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High Density Avocado Production

A Method to Improve Yield per Acre

How does a grower in California make a profit when the water prices keep increasing and yet, mostly due to foreign competition, market prices remain fairly static?

This was the question we were facing back in 2011 when growers in the Valley Center and Fallbrook areas started to turn off their water and were letting their groves dry up. Yield per acre that year in our county was about 5,000 pounds per acre, and the water requirement in the inland valleys was about 4.5 acre feet per acre. At that, the grower was losing money just by paying the water bill. As the farm advisor for San Diego County, this was the complaint that came into my office every day, and there didn't seem to be a good answer.

Since we couldn't seem to do much about reducing water costs, the answer simply appeared to be increase yield per acre so that water bills and other costs could be paid, and (hopefully) there would be enough left over to make the grove profitable. That sounds simple, right? A lot of growers thought there could be some type of fertilizer or microbe one could buy at the fertilizer store to dramatically increase production, but that didn't seem to be the case. On the downside, the grower could

dramatically decrease his or her yield if enough nitrogen and minor elements weren't applied.

What else is out there that could increase yields? For some time, there had been research going on in Chile and South Africa where they were experimenting with higher density production. This was reported to us by Fallbrook grower Reuben Hofshi in 1999. They weren't sure about the exact spacing but many of the trials were on 3 meter x 3 meter spacing (about 10' x 10'). A few of our growers had tried this spacing and John Cornell in Temecula showed me that he produced more than 32,000 pounds per acre in the sixth year, and Steve Howerzyl in Escondido produced more than 24,000 pounds per acre in the fifth year. But both were having problems. John had done his pruning and had apparently cut all of the fruiting wood off for next spring (and his trees were in alternate bearing) and Steve was not pruning and his grove became impenetrable for the irrigator to check the sprinklers, and his yields were declining.

So a high density spacing looked possible, but we had to work out the pruning system. But I thought the increase in yield was still too slow; in or-

der to save groves in our county we had to increase yields faster than that. The only other method that could increase yields might possibly be cross-pollination. Fortunately, Mary Lu Arpaia had run a cross pollination experiment in Ventura County and determined that Zutano was one of the best for increasing production in Hass. And from personal experience, I had seen many Hass trees next to Zutanos that were always loaded with fruit. But these trees were always side by side. Walking away from the Zutano tree I could see that the yield on Hass usually dropped off fast.

There also was an important paper from Israel that showed that Hass fruit pollinated by a B-flower avocado had a lower drop rate; Hass fruit pollinated by Hass had a higher drop rate.

So the thought was: in order to increase yields as fast as possible, why not combine these factors and plant on a 10' x 10' spacing with a pattern of eight Hass trees surrounding a Zutano, and include a lot of beehives near the trial. We also had the nursery graft our Hass and Zutanos onto clonal Dusa rootstocks because these were the best root rot tolerant rootstocks available at the time. And they apparently have some salt tolerance and looked to be a

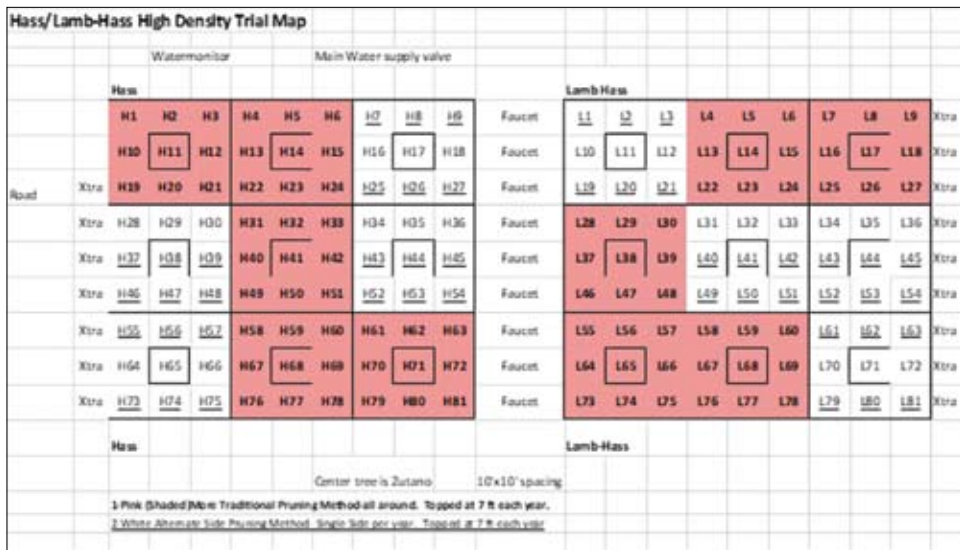


Figure 1. High Density Trial Map

good high-yielding rootstock.

From research done in South Africa, we knew that the height of the trees should be about 80 percent of the spacing. Therefore, our 10' x 10' planting should have a height of eight feet. (A 20' x 20' spacing should have a height of about 16 feet.) This height allows sunlight to pass over the top of a neighbor tree and shine light on the lower canopy of the next tree. This arrangement tends to keep leaves on the trees all the way down to the ground, which in turn allows us to keep our fruit low in the tree and pick without using ladders.

From work done by Carol Lovatt at UC Riverside, we knew we shouldn't be pruning in the summer as it tends to remove fruiting wood for the following spring. So the pruning method for high density was still unknown.

The trial proposed to the California Avocado Commission in 2011 was to compare two pruning styles. The trial was funded in 2012 with the following objectives.

Project objectives: 1. Set up a high density Hass grove and a Lamb Hass grove with B-flowered pollinizer trees (Zutano) in order to maximize production. The density chosen for this project was 10' x 10' with topping at eight feet

(later reduced to seven feet due to rapid growth of the trees). An important component for this trial was the grower/cooperator. The grower/cooperator for this trial was the Nick Stehly Ranch in Valley Center. This family had participated in several previous trials and I knew from experience they were interested in research and were very helpful taking care of the trees and helping us with the harvest data collection.

2. Compare two styles of pruning in order to keep avocado trees growing effectively in a high density pattern, but keep the maximum amount of fruiting wood on each tree. Yield per tree and fruit size would be used for data collection.

3. Keep track of hours for pruning labor to determine if high density is cost effective.

4. Keep track of irrigation amounts to determine if high density results in less, more or the same amount of water use compared to nearby tall trees on a 20' x 20' spacing on the same ranch.

Setting up the high density planting: The primary objective for this project was to produce the maximum amount of fruit per acre on a sustained basis. As noted, we set up the planting in nine-tree units, eight Hass

trees surrounding a Zutano tree. The Lamb Hass side of the planting was set up the same way. In addition, because there was a lot of avocado root rot on the Stehly Ranch, we ordered the trees grafted onto clonal Dusa rootstocks, which were the most root-rot tolerant rootstock at the time of planting.

We asked for a hillside at the Stehly ranch that did not have a history of avocado root rot, and they gave us a gentle slope that had never been planted. The soil was a clay loam with a large amount of granite rock.

The trees were planted in August/September of 2012. There was a heat wave during planting and we lost 10 trees, but they were immediately replaced. The irrigation was set up as spot spitters aimed at the base of the trees. These were changed to full circle 14 gallons per hour micro-sprinklers in 2014.

The trial was planted with 72 Hass/Dusa with 9 Zutano/Dusa trees on the Hass side of the project, and 72 Lamb Hass/Dusa and 9 Zutano/Dusa on the Lamb Hass side of the project. The planting pattern is shown in Figure 1. Sterilized metal stakes were installed and the top branch was tied to the stake in order to make a quasi-central leader. It should be noted that avocados normally come from the nurseries without central leaders, which makes it difficult to form a true pyramid shape.

The pruning trial: The traditional method of pruning high density trees is to prune all sides and top each year. Some growers don't prune at all and after a few years they give up because the groves get too crowded. So we knew the pruning was necessary, but there is disagreement as to how to prune. Pruning avocado is difficult because there is always young fruit, maturing fruit and/or flowers on the trees. We chose to compare two styles. We had enough room for five nine-tree units of Style 1 and

four nine-tree units of Style 2.

Style 1: Harvest fruit in early March and prune the trees similar to a fat Christmas tree shape, with topping at seven feet. The idea was to keep the tree height in the eight foot range in order to achieve the ideal height at 80 percent of the tree spacing (10') as proposed by Stassen in South Africa. Trees also were skirt-pruned at this time keeping the skirts one foot off the ground. This pruning began in 2014.

Style 2: Harvest fruit in early March and alternate-side prune starting with the south-west side in the first year. The side that was pruned was heavily pruned creating a 60-degree angle from the lowest branch on the pruned side to seven-foot height on the tree. The non-pruned side was left alone in order to preserve as much fruiting wood as possible. The following year the north-east side was pruned severely, and back to the south-west side the following year. Trees were skirt pruned at this time to one foot off the ground. This pruning began in 2014.

Clearing the aisles: Starting in 2015 it became necessary to clear the aisles in late July and late September. This was done each year during the trial. This allowed enough room for a worker to walk around each tree unimpeded and allowed sunlight to reach the lower branches.

Harvesting

Comparison of yield for two pruning styles: Each tree was harvested separately in March of each year (2014-2017). The actual data for the harvest comparing the two styles of pruning is being prepared for a journal article and will be presented in this magazine in a future article. However, results thus far have indicated no significant difference in yield per tree be-

tween the two pruning styles. Likewise, there was no significant difference in numbers of fruit per tree between the two pruning styles.

Yield per acre in the high density trial: This trial had 72 Hass trees and 72 Lamb Hass trees. A 10' x 10' spacing would have 430 trees per acre,

but this trial also had 18 Zutano trees, which would be equivalent to 43 Zutano trees/acre. Therefore, the yield for 72 trees from both pruning styles from our trial, divided by 72 gave us yield per tree. Multiply yield per tree times 387 would give the yield per acre of Hass or Lamb Hass based on the yield from this trial. In our trial from years 2014-

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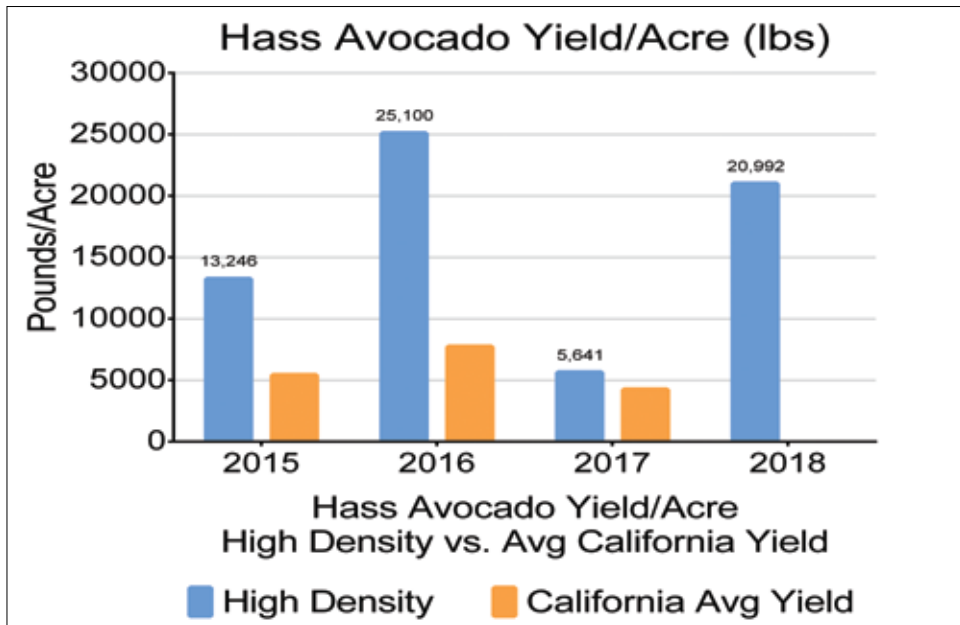


Figure 2. Comparison of the yield from this high density trial (387 Hass trees/ac) vs California average yield/ac (commonly 109 trees/ac).

2018 yield per acre in Hass has been 480 pounds per acre, 13,246 pounds per acre, 25,104 pounds per acre, 5,641 pounds per acre and 20,992 pounds per acre, respectively. The 2017 harvest was an off-year due to high temperatures in June 2016 and typical alternate

bearing. From years 2014-2018 yield per acre in Lamb Hass has been 975 pounds per acre, 8,796 pounds per acre, 15,243 pounds per acre, 10,274 pounds per acre and 11,706 pounds per acre, respectively. Charts for this data are in Figures 2 and 3.

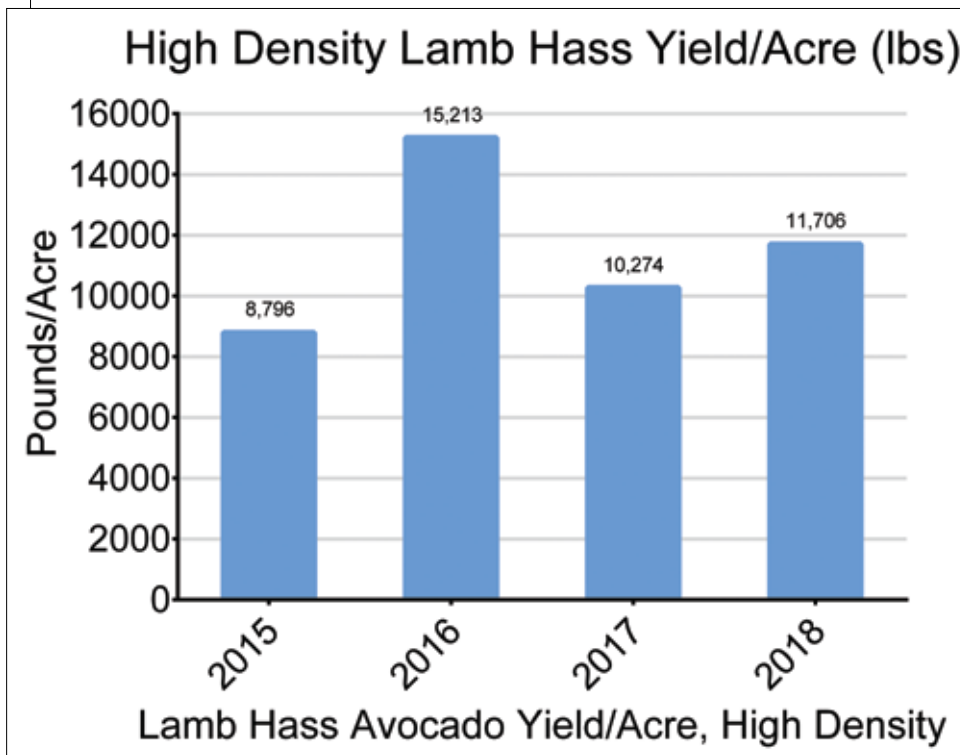


Figure 3. Yield per acre for Lamb Hass (387 Lamb Hass trees/ac) based on data from this trial.

Irrigation, water requirement

In late 2012 Watermark soil irrigation monitors were installed at the edge of the root balls, eight inches below the soil surface. These were hard-wired to a battery-powered box for monitoring. Watermarks were located at the top of the plot, mid-plot and in the bottom row of the plot. Because the soil had a high clay content, the trees were irrigated when the Watermarks averaged 35-40 centibars (cb). They seemed to work perfectly and our trees never had any tip-burn. Watering was done by the grower with guidance from us, but there were some mistakes made by both parties. For instance, we left the water on overnight and the grower also left the water on overnight in the summer of 2016. This is reflected in the high water use in 2016.

Monthly water use readings were taken on the last day of each month. Water use for each year is shown in Table 1.

Pruning labor

Because trees were being pruned in order for light to reach the bottom branches, and aisles were being cleared for workers to walk around trees, it was suspected by some growers that high labor costs might dramatically reduce the benefit from higher yields from high density plantings. We kept track of pruning labor and this data will be published in a journal and in a future article for this magazine. However, it can be said that the alternate side pruning took about two-thirds of the labor hours compared to the all sides pruning. And it was necessary to skirt prune about one foot off the ground to keep low hanging fruit from touching the ground. It also can be said that the increase in yield more than made up for the high pruning costs.

Table 1. Water applied to the 162 trees in the trial was recorded monthly. Yearly summations are presented below. Gallons/acre and acre feet/acre are calculated based on 430 trees/acre planted on a 10' x 10' spacing.

Time Period	Gallons applied per 162 trees	Gallons/acre	Acre feet/acre
2/15/2013 - 10/31/2013	14,388	381,926	1.17
11/1/2013 - 10/31/2014	405,232	1,075,615	3.30
11/1/2014 - 10/31/2015	353,610.5	938,595	2.88
11/1/2015 - 10/31/2016	591,991.7	1,571,336	4.82
11/1/2016 - 10/31/2017	46,501.8	1,234,293.3	3.79

Harvesting labor

Because trees were being kept below eight foot, ladders were not required and harvesting was much less expensive. We kept track of our hours for harvesting labor but we rarely had use of professional pickers. Also the harvesting we did was slower than normal because we required the fruit from each tree to be brought to the weighing scale. In addition, we used various people on the ranch that did not have experience with harvesting. Therefore, the hours are not considered reliable and are not presented in this report.

Conclusions

1. Earlier reports indicated that growers need to produce at least 10,000-11,000 pounds per acre to break even in conventional Hass avocado production in San Diego County. Our project showed that a high density planting is able to produce Hass avocados at 13,246, 25,100, 5,641 and 20,992 pounds per acre over a four-year period for an average of 16,245 pounds per acre per year. In this trial Lamb Hass produced at 8,796, 15,213, 10,274 and 11,706 pounds

per acre for an average of 11,497 pounds per acre per year.

2. The comparison of alternate side pruning and topping at seven feet versus all sides pruned and topped at seven feet each year did not indicate a significant difference in yield between the two methods.

3. There is a significant cost for pruning and, for Hass, we think it should be done right after harvesting in early spring. There should still be enough flowering left after pruning to go ahead and set a good crop. Heavy pruning later will remove young fruit that have just set. Pruning in the summer will remove fruiting wood for the following spring.

4. If a grower decides to try high density plantings there must be a commitment to a pruning program. If not, the trees will drop the lower leaves and become quite leggy.

5. Although cost and return data will be presented in a future article, it can be said that, based on information developed from this trial, there was an increase in dollars per acre from yield minus pruning costs in three out of the last four years.

6. Water use per acre was 2.88 acre feet per acre, 4.82 acre feet per acre and 3.79 acre feet per acre for an average of 3.89 acre feet per acre during 2014-2017, less than the 4.5- 5.0 acre feet per acre used by the Stehly Ranch for their big trees on 20' x 20' spacing (normal for Valley Center). Water use on the high density trial was probably less because our trees do not have branches with leaves up in the wind which drives heavy water use.

7. Lamb Hass yield was okay but not as good as Hass. Lamb Hass is harvested in the summer and we had difficulty trying to prune these trees and not remove fruit during the pruning. Lamb Hass also had a high drop rate in the heat.

8. It appears that high density production for Hass is a viable way to increase income per acre and can help the growers in high water-cost areas to stay in production. However, I question whether we can spread the harvest out through the year and not affect the yield with pruning.

9. Are all those Zutanos necessary? We often get that question. Unfortunately, we did not have a comparison trial without the Zutanos, but my feeling is yes, I think they help increase the yield. But I cannot support that statement with data. That will be up to the grower. But please don't expect to support cross-pollination with just a few Zutanos, Bacos or Fuertes on 10 acres of Hass... it's not going to happen!

Research funding: We appreciate research funding from the California Avocado Commission.

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