AVOCADO CANOPY MANAGEMENT
SUSTAINABLE PRODUCTION OF TOP QUALITY FRUIT

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Avocado trees exist to harvest the sun's energy and convert it into fruit with viable seed. Avocado growers aim to make money by nurturing this process, by managing the soils and water supply needed for plant growth, and by canopy management. This paper discusses the major avocado canopy management issues being covered by research in New Zealand.

Canopy management

So what is canopy management and why is it important? Canopy management is the manipulation of tree canopies to optimise the production of top quality fruit. It involves more than just pruning and tree training. It also includes the regulation of flowering and fruit growth.

In many fruit crops, improved production and fruit quality has come from producing more fruit from smaller trees. This is because small trees are better at capturing and converting sunlight into fruit than large trees. With avocados, smaller trees also mean safer and more efficient harvests. If we are going to have small tree orchard systems for avocados then we must develop the canopy management techniques needed to achieve this and we need to know how these modified canopies will affect fruit quality.

Converting sunlight into fruit

Fruit production involves the capture and conversion of light energy into fruit biomass (dry matter). The main controlling factors here are the amount of incoming radiation, the percentage of that radiation which is intercepted by the tree, and how efficiently the tree converts that energy into fruit (Wünche and Lakso, 2000).

Both climate and length of growing season determine the amount of incoming radiation. The grower can control neither of these, apart from in the initial choice of orchard site. Also, length of growing season is probably not that important for avocados, an evergreen tree, than it is with say apples which shed their leaves in autumn and thus have a finite growing season.

The percentage of incoming radiation intercepted by the tree is where growers have most control. Important decisions here relate to block size and planting density. In small orchard blocks the surrounding shelter trees shade a greater proportion of trees than they do in larger blocks. The situation is similar with high density plantings where shading from adjacent trees results in large volumes of shaded canopy and leaves operating well below their photosynthetic potential. In this case "high-density" is determined more by tree size than by planting distance. At the other extreme, low density plantings result in a high percentage of incoming radiation being captured by the grass growing between the trees and not by the avocado trees themselves.

Canopy management, particularly tree training and pruning, also affects the percentage of sunlight intercepted by the tree, as tree shape determines the presentation of the leaf area to incoming radiation. Generally a narrow tree that is wider at its base than its top will have the greatest area of leaves exposed to sunlight. It should come as no surprise then that this is the preferred tree shape for most tree fruit crops. In New Zealand, we have recently started to develop slender pyramid pruning systems for avocados (Fig. 1). Based on similar techniques used with apples (Tustin, 1990), the objective with these trees is to start with single axis trees provided by the nursery and to have minimal pruning in the first years so that the trees naturally produce a single dominant trunk. With the emphasis on minimal pruning, maintenance pruning involves only the removal of side branches likely to reduce the dominance of the central leader, and thus to promote the development of a slender fruiting canopy. Our oldest trees are 3 years old and will produce their first significant crop in the coming season. With high cropping levels we expect to be able to maintain these trees at around 3 m in height.

Figure 1. Slender pyramid pruning systems, developed for apples, are being adapted to avocados to enable high-density plantings.

Once trees have intercepted the incoming radiation, tree architecture will also influence the efficient conversion of this light energy into fruit. Put simply, the target is to have less wood and more fruit. Pruning trees to be shorter and with less structural wood can achieve this (Table 1), as will the slender pyramid pruning systems described above.

Table 1. Reducing tree height and the amount of structural wood (large branches) can lead to more and bigger fruit on each branch, without reducing tree yields (Thorp and Stowell, 2001).

Tree height	Tree Yield (t/ha)	Branch Yield (kg/branch)	Fruit size (g)
8-10 m (no pruning)	21.0	7.9	214
6 m (pruning)	19.3	9.2	222
	NS[1]	*	*

[1] NS = not significant; * = significant at $P<0.05$.

Smaller trees can also be achieved by utilising new fruiting cultivars with higher productivity and/or improved tree shape (Thorp and Sedgley, 1993), or with rootstocks that reduce tree size and/or increase fruit yields. Upright growing cultivars, for example 'Reed' and 'Lamb Hass', make more efficient use of the orchard space and with simple adjustments to canopy architecture can lead to extremely high orchard yields of more than 50 t/ha for 'Reed'. Dwarfing rootstocks, if they were available for avocados, would have a similar effect by reducing tree size and increasing the partitioning of dry matter to fruit production (Thorp and Hallett, 1999). In place of dwarfing rootstocks, growers can experiment with root restriction bags, as successfully used with apples and stonefruit.

Improving fruit quality

Smaller, more intensively managed trees will mean that more fruit will be produced on exposed parts of the tree. This is likely to affect fruit development and quality and needs to be considered when developing new pruning systems.

In New Zealand, the major fruit quality targets for avocados are increased fruit size without reduced fruit yields; fruit that are free from internal and external disorders; fruit that have excellent storage performance; and most importantly for consumers, fruit that have no rots. Canopy management has a major influence on the achievement of these targets. Importantly, it is the combined effects of canopy conditions over at least two years prior to harvesting a crop that can potentially affect fruit quality. For example, excessive determinate flowering on avocado trees (Fig. 2) is induced by conditions prevailing in the previous season. Excessive determinate flowering delays leaf growth in spring and may lead to smaller fruit with reduced mineral concentrations and poor storage quality. We still do not know what conditions promote the determinate flowering habit, but bloom pruning to stimulate leaf growth and thus increase the movement of nutrients to the new crop of fruit may reduce the impact of excessive determinate flowering. Bloom pruning may also reduce flower load and so increase fruit retention, increase photosynthetic potential and increase return bloom and fruit yields.

Figure 2. Excessive determinate flowering can mean less competition between developing fruit and vegetative growth, but the delayed leaf area production in spring may ultimately lead to smaller fruit with reduced mineral concentrations and poor storage quality.

Trees with excessive determinate flowering also have a large proportion of their crop directly exposed to the sun. In summer, these temperatures can be more than 45°C (Woolf et al., 1999a). But even in mid-June (lowest light intensity), we have measured temperatures of 35°C on exposed fruit, while shaded fruit were 12°C. We have examined the effect of these temperatures on fruit quality both at harvest and following a range of postharvest handling procedures.

For sun-exposed fruit at harvest, we observed higher dry matter and oil content, and higher levels of calcium, magnesium and potassium. In addition, the fatty acid makeup of oil in these fruit were also found to be different (Woolf et al., 1999b). Following harvest, exposed fruit took longer to ripen, and the exposed sides of fruit were firmer than the un-exposed sides. Exposed fruit were also more tolerant to both high temperature conditioning (50°C hot water treatments), and low temperature storage (0°C for 3-4 weeks) (Woolf et al., 1999a).

These responses have been observed in both Israel (Woolf et al., 2000) and New Zealand (Woolf et al., 1999a&b), and on a wide range of (but not all) avocado cultivars (Woolf et al., 2000). This indicates that these responses are widespread and their effects should be considered in management of avocado canopies.

Canopy management is also important to controlling fruit rots. This may involve pruning to remove inoculum from the canopy (e.g. dead wood, mummified fruit) and pruning to create more open canopies with increased air flow and lower humidity in the fruiting canopy.

References:

Thorp, T.G. and Hallett, I. 1999: Searching for "paradise" in the avocado germplasm. Revista Chapingo Serie Horticultural 5 Nium. Especial: 29-35.

Thorp, T.G.; Sedgley, M. 1993: Architectural analysis of tree form in a range of avocado cultivars. Scientia Horticulturae 53: 85-98.

Thorp, T.G. and Stowell, B. 2001: Effect of pruning height and selective limb removal on yield of large 'Hass' avocado trees. HortScience 36 (4): *in press*.

Tustin, D.S. 2000: The evolution of central leader apple tree management in New Zealand. Compact Fruit Tree 23 (3): 83-92.

Woolf, A.B.; Wexler, A.; Prusky, D.; Kobiler, E.; Lurie, S. 2000: Direct Sunlight Influences Postharvest Temperature Responses and Ripening of Five Avocado Cultivars. Journal of the American Society for Horticultural Science 125(3): 370-376.

Woolf, A.B.; Bowen, J.H.; Ferguson, I.B.; 1999a: Preharvest exposure to the sun influences postharvest responses of 'Hass' avocado fruit. Postharvest Biology and Technology 15(2): 143-153.

Woolf A.B.; Ferguson, I.B.; Requejo-Tapia, L.C.; Boyd, L.; Laing, W.A.; White, A. 1999b: Impact of Sun Exposure on Harvest Quality of 'Hass' Avocado Fruit. Revista Chapingo Serie Horticultural 5 Nium. Especial: 352-358.

Wünche, J.N. and A.N. Lakso 2000: Apple tree physiology – implications for orchard and tree management. Compact Fruit Tree 33 (3): 82-88.