

'HASS' AVOCADO LEAF GROWTH, ABSCISSION, CARBON PRODUCTION AND FRUIT SET

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Avocado (*Persea americana* Mill.) is an evergreen tropical fruit tree, with a short leaf life span (10-12 months) (Whiley and Schaffer, 1994). In the subtropical climate of southern California, most of the previous season's leaves begin to senesce and abscise in the spring, when vegetative and reproductive growth occurs (Koo and Young, 1977). Both the vegetative and the reproductive growth demand a large quantity of carbon (Wolstenholme, 1987). However, the senescing leaves gradually lose their photosynthetic capacity (Stoddart and Thomas, 1982) and decline in their ability to supply carbon for growth. What most likely happens is that the reproductive and vegetative growth cycles compete strongly for the limited carbon resources, especially before the new leaves transition from being a carbon sink to a carbon source (Wolstenholme, 1990). The lack of sufficient carbohydrate supply may be directly responsible for poor fruit set, a slow rate of early fruit growth and fruit drop (Whiley et al., 1988; Wolstenholme, 1987). A comprehensive understanding of the senescing leaf photosynthetic performance in association with the new leaf growth and photosynthetic capacity development is essential for interpreting tree carbohydrate production and utilization.

Single leaf photosynthetic capacity in relation to its developmental stage and age has been studied for several avocado cultivars (Schaffer et al., 1991; Whiley, 1990). Avocado leaves emerge at different times, which leads to a flushing shoot bearing different developmental stages of leaves with different photosynthetic capacities. The integration of the information from a single leaf level to a whole shoot level can aid in our understanding of canopy carbon sink and source strengths. In this report, we present some of our work on the development of avocado leaf photosynthetic capacity during the spring in southern California.

Materials and methods

Plant material. Six to Seven year old 'Hass' avocado trees on Duke 7 rootstock planted at the UC South Coast Research and Extension Center in Irvine, California were used for this study. The trees received standard irrigation, fertilization and pesticide control practices for California (Goodall et al., 1981; Snyder et al., 1985). The soil type is Yolo fine sandy loam with an average depth greater than 18 m.

Leaf growth, previous season's leaf abscission, fruit set and fruit drop. Three branches, in the southwest quadrant of each of three trees, were tagged, and the previous season's leaves and fruitlets (diameter >4 mm) were counted. Canopy leaf abscission was calculated as the percentage of previous season's leaves on the tagged branch relative to the maximum number recorded at the beginning of the observation period. Fruit set at a given point in time was calculated as the number of fruits on a branch relative to the highest number of fruit counted on the branch during the observation period. The growth of each new leaf on the shoots of the tagged branches was determined by monitoring the increase in their blade maximum width (w) and maximum length (l) using a ruler (accuracy = 1 mm). The leaf area (a) was estimated using the formula, $a = \pi \cdot w \cdot l / 4$. Total leaf area of a shoot was estimated as the sum of the area of its individual leaves. Shoot leaf growth was calculated

as the percentage of the maximum total leaf area recorded when all the leaves on a shoot have reached full expansion.

Leaf net photosynthetic rate. The leaf net photosynthetic rate (P_n) was measured using a Li-Cor 6200 Photosynthesis System in the field under light saturated conditions ($>900 \mu\text{mol m}^{-2} \text{s}^{-1}$). Four to five of the previous season's leaves on each tagged shoot were measured. To determine the relationship between leaf age and P_n , five trees were selected and the third or fourth flush leaves of each tree were used. The measured P_n -age relationship curve was fitted with a quadratic equation to estimate P_n of individual leaves on each shoot monitored for its leaf age and growth. The total net CO_2 assimilated by a new shoot was estimated by multiplying the estimated P_n of each leaf on a shoot by its leaf area and then adding the products together. The canopy new shoot net CO_2 assimilation capacity was then estimated as the percentage of the maximum total net CO_2 assimilation calculated for a shoot when its leaves reached a certain age during the growing season.

Results and discussion

Our observations indicate that about 65 days were needed for all leaves, which emerged from a leaf bud of 'Hass' avocado to reach full expansion after budbreak. Flushing began in late March and lasted until early June (Fig. 1A). About 35 - 40 days were needed for a single leaf to reach full expansion (data not shown), This is approximately one week longer than the reported growth of leaves of other avocado varieties grown in other regions (Whiley, 1990; Schaffer et al., 1991). A 'Hass' bud developed 9 - 11 leaves. The tenth leaf did not emerge until approximately 25 days after the emergence of the first leaf (data not shown). By the time all the new leaves were fully expanded, about 60% of the previous season's leaves had abscised (Fig. 1A).

After the new leaves had reached full expansion, photosynthetic capacity continued to increase. New leaves attain a positive P_n approximately 17 days after emergence and attain maximum P_n approximately 50 days after emergence. This corresponds to the time when the leaf color has developed to dark green. Leaf nitrogen also increases during this period (data not shown). Our data indicate that the canopy does not attain an overall maximum CO_2 assimilation by newly emerged leaves until early summer (mid June). This is approximately 20 days after the new leaves are fully expanded (Fig. 1A and B). When the new leaves reached their maximum CO_2 production, the P_n of the previous season's leaves had decreased to about 50% of the maximum recorded values (Fig. 1B). The P_n decrease combined with abscission of the previous season's leaves (about 80%) by that time (Fig. 1A and B), resulted in a 90% decrease in carbon production from the previous season's leaves. By the beginning of summer, avocado canopy carbohydrate production came mainly from the leaves from the spring flush. Approximately 25 days after spring budbreak (when newly emerged leaves were approximately 20% of full expansion), the new leaves within the canopy had attained a net positive P_n and, therefore, possibly contributed to tree carbohydrate demand. Before this time, the overall CO_2 assimilation of new leaves was negative or near zero, indicating that new leaf growth depended on carbon supply from either stored carbohydrates or from the current CO_2 assimilation of old leaves (Fig. 1B).

Fruit set began in late April and peaked at the same time as the new leaves had attained a positive P_n (Fig. 1A - C). During this period, the P_n of the previous season's leaves did not change (Fig. 1B) and any losses in canopy carbon production were the result of abscission of the previous season's leaves (40% abscission) (Fig. 1A). This suggests that old leaves are still an energy source and play a major role in supplying carbon to the tree. Later, after fruit set peaked, and even though the whole canopy new leaf photosynthetic capacity in-

creased, the shoot fruit number decreased by 80%. This coincided with the shoot vegetative flush (Fig. 1A - C). After all new leaves reached full expansion; fruit abscission ceased (Fig. 1A and C). Poor fruit retention during the rapid leaf growth period may be related to the competition for limited tree resources between fruit growth and new shoot growth (Whiley et al., 1988).

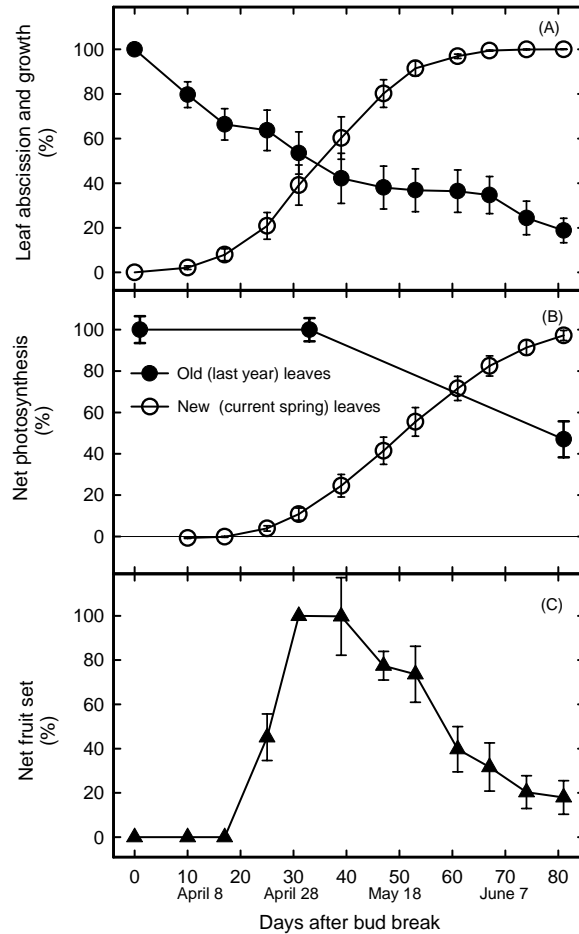


Figure 1. (A) Seasonal patterns of “Hass’ avocado canopy new (current spring) leaf growth and old (last year) leaf abscission as the percentage (%) of the maximum total new leaf area. (B) New and old leaf light saturated net photosynthetic efficiency as a percentage (%) of the maximum total light saturated for new and old leaves. (C) Canopy net fruit set as a percentage (%) of the maximum fruit number recorded.

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