

# **Improvement of Yield Per Acre by Close Spacing, Pruning of Close-Spacing ‘Hass’ and ‘Lamb Hass’ Trees, Combined with New Grower Education Classes - Final Report**

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*And the Nick Stehly Ranch, Valley Center, CA.*

**Introduction:** Water prices in San Diego County continue to increase and there is no end in sight, especially with periodic drought years and California losing some of its share of water from the Colorado River. In 2011, at the time this project was proposed, it was evident that growers who produced at the county average yield/acre of 5,000 lbs/ac and who applied 4 ac ft/yr in the inland valleys, were losing money and there seemed to be no answer, except to turn off the water and go out of avocado production. There needed to be a **substantial** increase in yield per acre in order for this industry to survive.

As outlined in a previous paper (1), a few growers who had switched to high density production were periodically producing into the 20,000-30,000 lbs/ac range, but they were having problems with pruning. If we could produce consistently at least above 11,000 lbs/ac (2) the avocado industry could remain viable for some time.

**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 8' (later reduced to 7').

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.

5. As part of this grant, we were funded to do new grower education courses each year. Despite losing acreage in San Diego County, we were apparently gaining new growers as existing growers were selling groves. This turned out to be true because we had 35-45 new growers signing up for the course each year.

***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. Based on observations during my career as a farm advisor and noticing that Hass trees always seemed to bear more fruit when next to a Zutano and/or other B-flowered avocado trees, (confirmed by Dr. Mary Lu Arpaia and Dr. Ben Faber in trials conducted in Ventura), 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 decided to order trees grafted onto Dusa rootstock which was 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, 2012. There was a heat wave during planting and we lost 10 trees, but they were immediately replanted. The irrigation was set up as spot spitters aimed at the base of the trees. These were changed to full circle 14 gal/hr 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 Fig 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 know the pruning is 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 7'. The idea is to keep the tree height in the 8' range in order to achieve the ideal height at 80% of the tree spacing (10') as proposed by Stassen in South Africa. Trees were also skirt-pruned at this time keeping the skirts 1' 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 7' 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 1' 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 one 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.

Figure 1.

Hass/Lamb-Hass High Density Trial Map																					
Watermonitor					Main Water supply valve																
Hass										Lamb Hass											
	H1	H2	H3	H4	H5	H6	H7	H8	H9	Faucet	L1	L2	L3	L4	L5	L6	L7	L8	L9	Xtra	
	H10	H11	H12	H13	H14	H15	H16	H17	H18	Faucet	L10	L11	L12	L13	L14	L15	L16	L17	L18	Xtra	
Road	Xtra	H19	H20	H21	H22	H23	H24	H25	H26	H27	Faucet	L19	L20	L21	L22	L23	L24	L25	L26	L27	Xtra
	Xtra	H28	H29	H30	H31	H32	H33	H34	H35	H36	Faucet	L28	L29	L30	L31	L32	L33	L34	L35	L36	Xtra
	Xtra	H37	H38	H39	H40	H41	H42	H43	H44	H45	Faucet	L37	L38	L39	L40	L41	L42	L43	L44	L45	Xtra
	Xtra	H46	H47	H48	H49	H50	H51	H52	H53	H54	Faucet	L46	L47	L48	L49	L50	L51	L52	L53	L54	Xtra
	Xtra	H55	H56	H57	H58	H59	H60	H61	H62	H63	Faucet	L55	L56	L57	L58	L59	L60	L61	L62	L63	Xtra
	Xtra	H64	H65	H66	H67	H68	H69	H70	H71	H72	Faucet	L64	L65	L66	L67	L68	L69	L70	L71	L72	Xtra
	Xtra	H73	H74	H75	H76	H77	H78	H79	H80	H81	Faucet	L73	L74	L75	L76	L77	L78	L79	L80	L81	Xtra
Hass										Lamb-Hass											
										Center tree is Zutano 10'x10' spacing											
1-Pink (Shaded)More Traditional Pruning Method-all around. Topped at 7 ft each year.																					
2-White Alternate Side Pruning Method- Single Side per year. Topped at 7 ft each year																					

**Harvesting.**

**Comparison of yield for two pruning styles.** Each tree was harvested separately in March of each year (2014-2017). A small amount of fruit was harvested from both Hass and Lamb Hass in the second year (2014). Yield for comparison of pruning styles is charted on the third, fourth and fifth years after planting (2015-2017) for ‘Hass’ (Fig 2) and on the third, fourth and fifth years (2015-2017) for ‘Lamb Hass’ (Fig 3).

Results thus far have indicated no significant difference in yield/tree between the two pruning styles. Likewise, there was no significant difference in numbers of fruit per tree between the two pruning styles. (Tables 1 and 2).

Fig 2. Comparison of Hass in two pruning styles 2015-2017. Style 1 Traditional Style, all sides pruned and topped each year in late March. Style 2 Alternate Side pruning in late March, starting with the south-west side.

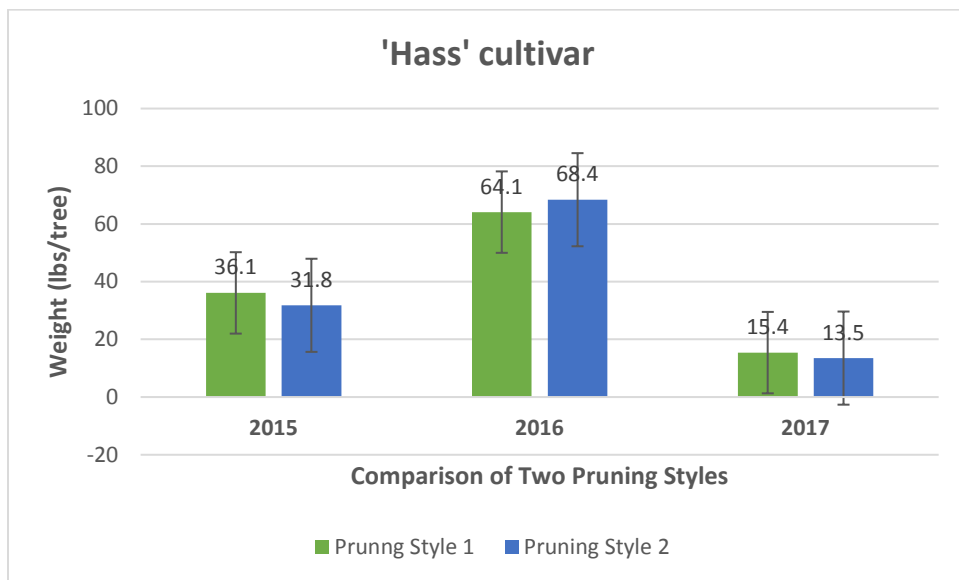


Fig 3. Comparison of Lamb Hass in two pruning styles 2015-2017. Style 1 Traditional Style, all sides pruned and topped each year in late June after harvest. Style 2 Alternate Side pruning in late June after harvest, starting with the south-west side.

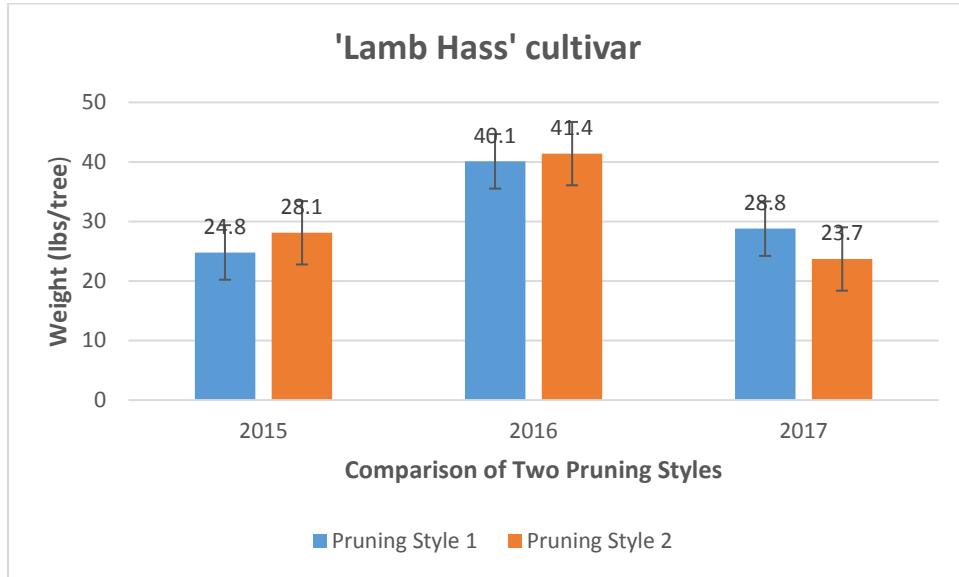


Table 1. Mean  $\pm$  standard error of the number and weight per tree of **Hass** avocados obtained with two pruning styles in 2015, 2016 and 2017. Style 1 Traditional Style, all sides pruned and topped each year in late March. Style 2 Alternate Side pruning in late March, starting with the south-west side.

	Number of Avocados/tree			Weight of Avocados/tree		
	2015	2016	2017	2015	2016	2017
<b>Pruning 1</b>	60.0 $\pm$ 3.9a	143.5 $\pm$ 7.2a	26.0 $\pm$ 6.4a	36.1 $\pm$ 2.1a	64.1 $\pm$ 2.8a	15.4 $\pm$ 3.4a
<b>Pruning 2</b>	53.2 $\pm$ 4.2a	151.4 $\pm$ 10.2a	19.9 $\pm$ 7.5a	31.8 $\pm$ 2.1a	68.4 $\pm$ 4.2a	13.5 $\pm$ 5.1a

Same letters within each column indicates no significant difference in the number or weight of avocados obtained with the two pruning methods.

Table 2. Mean  $\pm$  standard error of the number and weight per tree of **Lamb Hass** avocados obtained with two pruning styles in 2015, 2016 and 2017. Style 1 Traditional Style, all sides pruned and topped each year in late June. Style 2 Alternate Side pruning in late June, starting with the south-west side.

	Number of Avocados/tree			Weight of Avocados/tree		
	2015	2016	2017	2015	2016	2017
<b>Pruning 1</b>	31.6 $\pm$ 3.8a	58.7 $\pm$ 7.4a	44.6 $\pm$ 9.7a	24.8 $\pm$ 2.9a	40.1 $\pm$ 4.9a	28.8 $\pm$ 5.8a
<b>Pruning 2</b>	24.7 $\pm$ 4.1a	61.3 $\pm$ 7.7a	33.6 $\pm$ 10.6a	20.1 $\pm$ 3.1a	41.4 $\pm$ 4.9a	23.7 $\pm$ 6.3a

Same letters within each column indicates no significant difference in the number or weight of avocados obtained with the two pruning methods

**Yield per acre in the high density trial.** This trial had 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 divided by 72 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 2014-2017 yield/ac in Hass has been 480 lb/ac, 13,246 lb/ac, 25,104 lb/ac and 5,641 lb/ac respectively. The 2017 harvest was an off-year due to high temperatures in June, 2016 and typical alternate bearing. From years 2014-2017 yield/ac in Lamb Hass has been 975 lb/ac, 8,796 lb/ac, 15,243 lb/ac and 10,274 lb/ac respectively. Charts for this data are in Fig 3 and 4.

Fig. 3. Comparison of the yield from this high density trial (387 Hass trees/ac) vs California average yield/ac (commonly 109 trees/ac).

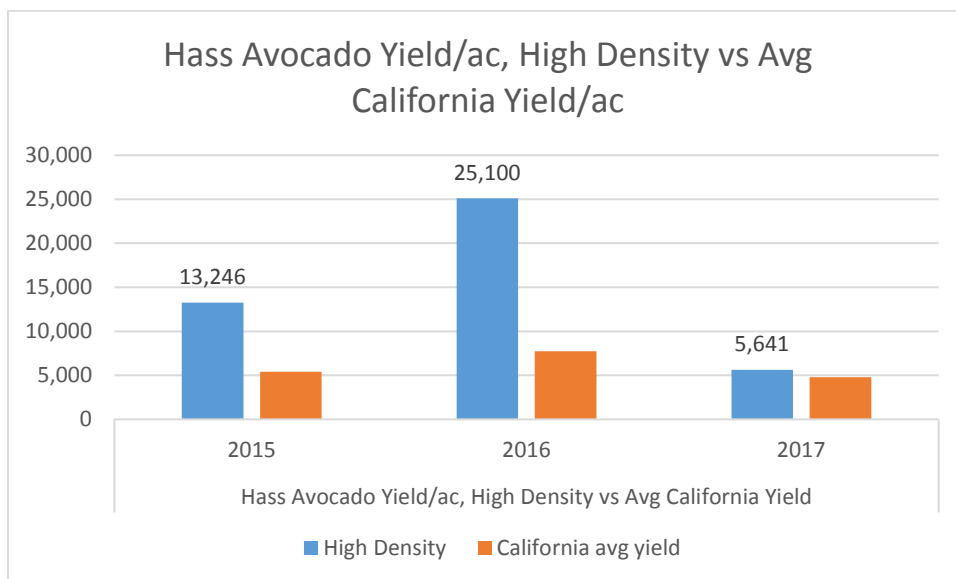
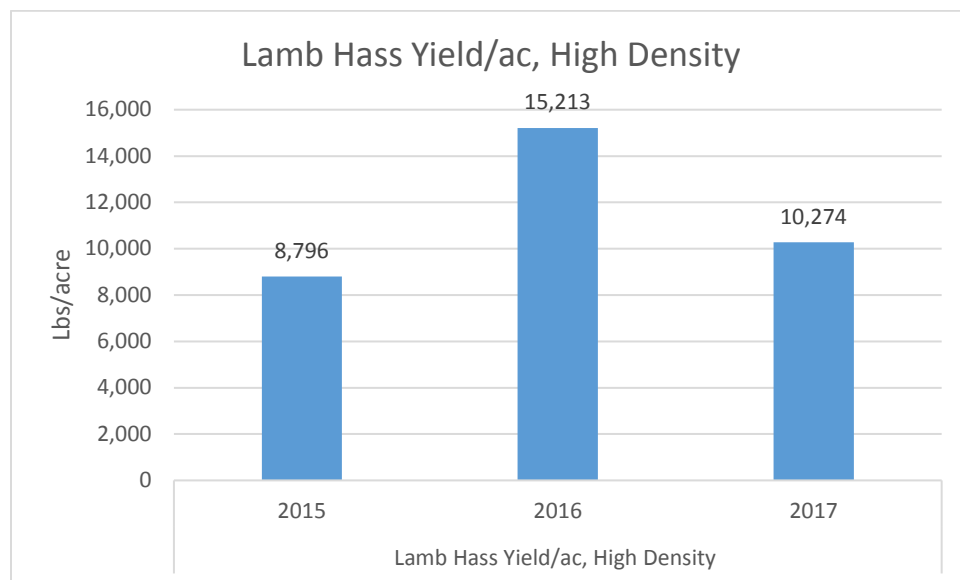


Fig. 4. Yield per acre for Lamb Hass (387 Lamb Hass trees/ac) based on data from this trial.



### ***Irrigation, water requirement***

In late 2012 Watermark soil irrigation monitors were installed at the edge of the root balls, 8” 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 large clay content, the trees were irrigated when the Watermarks averaged 35 40 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 3.

Table 3. 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/ac 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	14388	381926	1.17
11/1/2013-10/31/2014	405232	1075615	3.30
11/1/2014-10/31/2015	353610.5	938595	2.88
11/1/2015-10/31/2016	591991.7	1571336	4.82
11/1/2016-10/31/2017	46501.8	1234293.3	3.79

**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. This data is presented in Table 4 and data calculated for hrs/acre is presented in Table 5.

Table 4. Labor for pruning 18 Zutano trees, 72 Hass trees and 72 Lamb Hass trees.

Year	Topping Zutanos	Alternate side pruning-Hass	All sides pruned-Hass	Alternate side pruning-Lamb Hass	All sides pruned-Lamb Hass	Skirt pruning and aisle clearing, both Hass and Lamb Hass
2012*	0	0	0	0	0	0
2013	0.75	0.75	0.75	0.75	0.75	0
2014	1	4	6	0	0	3
2015	2	6	7	3	6.75	11
2016	2	8.25	5.5	3.75	8.25	13
2017	(2)**	7	11.75	0	0	14

\*Trees were planted in August/September, 2012.

\*\* Zutanos are not topped and pruned until December of each year, after the Zutano harvest on Dec 15 of each year.



Table 5. Hours of labor for pruning per acre, based on data from Table 4. Average number of trees per acre: 48 Zutanos, 387 Hass or 387 Lamb Hass.

Year	Topping Zutanos	Alternate-side pruning-Hass	All sides pruned-Hass	Alternate side pruning-Lamb Hass	All sides pruned – Lamb Hass	Skirt pruning and aisle clearing both Hass and Lamb Hass
2015-2017	6	21.25	24.25	6.75	15	38
Average per year in the trial plot (last three years)	2	7.1 for 40 trees	8.1 for 32 trees	2.25 for 40 trees	5 for 32 trees	12.7 for 162 trees
Average per acre	5.3	68.7	98.0	21.8	60.5	30.3
Cost per acre @ \$15/hr	\$79.50	\$1,030.50	\$1,470.00	\$327.00	\$907.50	\$455.08

### ***Harvesting labor***

Because trees are being kept below 8 ft, ladders are not required and harvesting is 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 and University of California staff. Therefore, the hours are not considered reliable and are not presented in this report.

***Increase (decrease) in Hass yield and dollars per acre due to high density based on this trial.***

Table 6. Increase in Hass yield due to high density (10' x 10'). California average yield\* is based on the assumption that most of California acres are on a 20' x 20' spacing. Increase in dollars/acre based on this trial.

Year	Hass yield/ac (Calif.avg)*	High density yield/ac	Increase in yield/ac	\$/lb (Calif. avg for March of each year)*	Increase in \$/ac due to high density
2015	5,240	13,246	8,006	\$1.12	\$8,967
2016	7,733	25,100	17,367	\$0.70	\$12,157
2017	4,801	5,641	840	\$1.53	\$1,285

\*California Avocado Commission

Table 7. Increase in \$/ac minus pruning costs for a high density grove.

Year	Increase in \$/ac due to high density compared to Calif. average (Table 6)	Pruning costs/ac (Zutano pollinizer trees and Hass all sides pruned and topped with aisle clearing)*	Increase (decrease) in \$/ac minus pruning costs/ac
2015	\$8,967	\$2,004.58	\$6,962
2016	\$12,157	\$2,004.58	\$10,152
2017	\$1,285	\$2,004.58	(\$720)

\*See Table 5

***Classes for new growers:***

As part of this project we also did classes for new growers. From 2013 – 2017 we taught avocado production classes, usually 2 hr sessions each week for 6-7 weeks, concluding with a Saturday field trip. Every year we had enrolment of 32-40 growers. We provided them with two Avocado Production books (authored by Gary Bender and other UC personnel) along with the Avocado IPM books. The level of interest was really good because there is a lot of grove turnover in San Diego County and there are always brand new growers who need a basic avocado production for education. All of our PowerPoints are posted online at <http://cesandiego.ucanr.edu>

***Conclusions:***

1. Earlier reports indicated that growers need to produce at least 10,000 – 11,000 lbs/ac to break even in conventional Hass avocado production in San Diego County. (2). This project showed that a high density planting is able to produce Hass avocados at 13,246, 25,100 and 5,641 lbs/ac over a three-year period for an average of 14,662 lbs/ac per year.

In this trial Lamb Hass produced at 8,796, 15,213 and 10,274 lbs/ac for an average of 11,428 lbs/ac per year. The trees are in a significant alternate bearing pattern and there will be a heavy crop harvested in March, 2018. We plan to weigh and count the fruit from that harvest.

2. The comparison of alternate side pruning and topping at 7 ft vs all sides pruned and topped at 7 ft each year did not indicate a significant difference in yield between the two methods.
3. As seen in Table 5, there is a significant cost for pruning. Based on information from this trial, to grow an acre of Hass using Zutanos for pollinizers, it would cost \$79.50/yr for topping Zutanos, \$1,470/yr for pruning all sides of the trees, and \$455/yr for skirt pruning and aisle clearing for a total of \$2,004.50/ac per year if the workers are paid \$15/hr.
4. Based on information developed from this trial, it can be seen from Table 7 that there was an increase in \$/ac from yield minus pruning costs in 2 out of the last 3 years. In 2015 this equaled an increase of \$6,962/ac, in 2016 this equaled an increase of \$10,152/ac and in 2017 there was a decrease of \$720/ac. This is assuming the average California grove does not have pruning costs.
5. Water use per acre was 2.88 ac ft/ac, 4.82 ac ft/ac and 3.79 ac ft/ac during the last three years of the trial, slightly less than the 4 – 4.5 ac ft/ac that is normal in Valley Center.
6. **It appears that high density production is a viable way to increase income per acre and can help the growers in high water-cost areas to stay in production.**
7. Interest in avocado growing in San Diego County is still strong based on the attendance by new growers at our yearly courses for new avocado growers.

***Literature cited:***

1. Bender, G.S. 2012. Avocado farming with high priced water. Can it remain viable? Topics in Subtropics 10(1):4-7. [http://ceventura.ucanr.edu/news/Topics\\_in\\_Subtropics/?newsitem=43393](http://ceventura.ucanr.edu/news/Topics_in_Subtropics/?newsitem=43393)
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