Enhancement of Avocado Productivity. II. Tree Phenology, Carbohydrate Cycling and Canopy Management

Continuing Project; Year 4 of 5 (of Revision)

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Benefit to the Industry

This project will supply the avocado industry with information regarding the growth and flowering behavior of the 'Hass' avocado under California conditions. Development of a phenology model for avocado will greatly enhance a grower's ability to plan management practices in relation to the events occurring within the tree and external to the tree such as temperature. Knowledge of the time of root and shoot growth, flowering and fruit set, and the relationships between these events and carbohydrate status within the tree will aid the grower in deciding the optimum time to undertake such cultural treatments as nutritional and root health treatments. It is also possible that an understanding of the carbohydrate status of 'Hass' avocado trees during successive seasons will lead to a better understanding of alternate bearing. We are committed to making the data from this project available to the industry in a timely manner. Data collected from this project will be available through the avocado home page (www.ucavo.ucr.edu) and other appropriate means.

Project Objectives:

A. To collect information on root and shoot growth, flowering and fruit set, yield, and carbohydrate partitioning for 'Hass' trees on selected clonal rootstocks at the University of California (UC) South Coast Research and Extension Center (REC) in Irvine, CA. This information will be correlated with meteorological data collected at this site (air, soil temperature, irradiation and relative humidity).
B. To establish additional research sites throughout the California avocado industry to collect data pertaining to shoot and root growth, flowering, yield, and carbohydrate cycling. Meteorological data will also be collected and correlated to the timing of phenological events as in objective A.
C. To collect comparative data on 'Lamb Hass' as compared to 'Hass' on Duke 7 in relation to phenological events and carbohydrate cycling at the UC South Coast REC.
D. To collect comparative data on stumped (rejuvenated) 'Hass' trees as compared to non-stumped 'Hass' trees on Toro Canyon in relation to phenological events and carbohydrate cycling at the UC South Coast REC. *(Data collection for this objective completed in 1999.)*
E. To establish a girdling project in a commercial grove and to follow fruit yield, size, and other tree characteristics over multiple years. *(Data collection for this objective completed in 2000.)*
F. To establish a program to examine the relationship of canopy management (light distribution and microclimate effects within an avocado tree) to long term effects on productivity.

Summary

We have divided the highlights of our activities for the last year into four sections.

A. Phenology of 'Hass' avocado on four rootstocks at South Coast Research and Extension Center (SCREC).

The data collected at SCREC between 1992 and 1996 has been analyzed and prepared up for publication in the Journal of the American Society for Horticultural Science. Figure 1 summarizes our findings, and will appear in the paper. A summary of the findings follows.

Mature 'Hass' avocado (*Persea americana* Mill.) trees on four rootstocks (Thomas, Topa Topa, Duke 7, or D9) were monitored from 1992 to 1996 to determine the relative timing of shoot and root growth, and bloom, as well as the relationships between these variables and yield in southern California. Trees exhibited typical alternate bearing patterns with heavy and light crop loads ("on" and "off" years, respectively) alternating from year to year. Shoot growth occurred during two distinct flushes each year, one in spring and one in late summer. Although yield varied among rootstocks, neither the rate of shoot growth during flushes nor the total cumulative shoot growth over a season differed among rootstocks. However, cumulative shoot growth was 35 times higher in 1993, when yield was almost nil, as compared to other years. The spring growth flush accounted for the majority of total shoot growth in most years; however, the summer growth flush accounted for more of the total shoot growth during 1993. Root growth did not exhibit dormant periods as shoot growth did, but in general, root growth was greatest when shoots were not actively growing. Crop load did not appear to affect root growth patterns or intensity. Bloom occurred each year from mid-March to mid-May. Bloom did not differ among rootstocks; however, bloom in "on" years occurred earlier and for a longer period than the bloom in "off" years. Shoot starch concentrations exhibited greater fluctuations during the year than trunk starch concentrations and were highest immediately before the spring shoot flush began. This information gives us insight into the relative timing of and relationships between growth events of avocado in southern California and will help growers determine the optimal timing of cultural practices.

B. Phenology of 'Hass' avocado on Duke 7 rootstock at various locations in California.

We are in the final year of a four-year study to examine the phenology of growth in 'Hass' avocado growing in various parts of California. Our data collection is scheduled to end in December of this year (apart from yield, which will be collected in 2002). It will take several weeks to enter and organize the growth data, as well as processing the remaining samples for carbohydrate and nutrient analyses. After that, the data will be analyzed and the project will be written up for publication in a refereed horticultural journal, as well as other appropriate grower-related publications. We hope to have this final phase of the project completed by the middle of 2002.

C. Effect of environmental conditions and cultural practices on avocado leaf photosynthesis.

In cooperation with Robert Heath at UC Riverside, we are examining the effects of various environmental conditions and cultural practices on avocado leaf photosynthesis with the goal of increasing yields through extending the diurnal period of optimal photosynthesis in avocado. We are working toward establishing specific thresholds at which photosynthesis is inhibited so that management decisions can be made with this information in mind. Recent work in the growth chamber suggests that high temperatures may be a more limiting factor than relative humidity in lowering stomatal conductance. This work is preliminary and much more work will need to be done before the relationship between relative humidity, temperature, and photosynthesis in avocado leaves is understood. We will be examining (during the 2002 growing season) the effects of evaportative cooling on avocado leaf photosynthesis with the goal of determining if this cultural practice can extend the period of optimal photosynthesis and, in turn, increase yields.

D. Avocado leaf surface morphology.

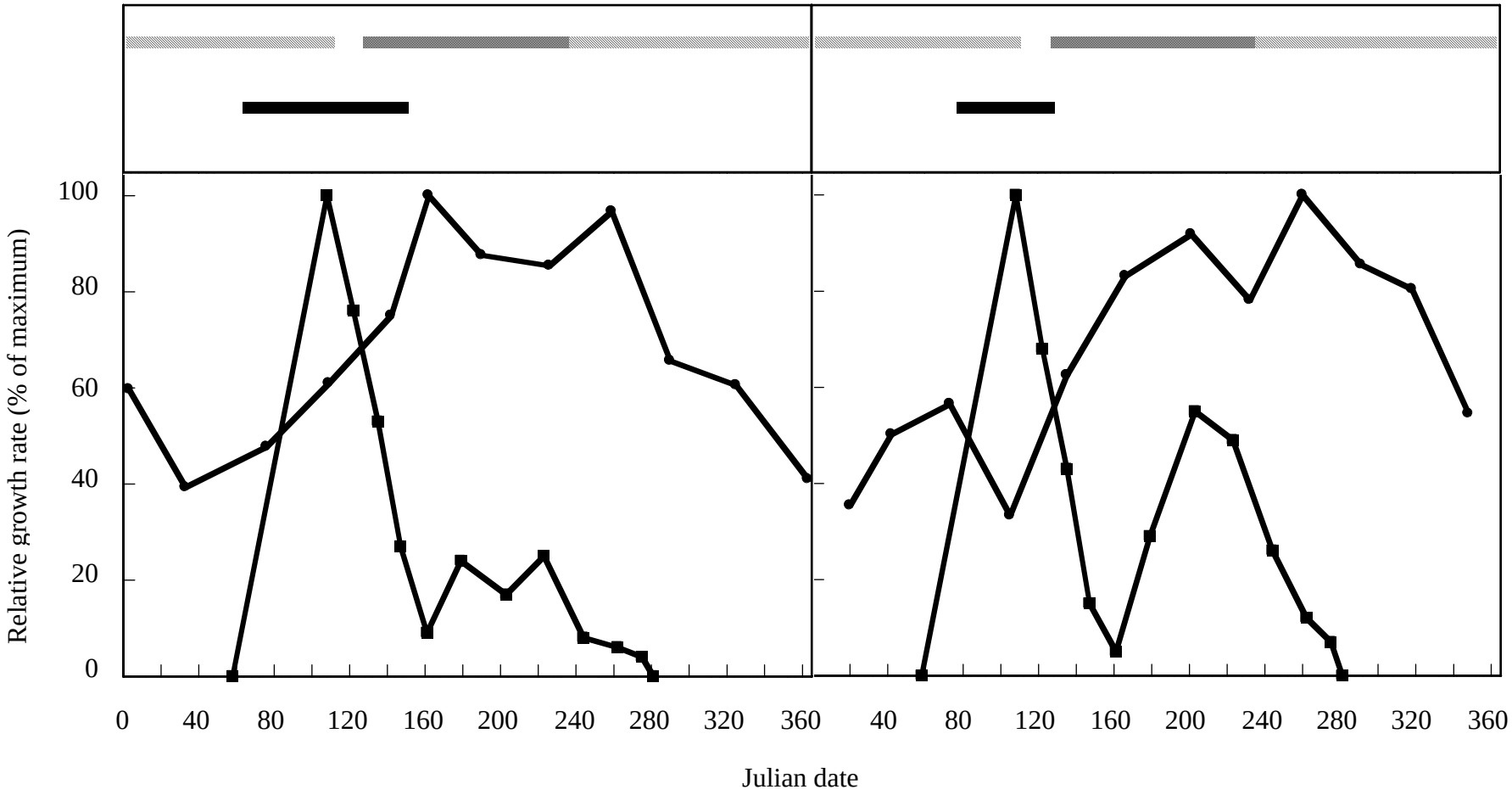
Through our collaborative efforts with Dr. Heath, we are interested in understanding the relationship between the environment and leaf gas-exchange in avocado. Ultimately, we are interested in prolonging the daily period of maximum gas-exchange between the avocado leaf and the environment in an effort to increase total carbon fixation. This, in turn, will hopefully lead to decreased flower and fruit drop, and larger, more consistent yields. Part of

deciphering the relationship between leaf gas-exchange and the environment is to examine the basic structural properties of the avocado leaf to determine how those properties might affect the physiology of the leaf. Relatively little work has been done on anatomy and surface characteristics of avocado leaves. We used scanning electron microscopy to determine the basic surface characteristics of avocado leaves and to examine any differences in these characteristics between leaf ages and among varieties.

There are clearly differences in the surface topology and the wax structure of the various avocado varieties examined. Figure 2 shows representative micrographs of the abaxial surface of recently matured leaves (from the spring flush) of several avocado varieties. 'Hass' leaves appear to have a very smooth abaxial surface compared to the other varieties, which often have noticeable depressions around individual epidermal and guard cells. 'Pinkerton' and 'Lamb Hass' leaves have trichomes on the abaxial leaf surface, while trichomes were fewer on 'Hass' and 'Gwen' leaves and were not observed on leaves of 'Fuerte'. We have not characterized any differences in wax load or chemistry among the observed varieties, but visual observations indicate that they may in fact be different Differences in wax load or structure may partially explain differences in gas exchange observed in different varieties (Liu et al., 2000).

We also observed differences in the amount of stomatal wax accumulation between leaves of consecutive flushes. Wax accumulation tends to be greater in stomata of older than in recently matured leaves. This may explain the observed decrease in avocado leaf stomatal conductance with time (Shaffer et al., 1991). We have observed differences in gas-exchange between leaves from consecutive flushes measured at the same time (Heath lab, unpublished data). One potential reason for these differences might be differences in wax characteristics of the abaxial surface or wax accumulation in the stomatal cavity. Stomatal opening in response to light appears to be slower in older avocado leaves than in younger leaves (Heath lab, unpublished results). This may also be partially explained by the fact that older leaves are accumulating wax deposits in the stomatal cavity. This may not be the case for all varieties, however, since some varieties, such as the unreleased variety, 'OA184', do not seem to accumulate more wax in the stomatal cavity with age.

Figure 1. Graphical model of relative timing of phenological events of ‘Hass’ avocado in southern California. Relative shoot (■) and root (●) growth, bloom (hatched line), and fruit growth (solid line = period of maximum growth increase, hatched line = continued growth period) in “on” (A) and “off” years (B) for ‘Hass’ on four clonal rootstocks. Shoot and root growth is expressed as the percent of the maximum growth rate observed. Fruit growth is for ‘Hass’ on Duke 7 rootstock only.



igure 2. Abaxial surface (200x magnification) of recently-matured ‘Hass’ (A), ‘Lamb Hass’ (B), ‘Fuerte’ (C), ‘Gwen’ (D), and ‘Pinkerton’ (E) leaves from mature trees growing in Riverside, California.