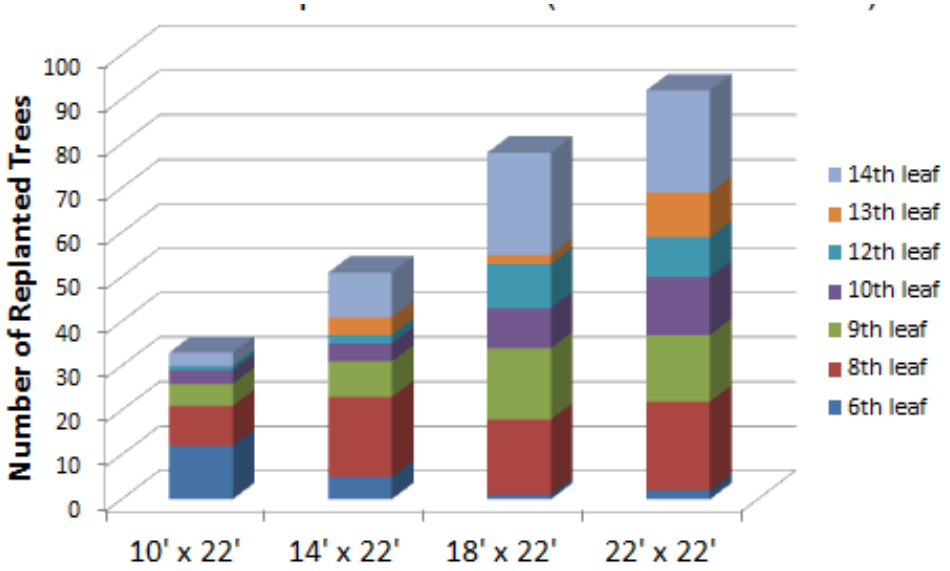

Figure 5. The Influence of Tree spacing on the Number of Replanted Trees (in the 37 acre trial)

Table 2. The Influence of Tree Spacing on the Cumulative Number of Replanted Trees and Resulting Lost Canopy Through the Fourteenth Leaf

	Cumulative Number of Replanted Trees	Area of Lost Canopy Due to Tree Loss (Sq. Ft.)
10' x 22'	33	7,260
14' x 22'	51	15,708
18' x 22'	78	30,888
22' x 22	92	44,528

Rootstock

During the development years, yields were highest for both varieties on the vigorous Hansen rootstock. In 2007 (eighth-leaf), yields were significantly lower for trees on Hansen compared to trees on Nemaguard. It is assumed that the lower yields of the Hansen rootstock in 2007 were a result of the very wet spring in 2006 (trees on Hansen were affected more than trees on Nemaguard). Carmel trees on Hansen continue to produce substantially less than Carmel on Nemaguard in this trial. This is very different than results seen in other rootstock trials and it may demonstrate that Hansen is not the appropriate rootstock for the relatively heavy soils of the Sierra foothills that often remain saturated throughout much of the spring.

*Previous year reports are available at Almonds.com/ResearchDatabase.