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Manipulation of Avocado Trees to Control Tree Size a Four Year Progress Report

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ABSTRACT

Manipulation of Hass avocado trees was started four years ago. A pyramidal tree shape was used to allow for maximum light penetration and the creation of an efficient and productive tree. To correct tree shape, pruning was done in winter, while follow up pruning was carried out during spring to remove watershoots, reduce competition for fruit set and stimulate the development of bearing wood. Summer pruning was done to remove unwanted shoots and to open the trees to allow sunlight penetration into the trees for the initiation process. Initial results, after four years, showed that shaping the avocado tree into central leader is possible. Yield data indicate that pruned trees perform as well or better than unpruned trees, tree size can easily be controlled and higher density plantings are possible. It is important to introduce a growth regulator into the manipulation programme to curb excessive growth in high potential soils. More work is planned in this regard for the following season.

Promoting flower and fruit initiation at an early tree age is important, as a good fruit load helps to control tree vigour. Results from these trials showed that cincturing in autumn increased fruit set and yield. This can be used to force vigorous young trees into bearing. Cincturing trees two years in a row did not increase the yield significantly and is not recommended. Growth inhibitor sprays applied in autumn to curb the last flush's vigour did not as yet give positive results but the timing and concentration of the chemical applications will be studied in detail for better results.

Yield results from the high density (1666 trees/ha) cultivar orchard at the Burgershall research station showed that compared to lower density (607) trees/ha) plantings, better yields were obtained with Hass, Edranol and Pinkerton, while Fuerte and Ryan did now show any difference in the second year after planting. This is due to the vigour of Fuerte that had to be controlled more regularly. For high-density plantings of Fuerte, chemical growth control is a necessity. Ryan as a compact growing cultivar, has not yet filled its space and therefore no yield improvement will be found even in the higher densities. Early recommendations for spacing are between 800-1000 trees/ha for Edranol and Pinkerton, between 600 and 800 trees/ha for Hass and Ryan and for Fuerte between 400 and 600 trees/ha. This research is continuing and alterations to the management programme are made on a regular basis as results become available.

INTRODUCTION

Pruning of avocado trees started four years ago on an experimental basis. From these pruning experiments a study was started to develop training and manipulation techniques for avocado trees. Based on earlier results, avocado trees were trained to a pyramidal shape. The reasons for, and principles involved in the training of pyramidal shaped trees were discussed by Stassen, Davie and Snijder (1995a), Stassen and Davie (1996a) and Stassen and Davie (1996b). The main aims for such a manipulation programme are:

1.To develop a tree framework that prevents orchard encroachment

2.To control tree size

3.To increase tree affectivity for better utilization of sunlight in order to keep the inside and base bearing wood productive and to stabilize yield.

4.To manage higher density orchards and to avoid having to thin-out orchards.

For effective and productive orchards it is important to use the correct row orientation as well as the right plant spacing (Stassen and Davie 1996b). These aspects are as important as obtaining the correct tree shape (Stassen, Davie & Snijder, 1997). A north-south row orientation together with a rectangular planting system was used for the reasons discussed by Stassen and Davie (1996b).

In the trials a pyramidal tree shape formed from a central leader was used (Stassen, Davie & Snijder in press). Multiple leader systems could have been used in the wider spacings, but for convenience of training, the central leader was chosen. The avocado lends itself to being trained into a central leader tree. This system is also practical and easy to obtain, and can be used for different plant spacings.

During the early stages of these long-terms trials the following has already been observed:

1. The avocado tree can be shaped easily into a central leader system. The upright growth habit after grafting lends itself to maintenance of this system, with some minor pruning actions required during the formative months.
2. Edranol, Pinkerton and Hass, in this order, are the easiest to manipulate, with Fuerte being the most difficult. Ryan needs to be brought into bearing earlier as this cultivar, with its compact growth, is also easy to manipulate.
3. In high potential soils the use of growth inhibiting measures is a necessity to curb the excessive vigour of the avocado tree. Pruning is a growth stimulating action, but doing it at the right time and using the right technique can bring about the growth of tame horizontal shoots and with the help of growth inhibitors regrowth can be restricted (Snijder & Stassen, 1997b).
4. Restriction of excessive vegetative growth can be done with judicious nitrogen and irrigation management (Stassen, Davie & Snijder, 1997).
5. Unwanted branches and watershoots have to be removed at an early stage of development as these can easily nullify the pruning action.

6. The base is established for easy mechanical trimming.

Research into avocado tree manipulation is still in its infancy, but the results obtained thus far are more than promising. In this paper the results of the previous four years are briefly discussed.

The pruning of fully bearing trees, that are experiencing a crowding problem, is being done on a trial basis on semi-commercial scale. Results of these trials will be presented next year.

MATERIAL AND METHODS

A full description of the trial sites have been given in the previous yearbook by Snijder and Stassen (1997a; 1997b). An additional site was added to the list (Kiepersol 5). The following additional treatments were applied at the different sites.

Kiepersol 1: Burgershall research station

In the high-density orchard (4m x 1.5m) the trees were treated to induce flowering and fruitset. The following treatments each were done to ten trees:

1. Cincturing during February and March
2. Chemical growth control in April on the latest flush by Cycocel @ 1500 ppm and with Cultar at 400 ml/100 l (all on non bearing trees)
3. Combination of cincturing and chemical control
4. Control trees without any treatment.

Kiepersol 2: Panorama

In the high (5m x 2.5m) and normal (5m x 5m) density orchards follow-up cincturing was done on 20 trees with a high fruit load and on 20 trees with a low fruit load during February. The rest of these orchards were left untouched to study the carry-over effect of cincturing (Snijder & Stassen, 1997a). Pruning in the high-density orchard was done as a standard practice. In the normal density orchard 30 unpruned trees were pruned to study the effect of belated tree shaping on yield and tree size control.

Kiepersol 3: Entabeni

No further treatments were carried out in these orchards and carry-over effects, from the 1996 treatments, were measured (Snijder & Stassen, 1997a). Thinning of fruit, per tree, was carried out on excessively high bearing trees to fruit numbers determined by Stassen & Snijder (1996a).

Kiepersol 4: Koeltehof farms

No further treatments were carried out on these trees. Carryover effects were measured and fruit thinning was done where necessary. These trees are currently overgrown by the unpruned controls, and no further work will be done on them.

Kiepersol 5: Panorama new site

The Hass on Duke 7 trees were planted in November 1995 at a spacing of 6m x 4m.

The block was subdivided into two blocks with one block being pruned in January 1997 and the other block left unpruned. The following treatments were applied from February 1997 to confirm the results from previous cincturing trials:

1. Cincturing in March, April and May 1997
2. Chemical growth control with Cycocel @ 1500ppm and Pix @ 1500 ppm in April on the latest flush.
3. No treatments- control trees. Twenty trees per treatment were used in this trial.

Regular pruning of the avocado trees was done at all the sites where pruning was part of the treatments. During winter unwanted branches growing on top of other branches, or those that were too strong, were removed. Branches that shaded lower branches were cut back to weaker side branches or totally removed. If the size of a side branch was thicker than one half the size of the main stem it was removed completely. If less than half the thickness but more than a third of the thickness, the branch was cut back to a weaker sideshoot. In high-density orchards (more than 1000 plants per hectare) the ratios were even less than stated above. During this time the balance in the treetops was restored where necessary by removal of shoots thicker than one-third of the main stem. In the lower part of the tree such branches were severely pruned back, but when these branches were thicker than half the main branch, they were removed.

During spring the upright growth was removed and any strong growing branch competing with the fruitlets for carbohydrates was tipped or pruned. No severe pruning was done during the time, as this would have stimulated new growth that would have dropped fruit.

During the summer months unwanted growth that hampered light penetration was removed and the balance in the tree was maintained. This was done by removal of wrong branches especially in the top of the tree, or by the pruning of branches that grew too wide. Also branch tipping should be done to stimulate regrowth of side shoots for better bearing wood. No drastic pruning was done during this period. Chemical growth may be followed up in summer by targeted sprays on strong growing branches, or by cincturing these branches.

Fruit thinning was done on the trees where necessary. This was decided on the arbitrary fruit load graph as proposed by Stassen & Snijder (1996b).

RESULTS AND DISCUSSION

Yield results over four seasons are given in table 1 for Hass in the different orchards. The expected yield was calculated on the basis of actual fruit counts done in February, multiplied by the number of trees per hectare and multiplied by the average fruit mass of Hass (250g/fruit).

From table 1 it can be seen that pruning the higher density trees increased yield per hectare. The flattening off of production at Kiepersol 4 is due to the fact that the pruned trees are overgrown by the unpruned trees as only a single row was pruned in this orchard. This orchard will therefore be excluded from the trail in future. It can also be seen that in orchards where growth was restricted by correct nitrogen management,

high yields can be obtained and maintained in early years with good management (Kiepersol 1 and 3). The lower yield at Kiepersol 3 in 1998 was due to severe water stress situations in this orchard during the 1997 season. Comparing Kiepersol 1 and Kiepersol 5 it can be seen that with the correct management avocado trees can produce higher yields at an earlier age.

Table 1. Yield of Hass avocado in the Kiepersol area at different spacings and pruning systems over three seasons.

Site and treatment	Planting date and spacing	1996 Yield T/ha	1997 Yield T/ha	1998 Exp. Yield T/ha	Cumulative yield T/ha
Kiepersol 4	*Nov 92*				
Pruned	6m x 6m	1.15	6.96	7.56	15.67
Unrpuned		0.42	5.73	7.94	14.09
Kiepersol 3	*Mar 93*				
Pruned	5m x 2,5	4,63*	15.4	15.2	34.85
Kiepersol 2	*Nov 94*				
Pruned	5 m x 2,5m		2.45	5.6	8.1
Unrpruned	5m x 5m		2.03	8.8	10.8
Kiepersol 1	*Oct 95*				
Low density	5,5m x 3m		0.5	4.4	4.9
High density	4m x 1,5m		1.2	6.5	7.7
Kiepersol 5	*Nov 95*				
Pruned	6m x 4m			0.94	0.94
Unpruned					0.64

* Yield calculations done on 400 trees/ha as the inter-plantings were done during September 1996

Results from the cincturing trials showed that in the first year following cincturing, a definite increase in production was obtained. These effects were not carried over into the second year. In table 2 the results from this trial are shown, indicating the yield results from the 1997 crop as well as the expected yield for the 1998 crop two years after treatment. From the figures in table 2 it can be seen that in the second year the control trees produced similar crops to the treated trees. The cumulative yields over two seasons showed that the treated trees produced an earlier but, non-significantly, better crop than the untreated trees.

The results with the follow-up cincturing are presented in table 3. High yielding trees were cinctured again to offset an off year after good initial yields, while low yielding trees were cinctured again to increase the production of these trees. It can be seen from the cumulative yield over two years that an increase was observed. This increase was however not significantly better than the control trees. In the standard unpruned planting the second year cincturing decreased the production over the previous year, but in the pruned high-density orchard it stayed the same.

In table 4 the results of the spraying trial are shown. The sprays were directed at the new growth developing with or directly after the autumn flush to curb the growth vigour

and help flower initiation. From these results it can be seen that no significant increase in yield was observed in these trials. These were initial trials and more work will be done with increased concentrations and different times of application of these sprays.

Table 2 Yield of cinctured, and non-cinctured two-year-old Hass avocado trees to increase yield and fruit size.

Treatment (Date of cincturing)	5m x 2,5m Pruned trees			5m x 5m Unpruned trees		
	1997 Yield	1998 Exp Yield	Cumulative Yield	1997 Yield	1998 Exp Yield	Cumula-tive yield
	T/ha	T/ha	T/ha	T/ha	T/ha	T/ha
29/02	6.7a	5.4a	12.1	6.2a	5.7a	11.9
20/03	6.5a	6.2a	12.7	5.1a	6.7a	11.8
02/04	6.1a	6.2a	12.3	5.3a	4.5a	9.8
16/04	7.0a	5.8a	12.8	6.0a	4.1a	10.1
04/05	6.7a	5.4a	12.1	4.7a	5.6a	10.3
16/05	6.7a	4.2a	10.9	4.4a	7.3a	11.7
Untreated	2.54b	8.8a	11.3	2.5b	5.6a	8.1

Table 3. Yield of Hass avocado trees cinctured a second year (February 1997)

Treat-ment	5m x 2,5m unpruned			5m x 5m unpruned		
	1997 yield	1998 Exp yield	Cumulative yield	1997 yield	1998 Exp yield	Cumula-tive yield
	T/ha	T/ha	T/ha	T/ha	T/ha	T/ha
High yield 97	9.7a	9.8a	19.5	7.0a	6.0a	13
Low yield 97	2.5b	12a	14.5	1.9b	7.6a	9.5
Control	2.5b	8.8a	11.3	2.5b	5.6a	8.1

Table 4. Yield of two-year-old Hass avocado trees sprayed and not sprayed with growth regulators to induce flowering. (April 1996)

Treatment Nr of Fruit	5m x 2,5m unpruned			5m x 5m unpruned		
	1997 yield	1998 Exp yield	Cumulative yield	1997 yield	1998 Exp yield	Cumulative yield
	T/ha	T/ha	T/ha	T/ha	T/ha	T/ha
Cycocel @ 1000 ppm	3.0a	6.0a	9.0	2.5a	7.0a	9.5
Pix @ 1000 ppm	2.4a	6.0a	8.4	2.2a	5.5a	7.7
Control	3.6a	5.0a	8.6	1.8a	7.0a	8.8

The effect of pruning against no pruning in a standard density orchard planted at a rectangular spacing (6m x 4m) combined with cincturing and growth inhibitor sprays was studied in a two-year-old Hass orchard. The results of these trials are shown in tables 5-7. In table 5 the results of the cincturing trials are presented. From the data it is again evident that cincturing does increase yield and forces the young avocado trees into production. Increase in yield is significantly better for treated trees compared to untreated trees. No significant increase in yield was observed in pruned as compared to unpruned trees. This is due to the fact that the trees were only pruned 15 months after planting and trees are still responding with strong vegetative growth to this treatment.

In table 6 the results from the growth inhibitor sprays on the trees are shown. The concentrations of the growth inhibitors were increased in comparison to the previous year, but again no increase in yield was observed. A full trial with different spray concentrations is planned for this orchard to establish minimum concentrations to curb growth in avocados and increase yield.

Table 5. The effect of cincturing on two-year-old pruned and unpruned Hass avocado trees.

Treatment Cincturing dates	Pruned trees Exp. yield (t/ha)	Unpruned trees Exp. yield (t/ha)
26/02/97	1.5a	2.2a
04/04/97	2.1a	2.1a
07/05/97	2.0a	2.9a
Control	0.6b	0.9b

Table 6. The effect of chemical growth inhibitors on two-year-old pruned and unpruned trees (April 1997)

Treatment	Pruned trees Exp. yield (t/ha)	Unpruned trees Exp. yield (t/ha)
Cycocel @ 1500ppm	0.9a	1.0a
Pix @ 1500ppm	0.9a	1.0a
Control	0.6a	0.9a

The intensity of winter pruning of avocado trees was studied in a three-year-old avocado orchard and the results of this trial are given in table 7. From this table it is clear that in a regularly pruned orchard the severity of winter pruning does not affect the yield of avocado trees. Fruit size, which will be measured at harvesting, is still the only factor that can be affected by pruning severity. In an unpruned orchard the effect of pruning is non-significant. An increase in yield is, however observed due to an increase in light in the trees forcing inner branches to flower and fruit. More inside fruit was found on the pruned trees as opposed to the unpruned trees.

Table 7. The effect of intensity of pruning on three-year-old pruned and unpruned Hass avocado trees.

Treatment	High density (5m x 2,5m pruned)	Standard density (5m x 5m unpruned)
	Exp. yield (t/ha)	Exp. yield (t/ha)
No pruning		6.3a
Light pruning	5.8a	7.3a
Severe pruning	5.8a	

In table 8 the yield results of the five different commercial cultivars at two different plant densities are given. From table 8 it can be seen that Pinkerton is the highest yielding cultivar at this early stage with Fuerte the lowest yielding. No significant yield increases can be found with Ryan and Fuerte for the two different densities. Hass, Pinkerton and Edranol showed significant increases in yield for the higher density at this early stage of the orchard's lifespan.

Table 8. Expected yield (t/ha) of two-year-old avocado trees at two different spacings.

Density	Fuerte	Hass	Pinkerton	Ryan	Edranol
	ExpYield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)
4m x 1.5m	2.57a	6.5a	17.9a	4.5a	9.2a
5,5m x 3m	2.45a	4.4b	10.0b	5.0a	4.7b

Expected yields calculated as stated earlier (table 1) with individual fruit mass as follows: (Fuerte 350g/fruit; Hass 250g/fruit; Pinkerton 400g/fruit; Ryan400g/fruit; Edranol 360g/fruit).

The low yields for Fuerte are due to the growth vigour of this cultivar and especially at the higher densities as more pruning was needed to curb the growth and to keep the trees within the allocated space. Curbing the growth of this cultivar is very important in order to maintain the tree size and to get an early high yield from this cultivar. Ryan as a slow growing cultivar has not as yet filled all the space allocated in the high-density orchard, and therefore a similar yield to the lower density is found.

To curb yield in the high density planting, trees were cinctured, sprayed with growth inhibitors at 2000ppm or a combination of these manipulations. The yield results for these treatments are presented in table 9 for the five commercial cultivars.

Table 9. Cincturing, spraying and combination applied to avocado trees at 4m x 1.5m

Treatment	Fuerte	Hass	Pinkerton	Ryan	Edranol
	Exp Yield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)	Exp Yield (t/ha)
Cincturing treatments					
1. Feb 97	4.4	11.5	16.6	9.8	7.7
2. Mrch 97	4.2	11.9	18.7	8.5	14.3
Growth inhibitor treatments (April 1997 @ 2000ppm)					
3. Cycocel	1.9	7.9	20.1	4.9	8.3
4. Cultivar	1.0	9.4	19.5	4.9	7.7
Combinations					
5.1 + 3	3.4	11.7	16.6	7.9	11.9
6. 1 + 4	3.9	14.1	18.7	10.8	11.9
7. Control	2.6	6.5	17.9	4.9	9.2

Statistical analyses of table 9 values will be done when the actual yield figures are available. Final deductions will also then be made. At this stage it is only possible to look at the trends.

In the case of Fuerte and Edranol, treatments 3 and 4 gave lower yields than the controls. With Hass and Pinkerton the yields were higher while Ryan had the same yield as the controls. Treatments 1 and 2 gave higher yields for Fuerte, Hass and Ryan than for the controls. The yields with treatments 5 and 6 were mostly higher than the controls. It does appear that cincturing has a positive effect on the yield of young trees except with a precocious cultivar such as Pinkerton. The influence of growth inhibitors was positive with Hass. More intensive research with regard to the time and concentration of spray applications will be conducted in the coming season.

CONCLUSION

The data presented in this paper is a summary of four years of avocado tree manipulation work on young orchards without encroachment problems. The main objective of this study is to manipulate the avocado tree to a pyramidal tree shape while maintaining tree size and increasing the productivity of high quality fruit. The data presented in the various tables showed that an increase in yield was possible with pruning and at higher densities. It is not just Hass avocado that is suited to this management strategy, but also the other four commercial cultivare. Fuerte is still difficult to manipulate and more work is needed to successfully manipulate this cultivar.

The pruning operation is not a once off action but needs to be followed up during the growing season. If done in time, this does not need more time than any other operation in the orchard. Removals of watershoots in spring, and the removal of unwanted and upright growing shoots overshadowing the next year’s bearing wood, during summer, are the most important tasks to be performed. Balancing the branches according to the

rules laid down is necessary during the growing season to keep the top of the tree smaller than the lower part. At the same time this will prevent branches lower down in the tree overtaking the leader, thereby losing tree structure. A crop has to be set on the trees as soon as possible after planting and any means to increase the yield in the early years will reduce the vigour of the trees. This will help with the pruning actions as the tree balances itself and watershoot development is restricted.

The results also showed that higher density plantings are possible within this manipulation programme. From the results, early recommendations for planting densities can be made. Edranol and Pinkerton should be planted at densities from 800 to 1000 trees/ha. These trees are upright growing and tend to crop early in their life. Hass and Ryan should be planted at densities from 600 to 800 trees/ha while Fuerte as the most vigorous cultivar should be planted at 400 to 600 trees/ha. Cincturing, the use of growth inhibitors and nitrogen management can all play a role in the manipulation programme to curb the growth of trees at higher densities, and to get trees into early cropping.

SUMMARY

Pruning and manipulation of avocado trees has already been carried out for four years and a pyramidal tree shape was chosen for testing the basic principles of manipulation. From the initial data the following positive results have emerged:

- Avocado trees can be shaped to a central leader.

- Edranol, Pinkerton and Hass are easer to shape than Ryan and Fuerte.

- Growth inhibitors are an essential part of the manipulation programme in high potential soils.

- Control and excessive growth can also be achieved by judicious nitrogen and irrigation applications.

- Unwanted growth must be timeously removed as it can negate effects of the pruning process.

- Early fruiting of trees help to suppress tree growth and is a necessary part of the manipulation process.

- Pruning is a regular action that must be followed-up during the growth season.

- Yield results have shown that pruning is beneficial especially with trees that have been shaped since planting.

- Cincturing of trees considerably increased yield and can be applied in autumn to force vigorously growing young trees into bearing. Cincturing for two successive years did not increase yields.

- Growth regulators applied in autumn were less effective in the present trial but further trials are planned for determining the timing and the optimum concentrations of applications.

- Mechanisation of the process after the initial training period is being examined.

OPSOMMING

Die snoei en manipulasie van avokado borne is reeds vier jaar aan die gang en 'n piramidale boomvorm is gekies om die basiese beginsels vir manipulasie te toets. Vanuit die aanvanklike data het die volgende positiewe resultate reeds na vore gekom:

- Avokado borne kan na 'n sentrale leier gevorm word.

- Edranol, Pinkerton en Hass is makliker om te vorm as Ryan en Fuerte.

- Groei inhibeerders is 'n noodsaaklike deel van die manipulasie program by hoe potensiaal gronde.

- Oormatige groei kan ook beheer word met oordeelkundige stikstof en watertoedienings.

- Ongewensde groei moet betyds verwyder word, aangesien dit die hele snoeiproses ongedaan kan maak.

- Vroeé drag aan die borne help om boomgroei te onderdruk en is 'n noodsaaklike deel van die manipulasie proses. Dit is waarom Pinkerton en selfs Edranol baie suksesvol in hoer digthede sal vaar.

- Snoei is 'n gereelde aksie wat gedurende die groeiseisoen opgevolg moet word.

- Opbrengs resultate het getoon dat snoei voordelige resultate lewer veral as borne vanaf planttyd gevorm is.

- Ringelering van borne het drag aansienlik verbeter en kan in die herfs toegepas word om geilgroeiende jong borne in drag te forseer. Ringelering wat twee jaar na mekaar gedoen is, het nie 'n verdere verhoging in opbrengs gelewer nie.

- Groeireguleerders wat in die herfs gespuit is, het in die huidige proewe minder gunstig gereageer, maar meer navorsing ten opsigte van die tye en konsentrasie word vir die toekoms beplan.

- Meganisering van die proses, na die aanvanklike opleidingsperiode, word tans ondersoek.

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