Integration of Tree Density & Minimal Pruning for Efficient Almond Produciton

Project No: HORT5

Project Leader: Roger Duncan, 3800 Cornucopia Way, Suite A. Modesto CA, 95358. 209-525-6800. raduncan@ucdavis.edu

A. Summary *(In laymen's terms – emphasize key findings and recommendations)*
2019 marked the 20th season for this very long-term pruning & spacing trial. Throughout the duration of this trial, the data have consistently shown that annual pruning to improve light penetration and preserve the lower canopy has not maintained yield better than trees that have been essentially unpruned except for equipment access and safety. In general, the more that trees have been pruned, the lower the cumulative yields have been, although differences are often insignificant within a given year. Based on results of this trial, annual pruning would have cost the grower between $7,500 and $14,000 per acre in cumulative pruning costs and loss of production, depending on variety and rootstock. In general, trees on Nemaguard rootstock have the highest cumulative yields at the more closely planted spacings (10 – 14 feet apart down the row), especially for the smaller Carmel variety. For the most vigorous trees (Nonpareil on Hansen rootstock) yields have tended to be highest in the more moderate spacings (14' – 18'). Closely planted trees are smaller, shake more easily, have less cumulative shaker injury on their trunks, have fewer mummies per acre and have lost far fewer trees than widely spaced trees, regardless of rootstock.

B. Objectives *(300 words max.)*

To evaluate the long-term effects of three key management factors: tree spacing (planting density), rootstock, and training/pruning strategies on orchard production and longevity.

C. Annual Results and Discussion

Effects of Pruning

- Pruning has not increased or sustained yield in the short term or long term. Pruning either has had no effect or has reduced yield, especially in the Carmel variety.
- At current almond prices and labor costs, conventional training and annual pruning would have reduced net income by $7,500 - $14,000 per acre in this trial, including pruning, stacking & shredding costs plus lower cumulative yield.
- Although untrained & unpruned trees tend to have the highest yields, they have been more prone to scaffold failure, especially in widely spaced trees.
- Sometimes pruning is needed for safety, equipment access, removing broken or diseased limbs, etc. but the reason to prune should justify the expense and potential yield loss.
- In this trial, "minimally" pruned trees often have the lowest yields. This is likely because when pruners are allowed only three cuts per tree, they tend to make larger cuts, often removing more wood than in the "conventional" pruning treatment.
- Annual pruning has not improved light interception within the canopy as measured by a

PAR meter (see Lampinen, et. al. annual report). Annually pruned and unpruned trees both reached their maximum light interception during years 10–12 and are now declining. Annually pruned trees appear to be declining a little faster than unpruned trees.

- The best strategy appears to train the tree to be structurally strong during the first 1-2 years and then only if necessary, for safety or equipment access thereafter.

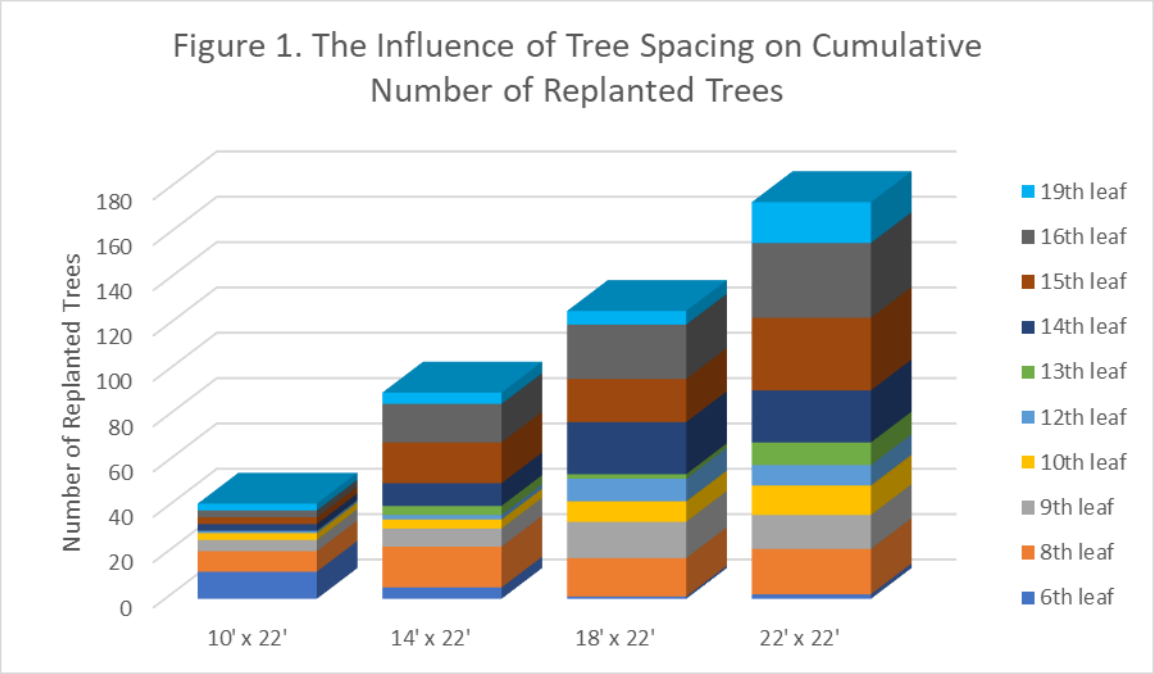
Effect of Tree Spacing

- In 2019, Nonpareil yield was similar for trees spaced 10, 14 and 18 feet apart for both rootstocks. Yields were lowest for trees spaced 22 feet apart.
- Cumulatively, Carmel trees on Nemaguard planted ten feet apart have yielded 7,564 pounds per acre more than trees planted 22 feet apart. There is a direct relationship between tree spacing and yield; the closer the trees are planted, the higher the annual and cumulative yields.
- Cumulatively, Nonpareil trees on Nemaguard and Carmel trees on Hansen tend to have higher yields at the more densely planted spacings (10 and 14 feet apart), but the pattern is less clear and the differences are relatively small.
- Canopy light interception appears to be declining earlier and faster in the more widely spaced trees. The reason for this is unclear but may be related to more shaker injury, more scaffold failure and more trees falling over in the larger, widely spaced trees.
- In the first 20 years of the 37-acre trial, we have had to replant 42 trees in the 10' x 22' areas compared to 175 trees in the 22' x 22' spaced areas (Fig. 1). This represents a loss of 9240 ft^2 of canopy in the closely spaced trees vs. 84,700 ft^2 in the most widely spaced trees.
- 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.
- This may mean that higher density orchards will be productive longer than low density orchards, a hypothesis counter to previous assumptions.
- Any yield advantage to tight in-row spacing is highly dependent on inherent tree vigor.
    - Lower vigor trees (small varieties, less vigorous rootstocks, poor soil) will benefit most from tight spacing.
    - Vigorous trees may not have a substantial yield increase if planted at high density. However, the risk of yield loss due to overly close planting appears to be low.
- There are advantages to tighter spacing other than yield.
    - Trees planted closer together are smaller. This results in less need for training & pruning, less tree structural failure, easier harvest, less trunk injury, fewer mummies and perhaps a longer lasting orchard.

Table 1. The Effects of In-row Tree Spacing & Rootstock on 2019 and Cumulative Yield (20th Leaf)[1]				
	Nonpareil			
	Nemaguard		Hansen	
	2019 yield (lb / a)	Cumulative	2019 yield (lb / a)	Cumulative
Tree Spacing				
10’ x 22’	1540 ab	43,952	2215 ab	45,146
14’ x 22’	1710 a	44,107	2123 ab	46,029
18’ x 22’	1730 a	38,711	2470 a	48,687
22’ x 22’	1249 b	36,757	1945 b	44,776
Nonpareil x rootstock	1557 b	40,882	2188 a	46,160
	Carmel			
10’ x 22’	3255 a	48,593	2691 a	38,654
14’ x 22’	2813 ab	45,595	2424 ab	39,398
18’ x 22’	2921 ab	43,805	2217 ab	38,052
22’ x 22’	2754 b	41,029	2196 b	36,099
Carmel x rootstock	2936 a	44,756	2382 b	38,051

*Data followed by the same letter are not significantly different (P< 0.05).

Table 2. The Effects of Pruning on Cumulative Yield Through the 19th Leaf (2000 – 2018).				
	Nonpareil		Carmel	
	Cum. Yield (lb / acre)	Difference	Cum. Yield (lb / acre)	Difference
Trained to 3 scaffolds; annual moderate pruning	41,326	-952	38,851	-4423
Trained to 3 scaffolds; unpruned after 2nd leaf	42,237	-31	41,732	-1542
Trained to multiple scaffolds; three annual pruning cuts	39,739	-254	40,780	-2494
No scaffold selection; no annual pruning	42,278	--	43,274	--



D. Outreach Activities

Information from this trial has been disseminated at multiple events through the years. In 2019, information was extended at the UC Almond Production Shortcourse (11-5-19, Visalia; ca. 175 attendees), Almond Board of California webinar (11-19-19, ca 36 participants) and the Almond Industry Annual Conference (12-10-19, Sacramento; ca. 300 attendees).

E. Materials and Methods *(500 word max.)***:**

In the fall of 1999, a commercial almond orchard with cultivars '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. Trees on Nemaguard 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:

1. <u>"Standard" training; "standard" annual pruning</u>. 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.

2. <u>Minimal training & pruning</u>. 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.

3. "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 fifteen years

4. Untrained, Unpruned. No scaffold selection was made during the initial training of these trees except to remove limbs originating too low on the trunk for equipment access. These trees are not pruned except to remove limbs that become problematic for cultural operations and operator safety.

The same professional pruning contractor has been hired to prune this trial throughout the years. 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.

In 2019, the pruning portion of the field trial has been terminated after 19 years. The orchard was sold to a new grower and we were unable to continue the pruning treatments. Yield will continue to be monitored for the tree spacing treatments for the next few years.

F. Publications that emerged from this work

No recent publications have been written about this trial except reports to the Almond Board.