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Effect of Time of Harvest on Fruit Size, Yield and Trunk Starch Concentrations of 'Fuerte' Avocados

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Abstract. **Fruit from cv. 'Fuerte' avocado *(Persea americana* Mill) trees were harvested at different stages of maturity judged by flesh dry matter (DM). Treatments included strip-picking trees when fruit reached 21 (the minimum legal standard for avocados in Australia), 24 and 30% DM as well as two other treatments where 50% of the fruit was picked when they reached 21 and 24% DM, respectively, with the balance harvested from these trees at 30% DM. The treatments were applied to the same trees for 3 consecutive years. The seasonal flux of trunk starch concentration was monitored in each of the treatments and the data for the first year of the experiment are presented.**

Strip-picking of the trees at 21% and 24% DM, and where 50% of the crop was harvested at 21% DM with the balance at 30% DM, produced about 3.6 t/ha more fruit annually (averaged over the three years) than from those trees harvested when fruit was more mature. The later harvesting of fruit, viz. the crop picked at 30% DM, resulted in pronounced biennial cropping over the 3 years studied. Mean fruit size was significantly greater from those trees where 50% of the fruit were previously harvested at 24% DM with the balance at 30% DM as well as where fruit were harvested after reaching 30% DM compared to fruit from trees which were strip-picked at 21 and 24% DM (about 345 vs. 304 g).

Trunk starch concentrations ranged between 4.5 to 6.3% during the time of active tree and fruit growth. In all treatments, except where the crop was left on the tree until 30% DM, the trunk starch concentration rose to about 7.7% in late winter prior to flowering. The treatment harvested late had a trunk starch concentration of 5.3%. During flowering and fruit set the flux of trunk starch concentrations was negatively correlated to the respective flowering and fruit retention performance of the treatments.

Biennial bearing in fruit tree crops is a persistent problem which by no means has been resolved. While many of the fundamental physiological principles extend over all fruit tree crops, the evergreen trees have a vastly different phenology compared to deciduous trees which creates specific problems in relation to flowering and fruiting. For instance, it is not uncommon for evergreen trees to be carrying fruit while flowering, e.g..'Valencia oranges', avocado. Low rates of photoassimilation can result in a greater dependence on reserve carbohydrate for cropping: avocado (Scholefield *et al.,* 1985; Hodgson and Cameron, 1935; mango (Chacko *et al.,* 1982; citrus (Goldschmidt and Colomb, 1982).

The avocado, rich in mono- and polyunsaturated fats (oil), has a high "energy cost" to produce a similar unit weight compared to sugar-producing fruit (e.g. apples, citrus) and consequently lower yields per hectare must be expected (Wolstenholme 1986, 1987). However, average avocado production in subtropical Australia is only about 33% of the estimated potential sustainable yield of 32 tons per hectare. Production efficiency must be improved for the avocado grower to remain competitive and to successfully service domestic and export markets which depend on stability of production for reliable supply to consumers.

The avocado belongs to a unique group of species which do not ripen fruit which are attached to the tree. This feature is commonly used by growers as "on-tree-storage" in the management of marketing their crop. The consequences of this practice are often reflected in chronic biennial bearing or complete crop failure in the following year. This paper describes the impact of harvesting fruit at different stages of maturity on subsequent fruiting and the seasonal concentration flux of trunk starch in these trees.

Materials and Methods

Seven-year-old 'Fuerte' trees grafted to seedling Guatemalan race rootstock growing in a commercial orchard in southern Queensland (latitude 25°S) were used in the study. The trees were planted 6 x 9 m (150 trees/ha) and were irrigated with micro-sprinklers. Nutrition was programmed using leaf and soil analysis and scheduled as described by Whiley *et al.* (1988). Trees were sprayed at 3 to 4 week intervals during fruit development with copper fungicides and pesticides to control diseases and insect damage (Peterson and Inch, 1980; Fitzell, 1987). Fruit was harvested at various stages of maturity as judged by the percentage moisture in the flesh (Swartz, 1976). The five treatments chosen are described as follows:

1. All fruit harvested at 21% DM;
2. All fruit harvested at 24% DM;
3. 50% of fruit harvested at 21% DM and 50% harvested at 30% DM;
4. 50% of fruit harvested at 24% DM and 50% harvested at 30% DM; and
5. All fruit harvested at 30% DM.

Starch concentration was determined in wood samples collected from the tree trunks. The samples were collected at monthly intervals by drilling four 9 mm diameter cores of wood to the depth of 40 mm from the trunks. Samples were oven-dried to constant weight at 60C, milled to 100 mesh (Wiley Mill), and stored in airtight containers at -4.0C. Starch was analyzed using a two stage enzymic procedure to hydrolyze the starch to glucose which was then determined colorimetrically using a coupled-enzyme chromogen system (Rasmussen and Henry, 1990).

Results

There were no significant differences in yield between any of the treatments in the first year (1988) of the experiment confirming that the choice of trees was relatively uniform (Table 1). In the second year of the experiment, harvesting at the most advanced stage of maturity (30% DM) the previous year significantly ($P<0.05$) reduced fruit yield by as much as 100 percent compared to some other treatments (Table 1). Fruit yield in the third year (1990) was not significantly different between treatments. The cumulative yield for the three years of the experiment gave significantly less fruit for the treatment harvested at 30% DM compared with the three treatments where fruit was harvested at the earliest stages of maturity (Table 1). Fruit size (pooled data for the three years) was significantly ($P<0.05$) larger from those trees harvested at the most advanced stages of maturity (Table 1).

Trunk starch concentrations were variable from January until June without any significant differences between treatments. However by August, starch concentrations in all treatments with some or all fruit removed at 21 or 24% DM, had risen sharply and were significantly ($P<0.05$) higher than the treatment where fruit were left until reaching 30% DM (Fig. 1). There were no significant differences in trunk starch concentrations in October but by December the treatment harvested at 21% DM was significantly ($P<0.05$) lower than the treatment harvested at 30% DM (Fig. 1).

Table 1. Annual and cumulative yield from trees harvested at different stages of fruit maturity (DM). Data are means from each of 6 trees. Means in columns not showing common letters are significantly different ($P<0.05$).

DM at harvest	Yield (kg/tree)				Mean fruit size (g) (Pooled for 1988-90)
	1988	1989	1990	1988 – 90	
21% DM	127.2	147.4 a	168.4	442.9 a	302.1 c
24% DM	142.6	135.7 a	180.3	458.6 a	305.6 c
21% + 30% DM	152.5	131.1 a	171.5	455. 2 a	328.0 b
24% + 30% DM	132.4	115.6 a	142.6	390.6 ab	347.6 a
30% DM	135.9	70.4 b	172.4	378.6 b	341.8 a

Discussion

Either complete harvest of fruit from trees when fruit reaches 21 to 24% DM or removal of 50% of the crop at 21 to 24% DM with the balance later, will maintain the greatest productivity in 'Fuerte' avocados. Fruit yields in the vicinity of 22.5 t/ha (averaged over 3 years) were recorded from trees managed in this manner. However, trees used for "on-tree-storage" of the crop until 30 % DM was reached yielded 18.9 t/ha (averaged over 3 years), 3.6 t/ha less than earlier harvesting practices. For the period of the study there were no real differences in fruit yield among those treatments where some or all fruit were removed by 24% DM suggesting a certain level of flexibility for the orchardist in handling his crop without an adverse impact on yield.

Prolonged "on-tree-storage" of 'Fuerte' fruit has demonstrated the ability of crop load to induce severe biennial bearing in trees (Table 1). The reduction in fruit yield from 20.4 t/ha (135.9 kg/tree) to 10.6 t/ha (70.4 kg/tree) and the subsequent recovery to 25.9 t/ha (172.4 kg/tree) in the third year, illustrates the severity of the biennial cycle that can be induced under environmental conditions favorable for production (Whiley and Winston, 1987). The impact of time of harvest on biennial cropping has similarly been reported for late maturing 'Valencia' oranges (Hilgeman *et al.,* 1967).

Reserve carbohydrate has been implicated with productivity of many tree crops (Monselise and Goldschmidt, 1982) and the relationship demonstrated for avocado growing in a "Mediterranean" type climate (Scholefield *et al.,* 1985). In the first year of our study (Fig. 1) trunk starch concentrations rose sharply immediately prior to anthesis (August-September) in those trees where at least 50% of the crop was removed by mid May. The low trunk starch concentration of the 30% DM harvest treatment is directly correlated to the low yield (10.6 t/ha) in the following season. The low starch concentration of the 21% DM harvest treatment in December likewise may be attributed to the heavy flowering and fruit set (data not presented) recorded in these trees.

While our first year data produces some evidence of relationships between trunk starch concentrations and tree performance, the seasonal concentration flux (about 3-8%) is far short of the magnitude (about 2-17%) reported by Scholefield *et al.,* (1985). Furthermore, we have not been able to demonstrate a significant relationship in the following two years of the study. Recent investigations have demonstrated a greater magnitude of seasonal flux of starch concentrations in other organs (viz. roots, shoots and leaves) and these will be a focus of future research.

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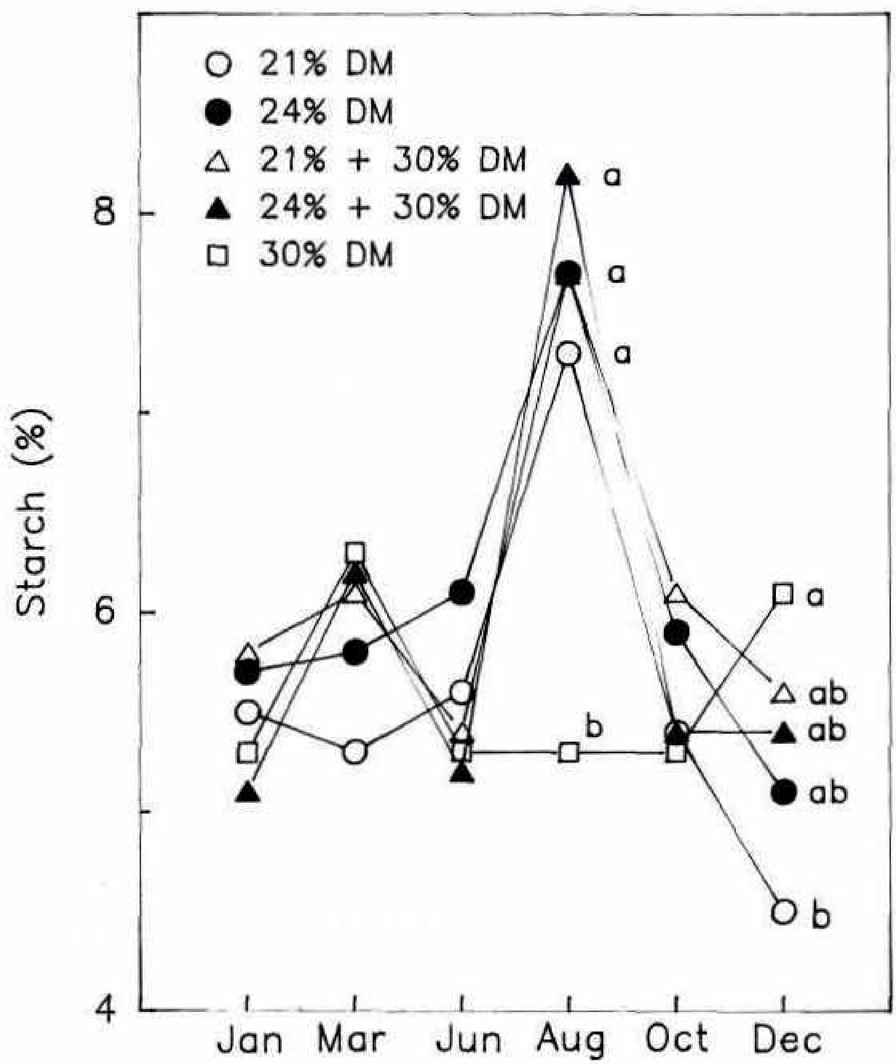

Fig. 1 Seasonal (1988) flux of trunk starch concentrations in cv. 'Fuerte' trees where fruit was harvested at different stages of maturity. Datum points are mean values from 6 trees. Points (vertically) not showing common letters are significantly different ($P<0.05$).