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DEVELOPMENT OF A PHENOLOGICAL MODEL FOR CALIFORNIA 'HASS' AVOCADO

M. L. Arpaia, P. W. Robinson, X. Liu, M. V. Mickelbart and G. W. Witney
Department of Botany and Plant Sciences,
University of California, Riverside

Development of a phenology model for avocados could greatly enhance a grower's ability to plan management practices in relation to the events occurring within the tree. Knowledge of the time of root and shoot growth, flowering and fruit set, and the relationships between these events will allow for application of irrigation, fertilization, and other cultural practices at optimum times. While a model has been proposed (Whiley et al., 1988; Whiley and Wolstenholme, 1990), it is based on Queensland, Australia and South African environmental conditions. The growing conditions in these humid semi-tropical areas are characterized by wet summers and relatively dry winters. This is the opposite of the Mediterranean climate of California which is characterized by wet winters and dry hot summers. Furthermore, the model was developed using trees on seedling rootstocks. Clonal rootstocks are used in California orchards because of their resistance to *Phytophthora cinnamomi* and may affect the phenology of the tree by influencing scion behavior. We currently have underway a long-term project to develop such a phenological model for the 'Hass' avocado in California. Planning for the project began in December 1991, and the field trial was installed in Spring 1992 at the UC South Coast Research and Extension Center in Irvine, California.

Our first objective is to determine the relationships between root and shoot growth, flowering, fruit set and yield in the 'Hass' avocado. Secondly we will determine the effects of environmental conditions such as temperature and precipitation on the phenology of 'Hass' avocado. The trees in this study are part of a larger rootstock trial which was planted in 1986 (Duke 7, D9 and Topa Topa rootstocks) and 1987 (Thomas) at the University of California South Coast Research and Extension Center in Irvine, CA. The following measurements and observations are collected:

Measurements	*Frequency*
Vegetative growth	Bi-weekly
Root growth	Bi-weekly
Yield	Annually
Canopy volume	Annually
Leaf nutrient analysis	Annually

Shoot growth are monitored on 5 trees of each rootstock. Twenty branches on the

Northeastern quadrant of the tree are tagged each spring and followed throughout the growing season. Root growth, yield, canopy volume and fruit size are monitored on 10 trees of each rootstock.

Flowering. Bloom occurred from late February to mid-May in 1992, 1993 and 1995. There was a pronounced early bloom period in 1994 which began in late December 1993 and extended into early March. This bloom period was characterized by scattered inflorescences in each tree. A more typical bloom period, similar to previous years, was observed from early March through mid-May (Figure 1). While the length of the bloom period did not differ between 1992, 1993 and 1995, the overall intensity of bloom was reduced in 1993. Avocados are known to alternate bear. During the 1992-93 growing season the trees had a heavy crop load which probably contributed to the reduced bloom intensity observed in spring 1993. Rootstock did not affect the timing or intensity of flowering.

Avocado floral buds may be mixed giving rise to an indeterminate floral shoot (shoot terminating with a vegetative meristem), or not mixed which produces a determinate floral shoot (floral shoot terminating with a flower) (Schroeder, 1944). In April 1994, 40 random branches per quadrant per tree were selected and categorized as either bearing indeterminate or determinate floral shoots. The southern half of the tree had significantly fewer determinate branches (36.7%) than the northern half (55.1%). There were no differences due to rootstock.

Shoot Growth. Vegetative flushes occurred in April (following bloom) and July in all years (Figure 1). The spring growth flush appears to precede increases in root growth. The rate of vegetative growth in 1993 was 10 times greater than in 1992, presumably due to the low crop load on the trees in 1993. Shoot growth in 1994 and 1995 followed the same pattern as observed in 1992; vegetative growth is reduced with a heavy crop load on the tree. A similar pattern was observed in 1995(we will harvest a moderate crop in April 1996). Rootstock does not affect the timing or intensity of shoot growth in any year.

Avocados are known to grow vegetatively in a rhythmic fashion (Thorp, 1992). The trees also produce both proleptic and sylleptic shoots. In December 1993 we examined all monitored shoots of the Duke 7 trees. Fifty-six point four percent (56.4%) of the axillary growth observed was due to proleptic growth. There was also no significant difference between the two types of shoots with relation to average shoot length. An analysis of the timing of shoot initiation did not reveal any difference in the timing of shoot initiation between sylleptic and proleptic shoots. These measurements were repeated in December 1994 and 1995. Less than 5% of the shoots sampled were sylleptic in these years suggesting that tree physiology is influenced by crop load.

Root Growth. In 1992, there were no differences in root growth related to rootstock. In 1993, however, the Topa Topa rootstock produced more roots throughout the growing season. This trend extended throughout the 1994 growing season. This increase in root growth does not appear to be related to other growth parameters. Root growth ceased in December of 1992 and resumed in March of 1993 (Figure 1). Root growth did not cease in the winter of 1993 -1994, 1994 - 1995, or 1995 - 1996 but continued at a reduced rate. The break in root growth in 1992 - 1993 can be attributed to the unusually heavy crop load on the data trees.

Preliminary carbohydrate analysis. Our preliminary data on starch and total soluble sugar cycling is shown in Figure 2. There is a suggestion from the preliminary data that the seasonal fluctuation in leaf starch and total soluble sugars is in synchrony (Figure 2a). In the shoot material, however, starch and total soluble sugars changes follow a pattern that suggests cyclical interconversion (Figure 2b). The peak in total soluble sugars in December occurs most likely due to a cessation of vegetative growth in late fall. The trees, however, continue to photosynthesize and accumulate the products of photosynthesis. The rise in starch in February and March reflect the quiescent state of the tree, prior to peak flowering and vegetative growth. Contrary to previous reports (Whiley and Wolstenholme, 1990) our data does not show dramatic seasonal fluctuations in trunk starch or total soluble sugars (Figure 2c). The fine feeder roots have very low levels of starch throughout the year and there is little evidence of dramatic cycling of the soluble sugars (Figure 2d).

The data in Figure 2 strongly suggests that total soluble sugars play an important role in carbohydrate partitioning in avocados. Amongst the soluble sugars, we have found in avocado tissue, D-mannoheptulose and the polyol, perseitol, are found in relatively high proportion compared to the common sugars, fructose, glucose and sucrose. We have also begun to monitor changes in these sugars in developing fruit.

While other avocado phenology models have been developed, none have been specific to the 'Hass' variety in California. An understanding of tree growth as affected by clonal rootstock and climatic conditions is desirable since this variety accounts for 90% of the total California production. A phenology model will provide a basis for future research on cultural practices as well as tree physiology. The timing and quantity of such things as irrigation, fertilization, and pesticides for optimal efficacy can then be determined. This phenology model will also provide us a better understanding of the effects of alternate bearing on tree phenology. Methods to control this serious problem might then be derived.

References

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Figure 1. Vegetative and root growth cycles of 'Hass' avocado at the South Coast Research and Extension Center.

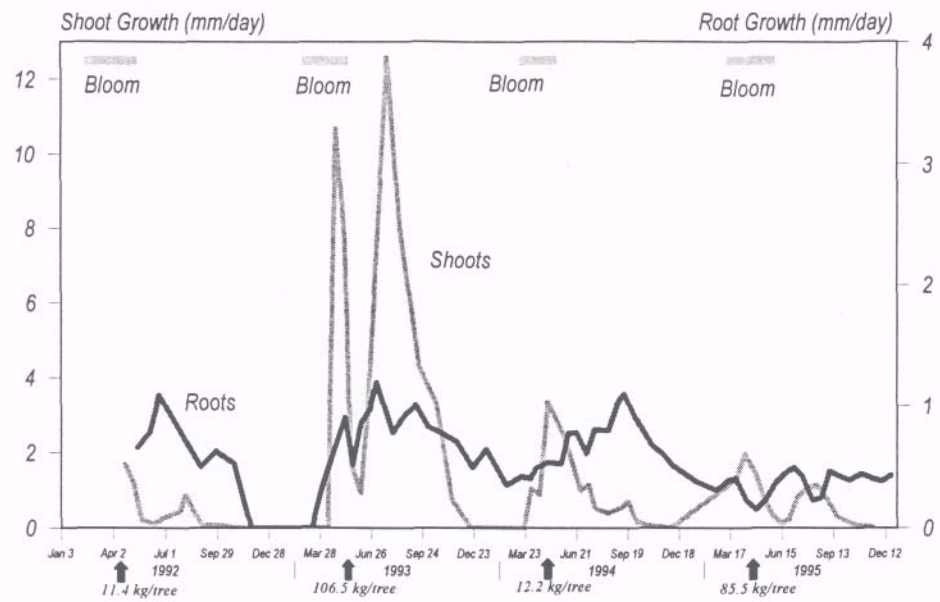

Figure 2. Seasonal starch and total soluble sugar patterns $(mg\,g^{-1})$