High-Density Avocado Planting - An Argument for Replanting Trees

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<u>Editor's Note:</u> The following article is written by Reuben Hofshi, a California avocado grower, and is a possible suggestion for a means to increase avocado productivity. This is presented in order to encourage discussion on the topic of how the industry can increase profitability. *Comments are encouraged from readers*. This article does not necessarily reflect the views of UC, CAC, CAS, or CRB.

Avocado growers have a limited number of options for managing overcrowded and shaded groves. Their options are tree removal (thinning) (Platt et al., 1975; Faber, 1991; Witney, 1992; Francis, 1994) or tree renewal by stumping (Faber, 1991; Partida, 1996). These options are viable but the benefits are short-term since the trees regrow rapidly, resulting in the same overcrowded situation. Production per acre after tree removal has been shown to increase for a few years. Stumping, on the other hand, although radical, reduces tree size and buys the grower a few additional years until the trees become overcrowded again. Productivity is reduced to zero for at least 1 - 3 years. Trees that are cut back to 8 to 15 feet will return to production sooner (Faber 1991; P. Stassen, personal communication). The new growth following stumping must be managed and requires the grower to repeatedly follow-up with tree canopy management through removal of water shoots and training. Growers' tendency to "baby" their rejuvenated trees by over irrigation and fertilization of the relatively smaller trees, in conjunction with limited understanding of how to manage the vigorous vegetative growth, will often push the stumped trees back to a dense canopy even before any profitable crop is produced. Reduced care by careful irrigation and nitrogen fertilization, combined with a program for canopy management, is probably the only way to slow recrowding (P. Stassen, personal communication). Stumping every other row, to keep the grove producing a year or two longer while the stumps regrow, is not a workable solution since the stumped trees require less water and fertilizer and are shaded by the remaining taller trees. Another solution is to retrain the regrowth to a single shoot or leader (Martin ,1998). On 'Hass' trees, single leader training tends to result in spindly vegetative trees with marginal crops especially if the grower only stumps alternate trees or rows. Canopy rejuvenation through branch renewal, a technique being practiced commercially in Israel and in some orchards in California, is an alternative for rejuvenating crowded orchards (Hofshi, 1996). The potential of this rejuvenation method is yet to be proven.

Tree replacement by replanting to densely planted orchards is another option that should be considered. There are several underlying premises:

1) To compete in the international market with low avocado prices will require more efficient farming and a significant increase in productivity.
2) Young trees are vigorous, produce large fruit early, have better canopy to root ratio and reach peak productivity approximately by 7 to 8 years.
3) Smaller trees are easier and less expensive to harvest, particularly when size picking is done, and are very amenable to snap harvest.

4) Spraying for different pests may become a way of life; smaller trees are probably the only ones that could be efficiently sprayed by ground rigs in hilly terrain (L. Mound, personal communication).

There is international interest in high-density plantings (G. Thorp, see pg. 8 of this issue; S. Köhne, see pg. 2 of this issue). Additionally, Piet Stassen (Institute of Tropical and Subtropical Crops, South Africa) in his recent visit to California (June 15 - 17, 1999) presented yield results of 'Hass' and 'Pinkerton' planted to two densities in South Africa. This data is presented with permission in Table 1.

The discussion that follows is intended to be an example of the potential that high-density plantings could achieve in California. The yield projections, which are used in the following tables are, based on farm records for 4 years of production ('Reed'), field observation ('Lamb Hass'), and research data ('Hass'). The projected yields may not reflect a real-life situation but are the basis for discussion on potential innovations in avocado production. The yield data sources are indicated in the text and in the footnotes of Tables 2 - 4. The intent of this article is to generate thought and discussion for high-density planting (Köhne, 1991; Razeto, 1998; Stassen et al., 1995; Stassen et al., 998). There are researchers who do not believe that growers should be planting avocado trees in a previously planted land with or without a rest period before replanting. It is the author's opinion and experience that avocado trees can thrive in replant situations and will actually benefit from the residual organic matter from the previous planting as long as the trees are managed properly. The residual plant material from the previous planting should pose no problem to a new planting, barring diseases (J. Menge, personal communication). If *Phytophthora cinnamomi*, the cause of root rot, has infested the site, rootstock selection and adequate soil preparation will be needed before replanting.

For high-density plantings to be successful, the following prerequisites are required:

a) A planting density of 7.5 ft x 7.5 ft (2.25 m x 2.25 m; approximately 773 trees per planted acre) for upright varieties such as 'Reed', 'Lamb Hass' and 'Gwen' (Table 2) and 10 ft x 10 ft (3.03 m x 3.03 m; approximately 435 trees per planted acre) for 'Hass' (Table 3). P. Stassen argues that planting in squares such as 7.5 ft x 7.5 ft (2.25 m x 2.25 m) will become problematical after 4 years as trees tend to expand equally on all sides. His experience prompted him to plant in a rectangular configuration, i.e. closer between the trees within the row and with a larger distance between the rows, such as 4.95 ft x 13.2 ft (1.5 m x 4 m) (Per tree square footage is almost identical in both schemes.) He states that this form of planting allows the creation of hedgerows, especially if trees are planted in a north-south direction on flat land. Hedgerows can be more easily manipulated to the pyramidal shape (closed vase) preferred by Stassen. He believes that this is the best tree form to allow for maximum light interception and light penetration into the canopy. His argument may not hold true under our hilly terrain where hydraulic considerations for adequate distribution uniformity of the irrigation system is preferred at the expense of "perfect" light interception. In this situation, planting in a square configuration, with trees trained to have a cylindrical shape with light intercepted by all sides of the tree, may be preferred over hedgerows (G. Thorp, personal communication).
b) Availability of large numbers of reasonably priced clonal trees so that high-density plantings are realistically affordable.

c) A plan for tree manipulation to extend the density of trees for a period of no less than 7 years and preferably 10 years after planting (M. L. Arpaia, S. Köhne, Y. Regev, G. Thorp, and M. Zilberstaine, personal communications).
d) A commitment to tree removal rather than rejuvenation when productivity begins to decline, i.e. 7 - 10 years after planting (M. L. Arpaia, personal communication). Rejuvenated trees have disproportionate root to shoot ratio, and rapid crowding will occur especially under very high-density conditions. Tree replacement provides the advantage of the utilization of new rootstocks and new varieties, which were selected in the previous 7 - 10 years. In South Africa, P. Stassen believes that if trees are managed correctly from the time of planting, that a high-density planting can be kept productive for up to 20 years. His data, however, just like ours, does not span over enough years to corroborate such a claim.

Table 4 is a potential scenario for a 6-acre futuristic avocado grove. The accompanying tables are a summary of the enterprise. This is only a model that could be modified for the variety planted, staggered vs. one time planting, and the tree density. These projected yields could be misleading since environment, alternate bearing habit of the avocado and other factors could positively or negatively alter productivity in any one year. However, it will remain relative in both cases (high-density and conventional planting) where the decrease in production in high-density will also mean the decrease in the other. There is a reduced risk in the multiple variety plantings, which will have a better chance of producing a good crop in at least one of the varieties. This presentation assumes a staggered planting of 2 acres at a time. The reason for staggered plantings is that the grove is never out of production once the trees have become productive. This scenario assumes that yield will decline quickly after year 8 due to overcrowding and excessive shading. **All references are made to the first year of planting, year one. Actual yield data sources are: 'Reed', years 1-5 based on some blocks at ACW Farms (7.5 ft x 7.5 ft spacing), years 6-8 are anticipated yields; 'Lamb-Hass', all years are anticipated yields based on field observations; 'Hass', all years are from the UC South Coast Research and Extension Center clonal rootstock trial (20 ft x 20 ft spacing) and extrapolated on a yield/tree basis.**

- *Year 1.* Plant 2 acres of 'Reed'.

- *Year 2.* Plant 2 acres of 'Lamb Hass'.

- *Year 3.* Plant 2 acres of 'Hass'. During this year, a minimal crop of 'Reed' (7.5 lbs. per tree) is achievable.

- *Year 4.* First reasonable crop of 'Reed' (30 lbs. per tree x 773 trees/acre = 23,200 lbs. per acre). Early production from 'Lamb Hass' is also attained. *Age of trees from planting: 'Reed' – year 4; 'Lamb Hass' – year 3; 'Hass' – year 2.*

- *Year 5.* 'Reed' may produce 75 lbs. per tree. 'Lamb Hass' are producing a commercial crop of 23,200 lbs. per acre @ 30 lbs. per tree. 'Hass' has the potential to produce 3,260 lbs. per acre at 7.5 lbs. per tree if the trees are cintured (P. Stassen, S. Köhne, personal communications). *Age of trees from planting: 'Reed' – year 5; 'Lamb Hass' – year 4; 'Hass' – year 3.*

- *Year 6.* The 'Reed' produces 85 lbs. per tree; 'Lamb Hass', 75 lbs.; and 'Hass', 25 lbs. *Age of trees from planting: 'Reed' – year 6; 'Lamb Hass' – year 5; 'Hass' – year 4.*

- *Year 7.* Production remains the same for 'Reed' and 'Lamb Hass' (85 lbs. per tree), while 'Hass' increases to 80 lbs./tree. *Age of trees from planting: 'Reed' – year 7; 'Lamb Hass' – year 6; 'Hass' – year 5.*

- *Year 8.* Due to shading and tree age, 'Reed' production declines to 40 lbs. per tree. 'Lamb Hass' remains steady for at least one more year. New trees are being made for the replacement planting. After harvest, the 'Reed' trees are removed and the 2 acres will be replanted and the cycle will begin again. This is done although the 'Reed' trees are still capable of reasonable production. *Age of trees from initial planting: 'Reed' – year 8; 'Lamb Hass' – year 7; 'Hass' – year 6.*

- *Year 9.* The original 'Reed' high-density planting was replanted the previous year and it has no production. The 'Lamb Hass' is down to 40 lbs. per tree and 'Hass' is in peak production of 80 lbs. per tree. The 'Lamb Hass' trees, like the 'Reed' the previous year, are removed and replanted following harvest. *Age of trees from planting: 'Reed' – year 1 of new planting; 'Lamb Hass' – year 8; 'Hass' – year 7.*

- *Year 10.* The 'Reed' and 'Lamb Hass' are out of production and 'Hass' yield is estimated at 70 lbs. per tree. *Age of trees from planting: 'Reed' – year 2 of new planting; 'Lamb Hass' – year 1 of new planting; 'Hass' – year 8.*

- *Year 11.* The 'Reed' is just beginning to produce 7.5 lbs. per tree. 'Lamb Hass' is non-bearing and 'Hass' declines to below 30 lbs. per tree, or 13,050 lbs. per acre. The 'Hass' trees are removed after harvest and replanted. It is likely that year 9 for 'Hass' production is not attainable, however, yield from these trees would offset the low yields from 'Reed' and 'Lamb-Hass' trees and make this scenario more feasible. *Age of trees from planting: 'Reed' –year 3 of new planting; 'Lamb Hass' – year 2 of new planting; 'Hass' – year 9.*

- *Year 12.* 'Reed' is producing approximately 30 lbs. per tree or 23,200 lbs. per acre; the 'Lamb Hass' is producing 7.5 lbs. per tree or 5,800 lbs. per acre. 'Hass' is out of production since it was replanted the previous year. *Age of trees from planting: 'Reed' – year 4 of new planting; 'Lamb Hass' – year 3 of new planting; 'Hass' – year 1).*

The total combined production over the 12-year period in the mixed 6 acres is 1,391,275 lbs. and the regular density 'Reed' planting (15 x 15 ft.) is 820,700 lbs. This is 570,575 lbs. more, a 70% increase in production. 'Reed' trees planted in a conventional planting would take an additional 5.78 years to equal the production of 12 years in a high-density planting. At year 17, the conventional planting is becoming less productive due to shading whereas, the high-density planting is back in peak production and beginning of the third cycle of replanting. The cost of establishment for this type of planting is primarily in the cost of the trees and the increased labor for planting. As for the infrastructure setup, the additional cost for increased irrigation emitters for a high-density planting is not significant. Clonal trees currently sell for $18 - 20 per tree with

a potential volume discount of 10 - 20%. The cost of the trees, therefore, at current prices is given below. This can be compared to planting the 'Reed' avocado at a standard spacing (193 trees per acre). The cost for this would be $3,743 per acre or $22,458 for 6 acres.

Variety	**# trees per acre**	**Price per tree**	**Price per acre**
'Reed'	773	$18	$13,914
'Lamb Hass'	773	$20	$15,460
'Hass'	445	$18	$ 8,010
Total cost for 6 acres			**$74,768**

This is a substantial expense and most likely the most limiting factor for a grower considering a high-density planting. Therefore, a prerequisite for such an enterprise is the availability of relatively inexpensive trees either through an accommodating nursery or a nursery cooperative. The discussion concentrating on the subject of a nursery cooperative, its costs and benefits as a source of less expensive trees are discussed in the following article.

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Table 1. Yield (lb/acre) of 2 avocado cultivars at two spacings over 3 seasons (planted in October 1995). Data from South Africa and reprinted with permission from P. Stassen, Institute of Tropical and Subtropical Crops, Nelspruit, South Africa.

Cultivar	Spacing (feet)	Months after planting (lb/acre)		
		19 months	31 months	43 months
'Hass'	18 x 10	445	4,336	8,319
	13 x 5	1,068	7,808	12,113
'Pinkerton'	18 x 10	597	6,259	7,188
	13 x 5	1,202	27,214	8,248

Table 2. Illustration of the influence of planting density on tree productivity (pounds/acre) in the 'Reed' or 'Lamb Hass' varieties (years 1 – 10 after planting).

Tree spacing (feet)	Area (ft^2) per tree	Trees per acre	Projected Production (lbs.)	Years after planting										Cumulative Yield
				1	2	3	4	5	6	7	8	9	10	
7.5 x 7.5	56.25	773	*per tree*	*0*	*0*	*7.5*[y]	*30*	*75*	*85*	*85*	*40*[z]	*0*	*0*	
			per acre	0	0	5,800	23,200	58,000	65,733	65,733	30,933	0	0	249,400
10 x 10	100	435	*per tree*	*0*	*0*	*7.5*	*30*	*75*	*85*	*85*	*85*	*40*[z]	*0*	
			per acre	0	0	3,263	13,050	32,625	36,975	36,975	36,975	17,400	0	177,263
10 x 15	150	290	*per tree*	*0*	*0*	*7.5*	*30*	*75*	*85*	*85*	*85*	*85*	*40*[z]	
			per acre	0	0	2,175	8,700	21,750	24,650	24,650	24,650	24,650	11,600	142,825
15 x 15	225	193	*per tree*	*0*	*0*	*7.5*	*30*	*75*	*85*	*85*	*85*	*85*	*85*	
			per acre	0	0	1,450	5,800	14,500	16,433	16,433	16,433	16,433	16,433	103,917
20 x 15	300	145	*per tree*	*0*	*0*	*7.5*	*30*	*75*	*85*	*85*	*85*	*85*	*85*	
			per acre	0	0	1,088	4,350	10,875	12,325	12,325	12,325	12,325	12,325	77,938
20 x 20	400	109	*per tree*	*0*	*0*	*7.5*	*30*	*75*	*85*	*85*	*85*	*85*	*85*	
			per acre	0	0	816	3,263	8,156	9,244	9,244	9,244	9,244	9,244	58,453

[y] Yield projections are based on actual production data for years 1 – 5 from ACW Farms in De Luz for 'Reed' in a 7.5 ft x 7.5 ft planting, years 6 - 8 anticipated yields; and 'Lamb Hass', all years are anticipated yields based on field observations.

[z] Assumes tree crowding due to planting density and tree removal following harvest. Field is replanted.

Table 3. Illustration of the influence of planting density on tree productivity (pounds/acre) in the 'Hass' variety (years 1 – 10 after planting).

Tree spacing (feet)	Area (ft^2) per tree	Trees per acre	Projected Production (lbs.)	Years after planting										Cumulative Yield
				1	2	3	4	5	6	7	8	9	10	
10 x 10	100	435	*per tree*	*0*	*0*	*7.5*[y]	*25*	*80*	*80*	*80*	*70*	*40*[z]	*0*	
			per acre	0	0	3,263	10,875	34,800	34,800	34,800	30,450	17,400	0	166,388
20 x 15	300	145	*per tree*	*0*	*0*	*7.5*	*25*	*80*	*80*	*80*	*80*	*80*	*80*	
			per acre	0	0	1,088	3,625	11,600	11,600	11,600	11,600	11,600	11,600	74,313
20 x 20	400	109	*per tree*	*0*	*0*	*7.5*	*25*	*80*	*80*	*80*	*80*	*80*	*80*	
			per acre	0	0	816	2,719	8,700	8,700	8,700	8,700	8,700	8,700	55,734

[y] Yield projections are based on actual production data a UC South Coast REC clonal rootstock trial planted at 20 ft x 20 ft and extrapolated on a yield/tree basis.

[z] Assumes tree crowding due to planting density and tree removal following harvest. Field is replanted.

Table 4. Projected production (lbs. per acre) for staggered planting of 'Reed', 'Lamb Hass' and 'Hass' in high-density as compared to either a single variety 6 acre planting under high-density or conventional spacing.

	Tree Spacing (ft)	Trees per acre	Years from Planting												Cumulative Yield		
			1	2	3	4	5	6	7	8	9	10	11	12	1 acre	2 acres	Total 6 acres
Combined Variety and Staggered Planting																	
'Reed'	7.5 x 7.5	773	0	0	5,800[y]	23,200	58,000	65,733	65,733	30,933	0[z]	0	5,800	23,200	278,400	556,800	
'Lamb Hass'	7.5 x 7.5	773	-	0	0	5,800	23,200	58,000	65,733	65,733	30,933	0[z]	0	5,800	255,200	510,400	
'Hass'	10 x 10	435	-	-	0	0	3,263	10,875	34,800	34,800	34,800	30,450	13,050	0[z]	162,038	324,075	1,391,275
Single Variety; Planting not staggered over years and varying densities																	
'Reed' or 'Lamb Hass'	7.5 x 7.5	773	0	0	5,800	23,200	58,000	65,733	65,733	30,933	0[z]	0	5,800	23,200	278,400		1,670,400
	15 x 15	193	0	0	1,450	5,800	14,500	16,433	16,433	16,433	16,433	16,433	16,433	16,433	136,783		820,700
	20 x 15	145	0	0	1,088	4,350	10,875	12,325	12,325	12,325	12,325	12,325	12,325	12,325	102,588		615,525
	20 x 20	109	0	0	816	3,263	8,156	9,244	9,244	9,244	9,244	9,244	9,244	9,244	76,941		461,644
'Hass'	10 x 10	435	0	0	3,263	10,875	34,800	34,800	34,800	30,450	17,400	0[z]	0	3,263	165,301		991,806
	20 x 15	145	0	0	1,088	3,625	11,600	11,600	11,600	11,600	11,600	11,600	11,600	11,600	97,513		585,075
	20 x 20	109	0	0	816	2,719	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	73,134		438,806

[y] Yield projections are based on actual production data for years 1 – 5 from ACW Farms in De Luz for 'Reed' in a 7.5 ft x 7.5 ft planting, years 6 - 8 anticipated yields; 'Lamb Hass', all years are anticipated yields based on field observations. 'Hass', all years are from UC South Coast REC clonal rootstock trial planted at 20 ft x 20 ft and extrapolated on a yield/tree basis.

[z] Assumes tree crowding due to planting density and tree removal following harvest the previous year. Field is replanted.