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

Project No.: **12-HORT5-Duncan**

Project Leader: Roger Duncan
UCCE – Stanislaus County
3800 Cornucopia Way, #A
Modesto, CA 95358
209.525.6800
raduncan@ucdavis.edu

Project Cooperators and Personnel:
Bruce Lampinen, UC Davis

Objectives:

1. 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.
2. To evaluate economic advantages and disadvantages.

Interpretive Summary:

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. Planting trees densely and on a vigorous rootstock such as Hansen 536 has resulted in maximum early yields and gross income in this trial. 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. Many people feel that more densely planted orchards may be more susceptible to foliar diseases or hull rot. We have not noticed this in the trial, but the relatively small plots may not allow for differential disease development among planting density or pruning treatments.

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 – possibly 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 as or better than almond trees that are annually pruned in a “conventional manner,” at least for the first thirteen 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 cvs. Nonpareil, Carmel, and Sonora were 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. This is the traditional pruning strategy practiced by the majority of local growers.

Minimal training & pruning. The initial goal was to establish bushy trees with only minor emphasis towards keeping the centers open. 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. Three permanent scaffold limbs were selected at the first dormant pruning. Due to the large number of water sprouts that grew during the second growing season, these trees were conventionally pruned the second dormant period, as in Treatment #1. The intent is that these trees will not be pruned for the duration of the trial except to remove limbs that become problematic for cultural operations.

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. Tree size is measured annually by recording trunk circumference and canopy size. 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:

Pruning

- In 2012, Nonpareil yield was similar in annually pruned trees, untrained, unpruned trees, and trees trained for two years and then unpruned (**Table 1**). Minimally pruned Nonpareil trees tended to have the lowest yields and were significantly lower than trees trained for two years and then unpruned. The pruning crew is allowed only three pruning cuts each year on minimally pruned trees. Now that the trees are large, these cuts tend to be saw cuts to remove large limbs out of the center of the trees. It is likely that these relatively large cuts are removing at least as much fruiting wood as in the standard, annually pruned trees and perhaps aren't actually minimally pruned anymore.

- In most years Nonpareil yields are statistically similar in conventionally pruned, minimally pruned and unpruned trees. Cumulatively, unpruned Nonpareil trees have yielded just 1345 pounds more than conventionally trained & pruned trees through the 13th leaf.
- Annually pruned Carmel trees were significantly lower than both "unpruned" treatments in 2012.
- In most years, Carmel yields are highest in the untrained and unpruned trees. Cumulatively, untrained & unpruned Carmel trees have yielded 3218 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 $7000 per acre to date.
- It does not appear that pruning leads to better nut removal at harvest, as measured by overwintering mummy nuts (**Table 2**).
- 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 2012, Nonpareil and Carmel yield per acre was similar for all tree spacings (**Table 1**).
- Cumulative Carmel yields are significantly higher on closely planted trees (**Figure 2**), but there is no obvious yield advantage to close planting of the larger Nonpareil variety, especially on the vigorous Hansen rootstock (**Figure 1**).
- 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 (**Figure 3**) and fewer mummies per acre than widely spaced trees.
- This may mean that higher density orchards may be productive longer than low density orchards, a hypothesis counter to current assumptions.
- Wider plantings have more missing trees, missing canopy and have more replants, because larger trees are more prone to blow over (**Figures 4 and 5**).

Yield vs. Rootstock

- During the development years, yields were highest for both varieties on the vigorous Hansen rootstock.
- In 2007 (8th 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.

Table 1. The effect of pruning, tree spacing, and rootstock on current (2012) and cumulative (through 13th leaf) yield (lb per acre).

	Nonpareil		Carmel	
	2012	Cumulative	2012	Cumulative
Training & Pruning				
Trained to 3 scaffolds; annual conventional pruning	4209 ab	29,338	3126 b	25,620
Trained to 3 scaffolds; unpruned since 2nd leaf	4387 a	30,670	3508 a	27,535
Trained to multiple scaffolds; Three pruning cuts each year	3979 b	28,769	3308 ab	27,080
No scaffold selection; No annual pruning	4220 ab	30,683	3685 a	28,836
Tree Spacing				
10' x 22'	4228 a	29,871	3436 a	28,324
14' x 22'	4148 a	30,400	3454 a	28,234
18' x 22'	4334 a	30,128	3528 a	26,876
22' x 22'	4083 a	29,059	3208 a	25,637
Rootstock				
Hansen	4470 a	29,534	2922 b	25,141
Nemaguard	3927 b	30,195	3891 a	29,394

Table 2. The influence of tree spacing and pruning on overwintering mummy nuts of Nonpareil almond trees.

Number of mummy nuts per acre (January 2010)					
	Treatment spacing				
	10 x 22	14 x 22	18 x 22	22 x 22	**Average**
Standard annual pruning	4,297	9,545	12,386	10,845	**9,268**
Trained 2 years, no annual pruning	5,207	6,179	10,527	12,276	**8,547**
Minimal training, minimal pruning	5,841	7,650	15,059	13,473	**10,506**
Untrained & unpruned	3,802	5,090	7,557	9,729	**6,545**
Average	**4,787**	**7,116**	**11,382**	**11,581**	

Number of mummy nuts per acre (February 2012)					
Standard annual pruning	4,752	8,767	6,710	9,630	**7,465**
Trained 2 years, no annual pruning	6,138	4,666	4,950	7,200	**5,739**
Minimal training, minimal pruning	5,148	9,757	6,380	15,750	**9,259**
Untrained & unpruned	6,534	7,636	6,160	13,590	**8,481**
Average	**5,643**	**7,707**	**6,050**	**11,543**	

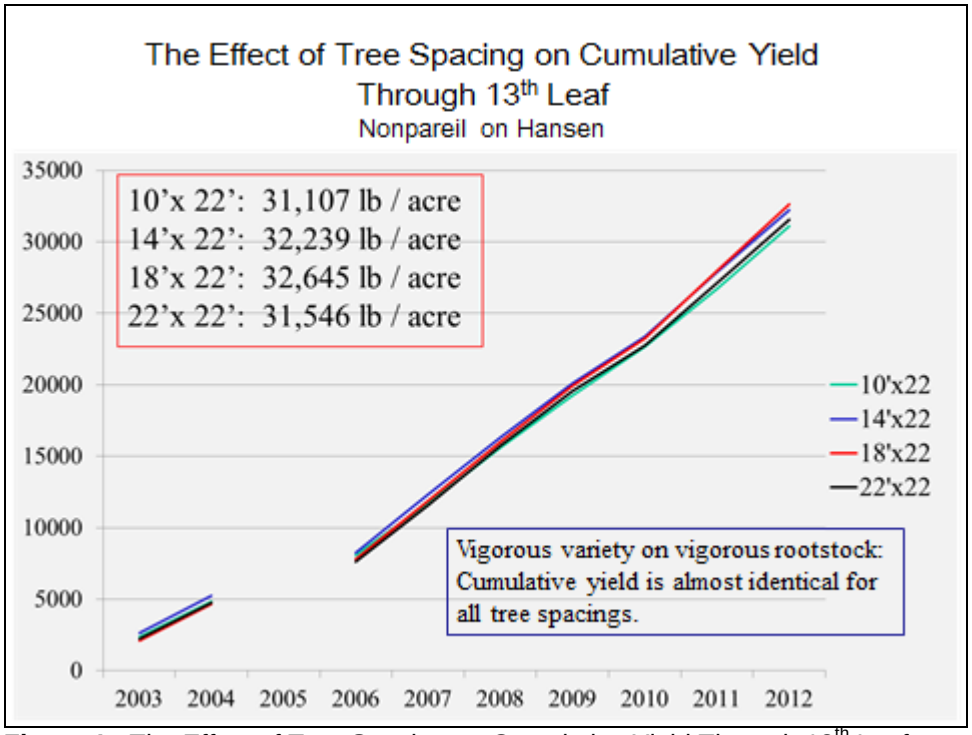

Figure 1. The Effect of Tree Spacing on Cumulative Yield Through 13th Leaf on cv. Nonpareil, Hansen rootstock. This graph indicates that there has been no significant cumulative yield difference among tree planting densities for Nonpareil on the vigorous Hansen hybrid rootstock through the 13th leaf.

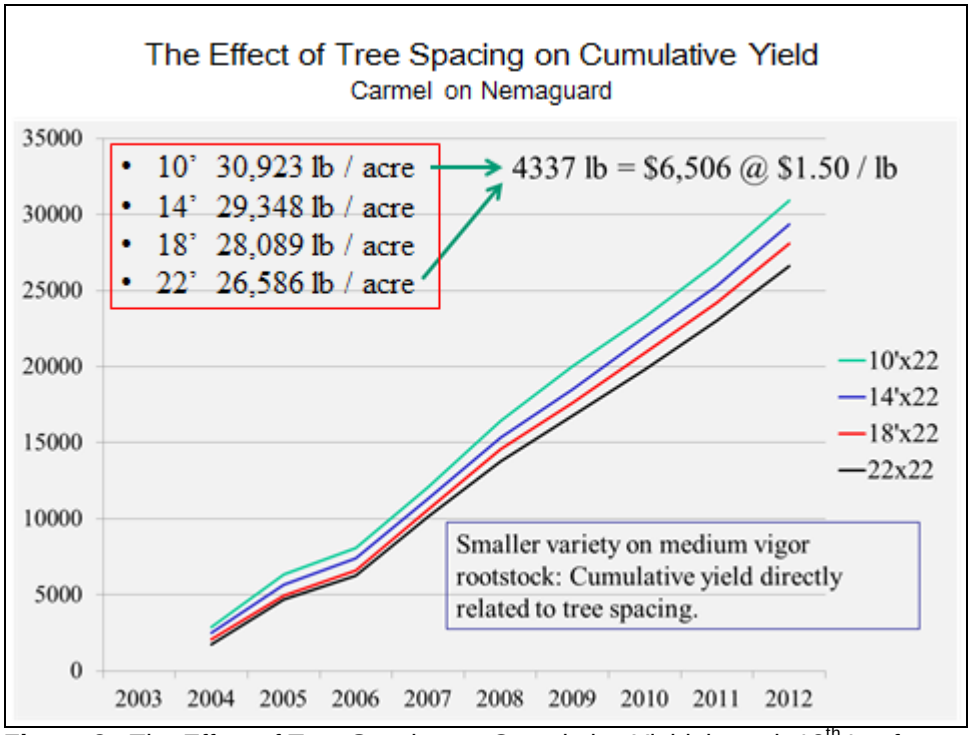

Figure 2. The Effect of Tree Spacing on Cumulative Yield through 13th Leaf on cv. Carmel, Nemaguard rootstock. This graph indicates that the smaller Carmel variety on the intermediate vigor rootstock Nemaguard benefits much more from closer tree spacing. This trend has continued through the 13th leaf. Carmel at the highest density planting (10' x 22') has accumulated 4337 lb/ac more cumulatively than the widest spacing (22' x 22') which calculates to approximately $6,506 more gross income per acre.

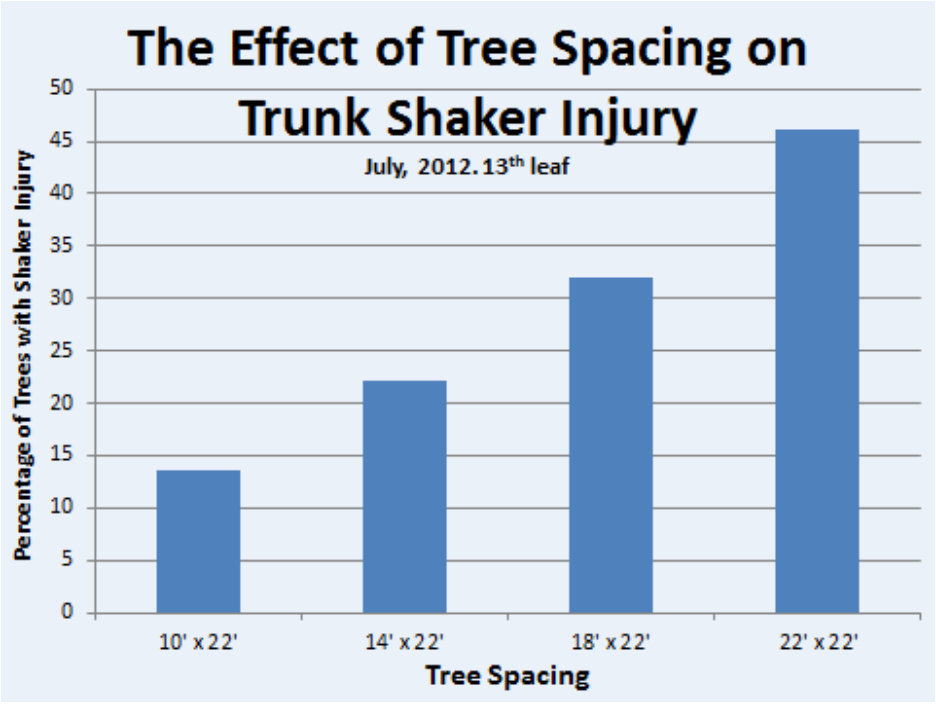

Figure 3. The effect of tree spacing on trunk shaker injury as measured in July 2012 during the orchard's 13th leaf.

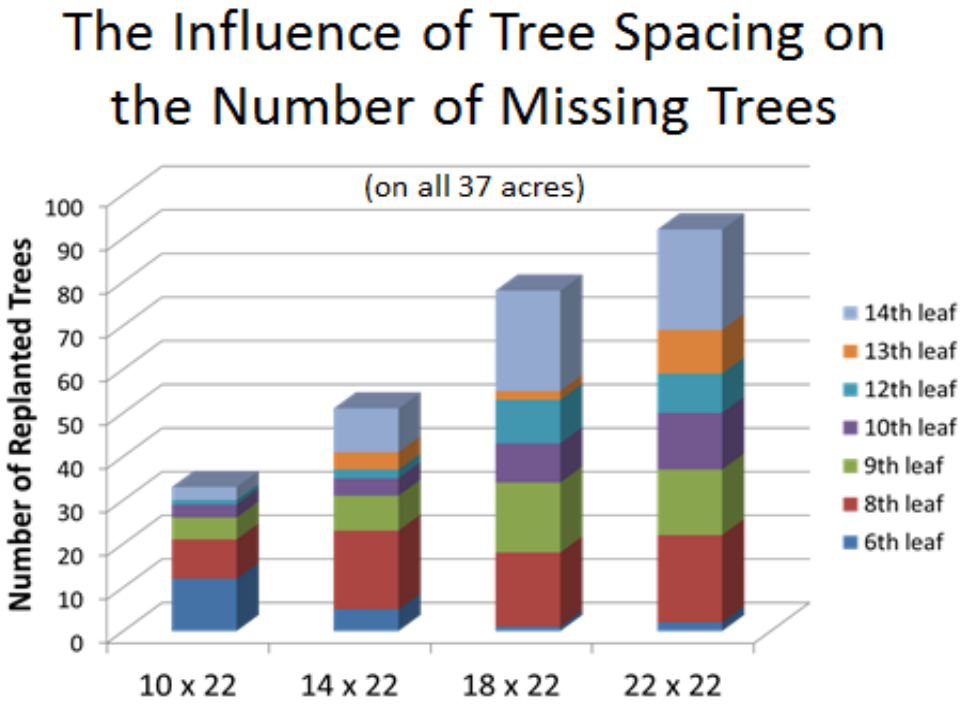

Figure 4. The influence of tree spacing on the number of missing trees through the 13th leaf.

	Cumulative Number of Replants	Square Footage of Missing Canopy
10 x 22	33	7,260
14 x 22	51	15,708
18 x 22	78	30,888
22 x 22	92	44,528

Figure 5. The influence of tree spacing on number of replants and square footage of missing canopy cumulatively through the 13th leaf.