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Carbohydrate management in avocado trees for increased production

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ABSTRACT

It is proposed that productivity management in avocado trees is dependent on the management of carbohydrate in the tree. The seasonal concentration fluxes of reserve starch in the woody tissues of the tree are modelled with tree phenology. Factors affecting starch accumulation are discussed and management strategies improving fruit yield are defined.

Carbohydrate and phenological cycling

The concept of carbohydrate and phenological cycling as management tools for avocado orchards has previously been presented (Whiley *et al,* 1988; Wolstenholme & Whiley, 1989). Briefly it proposes that there are successful phenological (growth) cycles in specific environments which are congruent with high cropping performance, eg cultivar x temperature x flowering interactions (Whiley & Winston, 1987). The recognition of successful cycles and their maintenance on a perennial basis is assisted by management decisions including the correct choice of cultivars for specific environments, the timing and amount of irrigation and fertilisers and effective *Phytophthora* root rot control.

It is further proposed that productivity management, where productivity is defined as a function of total fruit weight and quality, is dependent on the management of carbohydrate in the tree (Whiley *et al*, 1988; Cull, 1990). All inputs, be they environmental or cultural, affect either carbohydrate formation, storage or allocation to the competing organs within the tree. In the final analysis it is the ability to direct a high proportion of the available carbohydrate pool (a major component of energy) to the reproductive structures (fruit), particularly during periods of competitive demand, which ultimately decides economic yield.

It is important to differentiate between low productivity resulting from failure of trees to flower, and good flowering but poor yields. A successful stimulus for flower initiation is likely to result from the activity of other endogenous substances within the tree (Whiley *et al,* 1989a; Bower *et al,* 1990). The management of carbohydrate in the context of this paper refers to the accumulation and mobilisation of assimilates to ensure that the flowering event is successful in terms of fruit set, fruit retention is at an acceptable level, vegetative growth proceeds but does not become highly competitive with fruiting, root growth is maintained and the crop is matured with an acceptable quality.

The starch curve and its relationship to tree phenology

Based on significant correlations between reserve carbohydrate (starch) prior to flowering and fruit yield in citrus and avocado (Goldschmidt & Golomb 1982; Scholefield *et al,* 1985), Wolstenholme and Whiley (1989) proposed integrating a starch curve with the phenological growth model to be used as a quantitative index for predicting **potential** yield. To develop such a curve as a management tool we must determine events during the tree phenology which have impact on reserve starch concentrations and those critical periods during which competitive sinks have source limitations. We reiterate that while this may be considered a simplistic approach to a complex issue it is the interpretation and simplification of research into effective management strategies which ultimately decides their usefulness at the farm level.

We can construct an annual starch curve (Figure 1) for avocado trees from the work of Scholefield *et al* (1985) and more recently Whiley *et al* (unpublished data). When related to the phenological cycle we see that starch reserves in the wood of trunks are at their highest during the prolonged winter rest period when growth demands are lowest. Starch reserves fall rapidly during flowering and fruit set and reach their lowest concentration during the summer fruit drop period before increasing to their winter maximum.

Factors affecting starch accumulation

Growth activity depletes carbohydrate (starch) reserves, particularly if assimilates from current photosynthesis are limiting. In avocado it is the summer flush growth which is the major contributor to starch accumulation during the winter months. However, the promotion of vigorous and extended summer flushing in the tree delays starch accumulation and may ultimately reduce the potential levels for that season.

Whiley *et al* (1989b) have shown with mangoes that the length of the vegetative rest period has a direct effect on the concentration of starch accumulated in trunk tissues. Furthermore, there are marked differences between the highest concentrations recorded for trunk starch in avocados in temperate southern Australia (18%, Scholefield *et al,* 1985), where there is an extended winter rest, and subtropical northern Australia (8,5%, Whiley, unpublished data) where growth may occur through to early winter.

Crop load and the persistence of fruit on the tree also affects starch accumulation during the winter months. This area is currently being studied by the authors in Queensland and Natal. Preliminary results from Queensland show that the time of crop removal effects the starch concentration in trunk tissues at the end of winter (Figure 2). Later removal delayed flowering and reduced the intensity but not the percentage of terminals flowering. The following season's crop was significantly lower where fruit were hung late on the trees (Figure 3).

Phytophthora root rot is a particularly severe disease of avocado causing major disruption to the physiology of the tree (Whiley *et al,* 1986; 1987). Often sub-clinical activity of this disease affects tree physiology without the expression of obvious symptoms. Root rot impacts on tree carbohydrate status in two ways. It disrupts photosynthesis, the source of carbohydrate, and it destroys feeder roots leading to a continual regeneration process which depletes tree reserves. Effective management of this disease in the orchard is critical to maximising production.

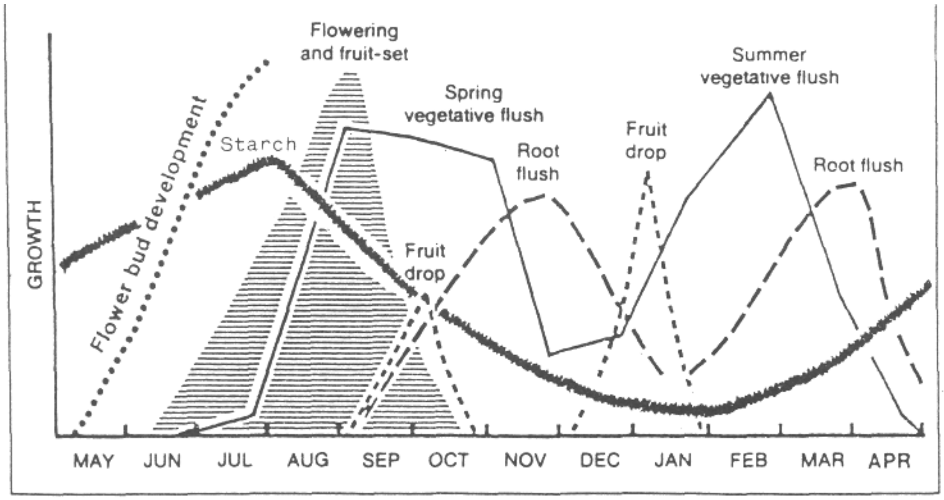

Fig 1 The total growth cycle of cv Fuerte showing the relationship between vegetative and reproductive growth and reserve starch in the trunks of trees.

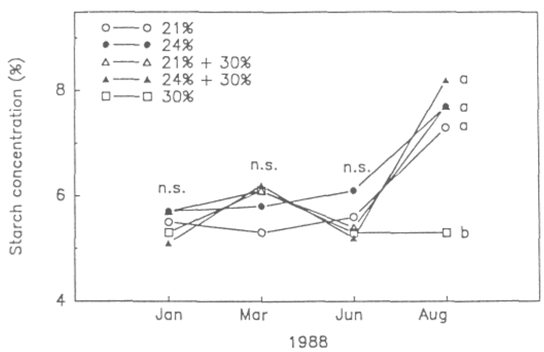

Fig 2 Starch concentration (%) in the trunks of trees when all fruit was harvested at 21% or 24% dry matter; half the crop removed at 21% and at 24% with the balance removed at 30%; the crop not harvested until fruit reached 30% dry matter. Data are means from five trees. Treatment means in columns not sharing a common letter are significantly different ($P \leq 0,05$); n.s. = not significantly different (Whiley *et al*, unpublished results).

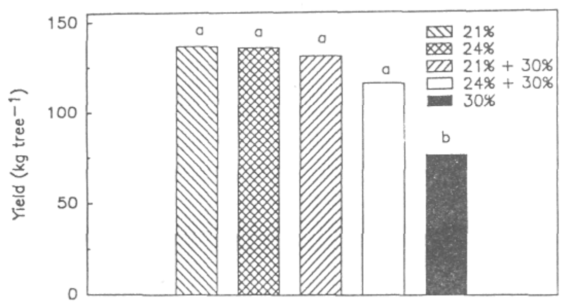

Fig 3 Fruit yield following differential harvesting times the previous season. All fruit were harvested at 21% or 24% dry matter; half the crop removed at 21% and at 24% with the balance removed at 30% dry matter; the crop not harvested until fruit reached 30% dry matter. Data are means from five trees. Treatment means not sharing a common letter between columns are significantly differnet (P $\leqq$ 0,01) (Whiley *et al*, unpublished results).

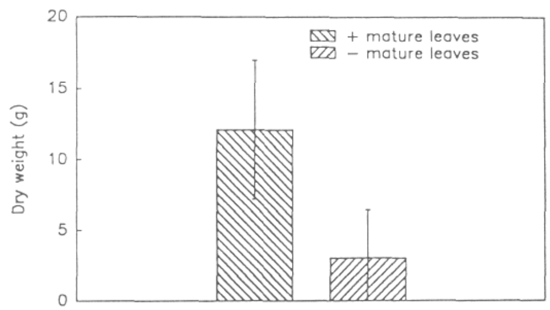

Fig 4 Dry weight of fruit at the matunity of spring flush growth on cinctured shoots with or without mature summer leaves. Data are means of three shoots from each of four trees. Vertical bars are ± s e (Whiley, unpublished results).

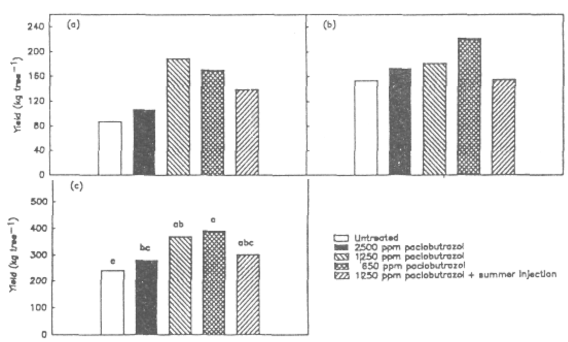

Fig 5 Fruit yields from trees treated with foliar sprays at full bloom (+ pre-summer flush injection) of paclobutrazol (Cultar®). Data are mean values from five trees: (a) fruit yields in 1988 (no significant difference); (b) fruit yields in 1989 (no significant difference); (c) combined fruit yields from 1988 and 1989. Treatment means not sharing a common letter between columns are significantly different (P $\leqq$ 0,05). (Whiley *et al*, unpublished results.)

Interactions between competing sinks

There is a sufficient volume of evidence demonstrating competitive sinks between young fruit and spring shoot growth (Biran, 1979; Blumenfeld *et al,* 1983; Köhne & Kremer-Köhne, 1987; Woistenholme *et al*, 1990; Whiley, 1990). During this period the carbohydrate source is from current photo-assimilates from mature summer leaves (Figure 4) and from reserves (Blumenfeld *et al,* 1989). Source limitations and strong vegetative sinks during this critical stage result in reduced fruit retention. Manipulation which reduces the spring vegetative vigour has proved successful in improving fruit retention (Köhne & Kremer-Köhne, 1987; Wolstenholme *et al,* 1990) and yield (Figure 5).

There is less known about summer fruit drop coincident with the summer growth flush (Whiley *et al,* 1988; Woistenholme *et al,* 1990). Environmental stress will accelerate fruit drop but may not be the primary cause. Wolstenholme *et al* (1990) suggest that carbohydrate stress is implicated. Limiting fruit loss at this stage, when there has already been an investment of 10-40% in potential individual fruit mass by the tree, remains a challenge for the future.

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