

## **ENHANCEMENT OF AVOCADO PRODUCTIVITY. PLANT IMPROVEMENT: SELECTION AND EVALUATION OF IMPROVED VARIETIES AND ROOTSTOCKS**

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Since the commercial introduction of avocados to California approximately 100 years ago, growers, enthusiasts and researchers have been searching for the “perfect” avocado. The annals of the California Avocado Society catalogue the many descriptions of new selections of avocado. The 2 most successful commercial cultivars, ‘Fuerte’ and ‘Hass’ were both chance seedlings. The ‘Fuerte’ variety originated as a dooryard seedling in Atlixco, State of Puebla, Mexico. The original tree was discovered by Carl Schmidt and was subsequently introduced into California. For many years, the ‘Fuerte’ was the preeminent California variety and was only replaced by ‘Hass’ as the leading California variety until the large scale industry expansion in the late 1970s. The ‘Hass’ originated as a chance seedling in La Habra Heights, California. The variety was originally planted in 1926 and subsequently patented in 1935 by Rudolph Hass.

The search for improved rootstocks began in earnest after the discovery of avocado root rot (*Phytophthora cinnamomi* Rands) and the need for resistant rootstocks became critical. It was only with the commercial introduction of the clonal rootstock method in the late 1970s that it became possible to vegetatively reproduce clonal rootstock material and therefore introduce improved rootstocks. This technique was first described by Frolich and Platt in 1971 and commercialized by W. H. Brokaw in 1977 with the first planting of Hass, Pinkerton and Bacon on clonal Duke 7 rootstock. Today, the majority of new generation avocado trees planted in California are on clonal rootstocks. The California grower has an increasing selection of rootstocks to choose from and we are beginning to better understand the environmental adaptation and influence of the rootstock on the scion’s productivity and growth habits.

Dr. Bob Bergh, plant breeder at the University of California outlined the general breeding objectives for the California industry (Table 1). With these objectives in mind, we have continued through our cooperative programs to search for both improved varieties and rootstocks.

**Table 1. Avocado breeding objectives.**

Fruit quality	
Medium size	Thick ovate shape
Uniformity	Pulp
Skin	Proper softening
Medium thickness	Appetizing color
Readily peelable	Absence of fibers
Insect, disease resistance	Pleasing flavor
Free from blemishes	Long shelf life
Attractive color	Slow oxidation
Long tree storage	Chilling tolerance
Seed	High oil content
Small	High nutritional value
Tight in its cavity	
Shoot qualities	
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	
Rootstock qualities	
Conducive to high quality fruit	Easily grafted
Conducive to healthy, productive trees	Tolerant to <i>Phytophthora</i> and other organisms
Free from sun-blotch	Tolerant of salinity
Dwarfing or semi-dwarfing	Tolerant of chlorosis
Genetically uniform	Tolerant of drought
Hardy and vigorous	Tolerant of other adverse soil conditions
Easily propagated	

## Improved Avocado Varieties

### *Program Overview and Synopsis*

A formal avocado variety breeding program has existed at the University of California for several decades. Dr. Art Schroeder, based at the University of California, Los Angeles, was active in the selection of promising material in the 1930's and 1940's. In the 1950's the UC hired a dedicated breeder, Dr. Royce Bringhurst (UC, Los Angeles) to develop new avocado varieties. He was followed by Dr. Bob Bergh (UC, Riverside) in the 1960's 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 in 1994 through 1996. Dr. Mary Lu Arpaia with the assistance of David Stottlemeyer assumed full responsibility for the program in 1997. Since that time our activities have focused in 6 general areas.

***Material from the Bergh Breeding Program that is still under review***

The selections listed in Table 2 were ones selected (along with the already released 'Lamb Hass' and 'SirPrize') by Dr. Bergh and Mr. Martin in the early 1990's. In 2003, 2 of the selections, 3-29-5 (GEM) and the N4 (-) 5 (Harvest) were patented and commercially released. Field evaluation of these varieties are being conducted in trials established throughout California.

Table 2. UC Avocado Varieties\* currently under testing.

	Date of cross	Date planted in Field	First Evaluation	First Fruit Test at SCREC	Flower type	Season	Fruit Description	Tree Shape
<b>BL667 (Nobel)</b>	1983	Spring 1985	May 1991	May 1993	B	mid-late Hass	Hass-like	Upright semi-compact
<b>BL516 (Marvel)</b>	1983	Spring 1985	May 1991	June 1994	B	mid-Hass	small Hass	Upright semi-compact
<b>3-29-5 (GEM)</b>	1984	Spring 1986	April 1991	May 1995	A	mid-late Hass	smooth Hass	Mod. spreading
<b>N4 (-) 5 (Harvest)</b>	1984	Spring 1986	May 1993	June 1996	A	late Hass	Hass	Upright
<b>5-552</b>	1984	Spring 1986	Dec. 1990	Aug 1994	B	late Hass	small Reed (green)	-
<b>5-186</b>	1984	Spring 1986	May 1992	July 1995	A	late Hass	green-skin Hass	-

\*Parentage of all material: open pollinated 'Gwen' seedlings (as is the 'Lamb Hass').

***Development of new varieties***

In 1998 a new effort of scion selection using 2 approaches was initiated. The first approach undertaken after consultation with Dr. Bergh was the re-establishment of the isolation blocks. The second approach was undertaken after discussion with Dr. Uvi Lavi (Volcani Institute, ARO, Israel) who headed the avocado breeding program in Israel for several years. His suggestion,

due to the diversity within the species was to plant seeds of promising maternal varieties. To date we have planted approximately 900 seedlings out using a combination of these two approaches and anticipate planting an additional 700 seedlings within the next 12 months.

**Maintenance of the CAS Germplasm Plot at UC South Coast REC**

We have slowly revitalized this plot and conducted sunblotch testing of interesting material. New selections have been added when possible. Budwood of non-protected material is distributed when requested. The XX3, a ‘Murietta Green’ selection by Dr. Bergh was released for backyard growers in 2002.

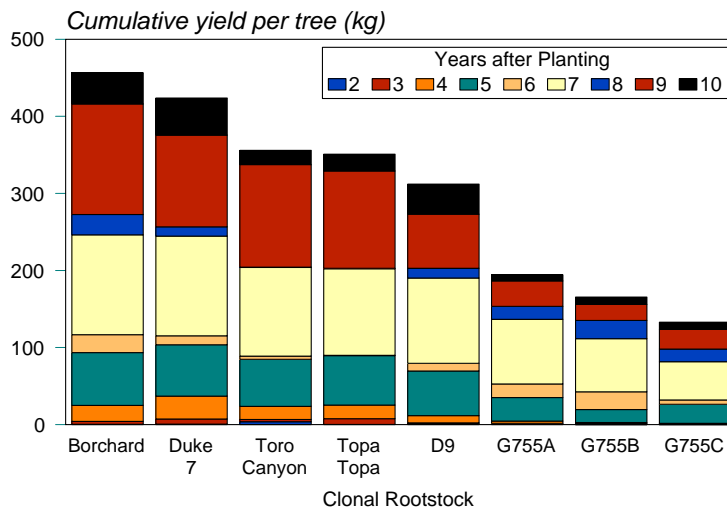
**Maintenance of Persea species collection**

We continue to maintain a small species collection at UC South Coast REC. More cold sensitive material is maintained at UC, Riverside in the campus greenhouse and lathouse facilities.

**Rootstock and pollinizer evaluation**

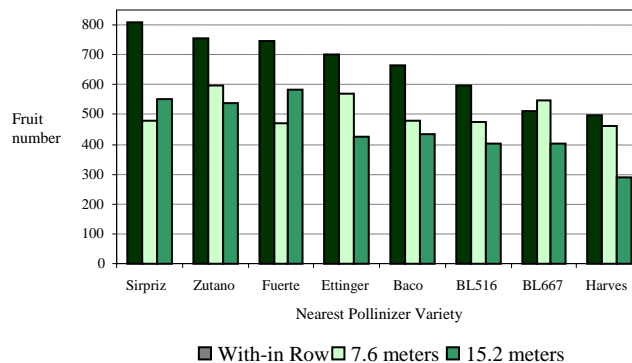
We have maintained a number of rootstock trials at UC South Coast REC. These trials are planted out under non-root rot conditions in order to evaluate the productivity of ‘Hass’ as influenced by rootstock. Figure 1 presents the 10 year yield data for the original rootstock trial using 8 clonal rootstocks. Note that rootstock greatly influence cumulative productivity. We have also introduced salinity tolerant rootstock material from Israel and this material is currently being evaluated as part of the rootstock program.

Figure 1. Cumulative yield of ‘Hass’ on 8 clonal rootstocks from 1986 – 1996 planted at the UC South Coast Research and Extension Center in Irvine, CA.



A large pollinizer trial was established in 1998 in Oxnard in Ventura County. Figure 2 presents the cumulative yield from this trial. You will note that ‘Hass’ yield is greatly influenced by both proximity to the pollinizer variety as well as the pollinizer variety. This research is on-going.

Figure 2. Cumulative ‘Hass’ fruit numbers from 2001 – 2004 as influenced by pollinizer variety and distance from a pollinizer at the DeBusschere Pollinizer trial near Oxnard, CA.



### **General activities**

We routinely index the trees in our foundation blocks for the sunblotch viroid with the Dr. Alan Dodds in the Plant Pathology Department at UCR. Any material distributed from the program is indexed prior to distribution. We also have maintain a website that is focused on the variety improvement program ([www.ucavo.ucr.edu](http://www.ucavo.ucr.edu)).

### **Improved Avocado Rootstocks**

The overall objective of the rootstock improvement program is to collect, select, breed and develop avocado germplasm which exhibits resistance to Phytophthora root rot of avocado. The program has been on-going for many years and was spearheaded until his retirement by Dr. George Zentmyer. Dr. Mike Coffey headed the program during the 1980's and in the early 1990's, Dr. John Menge also of UC, Riverside assumed responsibility of the program. The program's objectives are achieved through the following activities.

### **Collection and Selection of Germplasm**

Improved rootstock selections have been imported from other countries. The Merensky I and Merensky II from South Africa are currently under testing in the field and show interesting

results. Additional selections are currently being imported for field testing under California conditions. Dr. Richard Litz, University of Florida, genetically engineered avocado rootstocks using somatic hybridization techniques. Funding for this project was provided by the California industry. This material has been provided to UC and they are currently under evaluation.

### ***Breeding for Improved Rootstocks***

Approximately 2000 seeds from the rootstock breeding blocks have been screened for resistance to *Phytophthora cinnamomi* in 2003. Sixty-eight have been retained, which showed a high degree of resistance. Most of these varieties had maternal parents of G6, Barr Duke, Spencer, UC 2001, Thomas, Pond or Margy. This is the first time we have tested second generation fruit from trees which originally came from the breeding block. We now have 57 seedlings from the breeding blocks, which have shown exceptional resistance to *Phytophthora cinnamomi* after extensive testing. Twenty-two of these are being field-tested. Thirty-five more are ready for field-testing. Three varieties, Zentmyer, Uzi and Steddom are being patented and will be released to the California industry in the near future.

The breeding blocks are now composed of a combination of *Persea* species (*Persea steyermarkii* *Persea nubigena*, Aguacate de Anis, Aguacate de mico) and selections which have shown root rot resistance or other desirable traits. In 2003 a new breeding block for salt resistance was established at UC, Riverside. Seeds from this block will be harvested and planted at a site in San Diego County, CA where salinity is a major limiting factor in terms of tree survival and productivity. Trees surviving at this site will be subsequently tested for root rot resistance. In 2004 a new dwarfing plot consisting of Wilg (South Africa), Erin (PP 21 maternal parent D9), Frolic (PP37 maternal parent D9) and Witney (PP41 maternal parent D9) was established at UC, Riverside.

### ***Screening and Greenhouse Evaluation of Rootstocks***

Intensive greenhouse experiments involving the root rot resistance of new selections are routinely conducted. There are a number of selections which are more resistant to *P. cinnamomi* than the Thomas (used as a control in all tests).

### ***Field Evaluation***

We now have 29 field trials (6,500+ trees) testing 55 clonal root rot tolerant rootstocks throughout Southern California. The results of these trials vary from site to site but highlight the success of the selection program being conducted in California and elsewhere in identifying resistant material.

### **Summary for Avocado Rootstock Improvement**

It appears that we have several rootstocks that are consistently performing better than our standard resistant variety, Thomas under root rot conditions. These are Uzi (PP14, maternal parent G6), Merensky I (Latas, South Africa), and Steddom (PP24, maternal parent Toro Canyon). Zentmyer (PP4, maternal parent Barr Duke) is also growing well but is sensitive to salt. We are preparing to release these 4 rootstocks to the California industry. There are several new rootstocks which appear to be showing promise. We believe that we have identified 3 rootstocks that are dwarfing and may be useful in the future as rootstocks in high density plantings.

### **Concluding Remarks**

It is important to remember up until recently most important rootstocks and varieties were a result of exploration and testing/evaluation of chance seedlings. Although in recent years we have moved more into the realm of controlled breeding and selection it is critical for growers to be observant in the field for both promising varietal material and exceptional rootstocks. Remember highly productive trees are likely to be a result of rootstock/scion interactions. Copy trees are an important component of the evaluation process.

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

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