

**Breeding, Varieties & Genetics**

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**Enhancement of Avocado Productivity. Plant Improvement:  
Selection and Evaluation of Improved Varieties and Rootstocks**

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A formal avocado variety breeding program has existed at the University of California for several decades. The first controlled selections were made in 1937 by J. W. Lesley at UC Riverside, and in 1939 by W.E. Lammerts at UCLA (Lammerts, 1943). Dr. Art Schroeder, was also active in the selection of promising material in the 1930's and 1940's and participated in several plant exploration trips to Central America. In the 1950's the UC hired Dr. Royce Bringham (UCLA) to develop new avocado varieties. He was followed after a short tenure by Dr. Bob Bergh (UC, Riverside) in 1956 who worked on the development of new varieties until his retirement in the early 1990's. Gray Martin, carried on Dr. Bergh's work upon his retirement and was supervised by Dr. Guy Witney briefly from 1994 through 1996. Dr. Mary Lu Arpaia assumed full responsibility for the program in 1997. She has been assisted by Mr. David Stottlemyer (1996 – 2006) and by Mr. Eric Focht (2005 –present).

Dr. Bergh outlined the general breeding objectives for the California industry (Bergh, 1976; Table 1). With these objectives in mind, we have continued our program to search for improved varieties. The goal of the current program is to produce new avocado varieties, superior to 'Hass' in consistent production and fruit size. These new selections also must have postharvest fruit quality equal or better than Hass: uniform fruit ripening, sensitivity to chilling injury and most importantly eating quality. Although it would be ideal to identify new varieties that have long harvest seasons, we will not necessarily eliminate promising material that have a more limited on-tree storage life or maturity season as compared to Hass. We believe that it is imperative that the California industry have an array of varieties to grow throughout the commercial season. Past history in other agronomic crops has clearly highlighted the dangers of single variety industries in terms of pest and disease outbreaks.

This project aims to help maintain and enhance the California avocado industry by introducing consistently heavier producing, high-quality avocado varieties, better pollinizer varieties, and to test improved rootstock hybrids. The goals of this project will be achieved through continued evaluation of new material generated through traditional selection techniques, collaboration with Dr. Clegg, Dr. Raymond Schnell and others as they develop refined techniques to increase the efficiency of selection and introduction of new material from other breeding and selection programs. Increasing the genetic diversity of varieties cultivated in California will decrease the risk of major pest and disease invasions on a susceptible monoculture. During the last year our activities have focused in the general areas described below.

**1. Development of new varieties**

We have taken 2 approaches towards generating new material for the California industry. These strategies are the outcome of discussions with B. O. Bergh, U. Lavi (Avocado breeder, retired, Volcani Institute, Israel), J. Chaparro (Univ. of Florida, Gainesville) and A. W. Whiley (Australia). We have

continued to implement many of the suggestions offered by Drs. Chaparro and Lavi following their 2005 breeding program audit to streamline the breeding program and increase efficiencies.

The first approach, suggested by U. Lavi, is to plant out seedlings from interesting maternal sources; this is done without any effort to control paternity. Since 2000 we have planted approximately 2,500 seedlings at UC South Coast REC from “open-pollinated” sources. In the second approach we took the more traditional strategy of Dr. Bergh by establishing isolation plots in various locations. The potential parents were selected under consultation with Dr. Bergh. Table 2 lists the location, year established and selections in each isolation block. During the current funding year, following harvesting of fruit from the Ventura County isolation blocks, the trees were removed to make way for planting of other commodities by the landowner. We will therefore carry forward only with the UC Isolation Blocks in the upcoming year. A total of 1738 seedlings have been thus far planted out from the isolation blocks. We will have a carryover of approximately 700 seedlings to be planted in the field in Spring 2010 from the 2009 seed collection effort from both strategies.

**Table 1.** Avocado breeding objectives (Based on Bergh, 1976).

| <b>Fruit quality</b>                |                               |
|-------------------------------------|-------------------------------|
| <b>Size and shape</b>               | <b>Pulp characteristics</b>   |
| Medium size                         | Proper softening              |
| Thick ovate shape                   | Appetizing color              |
| Fruit uniform in size and shape     | Absence of fibers             |
| <b>Peel characteristics</b>         | Pleasing flavor               |
| Medium thickness                    | Long shelf life               |
| Readily peelable                    | Slow oxidation                |
| Insect and disease resistant        | Chilling tolerance            |
| Blemish free                        | High oil content              |
| Attractive color                    | High nutritional value        |
| <b>Seed characteristics</b>         |                               |
| Small                               |                               |
| Tight in its cavity                 |                               |
| <b>Tree characteristics</b>         |                               |
| Upright to slightly spreading habit | Tolerant of chlorosis         |
| Easy to propagate                   | Tolerant of other stresses    |
| Strong grower                       | Short fruit maturation period |
| Tolerant of pests and diseases      | Precocious                    |
| Tolerant of wind                    | Regular bearing               |
| Tolerant of cold                    | Wide adaptability             |
| Tolerant of heat                    | Heavy bearer                  |
| Tolerant of salinity                | Long tree storage             |

**Table 2.** Isolation blocks established in 1999 – 2001. The isolation blocks at Nakamura in Ventura Co. were removed following harvesting of fruit in Winter 2009.

| <b>Parents</b> | <b>Year established</b> | <b>Location</b>       |
|----------------|-------------------------|-----------------------|
| GEM x Marvel   | 1999 (topwork)          | UC, Riverside         |
| GEM x Thille   | 1999 (topwork)          | UC, Riverside         |
| Gwen x Gwen    | 2001 (clonal tree)      | Nakamura, Ventura Co. |
| Lamb x GEM     | 2001 (clonal tree)      | Nakamura, Ventura Co. |
| Lamb x Nobel   | 2001 (clonal tree)      | Nakamura, Ventura Co. |
| Lamb x Thille  | 2001 (clonal tree)      | Nakamura, Ventura Co. |
| Lamb x Reed    | 2001 (clonal tree)      | Nakamura, Ventura Co. |
| Stewart x Reed | 2001 (clonal tree)      | Nakamura, Ventura Co. |

Each fall we do a fruit estimate on all seedling trees planted at UC South Coast REC. If multiple fruit are available, the fruit from the seedling are sampled several times over the year. When only a few fruit

are available then the trees are sampled only once during the season, generally in the Spring. When we sample fruit from the field we collect data pertaining to fruit shape, weight and other general characteristics as well as dry weight (coring method) and ripe characteristics including flavor. Fruit that appear interesting are photographed and are entered into a database. During the current funding cycle, we selected an additional 3 seedlings for further evaluation. This makes for a total of 19 selections from seedlings planted since 2000. Trees of these selections are propagated for further evaluation at UC South Coast REC. (Additional information on these selections are available upon request and were shared with the PRC Genetics Subcommittee when they visited the UC South Coast REC in June 2009.)

We collected approximately 1289 seeds from the UCR and Nakamura Isolation plots during 2009. Additionally 300 seeds were collected from targeted maternal parents. These seeds are in the process of being germinated for field planting in 2010 and early 2011 and will be planted out most likely in Field 45 at UC South Coast REC. In order to find room for our continued plantings, we have removed several rows of older material that has already been evaluated and re-propagated when appropriate.

In 2009 we began the removal of rows 71-74 in field 46 as these have been in the ground for an average of 6 years (33.47% of trees in these rows have been evaluated). 2009 was the last year for evaluation of trees in rows 75-81 in field 46 (20.1% of trees in these rows have been evaluated). Conditions in the extreme north of this field should be contrasted to more favorable conditions in rows 19-40 of field 44 where after 2 years of fruit data collected (2009) we have already evaluated 43.1% of the trees. In the future we do not plan to use the poor and unproductive rows of field 46. Instead, we have consulted with the UC South Coast REC management to begin using a more productive section in the southernmost portion of field 45.

We have continued to convert Field 4 into our maternal seed block. Currently we have left roughly half of the older trees in combination with a mix of replanting and topworking of different germplasm into the field. We plan to remove all older trees overtime as we revamp this field to be the maternal seed source block for the scion breeding program. Seedling selections are either topworked onto Duke 7 rootstock *in situ* or have been planted as grafted nursery trees. Our intention is to focus on topworking rather than nursery trees for 2<sup>nd</sup> stage selections in subsequent years.

## **2. Collaboration with Dr. R. Schnell – Mapping Population.**

During this last year we initiated a collaborative project with Dr. Raymond Schnell of USDA in Miami Florida. We collected ‘Bacon’ and ‘Hass’ seed from a planting in Ventura county that Dr. Schnell collected seed from in 2008. The seed have been germinated and we are in the process of determining parentage of the seedlings. The seedlings will be planted in Spring 2010 as part of a mapping project with Dr. Schnell.

## **3. Overseas cooperation.**

We have answered several questions regarding exchange of material with potential overseas cooperators and are coordinating these activities with the Office of Technology Commercialization at UC Riverside.

## **4. Introduction of new plant material.**

We continue to evaluate material introduced into the variety block in recent years.

## **5. Sunblotch Indexing**

We continue to test material within the program for Sunblotch with the assistance of Dr. Deb Mathews. Leaf samples are collected routinely from fields 4, 44, and 46 at UC South Coast REC. In 2005 we began to institute a more aggressive policy to contain sunblotch; we now remove the negative or untested trees adjacent to a positive tree.

## **6. Maintenance of the CAS Germplasm Plot and Persea species collection at UC South Coast REC**

We have slowly revitalized the CAS germplasm plot and conducted sunblotch testing of interesting material. New selections have been added when possible. Budwood of non-protected material is distributed when requested. We also continue to make selections in our heritage collection available to nurseries upon request. We continue to maintain a small species collection at UC South Coast REC that was planted by Dr. Rainer Scora in the late 1980's and early 1990's. We provided Dr. Jorge Pena from the University of Florida bolts of selected species for screening for resistance/susceptibility to the Ambrosia Beetle. We are awaiting results.

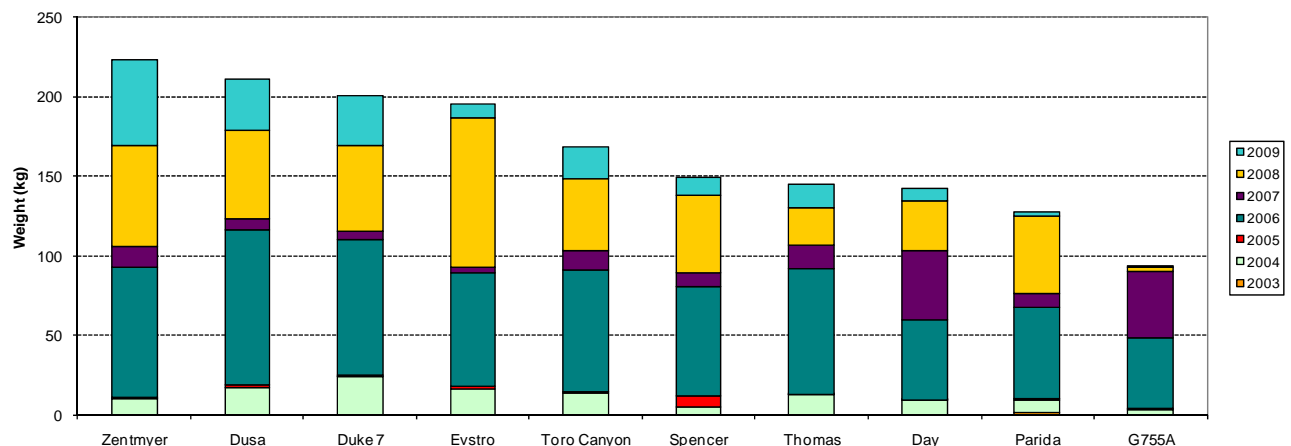
### 7. Rootstock and pollinizer evaluation

We have conducted a number of rootstock trials at UC South Coast REC. These trials are planted out under low root rot pressure in order to evaluate the productivity of 'Hass' as influenced by rootstock. In 1999 we established a new rootstock trial at UC South Coast REC. This trial includes both 'Hass' and 'Lamb Hass' on several interesting rootstocks from the Menge program (Day\*, Duke 7\*, Dusa, Evstro\*, G755A, Parida, Spencer, Thomas\*, Toro Canyon\*, and Zentmyer; \* = 'Lamb Hass'). We also have 1 row of 'Carmen Mendez' on Toro Canyon for evaluation of that variety.

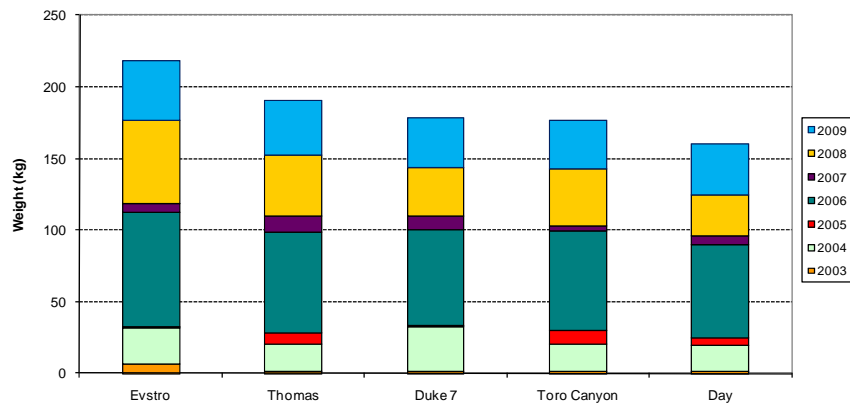
The yield data has been summarized and is presented in Figures 1 – 3. Figure 1 reports the yield for the 'Hass' portion of the trial. In terms of cumulative yield, the top 4 highest yielding rootstocks (Zentmyer, Dusa, Duke 7 and Evstro) are not statistically different from each other. There are small but significant differences in average 'Hass' fruit size due to rootstock. The largest fruit have been from the Zentmyer and Thomas rootstocks.

The 'Lamb Hass' dataset is similar (Figure 2) with the Evstro rootstock producing the highest yield. The Thomas is the second most productive rootstocks for the 'Lamb Hass' (not statistically different from Evstro); quite different from the 'Hass' portion of the trial where the yield on Thomas is mediocre. The largest fruit, looking at average cumulative fruit size, has been with the Evstro and Day rootstocks.

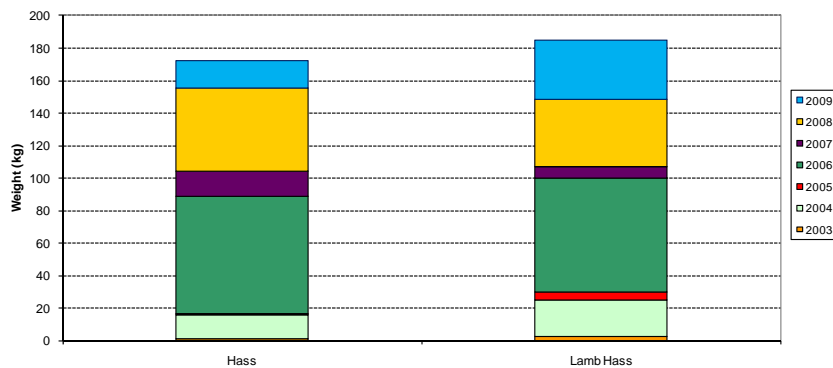
When comparing yield of 'Hass' and 'Lamb Hass' on the same rootstocks the Evstro once again has significantly higher annual and cumulative yield followed by the Duke 7 rootstock. At this time there is no significant difference between 'Hass' and 'Lamb Hass' with respect to cumulative yield (Figure 3), although we have harvested significantly greater numbers of fruit from the 'Hass' due to the variety's smaller fruit size. There was no significant rootstock x scion interactions detected.



**Figure 1.** Cumulative yield by year for 'Hass' on several rootstocks. Plot at the UC South Coast Research and Extension Center in Irvine, CA. Trees planted in 1999.



**Figure 2.** Cumulative yield by year for 'Lamb Hass' on several rootstocks. Plot at the UC South Coast Research and Extension Center in Irvine, CA. Trees planted in 1999.



**Figure 3.** Cumulative yield by year for 'Hass' and 'Lamb Hass'. Comparison based on cultivars on the same rootstocks. Plot at the UC South Coast Research and Extension Center in Irvine, CA. Trees planted in 1999.

## 7. Outreach Activities

These can be summarized into 3 general areas:

1. **Web Site.** The web site continues to be updated and changed on a periodic basis. We have contracted with David Stottlemeyer to maintain and update the website as appropriate.
2. **Answered Email.** We have received and answered numerous email requests for information on avocados since November 1, 2008. These range from specific questions regarding avocado germplasm to questions from avocado enthusiasts worldwide.
3. **Site visits to UC South Coast REC.** We have hosted several visitors (domestic and international) who have expressed interest in the avocado scion breeding program. We have also participated in industry related tours whenever requested.
4. **Other Outreach Activities.** We have given several presentations of data collected from this trial, as requested. This has included several field tours as well as oral presentations to grower groups and visitors to the field station.

**Planned Activities for Remainder of Fiscal Year:**

1. Further propagation of varieties of interest from our new selections' seedlings. Promising selections will be topworked or grafted onto Duke 7 clonal rootstock.
2. Further collection of seed to provide a total of slightly more than 1000 seeds in 2010 for the new selections.

**Selected References** (*All references available at [www.avocadosource.com](http://www.avocadosource.com)*)

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