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# PROGRESS REPORT: A PRELIMINARY REPORT ON THE EFFECT OF MULCHING ON 'HASS' AVOCADO FRUIT GROWTH.

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***ABSTRACT***

*The 'Hass' avocado is important to the South African avocado industry as it extends the length of the harvesting season and it is preferred by overseas consumers. The major draw-back of this cultivar is that it bears a large percentage of undersized fruits, with the problem being more pronounced in warmer climates and as the trees become older. The philosophical basis for this project is that lack of cell division in the pericarp tissue, and early seed coat abortion appear to be the major physiological reasons for undersized fruit. Cytokinins are responsible for promoting cell division and therefore affect growth and differentiation in plant tissues. They are predominantly root-produced and translocated to regions of high meristematic activity, such as developing fruits. In a field trial at Everdon Estate, Howick, root health has been improved by the application of coarse pine-bark mulch and calcium acetate crystals (500g every 14 days). Phenological comparisons have been made between these trees and a control (trees without a mulch treatment). Preliminary results will be presented on the effect of improved root health on fruit growth.*

## INTRODUCTION

The South-African avocado industry is largely export orientated and must compete with other countries for major markets. The industry relies on its reputable ability to produce fruits of a superior quality, and hence only fruit of a certain standard, e.g. minimum fruit size (>200g), are exported (Toerien, 1989). The 'Hass' cultivar is important to the South-African avocado industry, particularly as it is preferred by overseas consumers (Cutting, 1993). Since it is a late maturing cultivar it is useful for extending the avocado season; this has major economic implications.

The major draw-back of this cultivar is that it is known to bear a large percentage of small fruit (up to 50% of the countries' crop may be undersize in any particular year) (Könne, 1992). The small fruit problem, a physiological problem of the tree without pathogen involvement (Blanke and Bower, 1991), is more pronounced as the trees become older (Cutting, 1993), and in orchards situated in warmer and/or drier climates (Hilton-Barber, 1992).

It is probable that endogenous cytokinins, which are known to regulate cell division, influence or regulate fruit growth and therefore fruit size. The purpose of this paper is to provide a synopsis of how cytokinins may influence fruit growth, and preliminary results will also be presented on the effects of mulching on 'Hass' avocado fruit growth. Furthermore, there is a need for a detailed study of the effect of mulching on avocado tree phenology, including yield, size and quality of fruits.

## FRUIT GROWTH AND DEVELOPMENT

Unlike most sub-tropical fruits (Coombe, 1976), cell division in avocado pericarp tissue proceeds throughout the life of the fruit whilst attached to the tree (Cummings and Schroeder, 1942; Schroeder, 1953; 1960). The rate of growth is higher at the beginning of the fruit's life and gradually decreases throughout the growing season (Schroeder, 1958; Robertson, 1971; Zilkah and Klein, 1987). This decrease may reflect a reduction in the contribution of cell division to total fruit growth throughout its development (Schroeder, 1953; 1960). Cell size increases until the fruit is approximately 70 mm in length, and from thereafter cell size remains constant (Schroeder, 1953).

Schroeder (1958) observed that different sizes of horticulturally mature fruits all have the same average cell size. It was concluded that differences in fruit size must be attributed primarily to differences in cell numbers, i.e. cell division is limiting in small fruit.

Seasonal growth of the avocado has been shown to follow a sigmoidal growth pattern (Robertson, 1971; Lee and Young, 1983; Muñoz-Perez *et al.,* 1988), and can be divided into three main stages (Robertson, 1971). During stage I there is a slow growth rate (Robertson, 1971), and involves the "decision" to abort or proceed with further cell division and fruit development (Gillaspy *et al.,* 1993). The second stage is characterised by rapid fruit growth and cell expansion (Robertson, 1971), whilst during stage III, physiological maturity proceeds, i.e. the seed matures and the rate of cell division declines (Robertson, 1971).

Small 'Hass' fruits have a more moderate growth rate at the initial stages and a higher rate at the later stages when compared with larger fruit. Diameter of small fruit approaches that of larger fruit faster than the corresponding lengths approach each other. The length: diameter ratio increases gradually and eventually reaches an almost stationary level at approximately 30 and 60 days in small and large fruits respectively, i.e. the final fruit shape was reached earlier in small fruits. It appears that the length-ways growth of small fruit was restricted in the initial stages of growth. Increasing the length axis by exogenous growth treatments might improve the growth of small fruits (Zilkah and Klein, 1987).

## PARTITIONING OF ASSIMILATES

Crop productivity is the ability of a plant to produce high levels of photosynthate and to allocate a large proportion of them to the economically important organs (Gifford *et al.,* 1984; Patrick, 1988; Wright, 1989). For fleshy fruits, assimilate supply is critical as this influences cell division (Ho, 1988; Patrick, 1988), the factor most limiting fruit size in avocados.

Cull (1989) proposed that carbohydrates may be the key to the understanding and management of tree crops. Early fruit development and eventual yield has often been correlated to the plant's carbohydrate content (Finazzo and Davenport, 1987). All inputs, environmental or cultural, affect carbohydrate formation, storage or accumulation to the competing organs within the tree. In the final analysis, it is the ability to direct a high proportion of available carbohydrate to the fruit which ultimately decides final yield (Whiley and Wolstenholme, 1990).

Assimilate partitioning is the end result of a co-ordinated set of transport and metabolic processes governing the flow of assimilates from sites of production (sources) to sites of utilization (sinks) (Salisbury and Ross, 1978; Patrick, 1988). Sink strength is the capacity of the harvested organ to accumulate assimilates in order to gain biomass (Patrick, 1988; Wright, 1989). Cytokinins have been shown to bring about nutrient mobilization within plant tissues (Mothes and Engelbrecht, 1961), and there is considerable evidence that cytokinins are involved in the regulation of assimilate partitioning (Richards, 1980). High cytokinin levels may increase sink strength activity of the avocado fruit for nutrients and other metabolites, and thereby promote fruit growth (Blumenfeld and Gazit, 1970).

Most attempts to explain source-sink interactions have been based upon some form of competition between developing sinks (Wright, 1989). The nature of carbohydrate sinks in avocado varies from meristematic to storage (Gifford and Evans, 1981), and the order of priority among sinks is a function of both activity and size of sink (Lee & Young, 1983; Cannell, 1985; Patrick, 1988; Wolstenholme, 1990). Cannell (1985) suggested precedence in rank between sinks where developing seeds would appear to have priority for assimilates and storage organs the least command for metabolites.

It seems that avocado fruits are dependant on their seeds for virtually the entire period of fruit development (Wolstenholme *et al.,* 1985; Bower and Cutting, 1988). By the time the endosperm has been used up (approximately January in South Africa), the seed coat has become a very important and rich source of cytokinin (Wolstenholme *et al.,* 1985). Once the seed matures and seed coat dries, the potential for further fruit growth is limited. This is related to the fleshy pericarp being cut off from its nutrient and plant growth substance supply (Wolstenholme *et al.,* 1985; Cutting *et al.,* 1986).

## CYTOKININS

The presence of cytokinins in meristematic regions such as developing fruits is well established (Goldacre and Bottomly, 1959), and it is surprising that very few complete studies on the relationship between endogenous plant growth substances and fruit development have been compiled (Bower and Cutting, 1988).

Today it is well established that cytokinins are a class of naturally occuring substances active in promoting cell division (Skoog *et al.,* 1965; Lackie and Dow, 1989; Smith and Wood, 1992), and therefore affect growth and differentiation in plant tissues (Smith and Wood, 1992).

There is considerable evidence that cytokinins are involved in controlling fruit development (Cutting *et al.,* 1986) and increasing fruit size. Köhne (1992) showed that 'Hass' fruit size can be increased by as much as 28%, when a urea cytokinin fruit dip is used shortly after fruit set. It is not known whether cytokinins affect fruit size by controlling cell division (Smith and Wood, 1992), or assimilate partitioning (Richards, 1980), or both.

Miura and Millar (1969) suggested that all plant cells have the ability to synthesise cytokinins provided that mechanisms for synthesis are "switched on". This, however, does not mean that synthesis normally occurs throughout healthy plants (van Staden and Davey, 1979). Today, it is recognised that zones of high meristematic activity, e.g. root meristems (van Staden and Davey, 1979) and developing seeds (Letham and Williams, 1969) are sites of cytokinin activity.

Cutting (1993) investigated the possibility that endogenous cytokinins may regulate fruit size and compared the cytokinin complex of 'Hass' fruits from warm and cool climates. A comparison between warm and cool climates was made because it seems that the small fruit problem is more pronounced in warmer climates. He concluded that seed and seed coat concentrations of zeatin and dihydrozeatin type cytokinins were greater in fruit from cool areas. The most important physiological consideration appears to be seed coat health (Wolstenholme *et al.,* 1985; Cutting, 1993) and fruits from warmer areas show signs of earlier seed coat degradation. In warmer areas it is evident that climate interferes with cytokinin transport and/or synthesis as endogenous cytokinin levels are lowers (Cutting, 1993).

## MATERIALS AND METHODS

Six-year-old 'Hass' avocado trees grown on Everdon Estate, near Howick, in the Natal midlands were used for this study. The orchard is situated in Bioclimatic region 3, which is characterised by cool, mesic conditions, typical of a mist-belt type climate. The trees are grown on a Hutton type soil and normal cultural methods are practised. Coarse pine-bark mulch was applied in February 1993 under six trees to a depth of approximately 15cm, and these trees were compared to a control (unmulched trees). A 500g calcium acetate crystal was applied to the mulch every two weeks.

The rationale behind the choice of treatments is that the avocado tree, with its upland tropical rainforest origin, is a "litter-feeder" and that a thick mulch of fairly coarse particles will encourage surface feeder roots to proliferate into the mulch. The roots will benefit from better aeration (an important criterion for avocado fruit health) and from nutrient element mineralization and a favourable moisture regime.

Our hypothesis is that good mulch will therefore encourage healthy root growth for longer periods, resulting in higher levels of cytokinin synthesis and translocation to various aerial organs, including setting and growing fruit. Hopefully, also, this will counter premature seed coat abortion. The calcium acetate is a soluble, readily available form of calcium which will be taken up by active root growth and move, at least in part, into growing fruits.

Root flushes have been monitored by visually estimating the area covered by white healthy feeder roots under newspaper mulch. A visual estimate of root flushing was performed using a rating of 0-10. The groupings of "poor", "medium" and "good" were chosen as 0-2, 3-4 and >4.

A total of 240 fruit per treatment were tagged on 26 October 1993 when all the fruit were approximately 10mm in length. Subsequent measurements using digital calipers were taken at regular intervals.

The following measurements are currently being taken and will not be reported in this paper;

1. seed coat cytokinin levels
2. xylem cytokinin levels
3. cell counts across the fruit
4. phenological measurements, including leaf dynamics

**RESULTS AND DISCUSSION**

The problem of small sized 'Hass' avocados becomes worse as the trees age (Cutting, 1993), and this may be related to the amount of cytokinin produced by the roots, as well as to declining leaf: fruit ratios and reduced leaf photosynthetic efficiency. The initiation of cytokinin synthesis may well be determined by the age of the roots; the older the roots, the lower the cytokinin activity, the smaller the fruits (van Staden and Davey, 1979). Root health also seems to be crucial in cytokinin synthesis. Cultural practises to improve root health, e.g. increased irrigation and mulching, may lead to increased production of cytokinin by the roots (Itai and Vaadia, 1965).

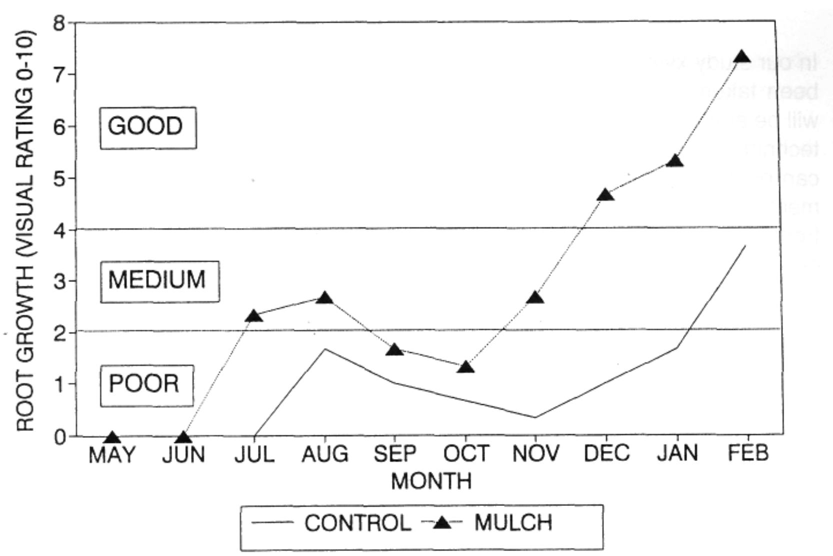


FIG. 1
Root flushes as determined by a visual rating where there is no root growth for a rating of 0 and extensive root growth for a rating of 10.

In our study the application of coarse pine-bark mulch has led to enhanced root activity (Fig. 1). From the results it is apparent that not only is root growth in the mulch treatment greater but also occurs earlier than in the control treatment. There was a delay of approximately four months, the mulch being applied in February, before the treatment showed any positive effect on root growth.

Results of the initial stages of fruit growth are promising with fruit growth on the mulch treatment showing an enhanced growth rate when compared with control fruit (Fig. 2). This increase in fruit growth rate is most likely to be as a result of enhanced cell division in the pericarp tissue. Cell counts currently being taken across the fruits at regular intervals will provide more positive results on the mitotic activity with in the avocado pericarp.

It is important to point out that the small fruit problem on Everdon Estate is not as severe as it is in the warmer avocado producing regions of the north-eastern Transvaal, so one would expect a more dramatic improvement by mulching in these regions. Furthermore, trees on Everdon Estate are presently in an "off-year", i.e. fewer fruits per tree are produced, and therefore the small fruit problem is not as pronounced. Consequently one would expect to see mulching having a more dramatic effect in an "on-year".

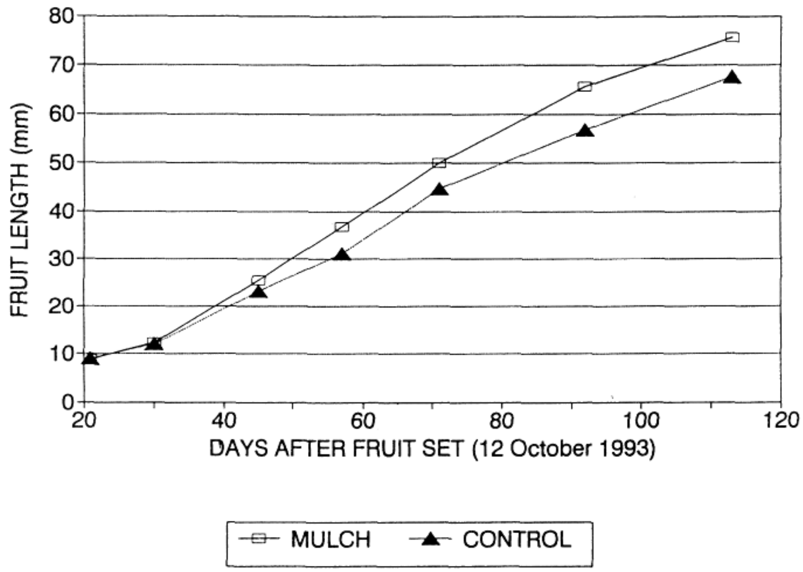


FIG.2
Fruit growth curves for the mulch and control treatments on trees at Everdon Estate in the Natal midlands.

In our study xylem sap samples have been taken at monthly intervals and will be analysed using HPLC and RIA techniques. From this a comparison can be made between the two treatments on the movement of cytokinins from roots to aerial plant parts. It is generally accepted that the seed (Blumenfeld and Gazit, 1970; 1974) and more specifically the seed coat (Cutting, 1993) controls fruit growth by synthesising and/or attracting plant growth substances. Seed coat samples have been taken at monthly intervals and will be analysed for cytokinins using HPLC and RIA techniques. This trial is at an early stage, and will run for at least one more season before reliable results can be obtained.

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