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Training and manipulation of young avocado trees

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ABSTRACT

Loss of production and fruit quality in older avocado orchards is mainly the result of overshadowing which results in die-back of bearing wood inside and in the lower part of the tree.

This is brought about when:

- **tree tops become wider and in this way partly overshadow the base of the tree**
- **the top of one tree overshadows the base of an adjacent tree. This is caused by incorrect row to tree height dimensions.**
- **the radius of the tree is too large and no light can effectively penetrate to the centre of the tree. Bearer shoots on the inside of the tree die off and trees grow larger to compensate.**
- **the tree canopy becomes too dense as a result of large branches and shoots destroying the tree's branch hierarchy.**

Light management in the orchard and in individual trees is of utmost importance to maintain annual production of quality fruit. In order to apply light management effectively, it is necessary for certain physical aspects such as row orientation, tree dimensions, tree shapes and work row to tree height ratios, to be taken into account.

In this paper the following will be discussed:

- **Suggestions regarding the most suitable planting system for attaining optimal light interception.**
- **Training of trees into a shape that will improve light penetration.**
- **The principle of tree branch hierarchy where side branches and shoots are maintained in an inferior position to leader branches.**
- **The stimulation and renewal of the bearer shoots for early development and maintenance of optimal tree complexity to increase fruitfulness.**
- **The outstanding results that have already been commercially achieved.**

Economic realities force producers to implement more intensive, easily manageable systems where higher yields of quality fruit are produced annually. For this purpose it is necessary that each tree, and the orchard as a whole, functions effectively.

INTRODUCTION

Favourable climatic conditions which enhance vigorous growth are experienced in most commercial areas and, together with fertile soils and higher plant densities, give rise to rapid tree encroachment. This leads to a decrease in yields and fruit quality and provides problems with regular orchard management practices. Over the past five years, researchers at the Institute for Tropical and Subtropical Crops (ITSC) have been investigating possible solutions to this problem (Stassen *et al*, 1995; 1997; Snijder & Stassen, 1998; Renter & Stassen, 1998).

In 1931, Newman showed that a central leader avocado tree is better adapted to orchard conditions. It enhances light penetration into the tree with a better balance between the leader and bearing branches and with better production obtained from a more manageable tree. Stassen, Davie & Snijder (1995) discussed in detail the importance of a properly shaped tree. This will ensure higher productivity and better sunlight interception and penetration, which in turn will keep the tree healthy and vigorous. Stassen *et al.,* (1997) could already give provisional guidelines for avocado production, based on the first few years of research. These guidelines emphasize the following points:

- a pyramidal tree shape is best for light interception and penetration. (Not necessarily a sharp point pyramid, but the tree must be shaped at an angle, wider at the base and narrower at the top)
- tree manipulation to enhance or curb growth at different stages of tree development must be implemented to ensure early and high production.
- a rectangular planting system is better suited for optimizing light interception and orchard management.
- a manipulation and pruning programme includes optimising irrigation and fertilizer management as well as other measures of growth control especially on high potential and old banana soils.

In 1991, Köhne & Kremer-Köhne already advocated higher density plantings. However, in their research a correct and planned tree shaping programme as well as an appropriate planting system was lacking. The result was that after five years the trees were reaching an encroached stage where tree removal as prescribed by Toerien & Basson (1979) and by Whiley & Schaffer (1994) had to be done. Snijder and Stassen (1997b) showed that with a proper planting system, a tree manipulation and training programme in place, and appropriate orchard management strategies this high density orchard could have been maintained. It is also very important that tree training and manipulation has to be done timeously so that energy flow will always be directed towards fruit growth instead of vigorous watershoot production (Snijder & Stassen,

1998). Whiley & Wolstenholme (1990) showed that energy flow in avocados is always inclined towards vegetative growth. For better fruit quality, manipulation has to be done in the early stages of a vegetative flush to ensure more competition from the fruit.

In this paper we will deal with the process of tree training and related aspects. It will provide the producer with a guideline for producing avocado trees that can yield early in its life span because of a more effective tree structure and a complex bearing wood arrangement. Future research will concentrate around the development of a crop orientated management programme for avocados including physical and chemical manipulation as well as appropriate irrigation and fertilization management.

MATERIAL AND METHODS

Tree training and manipulation trials were started in 1994. They were extended to semi-commercial orchards in 1995 and additional orchards were planted in 1996 to confirm results thus far obtained. Details of the layout for the different trials have been published by Snijder & Stassen (1997a&b; 1998) in previous yearbooks. A summary of sites and treatments is given in Tables 1 and 2. From these tables it is evident that most of the work is concentrated in the Kiepersol area where close observations and detailed studies can be done. There are, however, also two trial sites at Levubu where the same type of work is being carried out in a more extensive way. The results from these studies are used to study climatic effects on the training and manipulation actions and specifically on the effect of timing.

RESULTS AND DISCUSSION

Over the past five seasons a lot of work has been put into the development of tree training techniques. The results from the trials listed above showed that avocado trees can be shaped and pruned into either a central leader or a closed vase, multiple leader system. The multiple leader system can be used with in-row spacings of 3.5m and wider, as this system is basically a manifold central leader. In the current trials most of our trees are 3m or less apart, therefore a central leader has been used in all cases. Initially selective pruning was the only method of tree training used in the trials, but recently, mechanical pruning has been successfully implemented.

The Tree Training System

The tree training system starts in the nursery, where the correct type of tree is produced for the specific planting system to be implemented. In South Africa all the avocado nurseries are not yet ready for these higher density planting systems with the result that avocado trees obtained from the nursery should be lightly shaped to the desired tree form directly after planting. This pruning entails the selection of the strongest upright-growing branch as the central leader of the tree. For a multiple leader system two or three leaders will be kept in balance with each other. Any other strong branch developing on this tree has to be removed immediately as this will compete with the leader for energy and nutrients. Horizontal side branches should be spaced evenly along the main stem to ensure the development of a strong framework of branches. This will in future provide optimum light penetration into the tree. During the rest of the

growing season vigorously growing branches have to be continuously removed, while horizontal branches can be tipped to stimulate side shoot development (developing branch complexity). The rule used to decide on the removal of branches is that any branch thicker than one-half the thickness of the leader should be removed. Anything thicker than one-third the thickness of the leader is pruned back severely to weaken its vigour. The growth in the top of the tree will under normal conditions develop a well-balanced branching system, with little pruning to be done. However, early in the season strong branches will develop at the base of the new flush which, if left untouched, will take over the vigour of the leader and destroy the branch hierarchy in the tree.

Table 1. Site description of the pruning and manipulation trials in the Kiepersol area from 1994 to 1998.

Site	Planting date	Spacing and pruning	General remarks
Kiepersol 1	1994	5m x 5m unpruned and 5m x 2.5m unpruned	High fertility soils, lower yields than expected, encrouched in 5m x 5m, Hass/Duke 7
Kiepersol 2	1993	5m x 2,5m pruned	Moderate soils, lower fertility, better yields, Hass/D7
Kiepersol 3	1992	6m x 6m pruned and unpruned	Highly fertile, single row treatments, encroached 1997. Hass/D7
Kiepersol 4	1995	5.5m x 3m and 4m x 1,5m both pruned	Moderate soils, medium growth rate, high early yields. Five cultivars/D7
Kiepersol 5	1995	6m x 4m pruned and unpruned	High fertility soils with low initial yields, trees filled in-row space. Hass/D7

Table 2. Treatments carried out during the past three cropping seasons (1996-1999)

Site	1996/97 season	1997/98 season	1998/99 season
Kiepersol 1	Girdling trial/selective pruning	Second girdling trial/ selective pruning	Chemical growth control/mechanical pruning
Kiepersol 2	Fruit thinning and girdling trial	Follow up yield/ selective pruning	Follow up yield/ mechanical pruning
Kiepersol 3	Fruit thinning/ selective pruning	Fruit thinning/ selective pruning	Follow up yields/tree thinning and mechanical pruning
Kiepersol 4	Selective pruning	Growth control/ selective pruning	Selective vs mechanical pruning and growth control
Kiepersol 5	Selective pruning	Girdling trial/selective pruning	Growth control and fruit setting trial/ mechanical pruning

It is advisable not to stress the tree while training and shaping is being done during the first growing season. Monthly applications of 25 g LAN are given to provide continuous sylleptic branching of shoots.

During the **first year** the following actions are taken:

- Select leader and allow to develop Remove any leader competition (rule of thickness)
- Induce shoot complexity (tipping of shoots after every 150 mm)
- Develop a well balanced branching system (branch hierarchy)

During the **second year** the trees are continuously pruned (tipped, cut back and cut away) and shaped to maintain the branch hierarchy, which was established during the first year. Vigorous watershoots and any side shoots that do not comply with the rule of thickness have to be removed. Shoots developing too closely together can be thinned to ensure enough light penetration into the tree. During the early spring flush period growth regulators can be used to curb vigorous growth in certain areas. During the latter part of the growing season (February-March), if the trees are growing strongly, girdling can be applied to induce flowering (Snijder & Stassen, 1997a). Tree balance can be restored during this period, before flower initiation, to ensure that enough light can penetrate into the trees. Flower initiation takes place from the end of February until April (Robinson, 1969).

The following actions are taken during the second year:

- Water shoot and unwanted shoot removal.
- Balancing of shoots and branches for light penetration.
- Shoot and branch thinning for light penetration.
- Reducing tree vigour with plant growth regulators.
- Inducing fruitfulness by girdling.

From the third year onward regular and timely pruning has to be done to continue shaping the trees. At the same time branch renewal can be done after harvest to maintain branch vigour for good production. This is done by pruning back the branch to a new developing branch nearer to the stem. From now on the height of the trees in the orchard will have to be maintained at 70% of the work row width. This ensures light interception into the rows onto the lower parts of the adjacent rows. The importance for this light interception is to keep the lower branches of the trees fruitful throughout its life span. Water shoot removal is a continuous action in the orchards, however, the use of growth inhibitors and correct nitrogen management can curtail the development of vigorous water shoots.

The following actions are taken in the third year and thereafter:

- Shaping of the tree to a pyramidal shape and maintaining height.
- Removal of the water shoots and other upright growing shoots

- Selective branch removal to restore the branch hierarchy and open the tree for light penetration.
- Summer flush control to open up the trees to sunlight.

As soon as the tree starts to flower there are three distinct times for pruning to ensure the correct balance between fruit and leaf and for light interception. These times are as follow:

During winter when the trees are dormant. In this period the tree balance is restored by removal of the unwanted branches. At the same time tree shape and tree height must be maintained. This will also remove a certain number of flowers which ensures more regular cropping of good quality fruit of acceptable size. This pruning action can be performed either mechanically or selectively, or as a combination of these methods. Follow-up selective pruning needs to be done to ensure light penetration into the tree for regrowth and fruitfulness inside the tree. Plant growth regulators can be sprayed as soon as the flowers reach the correct stage. Early flush sprays will be applied at the onset of the spring flush.

During the spring flush after fruit set has taken place. This pruning action is done selectively, as mechanical pruning will damage the fruit on the tree. Watershoots and any other upright growing branches are removed to reduce their nutrient and energy demand.

During midsummer with the summer flush. During this time pruning is concentrated on the restoration of the balance between fruit and leaf, and opening the tree for sunlight penetration. This action can be done as a light mechanical shaving of shoot tips, but should be done at such a time that the resulting flush will harden off before flower initiation takes place. In cooler areas this pruning should be finished before the end of December. Plant growth regulators can be sprayed on the new developing flush to help hardening it off sooner.

Girdling to induce fruitfulness can be done from February onwards on vigorously growing trees. The question whether selective or mechanical pruning should be done is often asked. During the winter and for summer flush control pruning actions can be mechanised to make the task easier and quicker. This does not exclude selective pruning completely. After the mechanical pruning, selective branch removal to open up the trees still needs to be done regularly to ensure light penetration into the trees and to restore the branch hierarchy.

Different cultivars are also treated differently. Pinkerton and Ryan with lower vigour do not have to be pruned as severely or as regularly as Hass and Fuerte. These last two cultivars tend to grow vigorously with watershoots in Hass and a very complex branching system in Fuerte. The weaker apical dominance in Fuerte creates a burst of new shoots that develop with every flush. This makes trees of this cultivar very dense and is also the reason for the lower yields obtained. With Pinkerton a certain amount of new growth has to be stimulated early in the season to carry the heavy crop on the trees. Not much shaping and pruning is done with this cultivar except for watershoot control where necessary. Edranol is in general the easiest of all the cultivars as its shoots develop evenly and well balanced. The biggest problem is that this cultivar

reaches its allotted height too soon and needs to be regularly controlled. Ryan on the other hand is a slow growing cultivar and mostly needs opening up of the tree in autumn for better sunlight penetration. The new regrowth after this pruning will also help sustain the following flowering season without a heavy leaf and fruit drop. In Table 3 the growth of the five different avocado cultivars over the first three seasons after planting is shown.

From table 3 it is evident that Hass and Fuerte are in general the more vigorous growing trees with Pinkerton the least vigorous. Ryan and Edranol are moderate growers. There is a sharp increase in tree volume from year one to year two. After year two the trees are starting to fill their space with the correct planting system and volume increase slows down. Trees are becoming fruitful and a good crop will suppress the growth of the trees.

In table 4 the yield for the same trees is given over the same three-year period.

From table 4 it is evident that Hass and Pinkerton are the more precocious avocado cultivars with the first crop already at 19 months. Fuerte has the lowest productivity and the highest vigour. It is also noted that the higher density in all instances, except for the Fuerte, gave significantly higher yields. The reason for the small difference with Fuerte is the fact that the trees in the higher density orchard need more drastic pruning to maintain tree size within the given space, thereby losing their fruit through fruit fall during the regrowth period. Pinkerton with its very high production early in its life span is inclined to overproduce. This is the main reason for poor shoot regrowth and probably also for poor fruit quality. Fruit thinning early in the fruit growth period will result in uniform fruit set and better shoot development (Snijder & Stassen, 1997a). The early results obtained with Ryan are due to the fact that sufficient young, healthy leaves and fewer flowers were on the trees when flowering occurred. This reduced the energy drain during flowering and therefore fruit development could be supported until harvest.

Table 3. Increase in tree volume of five avocado cultivars at two different spacings over three seasons (planted Oct 1995).

Cultivar	Spacing	1997 7 months old (m^3)	1997 19 months old (m^3)	1998 31 months old (m^3)
Fuerte	5,5m x 3m	0.06	3.34	6.22
	4m x 1,5m	0.05	2.54	5.99
Hass	5,5m x 3m	0.03	2.68	6.63
	4m x 1,5m	0.03	2.51	7.31
Pinkerton	5,5m x 3m	0.01	1.58	2.34
	4m x 1,5m	0.01	1.19	2.46
Edranol	5,5m x 3m	0.01	1.56	5.42
	4m x 1,5m	0.02	1.46	4.23
Ryan	5,5m x 3m	0.02	1.71	3.86
	4m x 1,5m	0.01	1.45	3.70

Table 4. Yield results of five avocado cultivars at two spacings over three seasons (planted Oct 1995).

Cultivar	Spacing	1997 7 months old ton/ha	1997 19 months old ton/ha	1998 31 months old ton/ha
Fuerte	5,5m x 3m	0.00	0.00	3.11a
	4m x 1,5m	0.00	0.00	3.39a
Hass	5,5m x 3m	0.00	0.50	4.87a
	4m x 1,5m	0.00	1.20	8.77b
Pinkerton	5,5m x 3m	0.00	0.67	7.03a
	4m x 1,5m	0.00	1.35	12.37b
Edranol	5,5m x 3m	0.00	0.00	6.08a
	4m x 1,5m	0.00	0.00	7.54b
Ryan	5,5m x 3m	0.00	0.00	4.96a
	4m x 1,5m	0.00	0.00	5.80b

From the above results, as well as the results obtained in the other trials reported on in 1998, the following guidelines for tree spacing can be given. It should, however, be kept in mind that certain aspects have to be taken into account before a final plant spacing can be recommended. These include soil fertility, row direction, type of implements to be used as well as orchard management capabilities. In Table 5 the recommended spacing for high potential soils are given.

From table 5 it can be seen that each cultivar has its own planting distance, but for high intensity plantings the three moderate growing trees can be planted at much higher densities. All plantings are done in a rectangular planting system, as discussed earlier, for better light interception and penetration, and also for creating a work row in which orchard tractors and implements can move. A tree training programme must then be in place from the time the trees are planted for achieving early and high yields. A general planting density recommendation for avocado will be 6x3 m.

CONCLUSION

From the results presented in the past two years it is evident that a considerable amount of research has been carried out with regard to tree training and manipulation. To date good results have been obtained. It was concluded in previous years that a central leader avocado tree with a lot of bearing wood can be maintained. This will produce a well-balanced tree with the potential of producing high yields and intercepting enough sunlight for optimal functioning. Various manipulation tools have been investigated to help curb the excessive growth of avocado trees. Girdling and the use of growth inhibitors have been shown to be very useful in achieving this goal especially on higher potential soils.

Table 5: Recommended plant spacing fro avocados under normal management situations.

Cultivar	Normal management	
Fuerte	7m x 3,5m	(408 trees/ha)
Hass	6m x 3m	(556 trees/ha)
Pinkerton	5m x 2,5m	(800 trees/ha)
Ryan	5,5m x 3m	(607 trees/ha)
Edranol	5m x 2,5m	(800 trees/ha)

The various avocado cultivars react differently under the tree training system due to their differences in growth habit and vigour. Pinkerton and Ryan can be easily pruned, but Fuerte and Hass need more intensive management under this system. Early yield data from these cultivars showed that the system can be commercially applied.

With the results obtained thus far and the development of the training techniques discussed, it can be concluded that the avocado tree can be trained to a central leader system especially for higher density orchards. However, multiple leader trees in orchards with less than 500 trees/ha can also be handled as described above. The actions are not labour intensive and when done correctly, do not need skilled labour. Timely management actions to control excessive growth and increase production will give the producer earlier and higher yields. This will ensure that avocado production can be continued economically. As a bonus the trees will be more labour friendly and easy to spray.

SUMMARY

The current situation in the avocado industry enhances rapid tree encroachment. With a proper tree training system and the correct planting system in place this can be avoided.

The training of the trees is as follows:

The first year after planting

- Select a strong upright growing branch as the leader
- Remove any competition according to the set rules
- Balance the shoots and branches for light penetration
- Remove any water shoot and upright growing branch

The second year after planting Continue with water shoot removal Balance shoot and branches for light penetration

- Apply shoot and branch thinning if necessary
- Reduce vigour with plant growth regulators in spring if necessary Induce fruitfulness by girdling in late summer

The third year and later

- Start with height and shape control in winter
- Continue water shoot removal Selective branch removal to restore branch hierarchy and for sunlight penetration
- Branch pruning to rejuvenate bearing units
- Pruning is done during three distinct periods

Timing of pruning

- *Mid winter during dormant period:* to open-up the trees for sunlight, restoring branch hierarchy and height control.
- *During spring flush after fruit set:* to remove competition with the fruit *i.e*. water shoots.
- *During summer flush*: to open up trees again and induce more complexity.

Good results were achieved with the central leader system with all the commercial cultivars.

Cultivars differ in terms of the seventy of pruning required as well as in their regrowth reaction. Pinkerton and Ryan need the least attention, Hass and Fuerte the most.

It is concluded that the central leader system together with a rectangular planting system can optimise yield of an avocado orchards early in its life-span.

Closer spacings than currently used can be implemented under a tree training system. Each cultivar has its own plant spacing range.

The system is not labour intensive when done timeously and correctly.

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