South African Avocado Growers' Association Yearbook 1998. 21:54-57

The Effect of Growth Inhibitors on Vegetative Growth, Fruit Size and Fruit Set in Hass Avocado Trees: A Preliminary Report

M.G. Renter & P.J.C. Stassen
Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit, 1200

ABSTRACT

Until recently, the primary means of controlling encroachment in avocado orchards was the removal of trees once overcrowding started to limit production. However, recent work has shown that tree manipulation particularly pruning can control encroachment without tree removal. However, pruning needs to be supplemented with additional manipulation methods in order to optimise tree size within the orchard.

This paper examines the role of growth regulating chemicals as part of a holistic orchard management programme. These chemicals have been used with considerable success in the deciduous fruit industry, and have been shown to reduce vegetative growth while increasing fruit set and size. The preliminary results presented in this paper indicate that these compounds also have a role to play in the avocado industry. With correct timing and concentration, increases in fruit set and size have already been obtained with certain regulators. Although considerable work has yet to be done, it seems that these compounds will become a vital ingredient in the effective management of avocado orchards.

INTRODUCTION

The avocado *(Persea americana)* has its origins in Central America and Mexico, where it grows naturally as a rainforest substory species (Whiley and Schaffer, 1994). The avocado is a relatively new orchard species and has only undergone intensive selection for the last 100 years or so (Wolstenholme, 1987). As such, it still retains the growth habit of a rainforest tree and shows a distinct bias towards strong vegetative growth.

The strong vegetative growth in the avocado results in two major problems for commercial avocado growers:

• The first of these problems is that of rapid encroachment in orchards trees in a 5m x 5m planting often outgrow their allocated space within 4-5 years (Köhne, 1988). This makes harvesting and spraying difficult, and leads to an increase in the costs of avocado production.

• The second problem is that the vegetative growth competes with fruit for photoassimilates, nutrients and water. The first major vegetative flush occurs shortly after flowering and is a strong carbohydrate sink for the first 40 days of its development (Whiley and Schaffer, 1994). The resulting decline in available resources during this

period often leads to a poor fruit set especially in the more vigorous cultivars. The situation is exacerbated by the appearance of the summer flush, which occurs when the fruit have attained 10-40% of their final mass. The competition arising from this flush may cause 45-60% of the set fruit to drop (Wolstenholme *et al.,* 1990).

As a result of the above factors, productivity of avocado orchards tends to be relatively low an average of 10t ha^{-1} compared to 120t ha^{-1} for grapefruit, 70t ha^{-1} for 'Navel' oranges and apples and 60t ha^{-1} for bananas and grapes (Wolstenholme, 1986). Not only is the overall productivity generally low, but the size of fruit tends to be problematical in certain cultivars- particularly Hass.

It is generally accepted that an effective way to improve yields from tree crops is to control the vegetative growth (Williams, M.W. 1988). This reduces vegetative: reproductive competition- in favour of fruit set and growth. Even when dwarfing rootstocks and less vigorous scions are available some form of tree manipulation is necessary. In most tropical crops, where breeding is in its infancy, tree manipulation is essential. It must be stressed, however, that manipulation on its own is not a solution- it must form part of a holistic orchard management programme which takes into account a variety of factors, including correct irrigation and controlled nitrogen application (Stassen and Davie, 1996a; Stassen and Davie, 1996b); Stassen *et al,* 1997)

There is a number of physical methods to control vegetative growth. Pruning methods in avocados have recently received a lot of attention and extensive guidelines for the pruning of avocado trees are provided by Stassen *et al.* (1995) and by Snijder and Stassen (1997). These methods result in good tree shape and size, and also remove excessively strong growth. However, additional tools are required to supplement these cultural practices and maintain the desired tree size. For more than 30 years researchers in the deciduous industry have investigated the possibility of controlling tree growth with chemicals. The most widely investigated compounds are the growth retardants, which generally inhibit gibberellin synthesis and thus reduce internode elongation (Sachs and Hackett, 1972). Chemicals that have this effect include Cultar, Sunny, Cycocel, Fix, Alar and Ancymidol. It has been shown that these growth retardants reduce shoot length by as much as a half (Forshey, 1991). They may also increase flowering (Batjer *et al.,* 1964), fruit yield (Rademacher, 1995), fruit size and shape (Davis *et al,* 1988) and may induce precocious bearing (see Luckwill, 1976). These are precisely the effects needed in the avocado industry.

Despite a long and successful history in the deciduous fruit industry, the growth regulators have only recently been considered for the management of tropical and subtropical crops. To date only one of these compounds has been extensively investigated in avocados- namely Cultar. Considerable work has been carried out to establish effective concentrations and the appropriate timing of sprays (Köhne and Kremer-Köhne, 1987; Köhne, 1988; Wolstenholme *et al,* 1988; Wolstenholme *et al,* 1990). One further advantage noticed in trials with avocado seems to be increase in fruit size (Whiley *et al,* 1991; Wolstenholme *et al,* 1988; Wolstenholme *et al,* 1990 and Symons and Wolstenholme, 1990). This is of particular importance in the cultivar Hass. Cultar has been registered for growth control and to improve fruit set on certain cultivars. However, work is still required to establish whether it will improve fruit retention through the summer flush. It must be mentioned at this stage that there are

disadvantages to using Cultar. The compound is fairly persistent and incorrect application may result in residues in the fruit. For this reason most deciduous growers have moved away from Cultar in favor of less persistent compounds. However, Cultar does have a role to play in non-bearing trees and is still used successfully in bearing trees when correctly applied.

The only other compound currently receiving attention in the South African avocado industry is the relatively new compound, Sunny (uniconazole). This chemical has shown promise in increasing fruit size and set, but work is required to examine its effect on vegetative growth and fruit retention.

The work with Cultar and Sunny indicates that there is definitely a role for growth inhibitors in the management of avocado orchards. However, further work with currently available growth inhibitors is required. Furthermore, there are several other growth inhibitors which are widely used in the deciduous industry but have never been used in tropical crops.

A good example of this is CCC. This chemical is not only used in the deciduous industry but has shown promise in controlling vegetative growth and improving flowering and fruit set in mango (Maiti *et al.,* 1971; Maiti *et al,* 1972). A further advantage to using compounds like CCC is that they have an extensive market in other industries and are economically viable (see table 1).

Table 1. The relative costs of some currently available growth inhibitors

	Cultar	Sunny	CCC	Pix
Price per litre	R434.32	R409.26	R59.28	R93.48
Concentration range*	1000 - 3000 ppm	500 ppm	2000 - 4000 ppm	1500 - 2500 ppm
Cost per 100ℓ of spray solution	R173.73 - R521.18	R409.26	R29.64 - R59.28	R280.44 - R467.40
Cost per Ha at 2.5l/tree and 400 tree/Ha	R1 737.28 - R5 211.84	R4 092.60	R296.40 - R592.80	R2 804.40 - R4 674.00

* Recommendations for Cultar = 1000 ppm; for Sunny = 500 ppm

With the preceding information in mind, it was decided that a trial was necessary in which currently used growth inhibitors (Sunny and Cultar) could be compared with some of the inhibitors not yet investigated in tropical crops. This trial is still in its early stages, with the harvest data for the first treatment yet to be collected.

METHODS AND MATERIALS

The trial was set up in the Kiepersol area. The trees used were part of a 6m x 6m Hass planting which is currently 6 years old. Each treatment was applied to 36 trees which

were divided into blocks of 6 trees. These blocks were selected at random within the orchard and separated from one another by guard rows, in order to avoid contamination due to drift of the spray.

Treatments were carried out using Cultar (1000ppm), Sunny (500ppm) and CCC (2000ppm). All treatments were applied to the spring flush when this flush was 2-4 cm in length. In order to compare the trial to previous work involving Sunny and Cultar, additional blocks were sprayed with these two chemicals at the flowering stage (before the emergence of the flush). In all cases, the wetting agent Nu-film was added to the treatment at 15 ml per 100 l and trees were sprayed to run-off. Control trees received no treatment.

At the time of spraying, tree height, canopy radius (on 4 lines at 90° to one another) and stem circumference were recorded. These measurements were repeated at the start of the summer flush to determine the effect of the chemicals on tree growth through the spring flush period. Furthermore, flush lengths of shoots were determined following the spring flush. In order to determine the effect of the chemicals on fruit set, one tree in each block was selected at random and the following data collected:

- Fruit count
- Fruit length and diameter (16 fruits per tree = 96 fruits per treatment)
- Spring flush length (16 shoots per tree = 96 shoots per treatment)

RESULTS AND DISCUSSION

Vegetative growth

The data for spring flush lengths (figure 1) shows no significant differences between the treatments, although the average flush lengths are shorter for the Cultar and Sunny treatments than for the controls. Results for CCC were very similar to those for the controls.

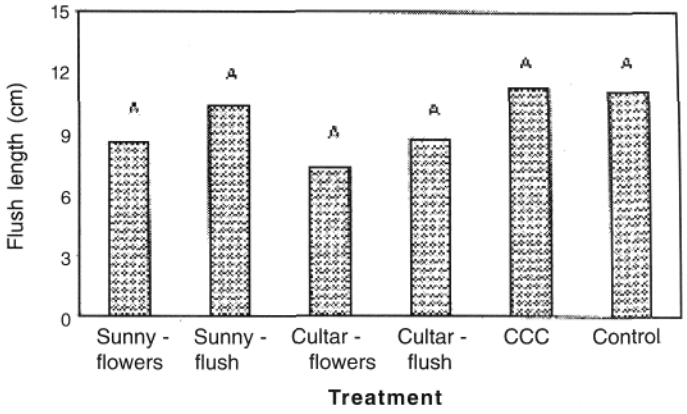

Figure 1. The effect of growth inhibitors on flush length

Similarly, there were no significant reductions in the increase in tree drip area between treatments (figure 2). However, trends in the data indicate that all of the chemicals had an inhibitory effect on vegetative growth, even though the difference was not statistically significant.

These results, although not significant, show a trend towards less vegetative growth in trees treated with the growth inhibitors. This trend is particularly strong in trees treated with Cultar. The CCC-treated plants show considerably less of a response regarding their vegetative growth. However, this product has never been used on avocados and an effective concentration has yet to be determined. In the one tropical crop where CCC has been used, CCC was applied in 4000 ppm before large differences in growth were observed in some cultivars (Maiti *et al*., 1972). This is double the concentration used in the current avocado trial and as such it will be necessary to run further trials using higher concentrations of CCC.

Fruit growth

Fruit set

The data collected at the time of the summer flush indicates that there is definitely an effect on fruit set (figure 3).

Cultar sprayed on the young spring flush caused a statistically significant improvement in fruit set. This correlates well with the observed decline in drip area for trees receiving this treatment. In contrast, Cultar applied at late flowering caused a decrease in fruit set compared to the controls. Symons and Wolstenholme (1990) also found that applications to flowers reduced fruit set, while a later spray to the flush enhanced the set. They suggested that the force of the spray may remove enough flowers to explain this observation. The current data would seem to support this.

All Sunny treatments caused a decline in fruit set the timing and application of Sunny sprays is an area that still requires some investigation. Figure 3 indicates that CCC had a marked effect with respect to the control trees, although the effect was not statistically significant. Once again, it seems that slightly higher concentrations of CCC may be required in avocados.

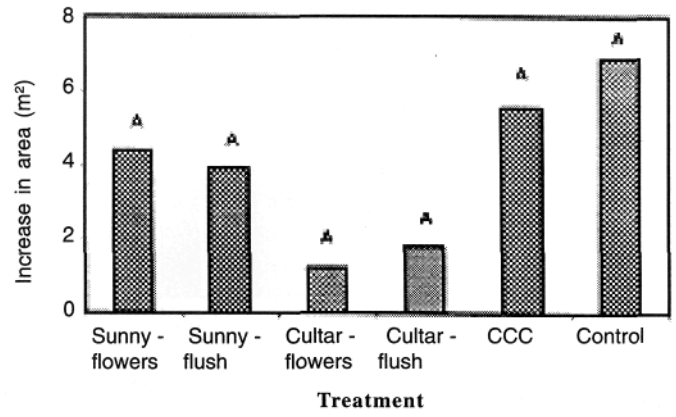

Fig. 2. The effect of growth inhibitors on tree drip area

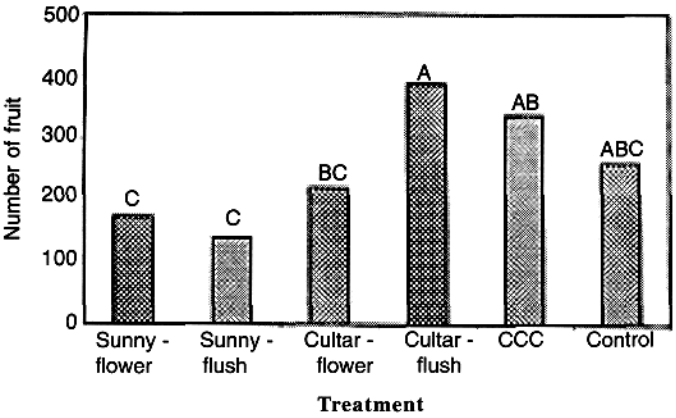

Figure 3. The effect of growth inhibitors on fruit set

Fruit size and shape

As shown in figure 4, there is no statistically significant change in fruit length in the treated trees.

However, trees sprayed with Sunny during the spring flush showed a significant increase in fruit diameter (figure 5).

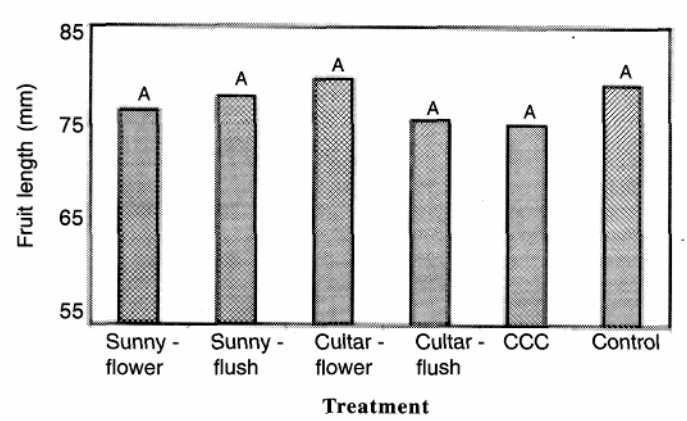

Figure 4. The effect of growth inhibitors on fruit length

This may well counter the effect of lower fruit set for this Sunny treatment. If the size increase holds until the final harvest, this will be particularly welcome, considering the problem of small fruit size in Hass avocados. The fruit diameter data also suggests that CCC had a beneficial effect on fruit diameter, although the effect was not statistically significant.

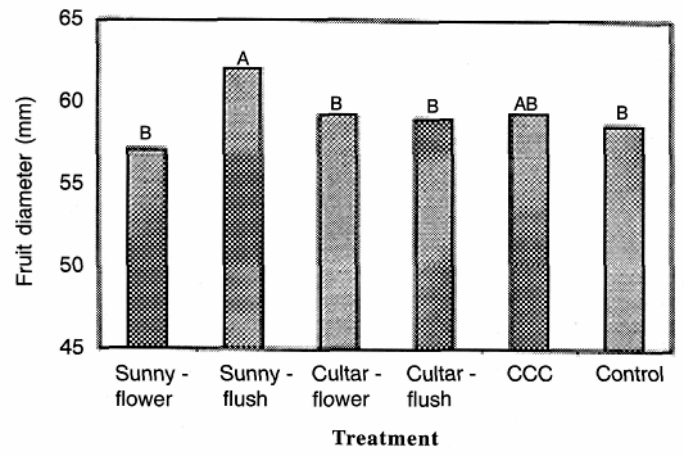

Figure 5. The effect of growth inhibitors on fruit diameter

The data for the full growth indicates that the timing of the application is critical in terms of the results obtained. Although the harvest data for this trial has yet to be collected, it would seem that applications to the spring flush may well have a greater effect than applications at the time of full bloom. It would also seem that more work on application rates is justified particularly in the case of CCC which appears to have the potential of being an economical alternative to some of the growth inhibitors currently used.

Based on the current trial and the data available for other trials, it would seem that growth inhibitors can play a considerable role in controlling avocado tree growth and

improving productivity. The current trial has some shortcomings in that large variations in the data mean that the results are not statistically significant, despite consistent trends in these results. This may well be due to the large tree to tree variation within the orchard used for the trial. With this in mind, several well-managed orchards with a considerable degree of uniformity have been identified for ongoing trials. These orchards will be used to establish the role of plant growth inhibitors as part of a comprehensive orchard management programme. Optimum timing and concentrations of sprays will be determined for a variety of compounds. It is hoped that these trials will contribute to a better orchard management programme for avocados and this bring about sustainable cropping of high quality fruit within the industry.

REFERENCES

BATJER, L.P., WILLIAMS, M.W. & MARTIN, G.G. 1964. Effects of N-dimethyl amino succinamic acid (B-Nine) on vegetative and fruit characteristics of apples, pears, and sweet cherries. *Journal of the American Society for Horticultural Science 85: 11 - 16.*

DAVIS, T.D., STEFFENS, G.L. & SANKHLA, N. 1988. Triazole plant growth regulators. *Horticultural Reviews 10:* 63 105.

FORSHEY, C.G. 1991. Measuring growth in complex systems: How do growth regulators alter growth? *Hort Science* 26(8): 999 - 1001.

KÖHNE, J.S. 1988. Methods of increasing avocado fruit production. *South African Avocado Growers' Association Yearbook.* 11: 53 - 55.

KÖHNE, J.S. & KREMER-KÖHNE, S. 1987. Vegetative growth and fruit retention in avocado as affected by a new plant growth regulator (Paclobutrazol). *South African Avocado Growers' Association Yearbook* 10: 64 - 66.

LUCKWILL, L.C. 1976. Growth regulation in top fruit. *Outlook on Agriculture 9(2): 46 - 51*

MAITI, S.C., BASU, R.N. & SEN, M P.K. 1972. Chemical control of growth and flowering in *Mangifera indica* L. *Acta Horticulturae* 24: 192 - 195.

MAITI, S.C., MUKHOPADHAYAY, A.K. & SEN, P.K. 1971. Effects of growth retardants on flowering and apical dominance of mango *(Mangifera indica* L.) *Current Science* 40: 388.

RADEMACHER, W. 1995. Growth retardants: Biochemical features and applications in horticulture. *Acta Horticulturae* 394: 57 - 69

SACHS, R.M. & HACKETT, W.P. 1972. Chemical inhibition of plant height. *HortScience* 7(5): 440 - 447.

SNIJDER, B. & STASSEN, P.J.C. 1997. Can more intensive plantings of avocado orchards be maintained? *South African Avocado Growers' Association Yearbook* 20: 74 - 77.

STASSEN, P.J.C. & DAVIE, SJ. 1996a Tree manipulation its application in the citrus and subtropical fruit industries. ITSC Information Bulletin 285: 2 - 10.

STASSEN, PJ.C. & DAVIE, S.J. 1996b Planting and training systems for citrus and subtropical fruit trees. ITSC Information Bulletin 285: 10 - 19.

STASSEN, P.J.C., DAVIE, S.J. & SNIJDER, B. 1995. Principles involved in tree management of higher density avocado orchards. *South African Avocado Growers'*

Association Yearbook 18: 47 - 50
STASSEN, P.J.C., DAVIE, S.J. & SNIJDER, B. 1997. Guidelines for planning future avocado orchards. Neltropika Bulletin 298:39 - 50.
SYMONS, P.R.R. & WOLSTENHOLME, B.N. 1990. Field trial using paclobutrazol foliar sprays on Hass avocado trees. *South African Avocado Growers' Association Yearbook* 13: 35 - 36.
WHILEY, A.W. & SCHAFFER, B. 1994. Avocado In Schaffer, B, and Andersen P.S. (Eds.) Handbook of Environmental Physiology of Fruit Crops v. 11 Sub-Tropical and Tropical Crops. CRC Press (Boca Raton) pp 3 - 35.
WHILEY, A.W., SARANAH, J.B., WOLSTENHOLME, B.N. & RASMUSSEN, T.S. 1991. Use of paclobutrazol sprays at midanthesis for increasing fruit size and yield of avocado *(Persea Americana* Mill. Cv. Hass) *Journal of Horticultural Science* 66(5): 593 - 600.
WILLIAMS, M.W. 1988 Cultural and chemical control of vegetative growth of deciduous fruit trees: Introduction to workshop. *Hort Science* 175:121 - 126.
WOLSTENHOLME, B.N. 1986. Energy costs of fruiting as a yieldlimiting factor with special reference to avocado. *Acta Horticulturae* 175:121 - 126
WOLSTENHOLME, B.N. 1987. Theoretical and applied aspects of avocado yield as affected by energy budgets and carbon partitioning. *South African Avocado Growers' Association Yearbook* 10:58 - 61.
WOLSTENHOLME, B.N., WHILEY, A.W. & SARANAH, J.B. 1990. Manipulating vegetative: reproductive growth in avocado *(Persea Americana* Mill.) with paclobutrazol foliar sprays. *Scientia Horticulturae* 41:315 - 327
WOLSTENHOLME, B.N., WHILEY, A.W., SARANAH, J.B., SYMONS, P.R.R., HOFMAN, P.J. & ROSTRON, J. 1988. Paclobutrazol trials in avocado orchards: Initial results from Queensland and Natal. *South African Avocado Growers' Association Yearbook* 11: 57 - 59