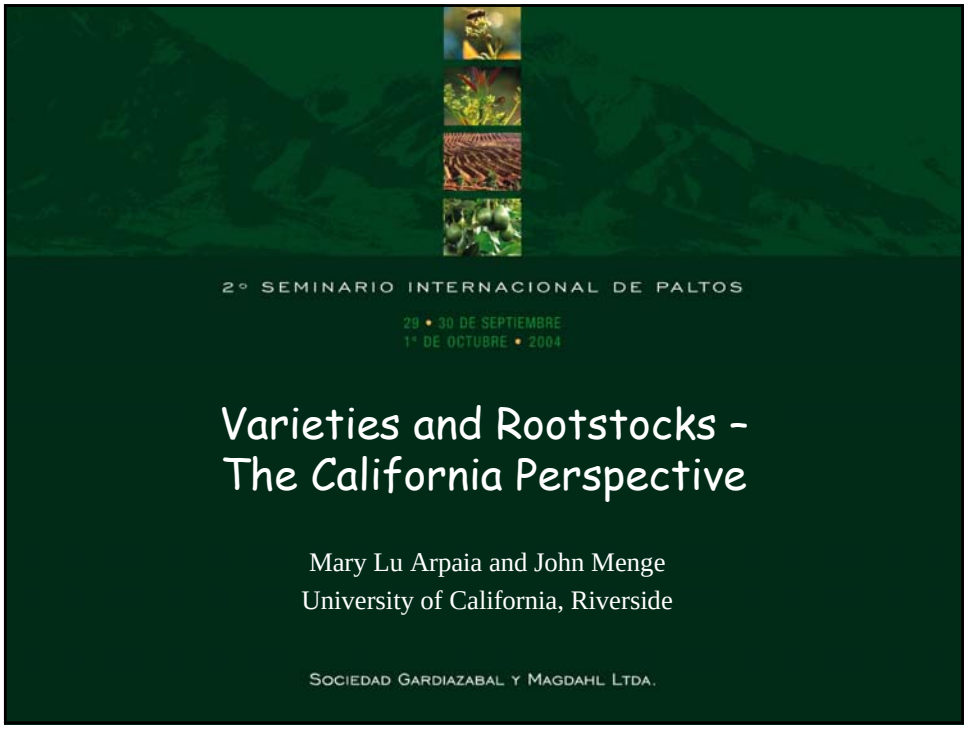


2° SEMINARIO INTERNACIONAL DE PALTOS

29 • 30 DE SEPTIEMBRE
1° DE OCTUBRE • 2004

Varieties and Rootstocks – The California Perspective

Mary Lu Arpaia and John Menge
University of California, Riverside

SOCIEDAD GARDIAZABAL Y MAGDAHL LTDA.

Why have an Improvement Program

Producing the Crop - Enhancing Productivity

- *High production of optimally sized fruit*
- *Tolerance to disease, pests*
- *Tolerance to environmental stress*
- *Tree "manageability"*
- *On-tree storage and minimize alternate bearing*

Marketing the Crop - Maximizing Fruit Quality

- *Minimizing physiological disorders*
- *Uniformity of ripening*
- *Tolerance to low storage temperatures*
- *Tolerance to handling "mis-management"*
- *Decreased postharvest fruit decay*

Requirements/Risks of a plant improvement program

- ✓ Long-term venture (10 – 20 years)
- ✓ Requires coordinated effort: academia, growers, packers, consumers
- ✓ Wide-scale adoption unknown: will there be a return on the investment?
- ✓ Most current cultivars and rootstocks are local selections – can improvements be found?

Challenges Specific to Avocado Plant Improvement

- ✓ Avocado is "relatively primitive" – commercial production <100 years
- ✓ Understanding limited on avocado genetics
- ✓ May be many years to come into production
- ✓ Highly heterozygous – seedling populations extremely varied

The goals of an avocado improvement program can be achieved through varietal and rootstock manipulation using either traditional breeding methods or as technology improves, molecular techniques.

Additionally, an important component for the future is germplasm conservation. Characterization and preservation of wild Persea and related genera is essential in order to preserve desirable traits useful for future breeding efforts.

University of California

Avocado Improvement Program

Rootstock Selection Program
- *Disease tolerance - J. Menge, G. Zentmyer*
- *Salinity tolerance - D. Crowley, M. L. Arpaia*
- *Field Productivity - M. L. Arpaia, G. Bender, B. Faber*

Varietal Improvement - M. L. Arpaia

Genetic Characterization - M. Clegg, T. Chao

Germplasm Conservation - R. Scora, J. Menge, M. L. Arpaia

Contributions of UC Avocado Program

Rootstocks

Identification of PRR tolerant material
Rootstock productivity and salinity tolerance
Dwarfing

Cultivars

New varieties for CA growers
Breeding stock shared with international community and has been the foundation of other intl. breeding programs

Avocado Breeding Program

Components

- Testing current selections
- Developing new selections

Varietal Selection UC, Riverside

B. O. Bergh: 1964 - 1994
G. W. Witney: 1994 - 1996
M. L. Arpaia: 1996 - present

Technical Support:
- Bob Whitsell 1964 - 1989
- Gray Martin 1984 – 1997
- David Stottlemyer 1997 - present

Varietal breeding in California

Current major cultivars are "local" or introduced selections

Released Cultivars to CA industry

Dr. B. O. Bergh and Mr. R. Whitsell
- Gwen, Whitsell and Esther - released in 1984

Dr. B. O. Bergh and Mr. G. E. Martin
- Lamb Hass and Sir Prize - released in 1996

Released 2003

Dr. Mary Lu Arpaia and Mr. David Stottlemyer
- 3-29-5 (GEM) and N4 (-) 5 (Harvest)

Components of evaluation

- Yield
- Fruit characteristics – size, seed size
- Maturity and postharvest quality
- Tree vigor – growth habit
- Flowering, stress tolerance

Avocado Breeding Program

Growth Habit Varies


Hass


Gwen

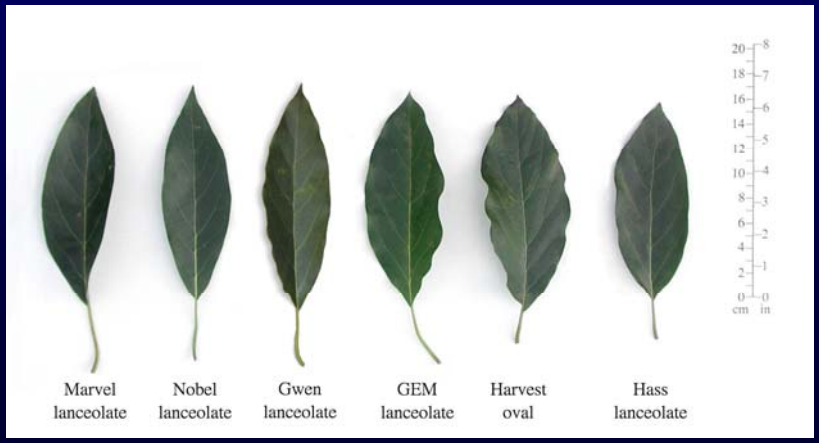

Lamb Hass


3=29-5 (GEM)

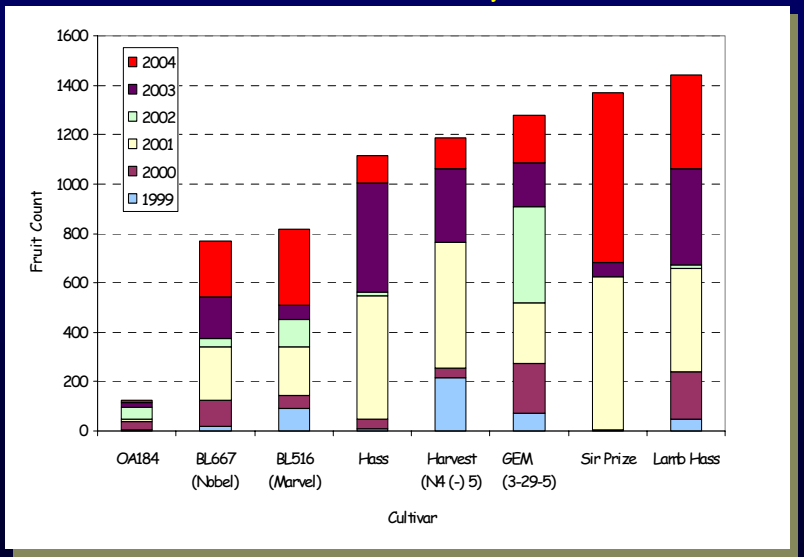

N4 (-) 5 (Harvest)


Marvel (BL516)

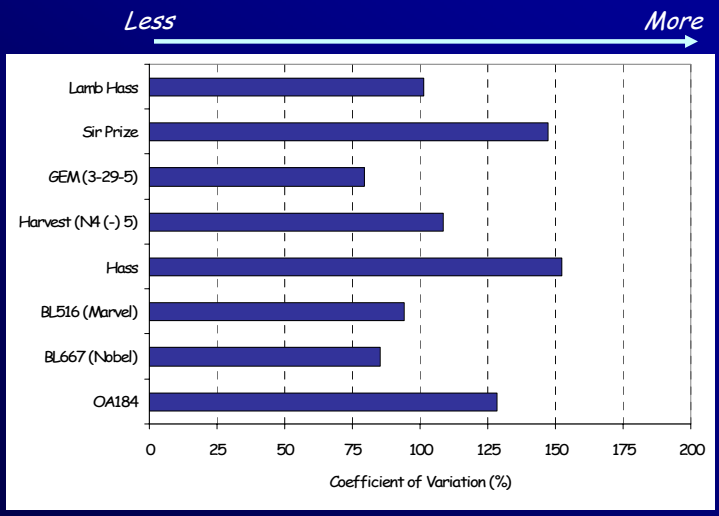
Leaf Shape - The unreleased varieties are all 'Gwen' offspring. Although the leaves tend to be similar, there are subtle differences between the varieties.



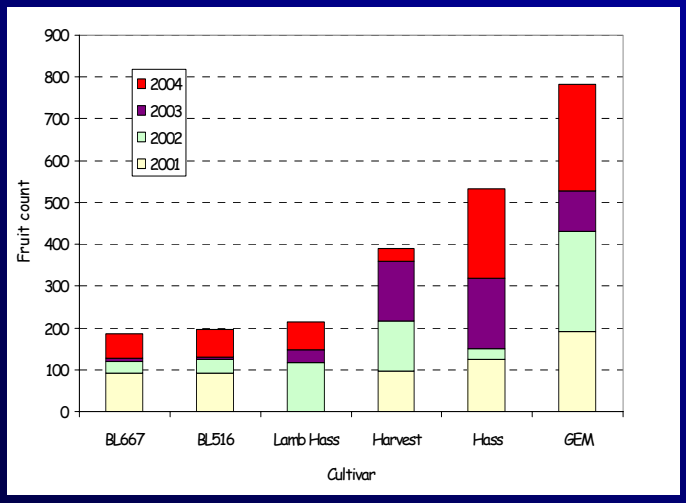
Yield
UC South Coast REC, Topworked Trees



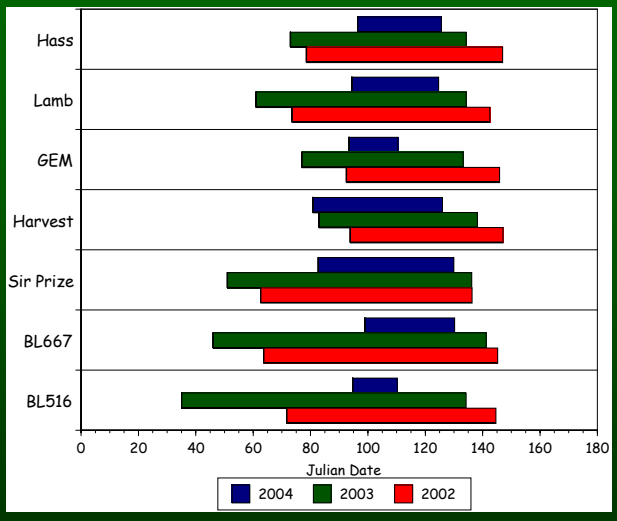
Alternate Bearing Tendency
UC South Coast REC, Topworked Trees



Yield
DeBusschere Variety, Clonal Duke 7 RS

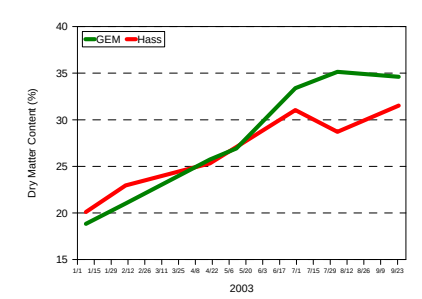


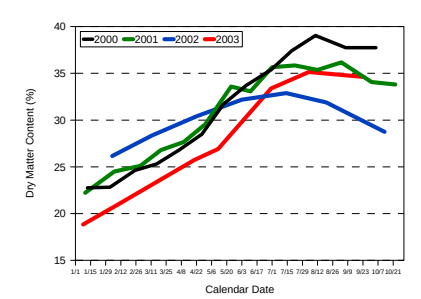
Flowering at UC South Coast REC in Irvine, CA. for 2002 - 2004



Flowering varies from year to year

Fruit Maturity
3-29-5 (GEM)

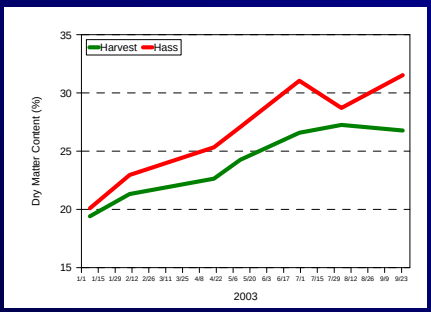


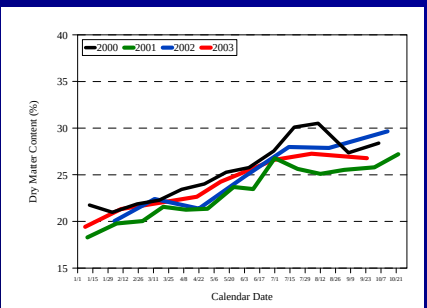


Similar pattern of dry matter accumulation to Hass

Comparison of dry matter changes over season

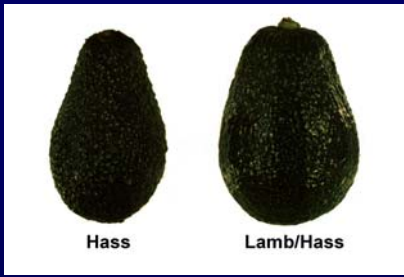
Fruit Maturity
N4 (-) 5 (Harvest)

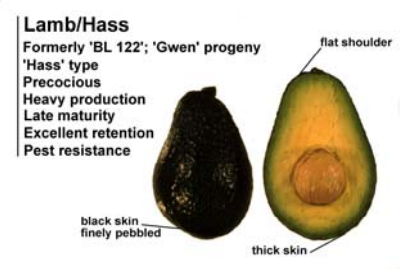




Slower pattern of dry matter accumulation to Hass

Comparison of dry matter changes over season

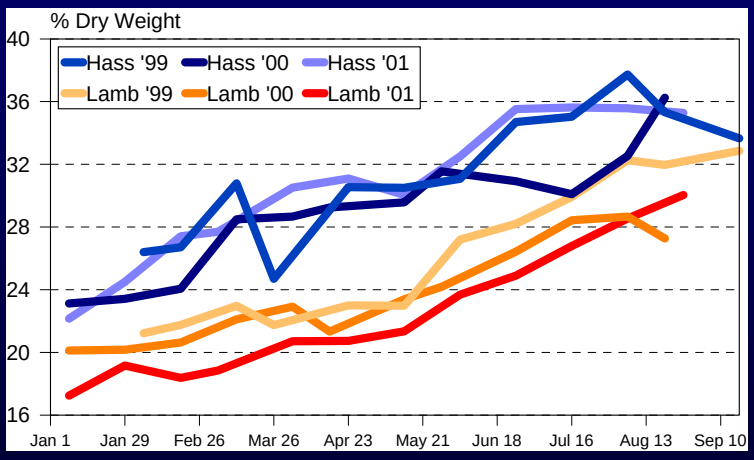




Differences between Hass and Lamb Hass

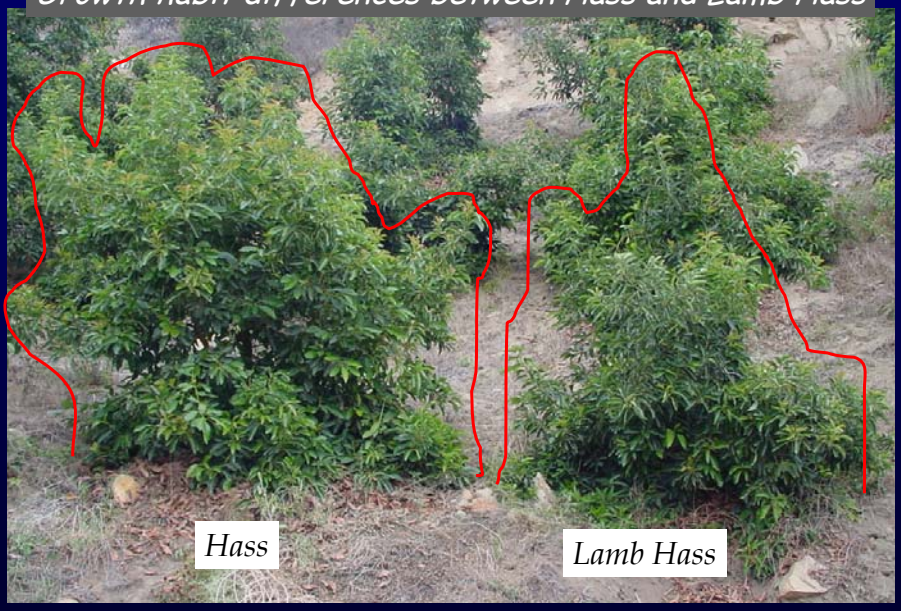
Lamb Hass maturity season – mid to late summer
Fruit shape – more "square"
Lamb Hass has more upright growth habit
Flexible wood – fruit borne interior of tree; tends to set fruit in clusters
Lamb Hass is more "tolerant" to Persea mite and other pests (?)
Photosynthetic rate approximately 30% higher than Hass and higher chlorophyll content

Fruit Maturity – Lamb Hass



Delayed dry matter accumulation compared to Hass
Pattern of accumulation similar over seasons

Growth habit differences between Hass and Lamb Hass



Avocado Breeding Program

Developing new selections

1. In consultation with U. Lavi (Israel)

Seed collection:

BL667, BL516, GEM,
Gwen, Lamb Hass, 5-552

2. In consultation with B. Bergh

Isolation Blocks:

BL516 x GEM	Gwen self
Thille x GEM	Lamb x GEM
Sir Prize x Gwen	BL667 x Lamb

Indexing for disease is a critical component

Critical to know:
- *Relative disease tolerance*
- *All introduced material should be tested*

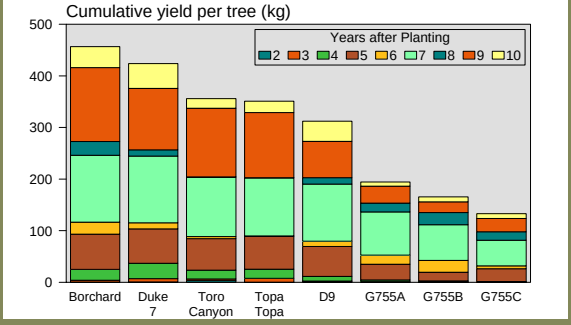
Clonal Rootstocks
The California Experience

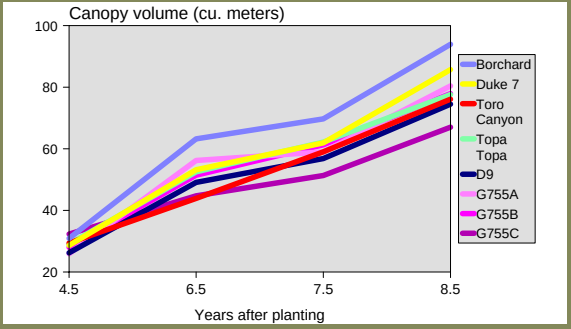
Rootstocks can influence many scion characteristics

- Yield
- Tree size/vigor
- Yield efficiency
- Leaf nutrient status
- Tolerance to environmental stresses

Use of clonal rootstocks relatively new

- Potential for future improvements high
- Significant differences due exist
- More uniform tree performance possible



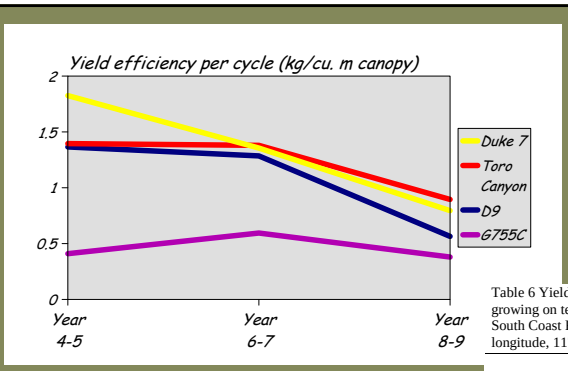


Rootstock influences yield and tree size

Tree Size – South Africa

Duke 7

G755C



Yield efficiency declines due to increases in tree size and loss of productive canopy surface

Significant differences in yield efficiency

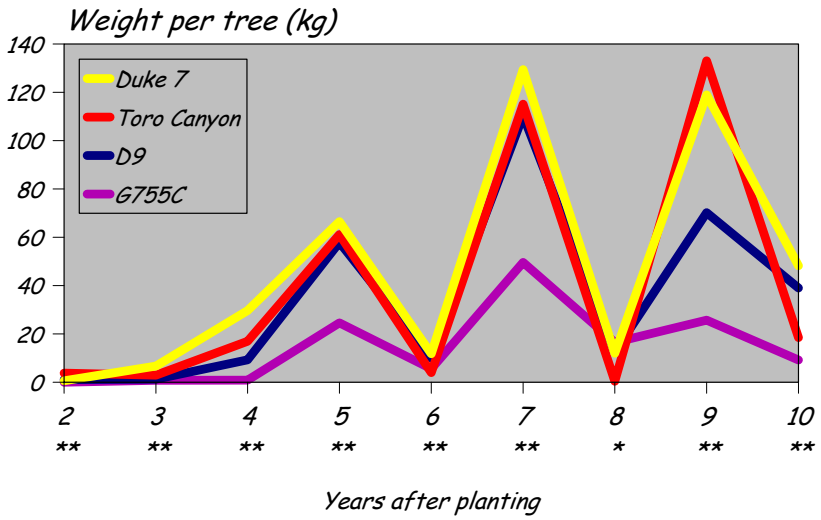
Not necessarily associated with vigorous trees

Table 6 Yield efficiency (kg fruit·m^{-3}) of 'Hass' avocado trees growing on ten clonal rootstocks at the University of California South Coast Research and Education Center (latitude, 33°44'N; longitude, 117°49'W) (n=20).

	Yield efficiency (kg fruit·m^{-3})			
Rootstock	1991/92	1993/94	1995/96	mean
G755A	0.60c	0.87c	0.238c	0.57c
G755B	0.48cd	0.83cd	0.182c	0.50cd
G755C	0.42d	0.69d	0.236c	0.45d
Topa Topa	0.81b	1.06b	0.935a	0.93b
Duke 7	0.97a	1.23a	0.958a	
Borchard	0.96ab	1.17ab	0.935a	1.02ab
D9	0.95ab	1.15ab	0.696b	0.93b
Toro Canyon	0.90ab	1.13ab	0.948a	0.99ab
	***	***	***	***
Thomas	0.75	1.00	0.50	0.75
G1033	0.58	0.94	0.69	0.74
	*	n.s.	*	n.s.

Mean separation tests within columns non-significant (n.s.), or significant at the P=0.05 (*) or 0.001 (***) level based on Fisher's Protected LSD test.

Alternate Bearing can be influenced by clonal rootstock



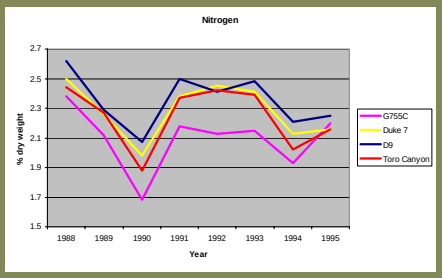
Significant differences detected

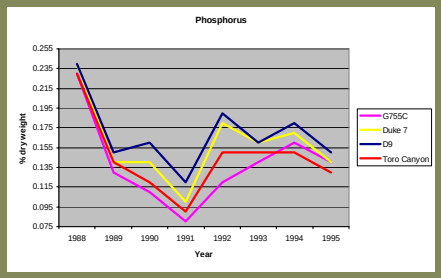
Table 2. Alternate bearing index of 'Hass' avocado trees growing on ten clonal rootstocks at the University of California South Coast Research and Education Center (latitude, 33°44'N; longitude, 117°49'W). See Materials & Methods section for calculation.

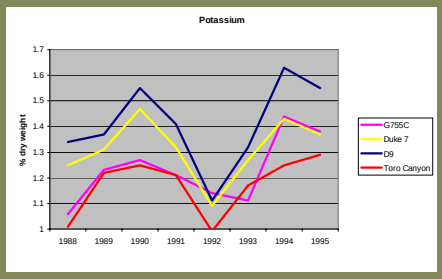
Rootstock	Alternate bearing index
G755A	1.49c
G755B	1.25d
G755C	1.21d
Topa Topa	1.91a
Duke 7	1.61bc
Borchard	1.70b
D9	1.56bc
Toro Canyon	1.92a
	***
Thomas	1.83
G1033	1.63
	n.s.

Mean separation tests within columns non-significant (n.s.) or significant at the P=0.001 (***) level based on Fisher's Protected LSD test.

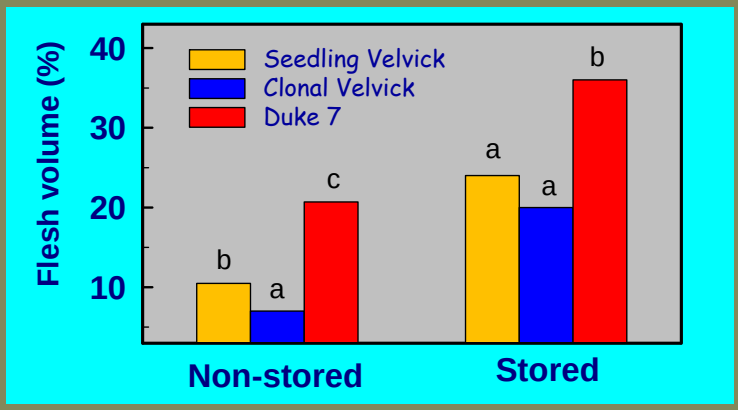
Rootstock can influence leaf nutrient status







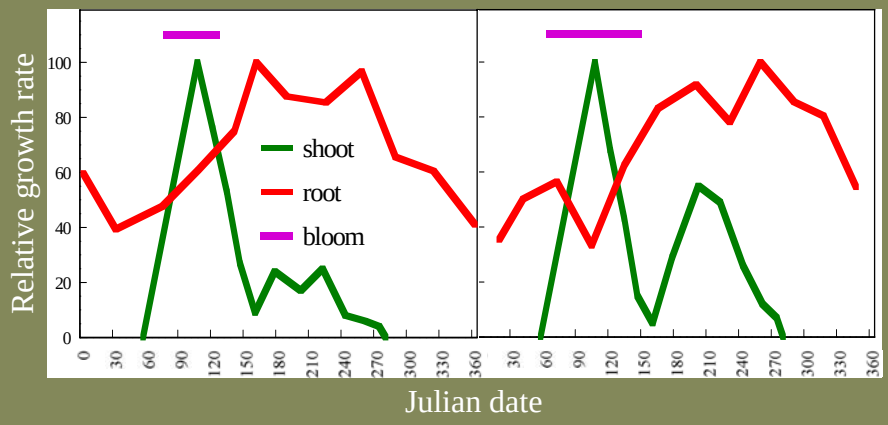
Rootstocks affect 'Hass' avocado fruit rots
- believed related to calcium uptake
4 wks @ 5C
Marques, Hofman et al 2001



'Hass' Avocado Phenology Model

"On" year = heavy crop load

"Off" year = light crop load



Are there rootstocks affects?

Root growth rate – No consistent differences

Annual root growth rate of 'Hass' avocado on four clonal rootstocks.

	Year				
Rootstock	1992	1993	1994	1995	1996
			$mm \cdot day^{-1} \cdot root^{-1}$		
'Thomas'	0.75ab	0.72	0.67a	0.52a	0.38a
'Topa Topa'	0.84a	0.97	0.75a	0.32bc	0.25b
'Duke 7'	0.60c	0.69	0.47b	0.18c	0.23b
'D9'	0.67bc	0.72	0.75a	0.38ab	0.24b
Sig. of F[x]	*	n.s.	*	**	*

[z]Means within a column with no letter(s) in common are significantly different (Fisher's Protected Least Significant Difference test at P=0.05).
[y]ns, *, **, *** are non-significant, or significant at P≤0.05, P≤0.01, or P≤0.001, respectively.

Rootstock had no effect of shoot growth rate

Shoot growth rate[z] ($mm \cdot day^{-1} \cdot shoot^{-1}$) of 'Hass' avocado on one of four rootstocks.

	1992		1993		1994		1995		1996	
	spring[z]	summer	spring	summer	spring	summer	spring	summer	spring	summer
'Thomas'	0.68	0.37	3.57	4.57	1.60	0.46	0.83	0.78	1.40	0.37
'Topa Topa'	0.65	0.26	5.71	5.81	1.80	0.36	0.51	0.41	0.97	0.20
'Duke 7'	0.61	0.27	5.34	6.49	2.00	0.46	0.70	0.92	1.17	0.32
'D9'	0.63	0.16	5.05	6.59	1.82	0.72	0.86	0.46	1.34	0.26
Sig. of F[y]	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Avg.	0.64	0.27	4.92	5.86	1.80	0.50	0.73	0.64	1.22	0.29

[z]Spring = average of spring (first) flush; Summer = average of summer (second) flush.
[y] ns, *, **, *** are non-significant, or significantly different at $P \leq 0.05$, $P \leq 0.01$, or $P \leq 0.001$, respectively. Statistical analysis performed using log transformed growth rates (log_{10} of rate + 1).

Environmental Stress – Phytophthora root rot

Young avocado with root rot resistant rootstock growing among older avocados dying from avocado root rot

Disease resistance/tolerance possible
New selections

Breeding program

Breeding blocks of resistant varieties planted together to enhance natural crossing.

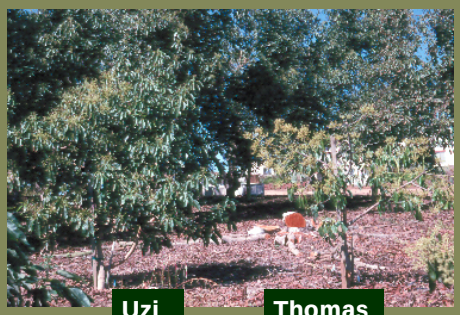
Screening and greenhouse evaluation of rootstocks

Fruit from breeding blocks is germinated in the greenhouse and inoculated with *Phytophthora cinnamomi*

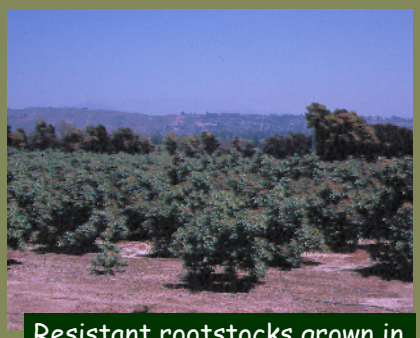
Selected resistant seedlings are reinoculated each time they are repotted

Resistant varieties are grafted to stumps in the field to get abundant budwood for experiments.

Production of clonal rootstocks for experiments



Field Evaluation



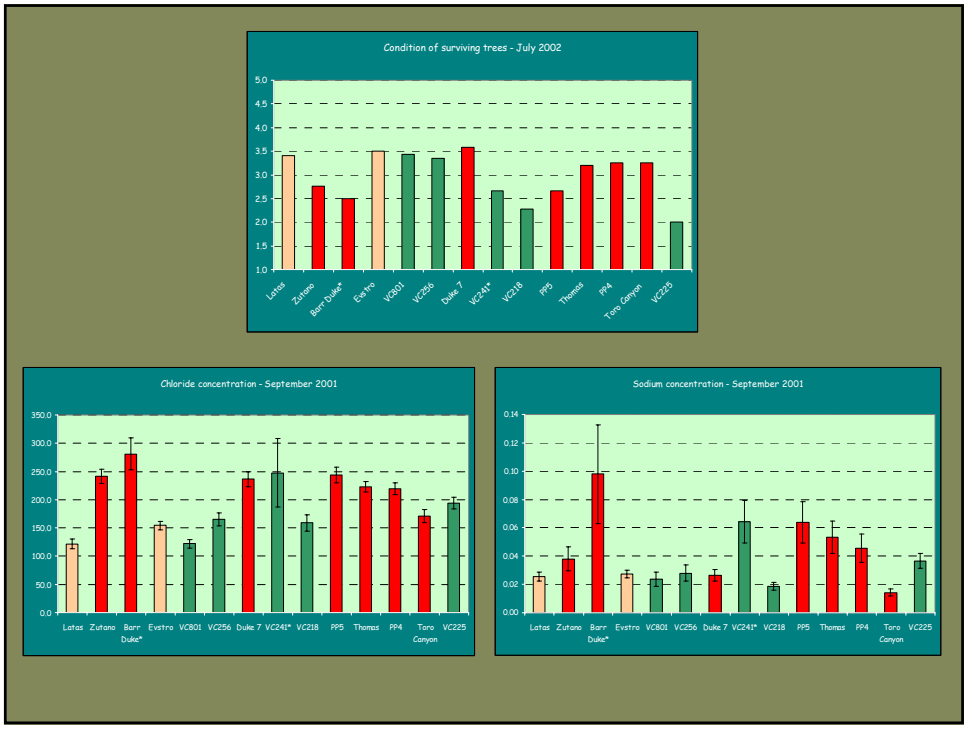
Resistant rootstocks grown in Phytophthora-infested soil

Environmental Stress – Salinity

San Diego County

Stehly Trial

December 2001



What we know - Much yet to be learned

- *Differences between avocado races needs to be better understood*
- *Clonals can improve overall tree performance and potentially postharvest quality*
- *As with other tree crops; with time we will find that varying environmental conditions will require different rootstocks*
  - *Salinity, Disease, Cold, Soil*

Greater cultural, harvesting and water costs coupled with increasing market competition

Approaches for the future

Enhancing Productivity

- *Understanding avocado tree physiology and stress responses*
- *Light manipulation*
- *High density plantings*
- *Rootstocks for disease, salinity tolerance, dwarfing*
- *Varieties w/ > productivity, pest tolerance, suitable for close spacings*
- *Pollinizers and Pollinators*

NEED INTEGRATED PROGRAM

For more information

www.avocadosource.com

- *Variety information*
- *Database of avocado varieties*
- *Information on rootstocks (ongoing)*