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Time and type of pruning cut affect shoot growth in avocado (*Persea americana*) Mill.

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SUMMARY

The effect of two pruning cuts in late summer or late autumn, either through the uppermost bud ring or below the bud ring, on resultant vegetative growth in avocado was investigated. The cuts were repeated at a second date to determine if time of pruning had an effect on shoot growth characteristics. The cut through the bud ring released an average of seven buds and greatly increased shoot complexity. The cut below the bud ring depressed vigour and released on average one bud. Time of pruning had an effect in that the later into autumn that the cut was done the longer was the resultant shoot. The results show that properly targeted and timed pruning could replace the need for growth-retardant chemicals in the manipulation of the vegetative: reproductive balance in an evergreen tree crop such as the avocado.

THE avocado is an important horticultural fruit crop of both tropical and subtropical origin from Central America. The most technologically advanced industries are in subtropical environments in countries such as Mexico, Israel, Spain, South Africa, Chile, Australia, New Zealand, Kenya and the states of California and Florida (Wolstenholme, 1987). This vigorous evergreen tree grows to a large size (Köhne and Kremer-Köhne, 1990) and is characterized by low yield and/or erratic bearing habit (Monselise and Goldschmidt, 1982; Scholefield *et al.*, 1985; Toerien, 1989; Wolstenholme *et al.*, 1991).

A recent strategy to improve yield on a land area basis has been a shift toward high density plantings (from 200 to 400 or even 800 trees ha^{-1}) combined with a controlled programme of tree removal as tree canopies converge (Köhne and Kremer-Köhne, 1992). However, growth rates of up to 1 m per season necessitate the first tree removal as early as the fourth or fifth year. If avocado yields are to be further increased, tree manipulation is necessary to control tree architecture and complexity and increase fruitfulness, as successfully done in deciduous tree culture. Avocado tree architecture has been superficially studied and general tree shape conforms with the Rauh model (Hallé *et al.*, 1978). A more detailed study showed that the modular growth habit and relative strengths of apical dominance versus apical control in the avocado ultimately determine tree shape (Thorpe and Sedgley, 1993). Earlier studies where avocado trees were non-selectively shoot tipped into the current flush to increase whole tree complexity and precocity concluded that this pruning approach encouraged additional, uncontrollable vegetative growth and increased fruit abscission (Toerien and Basson, 1979; Köhne, 1988). Besides these studies however, as far as we are aware, very little manipulation of tree architecture to improve whole tree complexity and fruiting has been attempted in the avocado.

A phenological growth cycle model for subtropical avocados has been described by Whiley *et al.* (1988). Vegetative shoot growth occurs in two major flushes during spring and summer, but does not necessarily affect all shoots. In this paper we report upon the vegetative response in a study where current-season shoots were pruned at two morphologically and physiologically different positions at two times after the summer growth flush had hardened.

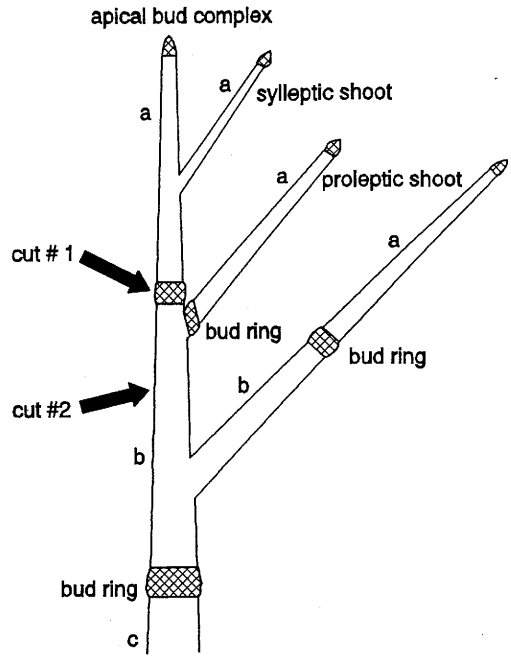

FIG. 1
Schematic diagram showing growth cycle units of modular construction in a typical avocado branch and the position of the two pruning cuts used in the study.

MATERIALS AND METHODS

The trees used in this study were seven year old (in 1992) 'Fuerte' on clonal 'Duke 7' in a well managed commercial orchard thinned in their fifth year from a 5 m × 5 m (400 trees ha^{-1}) to a 5 m × 7.5 m spacing (267 trees ha^{-1}). The orchard was located in the cool subtropical mistbelt region near Pietermaritzburg in Natal, South Africa. Trees were subject to normal cultural practices (except for the pruning treatments) and were not under any obvious cultural stresses at any stage of the trial.

Twenty trees were randomly selected and labelled 1 to 20. Three branches were selected on each tree, one north-facing, one east-facing and one west-facing ca. 2 m from the ground. Two pruning cuts were performed on different shoots on each branch, one through the bud ring and the other below the bud ring midway down the previous growth flush (Figure 1). A bud ring of several small, closely spaced buds without subtending leaves is invariably found immediately below the terminal bud which forms at the conclusion of a shoot growth flush in avocado (Figure 2). Unlike axillary buds, which are very prone to abscission (Chandler, 1958), these buds persist for a few seasons and are useful markers for distinguishing between growth flushes. The pruning was carried out on current season (previous flush) wood. The pruning cuts were initially made on 17 March 1992 (late summer). The experiment was repeated on a second pruning date about six weeks later on 27 April 1992 (late autumn) to determine whether season had an effect on growth response.

Growth responses were measured at regular intervals until the resultant flush had hardened off. The variates measured were the number of buds that broke in response to pruning, the time taken to budbreak, the length of the resultant flush and the growth flush shoot diameter. The results were analyzed as a simple random design with split for type of cut using the Genstat 5 computer package.

RESULTS

There were significant differences in the responses between type of cut (through the bud ring versus midway up the subtending growth section)(TableI) and to a lesser extent time of cut (Table II). The cut through the bud ring resulted in many buds (average of seven) breaking whereas the cut midway down the previous growth flush resulted in one bud or none breaking during the eighth month period after the cuts were made (Figure 3). In many cases no buds broke from the cut midway between the first and second bud rings. Nearly all buds that broke in response to the pruning developed into shoots. Budbreak continued over a long period of ca. six months through the winter and subsequent spring (Figure 3).

The shoot patterns were similar irrespective of time or type of cut as regards growth phenology, but final shoot length and rates of growth differed depending on treatment (Figure 4). Shoot growth was only slightly less vigorous when many buds broke as opposed to the vigour when only one bud broke (Table II). Within a treatment the response was repeatable and therefore predictable. Of interest was the observed (but not measured) high percentage of syllepsis in the shoot growth from cut 2 when compared with the shoot growth resulting from cut 1.

DISCUSSION

The main management tools used to control

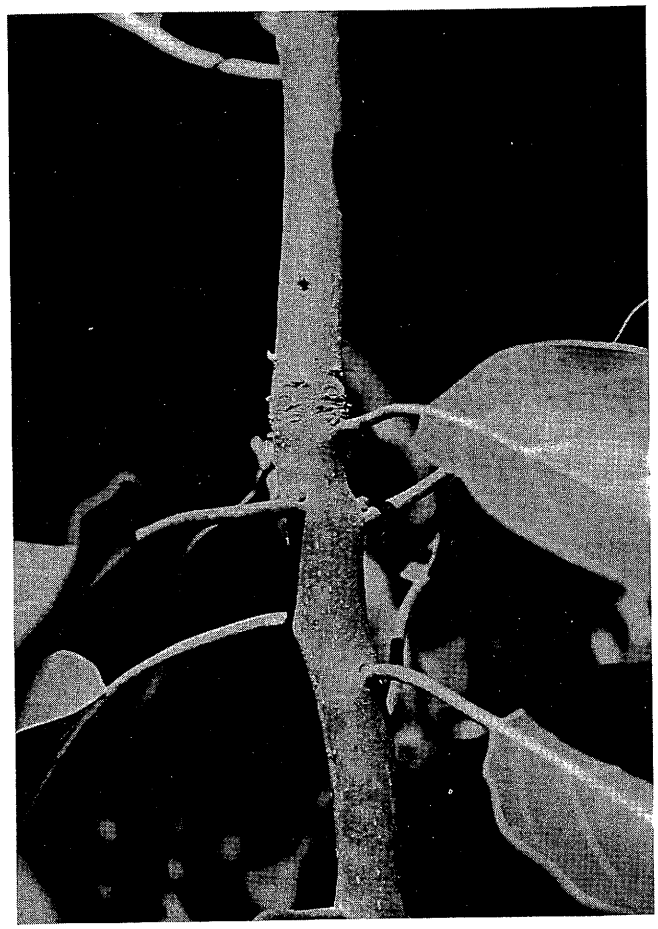

FIG. 2
Avocado bud ring junction between the uppermost and subtending growth flushes showing the closely spaced, long lived buds in the bud ring.

vegetative vigour in young closely spaced avocado orchards are paclobutrazol sprays, trunk injection and soil drenches (Wolstenholme *et al.*, 1990; Köhne and Kremer-Köhne, 1990; Adato, 1990; Whiley *et al.*, 1991) and careful monitoring of leaf nitrogen levels.

In any pruning research the decision where to cut is crucial. This is particularly important in avocado because a large percentage of the lateral buds abscise when they are about a year old or even a little sooner (Chandler, 1958). Buds in the bud ring however remain viable. This was the rationale behind our decision in selecting the two positions used in this study.

This study has shown that pruning an avocado tree to increase tree complexity is possible. However, the response is dependent on both type of cut and to a lesser extent on time.

TABLE I
Means with significance probabilities for differences between shoot growth response for one year old avocado shoots pruned through the bud ring (cut 1) or in the middle of a rhythmic flush section below the bud ring (cut 2)

	Cut 1	Cut 2	F ratio	*P* value
Number of buds broken	7.8	0.73	252.4	<0.001
Final shoot length (mm)	241.5	267.4	4.60	0.046
Final shoot diameter (mm)	4.12	5.83	12.05	<0.001

TABLE II
Means with significance probabilities for differences between shoot growth response for one year old avocado shoots pruned in late summer or late autumn

	17-03-1992	27-04-1992	F ratio	*P* value
Number of buds broken	3.80	4.02	1.74	0.204
Final shoot length (mm)	226.0	282.5	3.67	0.072
Final shoot diameter (mm)	4.69	5.27	4.61	0.046

A pruning cut into the bud ring was highly effective in inducing profuse, synchronized bud break from the closely spaced buds in this region (Figure 5). The resulting shoots competitively controlled each other's growth, so that the induced vigorous response was diluted. The average growth flush length on unpruned shoots was 400–600 mm (data not presented) as opposed to the 200–300 mm on pruned shoots. Therefore pruning was dwarfing when measured by canopy diameter. This would allow an extra year or two between tree thinnings. Increasing complexity in young trees is important in increasing the number of bearing sites and in maximizing the advantages of precocity in high density plantings before tree removal becomes necessary. This is the case in cultivars which exhibit strong apical control and either weak or strong acrotony, i.e. most avocado cultivars grown commercially in the subtropics (Thorpe and Sedgley, 1993).

Excessive vegetative vigour is a serious problem in many avocado growing areas, particularly when alternately bearing trees are in their off season. The problem is usually worse when excessively vigorous clonal rootstocks such as 'Martin Grande', or to a lesser extent 'Duke 7' are used to counter effects of *Phytophthora cinnamomi* root rot. At present there are no commercial dwarfing rootstocks for avocado. It is therefore important to find non-chemical means of controlling vegetative vigour. This study has shown that pruning in the middle of a subtending growth flush below the bud ring reduces vigour, particularly if the pruning cut is performed in late summer. This is because a large number of lateral buds have by then already abscised and partly because of some, as

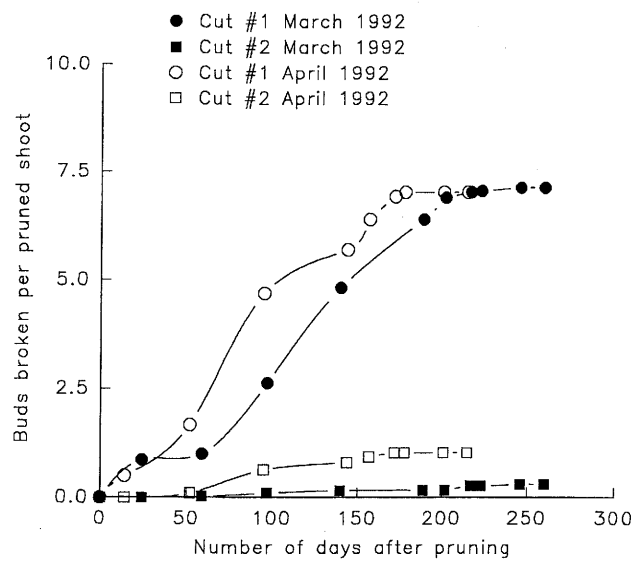

FIG. 3
Avocado bud break patterns on shoots pruned in late summer (March) or autumn (April) through the uppermost bud ring (cut #1) or below the uppermost bud ring midway down the growth flush (cut #2).

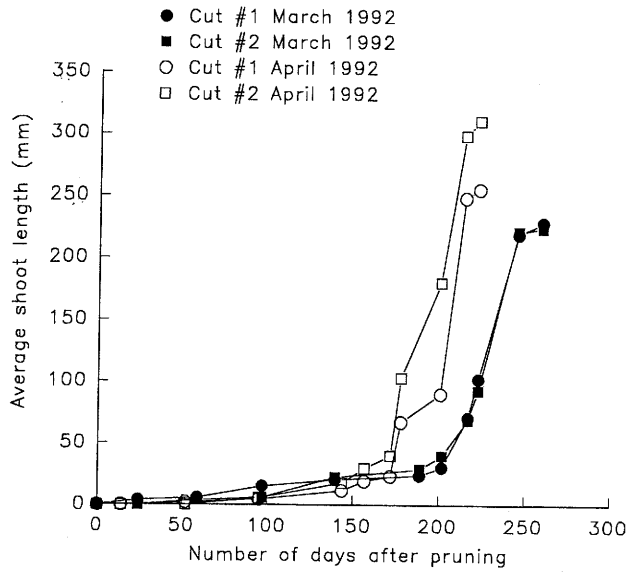

FIG. 4
Avocado shoot growth patterns on shoots pruned in late summer (March) or autumn (April) through the uppermost bud ring (cut #1) or below the uppermost bud ring midway down the growth flush (cut #2).

yet unexplained, physiological mechanism. The time of pruning needs to be accurately related to tree phenology (Whiley *et al.*, 1988) rather than to chronological date (to permit pruning

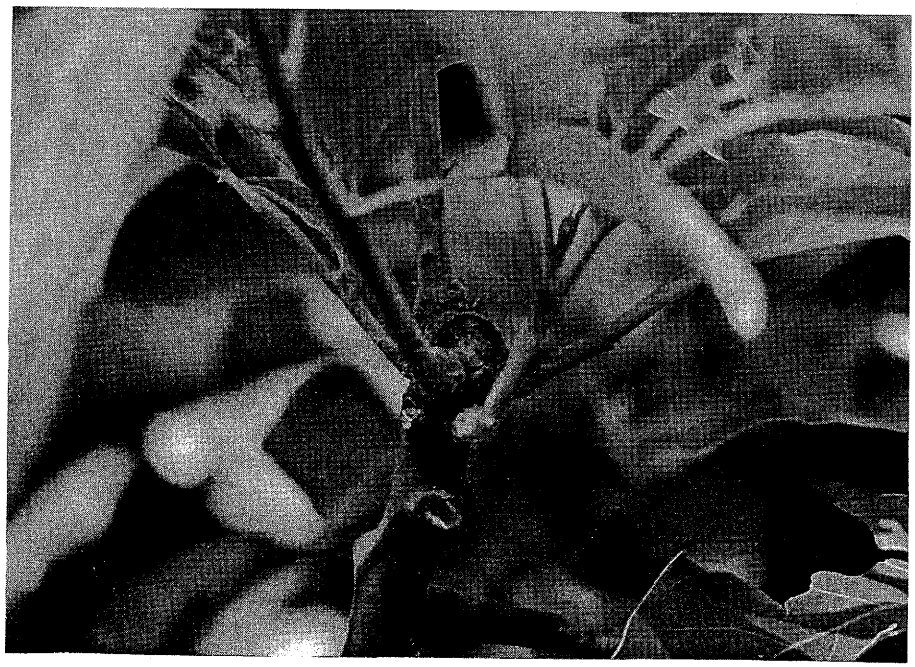

FIG. 5
Typical multiple bud break and shoot growth response in avocado when pruned through the uppermost bud ring in late summer.

for a specific response) as shoot growth response appears to be phenologically time sensitive.

Although the results obtained are preliminary, they were sufficiently clear-cut and predictable to generate optimism that properly targeted and timed pruning cuts may replace the need for growth retardant chemicals in the manipulation of the vegetative: reproductive balance in this low yielding evergreen fruit crop. Further research is underway.

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