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

Project No.: **10-HORT5-Duncan**

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Objectives:

In this trial, we examine the interaction between planting density, rootstock performance and minimal pruning strategies, and their effects on short term and long term orchard production. The trial was established in the fall of 1999 and the orchard has now completed its eleventh growing season in 2010.

Interpretive Summary:

Conclusions through the 11th leaf.

- Untrained trees and trees trained to multiple scaffolds are more prone to scaffold failure and blow over during the development years, especially in widely spaced trees.
- Tree spacing had more of an effect on tree failure than tree training. Closely planted trees are smaller and have had significantly fewer problems with scaffold breakage.
- A good compromise which allows growers to develop good tree structure while reducing pruning costs would be to train the trees to three scaffolds the first year, prune again during the second winter and then abandon pruning after that.
- Conventionally trained and annually pruned trees capture the least sunlight and tend to have the lowest yields.
- Pruning has not affected kernel size. In 2010, closely planted trees tended to have slightly smaller kernels.
- Through the first ten years of this trial, annual pruning has reduced net income by over $4000 per acre, including pruning costs and lower yields.
- Carmel yields are significantly higher on closely planted trees while there is no obvious yield advantage to close planting of Nonpareil.

- Unpruned trees tended to have the fewest mummies.
- Widely spaced trees had 2.5 times the number of mummies than closely planted trees.
- Trees on Hansen rootstock have struggled more in the relatively heavy soil of the Sierra foothills, especially during years with high spring rainfall and may not be appropriate for this area.

Materials & Methods:

Varieties. 'Nonpareil', 'Carmel' and 'Sonora'. All Carmel trees were replaced early in the 2nd growing season due to widespread noninfectious bud failure (crazy top) and are therefore about one growing season behind the Nonpareil trees. Harvest data is not collected for the Sonora variety.

Rootstocks. Nemaguard, Lovell and Hansen 536. Most data is collected only for the Nemaguard and Hansen rootstocks.

Spacing. The distance between rows is constant at 22 feet throughout the trial. Down the rows, tree spacing is varied in groups of 24 trees. The four tree spacings are: 10' x 22', 14' x 22', 18' x 22' and 22' x 22'.

Pruning. Four training and pruning strategies are being imposed across all varieties, rootstocks and spacing treatments. They are:

1. **"Standard" training & pruning.** Three permanent scaffold limbs were selected during the first dormant pruning. Trees continue to receive "moderate", annual dormant pruning to keep centers open and remove crossing limbs.

2. **Standard training for 2 years, then unpruned.** Three permanent scaffolds were selected as in the "standard" treatment. Trees were pruned normally the second dormant season. These trees have been unpruned since the second dormant season except to occasionally remove limbs that interfere with cultural operations.

3. **"Minimal" training & pruning.** Shoots on Nonpareil trees were tipped twice during the first growing season to stimulate secondary branching and establish a bushy tree. At the first dormant pruning, only very vigorous shoots growing in the center of the trees were removed. Four to six scaffolds were retained to maintain a full canopy. Only a maximum of three cuts per tree is now made each dormant pruning to maintain a minimally open canopy.

4. **Untrained & unpruned.** No scaffold selection was made except to remove limbs originating too low on the trunk for shaker access. There has been no annual pruning other than to occasionally remove limbs that break or interfere with cultural operations.

Results and Discussion:

Tree density and pruning style vs. tree size sunlight interception and yield. More densely planted trees have significantly smaller trunks, have canopies that are less broad, and tend to be slightly shorter than trees with wider spacing (see 2010 Almond Board final report). Because trees planted more closely are smaller, they have had the fewest problems with scaffold breakage and tree blow over. We have not noted any increased disease issues in closely planted trees.

Yields were improved by higher density planting of Carmel, but not Nonpareil in this trial (**Table 1**). By the 7th growing season, yields of Nonpareil on Nemaguard were similar at all tree spacings. There was never a clear yield advantage to high density planting of Nonpareil on the highly vigorous Hansen rootstock. Nonpareil yield was similar for all tree spacings in 2010 (11th leaf) and there is very little difference in cumulative yields. In 2010 (10th leaf), Carmel yield was significantly lower in trees spaced at 22' x 22' compared to the closer spacings (**Table 1**). Carmel trees planted at 10' x 22' have accumulated 2262 pounds per acre more than trees planted 22' x 22'. Carmel trees planted at 10' x 22' had the smallest kernel size in 2010 (**Table 2**).

Pruning vs. yield. Every 1% of sunlight intercepted by an almond tree equates to about 50 pounds per acre of increased yield potential (refer to B.D. Lampinen report in 2010 Almond Board Final Report). Light bar readings taken by Dr. Bruce Lampinen's lab show that untrained and unpruned trees were capturing 5.8% more sunlight on average than conventionally trained and pruned trees (**Figure 1**). This equates to a yield potential advantage of almost 300 pounds per acre in unpruned trees. Light bar readings also indicate that pruning may reduce yield potential more in widely spaced trees than in closely spaced trees. Trees that were not trained and are not pruned annually continue to maintain excellent yields and tend to have slightly higher yields than conventionally trained and pruned trees, although differences are not statistically significant every year (**Table 1**). Through the first eleven years of this experiment, untrained and unpruned trees have accumulated 1210 Nonpareil pounds per acre and 2283 Carmel pounds per acre more than trees that are conventionally pruned every year (**Table 1**). There is no difference in kernel size on pruned verses unpruned trees in this trial (**Table 2**).

Table 1. The Effect of Pruning, Tree Spacing and Rootstock on Current (2010) and Cumulative (Through 11th leaf) Yield (lb. per acre)				
	Nonpareil		Carmel	
	2010	Cumulative	2010	Cumulative
Training & Pruning				
Trained to 3 scaffolds; annual conventional pruning	3203 a	21,080	3359 b	19,488
Trained to 3 scaffolds; unpruned since 2nd leaf	3457 a	22,151	3736 a	20,948
Trained to multiple scaffolds; Three pruning cuts each year	3241 a	20,919	3508 ab	20,688
No scaffold selection; No annual pruning	3395 a	22,290	3785 a	21,771
Tree Spacing				
10' x 22'	3397 a	21,611	3742 a	21,686
14' x 22'	3379 a	22,132	3821 a	21,548
18' x 22'	3335 a	21,589	3529 ab	20,238
22' x 22'	3186 a	21,123	3297 b	19,424
Rootstock				
Hansen	3287 a	20,662	3268 b	19,290
Nemaguard	3324 a	22,558	3925 a	22,157

Fig. 1. The Effect of Tree Spacing and Pruning on Midday Light Interception

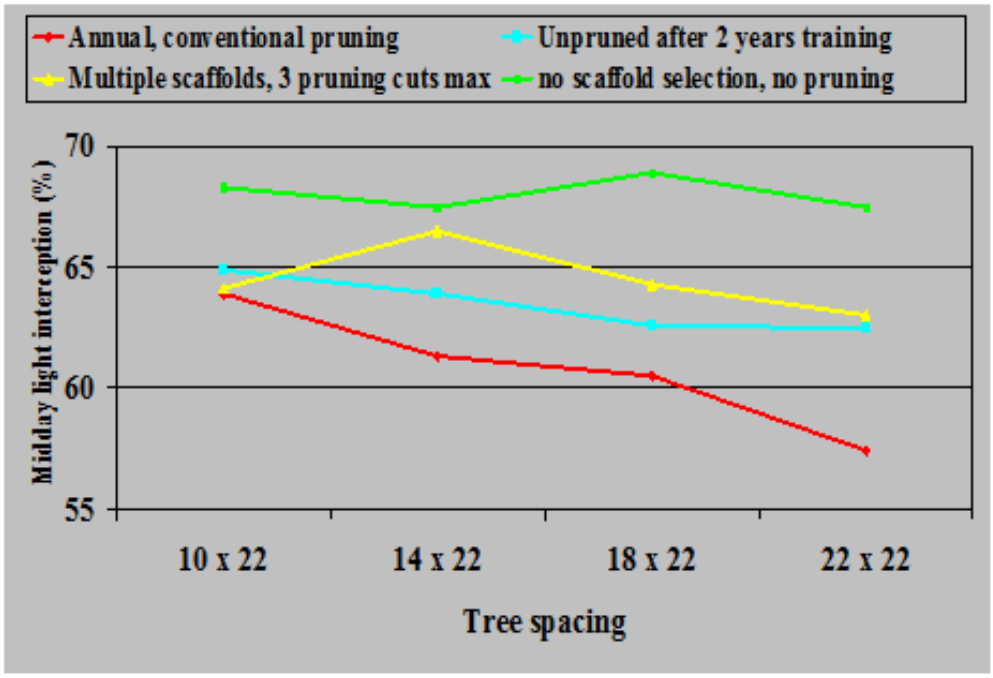

Table 2. The Effect of Pruning, Tree Spacing and Rootstock on Kernel Size and the Number of Mummies Left in the Tree After Shaking			
	Number of Kernels per oz.		Mummies per Acre
	Nonpareil	Carmel	Nonpareil
Training & Pruning			
Trained to 3 scaffolds; annual conventional pruning	20.7 a	22.7 a	9,268
Trained to 3 scaffolds; unpruned since 2nd leaf	21.2 a	23.1 a	8,547
Trained to multiple scaffolds; Three pruning cuts each year	20.7 a	22.3 a	10,506
No scaffold selection; No annual pruning	21.0 a	22.9 a	6,545
Tree Spacing			
10' x 22'	21.1 a	24.0 b	4,787
14' x 22'	21.1 a	22.5 ab	7,116
18' x 22'	20.7 a	22.3 a	11,382
22' x 22'	20.7 a	22.9 ab	11,581
Rootstock			
Hansen		22.7 a	
Nemaguard		22.8 a	

Rootstock Influence. During the early development years (through the sixth–leaf), yields were highest for both varieties on the vigorous Hansen rootstock. However, we had a very wet spring in 2006, which negatively affected the trees on Hansen more than trees on Lovell or Nemaguard (see Almond Board report 2006). Since 2007 (eighth-leaf), yields have tended to be lower, sometimes significantly, in the trees on Hansen rootstock. Cumulatively, trees on Nemaguard have yielded 1896 and 2867 pounds per acre more than trees on Hansen for Nonpareil and Carmel, respectively. In most rootstock trials, large Hansen-rooted trees generally out yield trees on Nemaguard. However, in the relatively heavy soil of the eastern foothills, Hansen may not be the appropriate rootstock. Kernel size was similar from Nemaguard and Hansen-rooted trees in 2010 (**Table 2**).