

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

Continuing Project: Year 6 of 20

Project Leader: Mary Lu Arpaia (559) 646-6561

e-mail: mary.arpaia@ucr.edu

Dept. of Botany and Plant Sciences, UC Riverside

Kearney Agricultural Center, 9240 S. Riverbend Ave., Parlier, CA 93648

*Cooperating Personnel: D. Stottlemyer, P. Robinson, W. Manor, K. Fjeld, J. Sievert,
UC South Coast Avocado Volunteers, R. Scora, J. Menge, D. Crowley, M. Clegg,
M. Hoddle, B. Faber and on-farm cooperators*

Benefit to the Industry

This project will help to maintain and enhance the California avocado industry by introducing consistently heavier producing, high-quality avocado varieties, better pollinizer varieties, and improved rootstock hybrids. Increasing the genetic diversity of varieties will decrease the risk of major pest and disease invasions on a susceptible monoculture.

Objectives

- A. To produce new avocado varieties, superior to 'Hass' in consistent productivity and postharvest fruit quality and marketability, with fruit of optimum maturity and size year-round. This includes determining the different cultural needs of each cultivar. Index trees for distribution for sunblotch viroid with assistance of Drs. Allan Dodds and Deb Mathews.
- B. To collaborate with other researchers worldwide in evaluating and exchanging promising plant material.
- C. To collaborate with Dr. Menge and Dr. Crowley on rootstock selection and evaluation for both root rot resistance and salinity tolerance.
- D. Evaluate the potential of new and established cultivars (B flower types) for use as pollinizers in collaboration with Dr. Ben Faber; assist Dr. Mike Clegg on coordination of pollinizer research plots as requested.
- E. To assist Drs. Morse and Hoddle on identifying plant material tolerant to *Persea* mite and the avocado thrips as requested.
- F. To maintain and improve the CAS variety block and the *Persea* germplasm block located at the UC South Coast Research and Extension Center.
- G. To insure the timely and effective dissemination of information developed from this research program.

Summary

A. To produce new avocado varieties, superior to ‘Hass’ in consistent productivity and postharvest fruit quality and marketability, with fruit of optimum maturity and size year-round.

There are 2 components of this objective. The first is the continued monitoring of varieties from the Dr. B. Bergh/Gray Martin selection program. The second component is the new phase of scion selection. Activities for both components are summarized below.

Component 1. Continued monitoring of Bergh/Martin selections

Various field trials have been established to monitor the performance of a number of the Bergh/Martin selections. The following is a list of the cooperator trials we are maintaining. In 2002 we installed data loggers to monitor air and soil temperature and relative humidity at all sites. We plan to use this data to help us assess the selection’s response to low/high temperature when these events occur.

There are also additional plantings of the Bergh/Martin selections scattered throughout southern California. We periodically visit these sites to evaluate trees and discuss tree performance with the cooperators.

Topworked trials at Non-UC Sites

Santa Paula (Ventura County); topworked in 1998; ‘GEM’, ‘Harvest’, ‘Sir Prize’, ‘RT5176’, ‘OA184’, ‘Marvel’, ‘Hass’; 10 replicates.

De Luz (San Diego County); topworked in 1998; ‘Lamb Hass’, ‘Sir Prize’, ‘GEM’, ‘OA184’, ‘Marvel’, ‘5-552’, ‘Nobel’, ‘Hass’, ‘Harvest’; 10 replicates.

De Luz (San Diego County); topworked in 1998; approximately 80 ‘GEM’ trees divided roughly into 3 groups at the cooperator site.

San Luis Obispo (San Luis Obispo County); topworked in 1998 (Trees suffered from freeze in 12/98 necessitating re-grafting of some selections in 1999; ‘RT5176’, ‘Hass’, ‘Sir Prize’, ‘GEM’, ‘Harvest’, ‘OA184’; 9 replicates.

Clonal trials at Non-UC Sites

Oxnard (Ventura County); planted in 1996; ‘Lamb Hass’, ‘Sir Prize’, ‘GEM’, ‘OA184’, ‘Marvel’, ‘Nobel’, ‘Hass’, ‘Harvest’. (This trial was flooded in 1997 and many trees died due to this, however we are now working with the current owners to collect data from the trees which survived after the winter of 1997)

HTH Ranch (Ventura County); ‘Lamb Hass’, ‘Marvel’, ‘GEM’ and ‘Hass’ A non-replicated trial used for dry weights and fruit evaluation only.

Topworked trees at UC, Riverside Campus – ongoing; Replacement trees in Field 10.

Topworked trees at UC, South Coast Research and Extension Center (SCREC); Field 4 at the Center has topworked trees (variable number of replicates) from which we collect data. These trees were topworked onto seedling rootstock trees in 1994 – 1996.

San Joaquin Valley Variety Trial – 1999 at two sites (Porterville, Lindcove) with clonal trees (Thomas rootstock); ‘Sir Prize’ ‘Lamb Hass’, ‘Harvest’, ‘GEM’, ‘Nobel’, ‘Marvel’, ‘Pinkerton’, ‘Fuerte’, and ‘Zutano’; 20 replicates per scion variety at each site. We had trouble with tree

establishment for certain varieties, therefore surviving tree numbers varies with site and variety. We have also had problems with certain varieties dropping fruit prior to harvest; however we do have 1 season's worth of dry matter testing and plan to collect further data this upcoming year.

Yield data from Bergh/Martin selections. We have collected yield data for the fifth year from Field 4 at UC-SCREC (UC South Coast Research and Extension Center). Data collection for 2003 shows that for most varieties, this was an 'on' year (Figure 1). The 'GEM' at this point has the largest cumulative yield over the five year period. Comparing the coefficient of variation shows that there is tendency toward less extreme alternate bearing in 'GEM' (Figure 2; this is calculated by dividing the standard deviation by the mean and gives one an idea of the relative variation of the data for a particular variety).

We have also collected the third year of yield data from the Oxnard and Santa Paula sites in Ventura County (Figures 3 and 4), the Righetti site near San Luis Obispo (Figure 5), and the De Luz site in San Diego County (Figure 6).

Fruit characteristics of Bergh/Martin selections. As an on-going process we are collecting fruit samples from all sites approximately every 4 to 5 weeks from winter through late fall. These fruit are evaluated using standard protocols for such characteristics as fruit shape, peel texture, peel color, flesh color, the percent seed, flesh and skin and skin thickness.

Seasonal dry matter content of Bergh/Martin selections. Figure 7 presents the trends in dry weight for all varieties at the UC-SCREC site for 2003. Similar trends were observed at the other 6 sampling sites (San Luis Obispo, Riverside, Santa Paula, Oxnard and De Luz). The general pattern for dry weight accumulations for each variety in 2003 is consistent with the 2000, 2001, and 2002 data presented last year. A comparison between dry weight accumulations between three maturity seasons for the 'GEM' variety is presented in Figure 8. This data is from the UC-SCREC site. All three seasons show the same general trends. The same can be seen for the 'Harvest' variety in Figure 9.

Bloom evaluation of Bergh/Martin selections. The bloom of spring 2003 was evaluated on the trees in the unreleased variety block at UC-SCREC. This is the second year of this type of data collection. Bloom was rated for intensity, and an estimate of the number of open flowers was made for each tree. This was done weekly throughout the bloom season. Figure 10 illustrates the relative timing of each variety over the 2 year period. Figures 11 and 12 show bloom intensity of the 'GEM' and 'Harvest' material as compared to 'Hass'. We observed in these first two years that 'Nobel' and 'Marvel' have somewhat earlier bloom timing as compared to 'Hass' (Figure 10). 'GEM' (Figure 11) is almost identical with 'Hass' and 'Harvest' (Figure 12) has a slightly later bloom period than 'Hass'.

Release of Bergh/Martin selections. The UC Office of Technology Transfer has obtained patents for two of the Bergh/Martin selections, 'GEM' (U.S. Plant Patent No. 14,239) and 'Harvest' (U.S. Plant Patent No. 14,238) effective October 14, 2003. The decision to move forward with patenting for these 2 selections differed for each. We believe that 'GEM' has

commercial potential for the California industry and wish to make this selection more widely available to growers. The ‘Harvest’, on the other hand, had been given by G. Martin to researchers in Spain, Israel and South Africa where there is interest in the variety from a commercial perspective. While we are not certain about the selection’s commercial potential for California, we were advised by UC-OTT to move ahead with patenting of the selection. The UC Office of Technology Transfer is currently working on patents in various foreign countries that are interested in this material.

Component 2. New Material for the Breeding Program

We are taking 2 approaches towards generating new material for the California industry. These approaches are the outcome of discussions with B. O. Bergh, U. Lavi (Avocado breeder, Volcani Institute, Israel) and A. W. Whiley (Australia). The first approach is to plant out seedlings from interesting maternal sources; this is done without any effort to control paternity. This approach was suggested by U. Lavi. In spring 2000, we planted the first 217 seedlings from mixed maternal sources to provide material for the “next generation” of avocado selections using this approach. An additional 237 seedlings were planted out in 2002. In 2003, 186 seedlings were planted out and changes were made to the greenhouse that would allow an expansion of the seedling germination program. As a result, over 1,000 seeds were collected in 2003 and are currently being transplanted into sleeves to be planted in the field in spring 2004. Table 1 shows the maternal parents of the current seedling population planted at UC-SCREC. Interestingly, we had 1 seedling flower and set fruit in 2001, only 1 year from planting. The maternal source of this fruit was ‘Nobel’ (BL667). Although the fruit quality is not acceptable (extremely large seed), these results are encouraging since we know that we have germplasm for the breeding program that is very precocious. Although there was some fruit set in 2002, most of the fruit was lost due to an irrigation problem that has since been resolved. In October 2003, Dr. Grant Thorp from HortResearch, New Zealand helped us to evaluate tree architecture of the oldest seedling population. Dr. Thorp is currently working with the dataset to help us define the “ideal” tree type. This will help us in the selection process as well in efforts to evaluate the performance of new selections on clonal rootstocks. In this process we identified one tree in the planting that has a sympodial growth habit which is not normally associated with avocado.

Table 1. Open pollinated seedlings from varying maternal sources planted at the UC South Coast Research and Extension Center from 2000 to 2003.

Year Planted	Maternal Source						Thille x GEM	Total Planted
	5-552	Marvel	Nobel	GEM	Gwen	Lamb		
2000	32	90	37	39	14	5		217
2002		75	51	91		20		237
2003		50	25	41	55		15	186
Totals	32	215	113	171	69	25	15	640

In the second approach we have taken the more traditional approach of Dr. Bergh by establishing isolation plots in various locations. Table 2 lists the location, year established and selections in each isolation block. The potential parents were selected under consultation with Dr. Bergh. The first seeds from an isolation block (GEM x Thille) at UCR were collected in 2002 and planted out this year (as indicated in Table 1 above: Thille x GEM). This year the isolation blocks produced 651 fruit which are currently being propagated for field planting in spring 2004.

Table 2. Isolation blocks established in 1999 – 2001.

Parents	Year established	Location
GEM x Marvel	1999 (topwork)	UC, Riverside
GEM x Thille	1999 (topwork)	UC, Riverside
Gwen x Sir Prize	2000 (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.

Sunblotch Viroid indexing. One hundred twenty-seven trees at the UC-SCREC were tested for the sunblotch viroid between October 1, 2002 and September 30, 2003. Of these trees, 13 tested positive for the Sunblotch Viroid and have been removed. All the positive trees were located in one area near the end of Field 46. Two trees at the Pine Tree variety trial tested positive for the sunblotch viroid. These trees have been scheduled to be removed. All the trees in field 4 at UC SCREC have been sampled and have tested negative for the sunblotch viroid.

B. To collaborate with other researchers worldwide in evaluating and exchanging promising plant material.

Introduction of new germplasm. In May 1999 D. Stottlemeyer, T. Chao and M. L. Arpaia visited Israel. One of our objectives was to visit with Dr. A. Ben-Ya'acov to review the status of the various rootstock selections, which he had made over the years. In May 1999 M. L. Arpaia brought material from 5 selections plus budwood of the 'Ardith' and the 'Galil'. The 'Ardith' is already in CA and is actually a selection from Dr. Bergh which has been commercialized in Israel. The purpose of this introduction was to confirm trait characteristics of the tree currently in the avocado variety collection at UC SCREC. M. L. Arpaia revisited Dr. Ben-Ya'acov in March 2000 and obtained additional material. Budwood from the 5 selections obtained in May 1999 was also once again acquired. The majority of this material is rootstock selections. Some of the material is known to be tolerant to root rot. This material will also be evaluated by Dr. John Menge's program. A number of the rootstocks, while having no known root rot tolerance, were selected based on Dr. Ben Ya'acov's recommendation due to salinity tolerance, poor drainage tolerance or other characteristics. We tested this material for the presence or absence of sunblotch when the material entered quarantine. Unfortunately, one selection, VC49 (introduced in 3/00), tested positive and was subsequently destroyed. The remaining material is currently in

quarantine at UC, Riverside and is scheduled to be released for propagation and subsequent testing during 2003 year. Table 3 lists the material brought to California in 1999 and 2000. These trees were released from quarantine in 2003 and in September 2003 we planted 2 trees of each variety in the Variety Collection at UC-SCREC. These trees will serve as budwood source trees for future evaluations.

Table 3. Material introduced into California from Israel in 1999 and 2000. Material is from the rootstock selection program of Dr. A. Ben Ya'acov and the scion selection program of Drs. E. Lahav and U. Lavi. The material obtained in 1999 was given to John Menge in June 1999.

VC#	Date of collection
6	April '00
7	April '00
15	April '00
26	April '00
28	April '00
31	April '00
40	June '99, April '00
49	June '99, April '00 (discarded due to sunblotch)
51	April '00
65	June '99, April '00
66	June '99, April '00
75	April '00
802	April '00
803	April '00
804	April '00
817	June '99, April '00
Ardith	June '99
Galil	June '99

C. To collaborate with Dr. Menge (Dept. of Plant Pathology, UCR), and Dr. Crowley on rootstock selection and evaluation for both root rot resistance and salinity tolerance.

As of July 2003 we discontinued the two clonal rootstock trials planted in 1986 and 1988 respectively. We planted a new clonal rootstock trial at UC SCREC with Dr. Menge in spring 1999 and collected a second year of yield data from this plot in spring 2003. The 'Hass' and the 'Lamb Hass' are included in this trial on selected clonal rootstocks ('Hass' on Day, Duke7, Dusa, Evstro, G755A, Parida, PP4, Spencer, Thomas, Toro Canyon; 20 replicates 'Lamb Hass' on Day, Duke 7, Evstro, Thomas, Toro Canyon; 20 replicates).

We continue to collaborate with Dr. Crowley in his salinity research and identified a research plot in Santa Barbara for testing of ‘Hass’ and ‘Lamb Hass’ on selected rootstocks from Dr. Menge’s program, South Africa and Israel.

D. Evaluate the potential of new and established cultivars (B flower types) for use as pollinizers in collaboration with Dr. Ben Faber; assist Dr. Mike Clegg on coordination of pollinizer research plots as requested.

In conjunction with Ben Faber we established a pollinizer site in Ventura County (Oxnard) in spring 1999. The varieties included in this trial are ‘Ettinger’, ‘Fuerte’, ‘Bacon’, ‘Zutano’, ‘Harvest’, ‘Sir Prize’, ‘Nobel’ and ‘Marvel’. There are 60 trees of each variety divided into 6 replicates of 10 trees each. We have reported the yield data from the trial each year. The data from the 2003 harvest is shown in Figure 13. This was an “off” year in the plot as shown by the fruit counts. The set in 2004 is very interesting since it is clear that fruit set is moderate to very high near the pollinizer trees but drops off quickly as the distance increases. The cumulative data for this trial is presented in Figure 14 and shows that there are distinct trends emerging from this trial. Most of the activities for this plot are being subsidized from a grant from the BARD. We have this project as a collaborative effort with Drs. Arnon Dag and Sharoni Shafir (Israel) and Dr. Tom Davenport (University of Florida).

We have continued our discussions with Dr. Clegg on ways to incorporate the B flower type selections into an organized research program to evaluate the value of outcrossing and which pollinizers to utilize and to discuss future directions for the breeding program. A boost to this effort came through the collaboration with Dr. Davenport who is working with Dr. Raymond Schnell (USDA-ARS, Miami, FL) on a more economical way to determine paternity. We assisted Dr. Davenport in October 2003 by collecting fruit samples from one of the replicates in the trial (48 samples of 20 fruit each). We are awaiting the results of their testing.

E. To assist Drs. Morse and Hoddle on identifying plant material tolerant to Persea mite and the avocado thrips.

We continue to discuss periodically with Dr. Hoddle the influence of tree phenology and variety on relative susceptibility to persea mite. We assisted Drs. Hoddle and Morse on their thrips studies in 2003.

F. To maintain and improve the CAS variety block and the *Persea* germplasm block located at the UC South Coast Research and Extension Center.

An accurate plot map has been generated for the CAS Variety Block at UC-SCREC. Any changes to the planting are being recorded in the master database maintained by David Stottlemeyer. The UC-SCREC avocado volunteers have been instrumental in maintaining this block. The volunteers graft several new and/or historical varieties on an on-going basis. In December 2002 we were able to obtain budwood of the ‘Puebla’ variety from the Catholic University of Valparaiso in Chile. This budwood is currently in quarantine. Once released, this material will be planted in the Variety collection.

G. To insure the timely and effective dissemination of information developed from this research program.

The current avocado web site at: www.ucavo.ucr.edu has been on-line since June 1998. The site is periodically revised and updated with new information and photographs of different varieties. Questions sent via e-mail or forwarded from the California Avocado Commission are answered on an ongoing basis.

Figure 1. Variety trial yield data (average fruit count per tree) collected from Field 4 at the UC South Coast Research and Extension Center in Irvine, CA from 1999 - 2003. Trees were topworked onto seedling rootstock in 1994 – 1996.

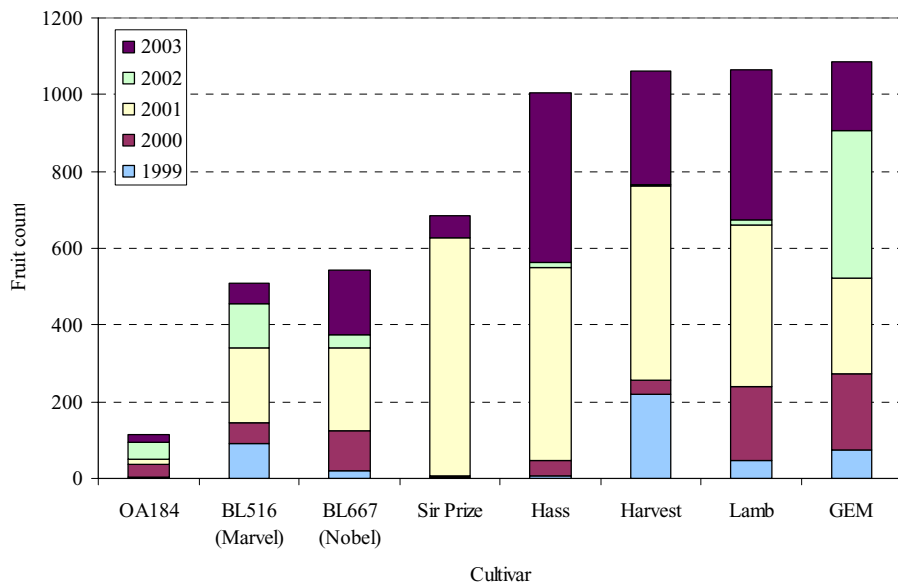


Figure 2. The Coefficient of Variation (%) in yield (fruit number) for each variety from Field 4 at the UC South Coast Research and Extension Center in Irvine, CA from 1999 – 2003.

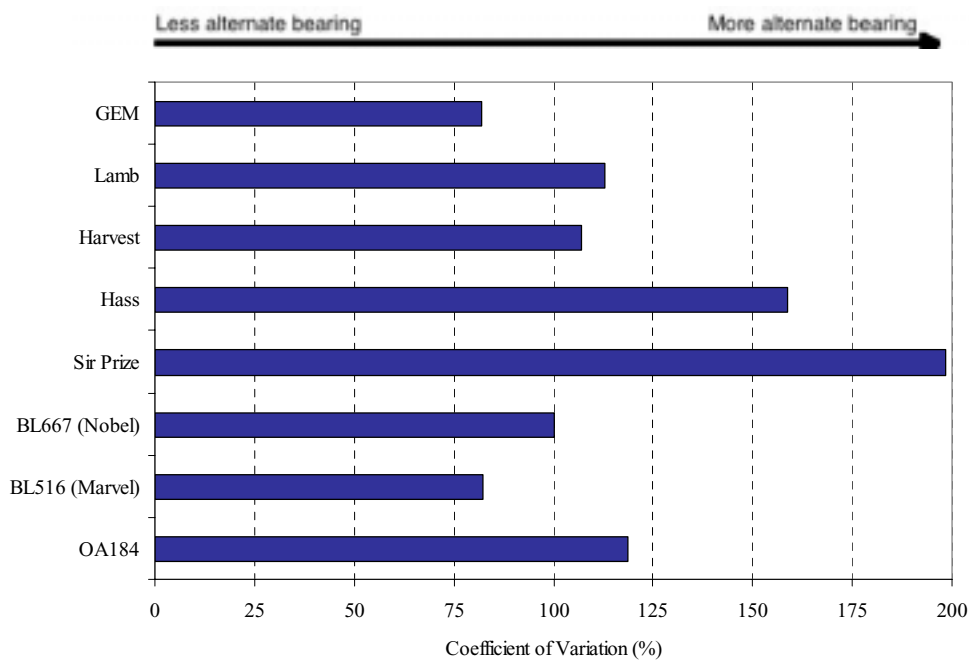


Figure 3. Variety trial yield data (average fruit count per tree) collected from DeBusschere Ranch, Oxnard, CA for 2001 – 2003. Trees were planted on clonal Duke 7 rootstock in 1996.

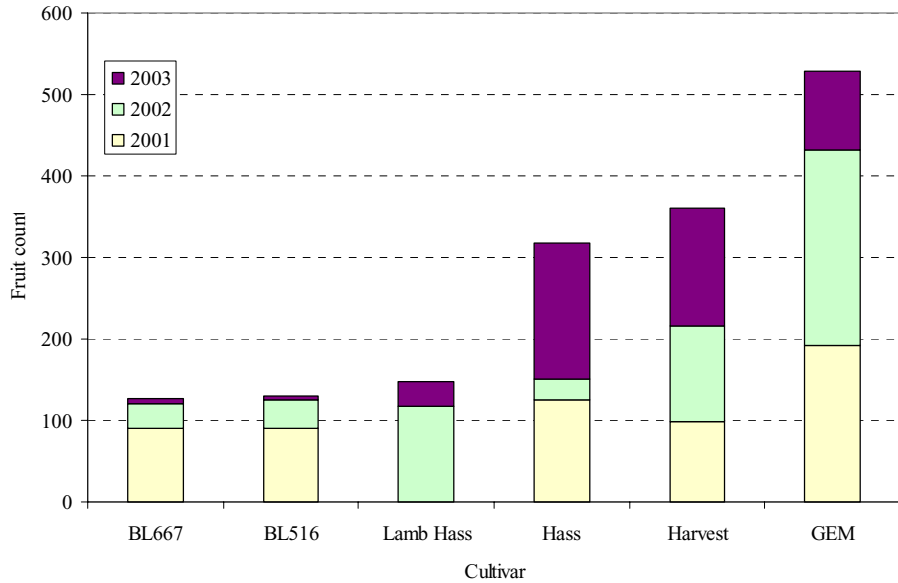


Figure 4. Variety trial yield data (average fruit count per tree) collected from Pine Tree Ranch in Santa Paula, CA for 2001 – 2003. Trees were topworked onto seedling rootstock in 1998.

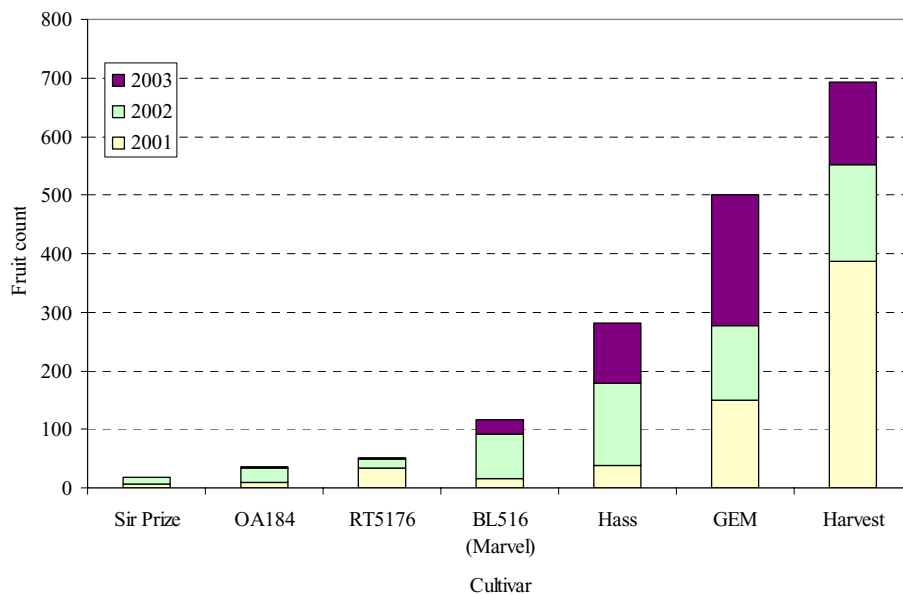


Figure 5. Variety trial yield data (average fruit count per tree) collected from Righetti Ranch in San Luis Obispo, CA for 2001 – 2003. Trees were topworked onto seedling rootstock in 1998 - 99.

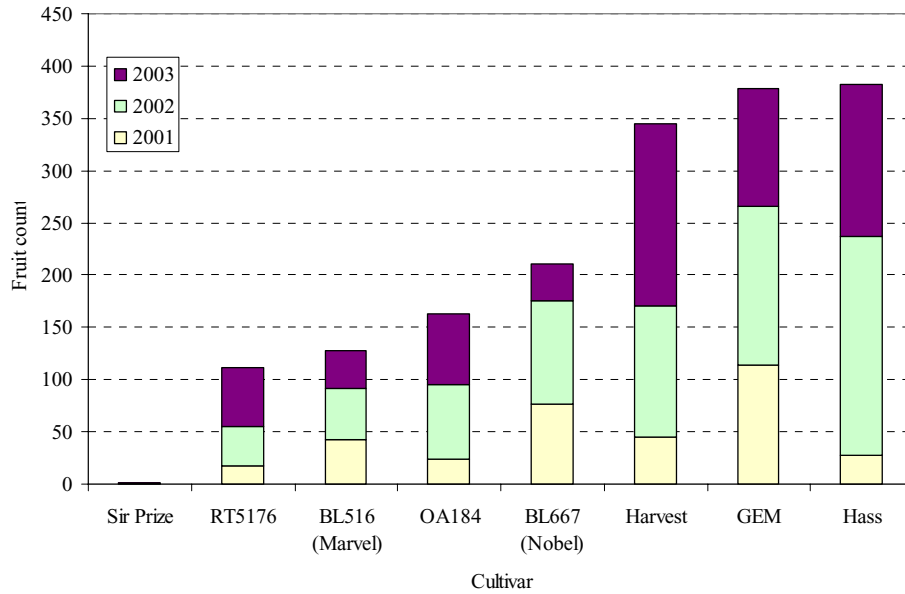


Figure 6. Variety trial yield data (average fruit count per tree) collected from ACW Ranch in De Luz, CA for 2001 – 2003. Trees were topworked onto seedling rootstock in 1998 - 99.

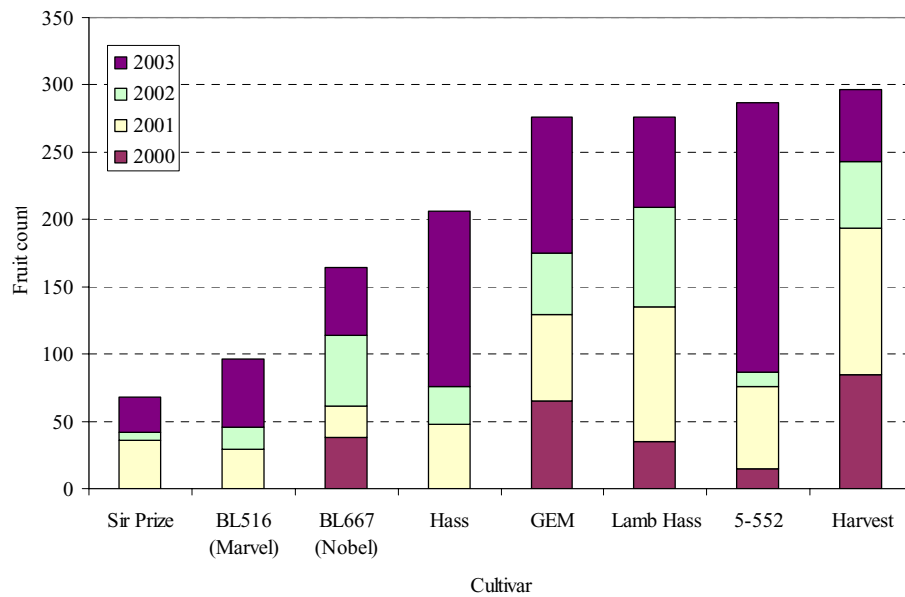


Figure 7. Comparison of changes in dry matter content (%) for all varieties harvested from January 2003 through September 2003 from the SCREC site, Irvine, CA.

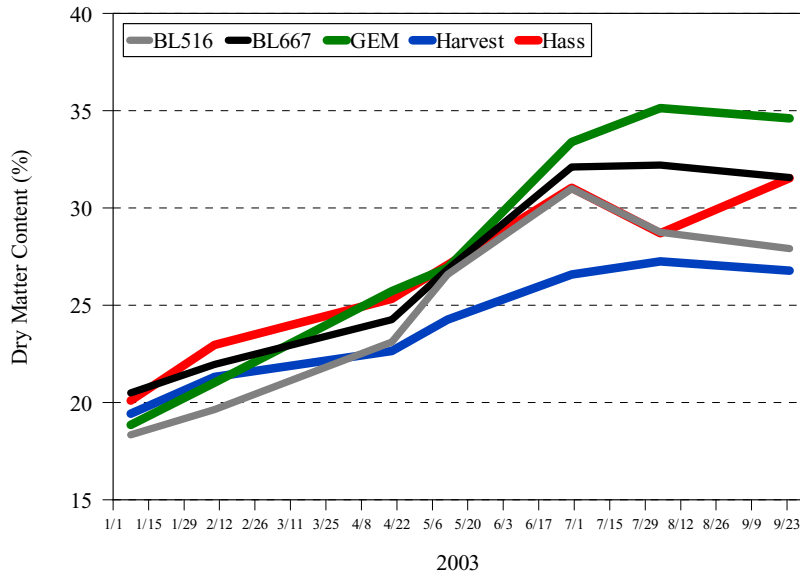


Figure 8. Comparison of changes in dry matter (%) for ‘GEM’ harvested during the 2000 - 2003 maturity seasons. Data collected from the SCREC site, Irvine, CA.

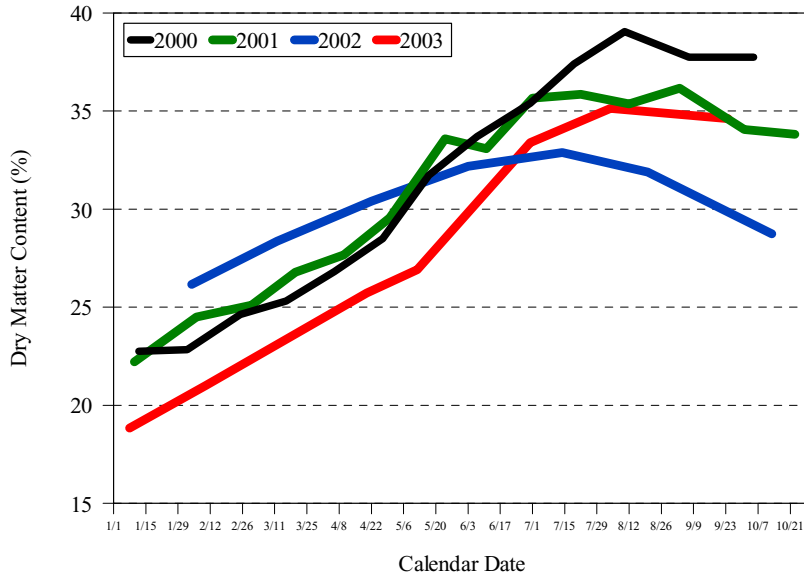


Figure 9. Comparison of changes in dry matter (%) for ‘Harvest’ harvested during the 2000 - 2003 maturity seasons. Data collected from the SCREC site, Irvine, CA.

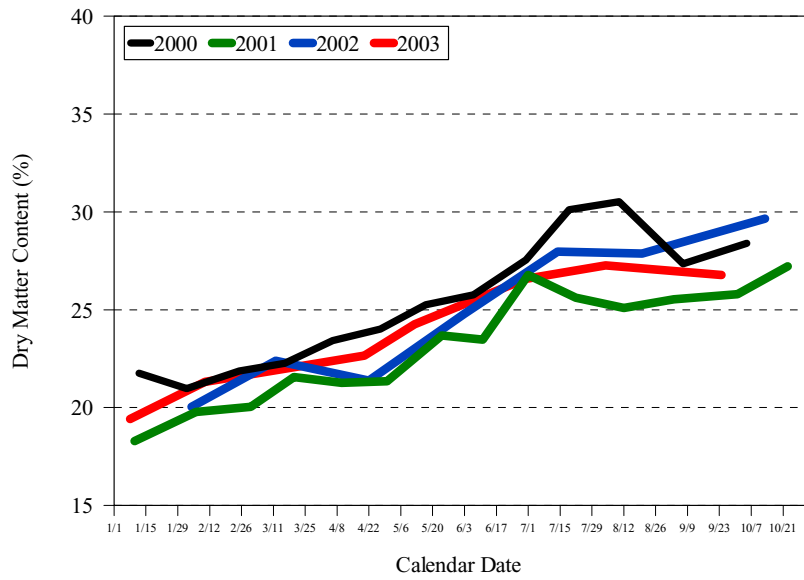


Figure 10. Comparison of average bloom dates for two years for all varieties from February through May at the UC South Coast Research and Extension Center, Irvine, CA.

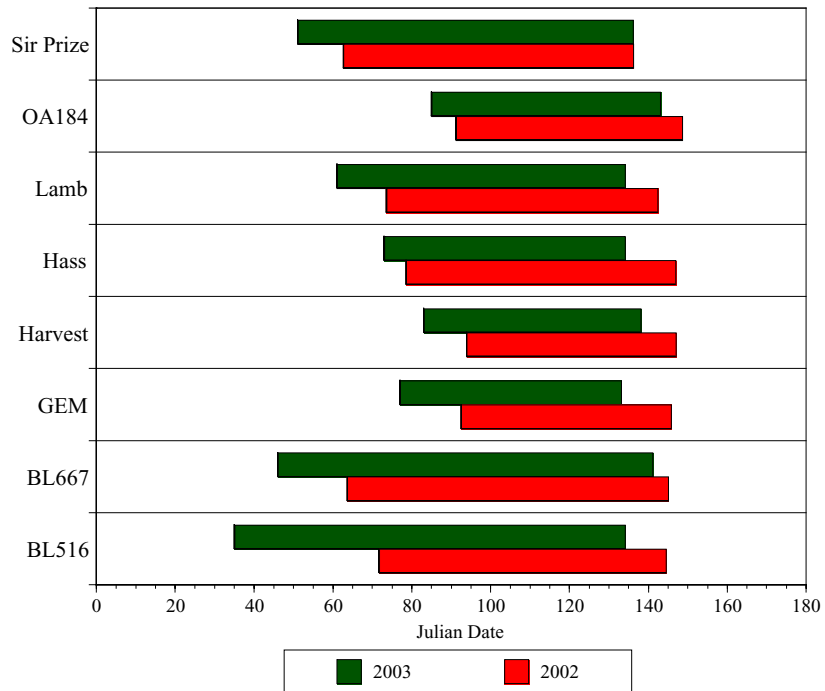


Figure 11. Comparison of percent bloom for ‘Hass’ and ‘GEM’ from February through May 2003 at the UC South Coast Research and Extension Center, Irvine, Ca.

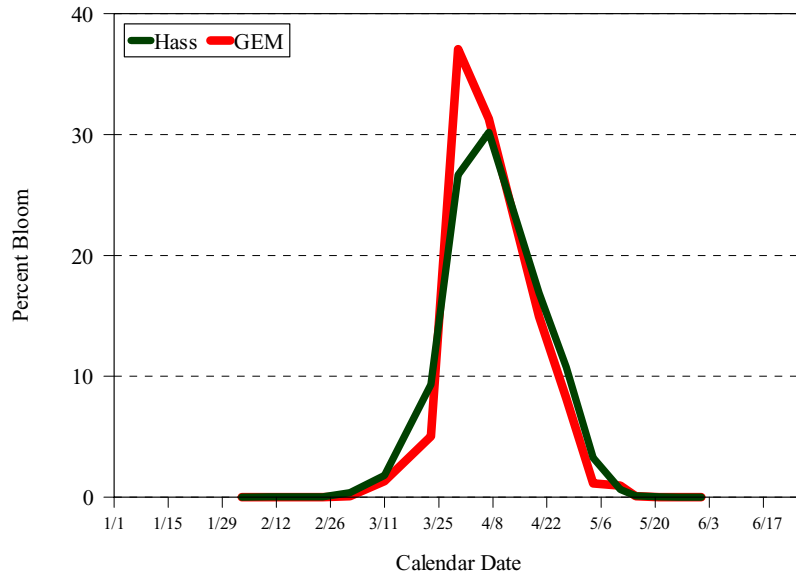


Figure 12. Comparison of percent bloom for ‘Hass’ and ‘Harvest’ from February through May 2003 at the South Coast Research and Extension Center, Irvine, Ca.

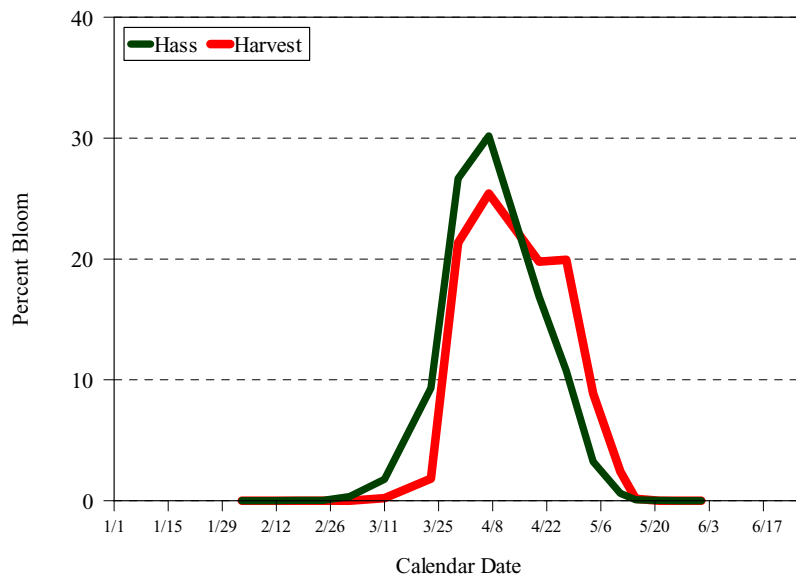


Figure 13. ‘Hass’ yield (fruit count) from the DeBusschere pollinizer trial in Oxnard in 2003 as influenced by pollinizer variety and distance from the pollinizer.

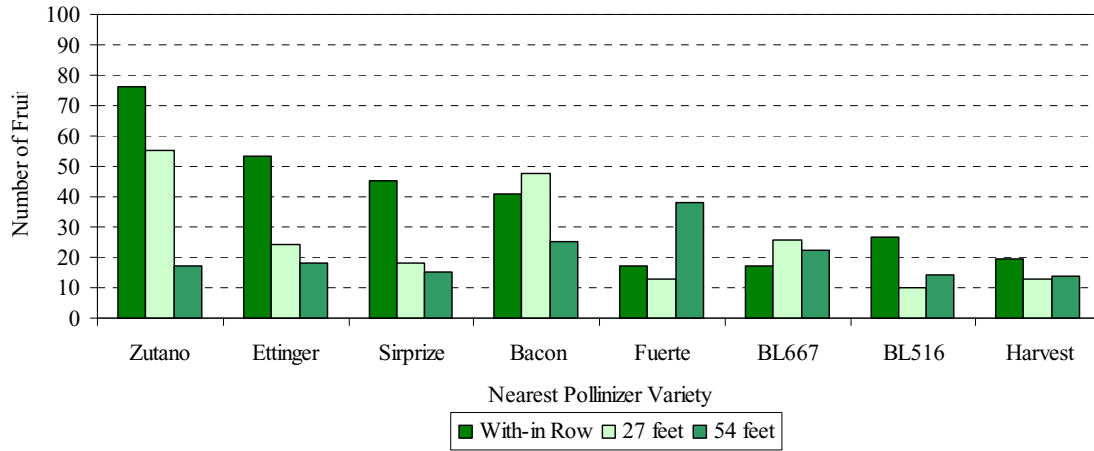


Figure 14. Cumulative ‘Hass’ fruit counts (2001 – 2003) from the DeBusschere pollinizer trial in Oxnard as influenced by pollinizer variety and distance from the pollinizer.

