Book 2

Chapter 7

Pruning/Canopy Management

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Most mature avocado groves in Southern California are over-crowded. Crowding leads to a situation where there is little light penetration into the lower canopy; leaves in low light conditions drop and are not replaced as the tree shifts to growth in the upper canopy where there is more light. This in turn has led to poor flowering and fruit set in the lower canopy and (we believe) a general reduction in fruit production per acre overall. In addition, our most common cultivar 'Hass' is well known for flowering on the outside of the canopy, the most abundant flowering is always where the outside of the canopy is exposed to full light. Therefore, removal of the outside of the canopy (as part of a pruning program) has generally not led to increased yields. Researchers at the University of California in the 1960's remarked- "experience has shown that heavy pruning does not increase production but reduces it by stimulating new vegetative growth at the expense of fruit production" (McCarty et al. 1962).

A review of the literature on avocado pruning reveals that there have been few scientific evaluations of pruning and the costs and yield returns that are related. More information needs to be developed on the proper time for pruning, and the best methods (and the most economical methods) of canopy management.

However, the desire to increase yield per acre is only one factor involved in the decision whether to maintain a pruning program; other factors such as reduced picking costs, improved safety for pickers working in shorter trees, and better spray coverage when applying pesticides are all good reasons for pruning avocado trees. The latter point has become more important in recent years with the infestations of thrips and persea mites in the California avocado groves.

This chapter will examine the reasons why canopy management in avocado is one of the most difficult cultural operations. Solutions to the problem will be discussed, and yield results from a pruning trial in California will be presented.

Figure 1.
A recently thinned grove (every other row removed) showing lack of canopy on the lower trunk.

Issues in Canopy Management

An understanding of the reasons behind the difficulties in canopy management is essential. The following six points on this subject were presented in the Australian Extension avocado handbook (Newitt and Vock, 2001):

1. "The avocado is a rainforest species, which has evolved to compete for light in that situation. Growth is rapid and, if left unchecked, the tree may reach 15 to 20 m tall and 12 to 15 m in diameter within 15 to 20 years. Under Australian conditions, trees of these dimensions are uneconomical to manage because of the extra costs of spraying and harvesting large trees. Good spray penetration of the canopy and coverage often is more difficult to obtain and they also pose a higher risk of injury to pickers."

2. "The combination of terminal flowering and the long cropping cycle in the avocado present a unique problem for canopy management. As fruit form on the perimeter of the tree and are carried for considerable time (in some cases, over 12 months from fruit set to final harvest), there are few opportunities for pruning that do not risk damage to fruit."

3. "One option for reducing tree size that has been used successfully in other tree crops is dwarfing rootstocks. However, no dwarfing rootstocks suitable for commercial avocado orchards have yet been found."

4. "When establishing an orchard, land is generally the highest value input and growers need to maximize the return per hectare in as short a time as possible. The standard approach is to plant trees at a higher than normal density (up to 400 trees per hectare). Densities of up to 2000 trees/ha are being tried in California, but these are not considered suitable for Australian conditions. When planted at higher densities, trees will soon grow into each other unless canopy management is practiced. Once the side canopies meet, light penetration into the orchard is significantly reduced and, as a result, the fruiting surface migrates to the tops of trees. This reduces fruit yield, size and quality, makes pest and disease control more difficult and increases the costs of harvesting. Poor light penetration also reduces growth of the inter-row grasses, increasing the risk of soil erosion between the tree rows."

5. "Avocado branches are highly susceptible to sunburn. Heavy pruning exposes large limbs to the sun, and these limbs need to be protected by applying whitewash or a white plastic paint (not mineral-based paint)."

6. "One of the most effective ways to minimize canopy growth is to maximize fruit load because a tree carrying a heavy crop has fewer resources to put into vegetative growth. Careful management of nitrogen is the key to maintaining a good balance between fruit production and vegetative growth."

Methods of Canopy Management

Canopy management methods for the mature grove fall into three categories: 1) thinning, 2) drastic pruning (stumping or staghorning), and 3) gradual pruning. Methods to develop the young grove are similar to methods used after an older grove is stumped. These include pruning to a vase shape or pruning to a central leader. Doing no pruning at all, but adjusting the tree spacing according to the variety of avocado, could also be a legitimate strategy. However since Hass is the only variety with good returns to the grower, we don't really have this opportunity.

1. Tree thinning (removal of every other tree) has traditionally been the method for dealing with the crowding problem and was promoted by University of California extension specialists and farm advisors in the 1970's (Platt et.al 1975). Even though thinning relieved crowding in the grove, growers often balked at removing mature trees, and the remaining trees continued to grow upward (albeit at a slower rate).

Thinning is advantageous in that the operation opens up the grove and allows light to reach the lower limbs. Light on the lower limbs initiates vegetative growth from dormant buds, and eventually flowering and fruit-set occurs. The thinning operation increases yield on the remaining trees, but does not solve the problem of picking fruit high up in the trees.

The question remains as to whether thinning can increase yield per acre. Surprisingly, there is little data from California to answer this question. Platt et.al presented yield data from a Fuerte grove that averaged 8760 lbs/ac during years 10-14 when the grove was not crowded, 7675 lbs/ac during years 15-19 when the grove was crowded, and 11,033 lbs/ac during years 20-22 after the grove was thinned. In this example, they showed that yield per acre increased after thinning, with half the number of trees per acre.

Using small plots in a pruning trial conducted from 1999-2004 in a high yielding grove, Bender and Faber (unpublished) have shown that thinning a Hass grove did not increase yield per acre over the non-thinned control block, but yields in the thinned block were good. The yield in the non-pruned control block averaged 20,583 lbs/acre over the six-year period, in contrast to 14,252 lbs/acre in the thinned block. In this trial, data from the control block was considered to be exceptional and not representative of an average crowded grove.

Thinning Methods. The first step is to map the grove and mark weak trees. Plan the tree removal to remove as many of the weak trees as possible. If a tree is missing, leave a nearby tree in and train it to fill into the empty space. Ideally, the grove should be thinned before crowding occurs. If crowding has already occurred and trunks look like telephone poles after the thinning, foliage will grow and fill in the lower branches and trunk in about two years.

Thinning is usually accomplished by removing every other row on the diagonal (Figures 2-5). This allows light to reach all sides of each of the remaining trees. If the grower wishes to remove every other row to leave a hedgerow, crowding will be eliminated in one direction, but not along the row. A comparison of long-term yields from the two types of thinning programs has not been made.

Platt et al. suggested that the grove may have to be thinned a second time as the trees start to crowd again, and perhaps even a third time if the soil is deep and the variety has a spreading habit (Figures 6-12). Due to the shallow soils on the hillsides in California, most groves that are thinned are only thinned once, followed up by some topping and selective limb pruning.

Figures 2-12 are from Platt et al. 1975.

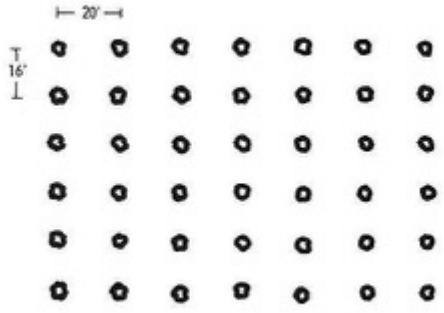

FIGURE 2. Original planting—136 trees per acre.

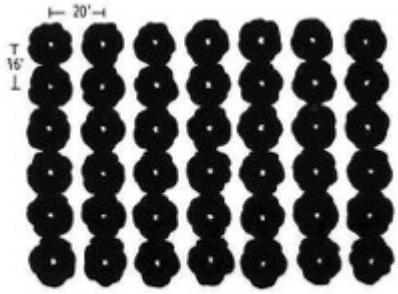

FIGURE 3. Trees starting to crowd.

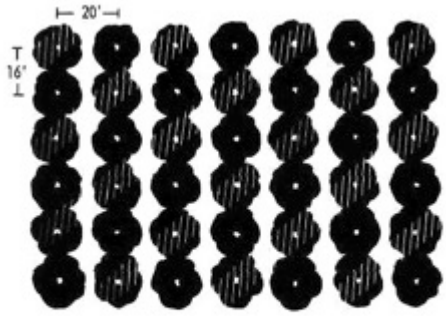

FIGURE 4. Every other diagonal row (temporary trees) removed.

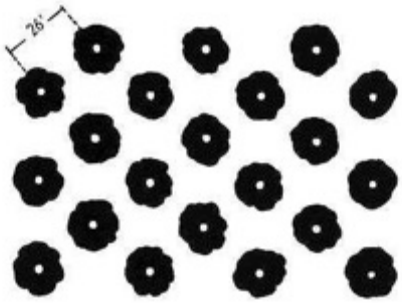

FIGURE 5. Orchard after first thinning—68 trees per acre.

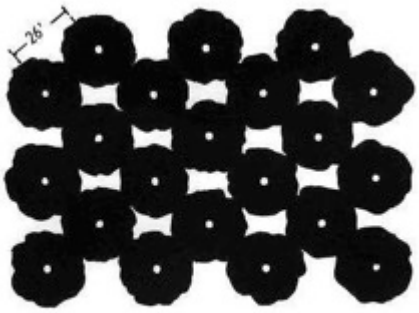

FIGURE 6. Trees crowding again.

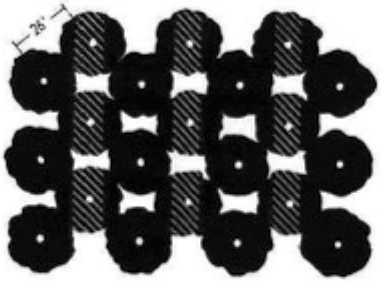

FIGURE 7. Removal of every other row. (semitemporary trees)

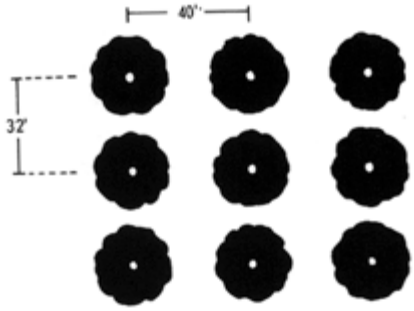

FIGURE 8. Orchard after second thinning—34 trees per acre.

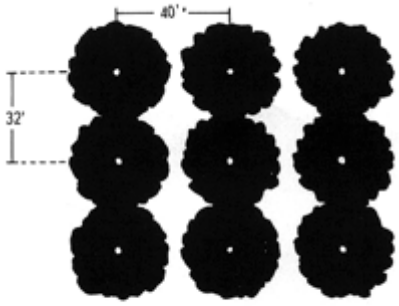

FIGURE 9. Trees crowding again.

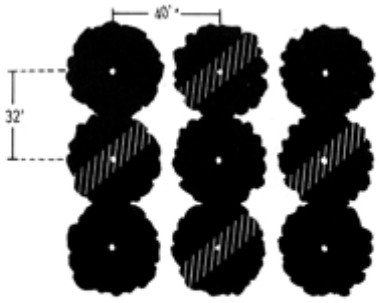

FIGURE 10. Every other diagonal row (semipermanent trees) removed.

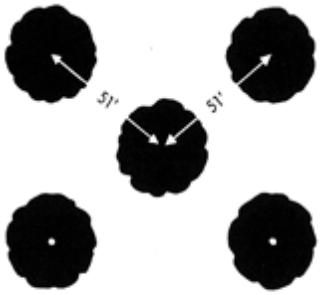

FIGURE 11. Orchard after third thinning—17 trees per acre.

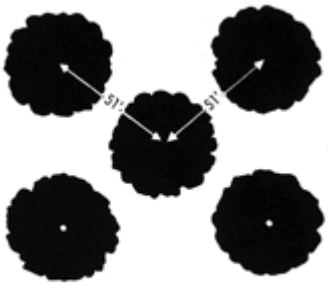

FIGURE 12. Mature orchard—17 trees per acre.

A question remains as to how to handle the irrigation system. Some growers cap the sprinkler where the tree has been removed, but other growers keep the sprinkler running with the belief that roots from the remaining trees have grown into this space. In our opinion, a "pig-tail" should be attached to the riser and the sprinkler relocated to the opposite side of a nearby remaining tree. This arrangement would give each remaining tree two sprinklers.

Figure 13. A stumped grove due to water cutbacks in San Diego County. Stumps have been painted with white water-based paint for sunburn protection. The firewood should be removed in order to reduce the fire hazard and to increase the efficiency of harvesting the trees after they grow back.

2. Stumping. When trees are just too tall, the grove may have to be stumped. In stumping, the tree is cut down to 4 or 5 feet in height leaving 2 ft-long stubs of the large scaffold limbs. Some growers take off all of the stubs to leave just the stump. Stumps should immediately be white-washed or painted with a white water-based paint to reduce sunburn damage to the bark. The main horizontal cut should be sloped slightly to avoid water puddling on the cut surface during a rain. It is not necessary to paint a tree sealant on the cut surfaces as a boundary layer of protective cells develops about ½ to 1 inch below the cut. This boundary layer reduces the invasion of fungi into the large cut, reducing the incidence of trunk rot. Applications of tree sealant often increase trunk rot because the sealant keeps the freshly-cut wood too moist. It is best to stump as early in the year as possible, but after the threat of rain has passed in order to reduce fungal infections in the wood.

It is best to stump an entire irrigation block at the same time. Irrigation can be discontinued until the trees begin to grow foliage. It is important to keep the soil moist when the tree starts to grow, but not over-watered. Water use by the trees as they start to grow will gradually increase and the use of a tensiometer or soil probe is necessary to guide the irrigation frequency and amount.

Stumping alternate rows has been tried with the thought that the grove could remain productive during the removal process; after the stumped trees grow and start to crowd, the taller trees are then stumped. It was discovered that the stumped rows were too shaded and would not flower, instead they grew vegetative upward and by the time they started to flower and fruit they were 2/3 of their original size. Also, it is difficult to irrigate this type of grove, and difficult to stump the remaining rows and not have branches crashing into the smaller trees.

Canopy Management after Stumping. Stumped avocados, if healthy, grow back very vigorously. Platt recommended that a progressive thinning program be practiced once the stumped trees began to crowd again. However, due to the high cost of picking fruit from extension ladders, others began to question if stumped trees could be maintained at a lower height and still remain productive. Greg Partida, professor at California State University at Pomona (Cal Poly Pomona) began a pruning program in which stumped trees were pruned to a modified vase shape by pruning lightly on the outside along with pruning in the center to create an opening for light penetration (Partida, 1996). Partida worked with a Hass grove that was interplanted with Zutano and Bacon for pollenizer trees. He pruned his trees in the spring, with light pruning in the summer to maintain the shape. During the spring pruning he reduced the height of the trees to 12 feet. He presented yield data on only 8 trees, but he showed that trees maintained at less than 15 feet tall had the potential to equal or exceed yield on trees that were 50 feet tall. Given the alternate bearing habit of avocado, several years of yield data with more replications would be necessary to convince the industry to enter into a pruning program after stumping, but this paper did create interest.

Gray Martin (working for the University of California Avocado Breeding Program) expressed the opinion that Hass trees should be pruned to a central leader shape after stumping or grafting, maintaining that increased light distribution to the tree canopy would eventually result in increased production (Martin 1991). Under his system, trees would more or less maintain a shape like a fat Christmas tree; this would require periodic pinching or bending down of lateral branches to decrease competition for growth with the central leader. No data was presented as to yield from this type of canopy management system.

Bender and Faber included the stumped-to-vase shape and the stumped -to-central leader pruning systems along with a stumped (with no follow-up pruning) control block, in their pruning trial that began in 1998. As of the last harvest in 2004, the stumped block with no follow-up pruning had the best production, followed by the stumped-central leader system. The stumped-vase shape system did poorly, but yields may have been suppressed by shade from nearby trees, and by the fact that they were pruned late in the year (October). From experience it appears that avocados should <u>not</u> be pruned after the summer flush, and it is best to prune in the spring. Yields from this pruning trial are listed in *Table 1*.

Table 1. Yield (calculated in lbs/acre) from an avocado (Hass) pruning trial in San Diego County. All trees were stumped in May, 1998. Central leader trees were pruned in June, vase-shaped trees were pruned in October of each year. Eighteen data trees per treatment.

Pruning Style	1999	2000	2001	2002	2003	2004	Average yield (lbs per acre)/yr
Stumped, vase shape	0	0	5,004	4,578	1,713	623	
Stumped, central leader	0	6	4,657	11,881	1,968	10,810	4,888
Stumped, no follow-up pruning	0	0	8,857	23,937	2,503	9,421	7,453

As can be seen, stumping takes a grove out of production for two years. When the trees were stumped and not pruned, a very high yield was attained in the fourth year, but then crowding set in and yields were reduced again. In this trial, pruning to a central leader with yearly maintenance pruning in June, and topping at 14 feet, gave good yields in the fourth and sixth year (the fifth year was an off year), and all of the fruit could be harvested from the ground with picking poles. The vase shape pruning was done in October due to labor availability, but this was too late to prune; most of the fruiting wood was cut off and did not have a chance to re-grow before the spring.

Experimentation is still in progress to find the best method to handle the canopies of stumped trees, and optimum time for pruning.

Staghorning. In other avocado-growing countries, the word "staghorning" includes stumping (the most drastic form of staghorning). In California, the word "staghorning" refers to trees that have been cut back to approximately 15 to 20 feet in height, leaving bare branches without foliage. "Stumping" (as described above) refers to a tree that has been cut back to 4-5 ft in height.

When staghorn pruning is finished, the general shape of the tree should be like a pyramid, narrow at the top and wider at the base. This allows for better light penetration into the lower canopy, with better flowering and fruit set.

Staghorning is done with the belief that trees will be back in production 1 year earlier than stumping. This is likely, especially if the trees are pruned early in the year (February or March). However, staghorning is not very popular in California for the following reasons:

- The pruning operation is difficult and dangerous. Chainsaw work is done mostly from a ladder, and branches do not always fall away from the person doing the pruning. Avocado branches are notorious for being out of balance, when pruned they often twist around and fall the wrong direction. It is better for the worker to have his/her feet on the

ground so that he/she can move out of the way if the branch begins to fall the wrong direction.

- Bare branches high off the ground are still susceptible to sunburn and should be painted with white water-based paint after pruning is finished. This is difficult to do with high branches, and is usually not done.
- Abundant vegetative growth occurs just below the pruning cut. This growth is high in the tree and is difficult to keep in check with follow-up pruning.

Although it would seem that staghorning might be more beneficial than stumping, it is not generally recommended in California.

3. Gradual Pruning. The concept behind a gradual pruning program is to keep the height of the trees down to a reasonable height, and to keep the tree canopy within it's allocated space. The idea is to keep the grove in production with as high a yield as possible. Several ideas have been advanced as to how to accomplish this goal, and some were incorporated into the Bender/Faber pruning trials.

Selective Limb Removal.

a. Israeli Method. This method was suggested to the author by some visiting Israeli farm advisors. In this method, the tree is divided into five main branches. (Some branches may be low in the canopy and some may be higher, but almost all trees can be divided into five main branches somewhere in the canopy.) Starting on the southwest side of the tree (the side facing the setting sun), a branch is removed the first year (cut to a two foot long stub). This allows light to penetrate into the lower canopy initiating vegetative growth. The next year a branch is removed on the opposite side of the tree. The third year a branch is removed in the middle of the tree, and in the fourth and fifth year the last two remaining branches are removed. This method is simple, most of the chainsaw work is done from the ground, and the tree never goes out of production.

b. Two-Cut Method. Each year one vertical branch is removed (cut at about the 20 ft height) and one side branch is removed. The side branch chosen is the one encroaching most into the neighboring tree. In the case of the vertical branch, it should be cut back to a horizontal branch to reduce the amount of vegetative re-growth around the cut surface. In the case of the side branch, it should be cut back to a branch to avoid leaving a stub. After the pruning is finished, there should be about 20% dappled light hitting the ground (if the grove floor was completely shaded prior to the pruning). In our experience, "two cut" pruning continued for four years before we reduced it to "one cut" pruning to avoid removing too much canopy. This method allows the grower to gradually reduce the height of the trees and to gradually bring the canopy back into its space.

c. Low Branches. In any type of canopy management system, low branches along the ground should be removed. They interfere with water distribution from the sprinklers and fruit are often lying on the ground, resulting in poor coloration of the peel.

1. **Pruning to the Pyramid Shape.** Stassen and colleagues from South Africa believed that the pyramid shape is the only shape that could allow enough light to all parts of the tree to

achieve maximum sustained production of the tree unit (Stassen et.al, 1997). They stated "plant parts differ in their sunlight requirement, but need between 30 to 50% of the available sunlight to function normally. When the minimum requirement is not met then inefficiency, retardation and ultimately die-back will occur."

The attempt to achieve the pyramid shape was the purpose behind stumping and pruning to a central leader system in the Bender/Faber trials (described above). Alternatively, pruning to a pyramid can be partially achieved (on two sides of each tree) by hedgerow pruning with machinery, or it can be achieved on all sides of each tree by hand pruning. The need to prune hedgerow trees can be reduced if the trees are grown like a pyramid in the nursery.

Figure 14. A grove that has been machine-pruned. Trees are machine-pruned in every other row each year, leaving the non-pruned row to develop fruiting wood and set a crop. The non-pruned row is harvested before pruning, usually in April. These trees are about 6 m (20 ft) in height.

a. Hedgerow Pruning using Machinery.

Hedgerow pruning is done in some avocado regions of the world where the ground is flatter and pruning machinery can be driven down the row. The method is seldom used in California due to the hilly terrain. Hedgerow pruning shapes the trees into the pyramid shape with a wall of foliage on two sides, separating the rows and allowing light into the lower branches. According to the Australian Avocado Extension Handbook, the best yields are achieved when the rows run north to south (the sun passes over the row illuminating both sides of the row equally).

Other characteristics of the hedgerow pruning system in Australia include:

- shape of the trees should be an A shape in cross section, narrow at the top and broad at the bottom, pruned to an angle of 22° to the vertical to achieve good light penetration down the face of the "wall".
- tree height should be up to 6 m (18-20 ft).
- tree canopy diameter at the base should be 5 m (15-16 ft).
- spacing between rows should be 7.5-8 m (24 ft) plus 3 m (9-10 ft) for a laneway.
- tree spacing within the rows should be as close as 4 m (12-13 ft).

b. Pyramid Pruning by Hand. As suggested by Stassen et. al 1997, the goal is to develop trees that are narrow at the top and wider at the base, with the tree width restricted and the inner branches and foliage thinned to keep the canopy from becoming too dense.

- This tree form is easier to achieve when the trees are shaped early, starting at the nursery.
- A central leader, or two or three leaders that are growing vertically are utilized.
- Branches on these leaders should be not more than one-third to one-half of the thickness of the leader. Branches or shoots at the top of the tree must be weaker than those at the base. Very strong branches and those in the wrong position must be cut away at the point of attachment. (Note that this recommendation differs from hedgerow pruning by machinery where all branches are sheared off along the outer wall, not the point of attachment to the central leader).
- Strong water shoots should be removed in June, August and October.

The "goal of pyramid pruning" as outlined by Stassen can be daunting for the grower when faced with an over-crowded orchard. Further suggestions to the practice were outlined by South African researchers Snijder, Mathumbu and Stassen in 2000.

1. **Time of pruning.** Initial severe pruning should be done after harvesting.
   - During **post harvest** pruning, individual branches are removed that cause overshadowing. The pyramid shape of the tree after pruning prevents the treetops from becoming too wide and too tall.
   - During **spring pruning** watershoots (upright-growing shoots) are either removed or headed back when they reach a length of about 10 inches. Terminal growth should be tipped back where excessive flowering occurs. Only small amounts of nitrogen should be applied during the spring to reduce growth.
   - During **summer pruning** a light skimming of the shoots tops is done to increase side branching in the trees. Special attention is made to the treetops to keep the trees from becoming too wide.

2. **Strategies for Pruning.**
   - **Little or no overcrowding.** In this case the trees have not grown together and leaf canopy is to the ground, but some die-back has begun on the inside of the trees. Trees should be pruned so that treetops are made narrower and branches

do not over-shadow the base. Upright shoots are removed, leaving more branches on a horizontal plane. Sides of the tree should be cut at a 10° angle, and the tree height should not be greater than 80% of the row width; this is done by cutting the top of the tree at a 25° angle.

- **Medium overcrowding.** Die-back at the base of the trees has commenced. Prune one side of the trees at a 10 angle and the tree tops at a 25 angle to get light into the lower branches. The other side of the trees will be pruned in the second year. Starting in the third year a light annual pruning maintenance pruning is begun.
- **Serious overcrowding.** In this case the tree trunks are visible with no foliage for 6-10 ft (or more) above the ground. Drastic pruning is required, the yield for at least one year will be sacrificed. A leader is cut at about 15 feet in height, and side scaffold pruning is done to create the pyramid shape as described above. The branches are painted with a water-based paint to reduce sunburn. The new growth is shaved at three months and six months after pruning to increase side branching and to maintain the pyramid shape.

Conclusion

Avocado pruning trials have thus far not been shown to increase yield per acre, but other factors important to production have benefited from pruning. These include lower picking costs, better safety for pickers and better spray coverage for pesticides. This is an area of active research in many avocado-producing countries. Hopefully, with research, we will soon reach a conclusion as to the best method of pruning, the best timing for pruning and the most economical method for maintaining a reasonable tree canopy.

LITERATURE CITED

Martin, G. 1991. Avocado tree structuring. Calif. Avocado Soc. Yrbk. 75:51-56.

McCarty, C.D., R.G. Platt and L.N. Lewis. 1962. Pruning avocado trees. Calif. Avocado Soc. Yrbk. 46:42-43.

Newett, S. and N. Vock. 2001. Avocado Information Kit. Dept. of Primary Industries, Queensland Horticulture Institute Agrilink Series QAL9906 Section 4:58-64.

Partida, G. J. 1996. Avocado canopy management for greater yields and orchard efficiency. Calif. Avocado Soc. Yrbk. 80:117-131.

Platt, R.G., G.E. Goodall, C.D. Gustafson, B.W. Lee., 1975. Thinning avocado orchards. University of California Leaflet 2799: pp. 1-8.

Snijder, B., J.M. Mathumbu and P.J.C. Stassen. 2000. Pruning and managing existing avocado orchards. S. African Avocado Growers Association Yearbook 23:36-38.

Stassen, P.J.C., S.J. Davie and B. Snijder. 1997. Guidelines for planning future avocado orchards. Neltropika (October, 1997). 39-50.