

# Avocado Rootstock Breeding at UC Riverside

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and Microbiology



The screenshot shows the homepage of the Eskalen Lab website. At the top, there is a dark blue header with the lab's name and contact information. Below the header, there is a large image of a man (Akif Eskalen) and another image of fruit (avocados and oranges). The main content area contains text about research interests and links to lab groups, programs, and job openings.

**Eskalen Lab**  
232 Fawcett Laboratory  
Department of Plant Pathology and Microbiology  
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**Research Interest**  
Plant diseases on subtropical crops indirectly reduce yields by debilitating the plant, and directly reduce the yield and quality of the fruit before and after harvest. Our research focuses on the identification, biology, epidemiology and control of pathogens associated with subtropical crops in California, including new potential threats, and addresses how these pathogens interact to contribute to subtropical crop decline.

[Lab group](#)  
[Program](#)  
[Job openings](#)



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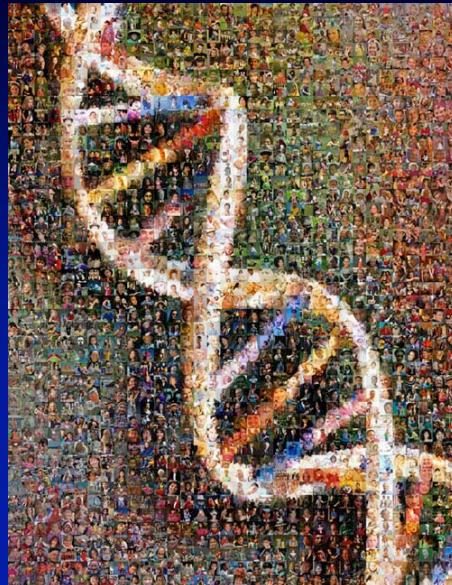
**Akif Eskalen**  
**CE Subtropical Pathologist**

[www.eskalenlab.ucr.edu/](http://www.eskalenlab.ucr.edu/)

## Grower Survey

<b>County</b>	<b>Location</b>	<b>Root Rot Rating</b>	<b>Chemical Control</b>	<b>Application</b>	<b>Application Time of Year</b>	<b>Buffered</b>	<b>Application Method</b>
San Diego	South	7	Phosacid	1 to 3	Feb, Aug	yes	injection
San Diego	South	3	Phosacid	Bimonthly		yes	irrigation
San Diego	South	3	Phosacid	2	Spr, Fall	yes	injection
San Diego	South	8	Phosacid	1	June	yes	irrig/spray
Riverside	South	7	Fertilizer 0-28-25	3 to 4	Spr, Fall	both	chemigated injection drench
Santa B.	North	7	Phosacid	1 (mature) 4 (young)	Spring Spr - Fall	both	injection drench
Santa B.	North	0	gypsum	3	Spr - Fall	no	irrigation
Ventura	North	6.5	Phosphate	2	Spr, Fall	no	chemigation
Ventura	North	7	Phosacid	4	all year	yes	irrigation
Ventura	North	1	None	0			
Los Angeles	North	5.5	None	0			

## Molecular Biology 101



# Molecular Biology 101

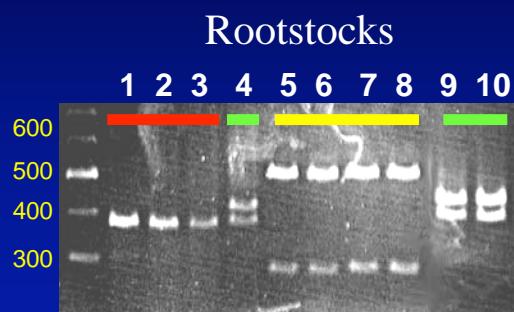
## DNA sequence data

Rootstock	DNA sequence
Duke 7	AGGGCTTCCAGAGAGGGCTTTCCAGAG
Dusa	AGGGCTTTCCAGAGAGGGCTTTCCAGAG
Uzi	AGGGCTTCCAGAGAGGGTCTTTCCAGAG



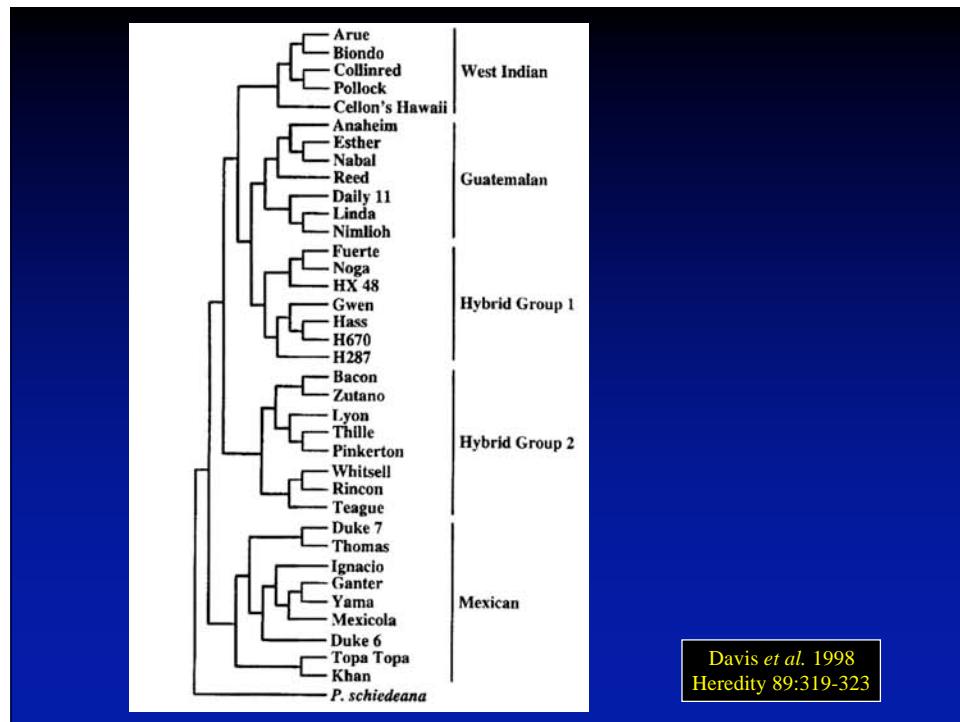
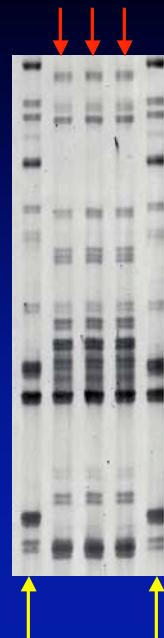
# Molecular Biology 101

## Molecular Markers



# Molecular Biology 101

## Molecular Markers



# Overview

Pathogen

Control

Breeding Program

## Avocado Root Rot

- “Avocado tree decline” noted in the 1920’s



## Avocado Root Rot

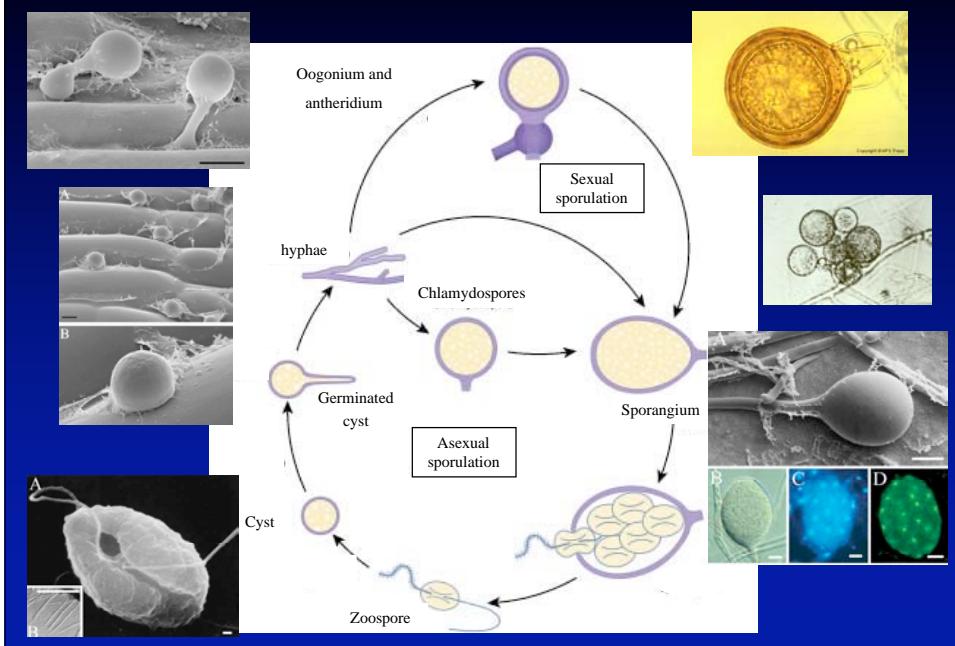
- “Avocado tree decline” noted in the 1920’s
- *P. cinnamomi* identified in the early 1940’s as the causal agent



# Avocado Root Rot

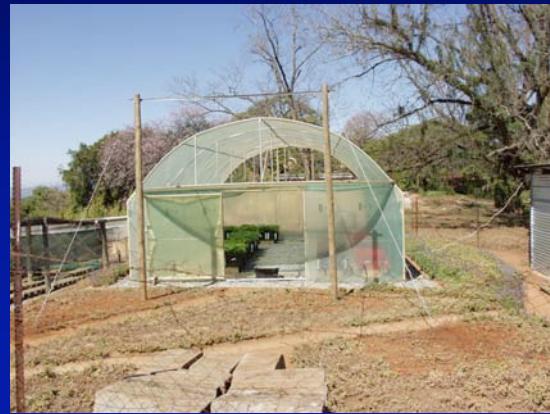
- “Avocado tree decline” noted in the 1920’s
- *P. cinnamomi* identified in the early 1940’s as the causal agent
- 100s of hosts

Life cycle of *Phytophthora cinnamomi*



# Control

- **Nursery practices**



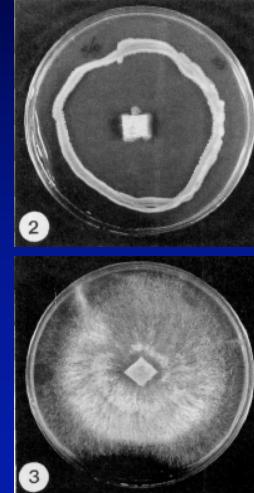
# Control

- **Nursery practices**
- **Cultural practices**



# Control

- **Nursery practices**
- **Cultural practices**
- **Biological control**



# Control

- **Nursery practices**
- **Cultural practices**
- **Biological control**
- **Chemical control**

United States Environmental Protection Agency  
Pesticide and Biocide Division  
730-3-90-001 January 1991

## EPA R.E.D. FACTS

### Fosetyl-Al (Aliette)

Pesticide use or sale in the United States must be registered by EPA, based on scientific information that can be used to evaluate potential risks to people or the environment. Because of advances in scientific knowledge, the law requires that pesticides which were first registered years ago be re-evaluated to ensure that they meet today's more stringent standards.

In evaluating pesticides for re-evaluation, EPA obtains data from pesticide producers and reviews a range of scientific information, including toxicology, exposure, and environmental fate information. The Agency imposes any regulatory controls that are needed to effectively manage each pesticide's risk. EPA then registers pesticides that can be used without posing undue hazards to human health or the environment.

When a pesticide is eligible for re-evaluation, EPA assesses this and explains why in a Re-evaluation Eligibility Document, or RED. This fact sheet summarizes the information in the RED for Fosetyl-Al.

**Fosetyl-Al** Fosetyl-Al, which is sold under the trade name Aliette, is a systemic fungicide used to control damping-off and root rot of plant roots, stems and fruit. It is applied as a plant dip treatment and as a soil drench. Fosetyl-Al is also used as a foliar spray to control powdery mildew and other leaf diseases and foliage. Fosetyl-Al is registered for use on the following food crops and ornamentals, and all of these uses are eligible for re-evaluation:

Almonds (non-bearing)	Ginseng
Apples	Ornamental plants, lawn and turf
Avocados (non-bearing)	Castorbeans
Blueberries (non-bearing)	Clover (bearing, and non-bearing)
Broccoli	Cotton
Cabbage	Flax (bearing)
Cantaloupes	Groundnut (bearing)
Corn	Hemp
Crabapples	Horseradish (bearing)
Daikon radishes	Onions
Dwarf pumpkins	Peas
Endive	Peanuts
Figs	Potato
Garlic	Rhubarb
Horseradish	Soybeans
Kale	Spinach
Lettuce	Turnips
Melons	Watermelons

**Regulatory History** Fosetyl-Al was first registered by EPA in 1982. EPA issued a Registration Standard for Fosetyl-Al in February 1988, after revising a December 1986 draft for public comment.

**Health Effects** All of EPA's toxicology data requirements for Fosetyl-Al have been satisfied. These toxicity studies indicate the following effects:

- Acute and Subchronic Health Effects Fosetyl-Al is a severe eye irritant, but it does not irritate the skin or pose a notable inhalation hazard.

## Control

- Nursery practices
- Cultural practices
- Biological control
- Chemical control
- Clonal rootstocks



## Control

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- Chemical control
- Clonal rootstocks



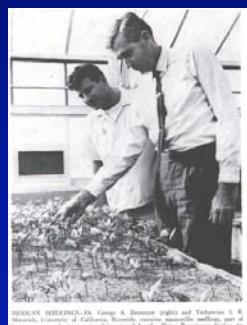
No one magic bullet yet!

## Rootstock Breeding at UCR



## Rootstock Breeding at UCR

- **George Zentmyer (1944-1983)**
- **Michael Coffey (1980's)**
- **John Menge (1990's - 2005)**



## Rootstock Breeding at UCR

- Since 1989, over 50,000 seedlings screened



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- Approximately 30 varieties (PP#'s) are being tested under field conditions from this project



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- Approximately 30 varieties(PP#’s) are being tested under field conditions from this project
- ~ 26 active field plots

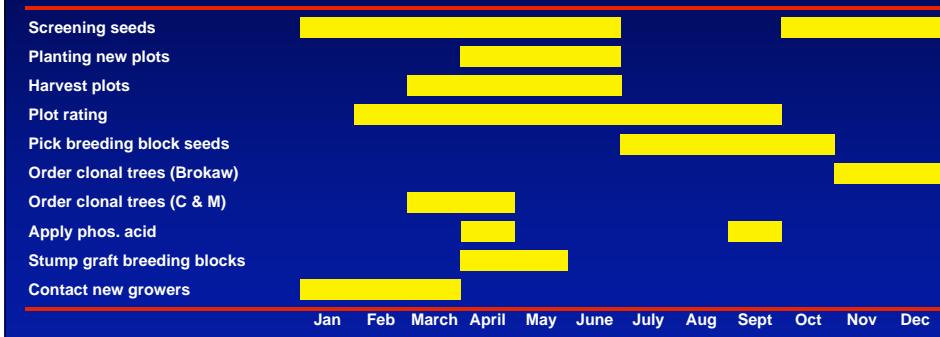


## Rootstock Breeding at UCR

- Since 1989, over 50,000 seedlings screened
- ~30 varieties are currently being tested under field conditions
- ~26 active field plots
- 42 plots dropped since the inception of Menge’s original research project proposal



# General timeline for avocado field work



# Southern California growing region

Northern CA										
	ok	20	30	ok	70	ok	30	40	2006 trees	
<b>Rootstocks</b>		-2004								
Thomas	x	2004								
Moresky II (Dusa)		x	2005							
Moresky I (Latosa)		x	x	x	x	x	x	x	x	x
Duke 7	x	x	x	x	x	x	x	x	x	x
Topara			x	x	x	x	x	x	x	x
VC 40				x						x
VC 66					x					x
<b>VC207</b>		x								
VC 18										
VC225										
VC241										
VC801										
PP46										
Zentmyer PP4	x	x			x					
Berg PP5										
PP11 Cl		x	x	x	x					
<b>PP15 Guillmet</b>										
<b>PP16 Rio Frio</b>			x	x	x	x	x	x	x	x
Pond			x	x	x	x	x	x	x	x
PP21 Erin	x	x	x	x	x	x	x	x	x	x
PP22 Medina		x	x	x	x	x	x	x	x	x
PP24 Stedman	x									
PP25 Margy										
PP26 Martin	x	x	x	x	x	x	x	x	x	x
PP28 Elinor	x	x	x	x	x	x	x	x	x	x
Pond	x									
PP33 Margy	x									
<b>PP34 Crowley</b>										
PP35 Anita	x	x	x	x	x	x	x	x	x	x
PP36 Dirac	x	x	x	x	x	x	x	x	x	x
PP37 Frolic	x	x	x	x	x	x	x	x	x	x
PP38 Fred	x	x	x	x	x	x	x	x	x	x
PP41 Witney	x	x	x	x	x	x	x	x	x	x
PP42 Johnson	x	x	x	x	x	x	x	x	x	x
PP43 Campbell		x	x	x	x	x	x	x	x	x
Fred										
PP45 Brandon		x	x	x	x	x	x	x	x	x
PP47 Cl #2		x								
PP48 Linda										
PP49 Faber										
PP52 Downer										
PP53 Janice										
PP56 Faber	x									
PP57 Mary Lou										
PP58 Lovana		x	x	x	x	x	x	x	x	x
PP59 Margy										
PP63 O'Connell		x	x	x	x	x	x	x	x	x
PP64 Balou #1										
PP65 Balou #2			x	x	x	x	x	x	x	x
PP66 Hortin				x	x	x	x	x	x	x
PP74 Farwell #1		x		x	x	x	x	x	x	x
PP75 Farwell #2			x	x	x	x	x	x	x	x
PP76 Farwell #3				x	x	x	x	x	x	x
PP77 Farwell #4				x	x	x	x	x	x	x
PP78 Farwell #5				x	x	x	x	x	x	x
PP79 Elizabeth				x	x	x	x	x	x	x
PP80 Lexa				x	x	x	x	x	x	x
PP81 Scuptum				x	x	x	x	x	x	x
PP82 Sandfield		x		x	x	x	x	x	x	x
UC2035				x	x	x	x	x	x	x
DUKE 9	x			x	x	x	x	x	x	x

## Northern California growing region

## Low Disease Pressure

Fallbrook, harvest April 2006

Rootstock	Total fruit weight (kg)	Individual fruit weight (kg)
Witney	36.62a	0.229a
Crowley	35.43ab	0.221a
Anita	34.51ab	0.231a
Thomas	30.66abc	0.232a
Pond	30.48abc	0.234a
Zentmyer	29.74abc	0.223a
Margy	29.05abc	0.237a
Duke 9	28.45bc	0.241a
Fred	27.79bc	0.233a
Frolic	23.28c	0.237a

## Moderate Disease Pressure

**Escondido CA, Harvest, April 2006**

Rootstock	Total fruit weight per tree (kg)	Individual fruit weight (kg)
Latas	26.34a	0.233a
Steddom	23.76ab	0.233a
Toro Canyon	22.90ab	0.241a
VC207	20.95ab	0.232a
Uzi	18.86b	0.229a
VC225	12.93c	0.234a
Afek	9.52cd	0.229a
VC241	6.33de	0.224a
Thomas	4.33de	0.242a
VC44	2.85e	0.242a

## Heavy Disease Pressure

**Escondido, CA, May 2006**

Rootstock	Fruit weight per tree (kg)	Individual fruit weight (kg)
Merensky II (Dusa)	53.24 a	0.18 a
Zentmyer	51.75 a	0.22 a
Merensky I (Latas)	50.46 a	0.23 a
Uzi	43.66 a	0.19 a
Steddom	41.00 a	0.20 a
VC241	27.96 a	0.20 a

## One year old plot-Rancho Ca

Rootstock	Tree rating (0-5; 5=dead)	Canopy vol (cu ft)	Trunk diam (cm)	Salt damage (0-5; 5=heavy)	Dead trees (%) <sup>1</sup>
Brandon	0.763g	27.40a	2.537a	2.026a	0
Eddie	0.947fg	24.03ab	2.390a	1.263bcd	0
Dusa	1.175efg	18.93bc	2.510a	1.175cd	0
Farwell 1	1.417def	19.70bc	2.383a	1.189ab	0
Campbell	1.658cde	16.21c	2.184ab	1.868ab	0
Farwell 2	1.833 cd	13.42cde	2.350a	2.139a	0
VC241	1.868cd	17.91bc	2.179ab	1.553abc	0
Gray	2.028cd	7.57e	1.917b	1.878d	0
Thomas	2.075bc	15.23cd	2.190ab	2.105a	5
Balou 1	2.700ab	7.36e	1.960b	0.778d	10
Balou 2	2.763a	8.84de	1.821b	1.625abc	16

Brandon



Thomas





# Breeding Blocks

- Block #1 (f16a) planted in 2001; Dusa, Duke 9, Duke7, Latas, PP4, UC 2001
- Block #2 (f16b) planted in 1999; PP4, Toro Canyon, Thomas, Spencer
- Block #3 (f16c) planted in 2000; Regrafted in 2005 with Zentmyer, Uzi, Steddom, Anita
- Block #4 (f16d) planted in 2001; PP#'s 1, 2, 3, 4, 5, 15, 16, 19, 21, 26, 29, 36, 40, 41, 42, 50, 52, 54, 55, 56, 57, 58, 59, 60, 62, 63
- Block #5 (dwarf) planted in 2005; Wilg, VC 241, PP21 Erin, PP37, Frolic, PP41, Witney
- Block #6 (vc's) planted in 2005; 7, 15, 26, 28, 40, 51, 65, 66, 802, 803, 804
- Block #7 (f15g) planted in 1991; Regrafted in 2005 with Zentmyer, Uzi, Steddom, Anita
- Block #8 (salt) planted in 2003; Toro Canyon, Dusa, Latas, VC207, VC218, VC801
- Block #9 (salt) planted in 2003; Dusa, Latas, Toro Canyon, VC218, VC207

Greenhouse study testing two types of materials



## Changes in the program

- Molecular methods
  - Parentage analysis

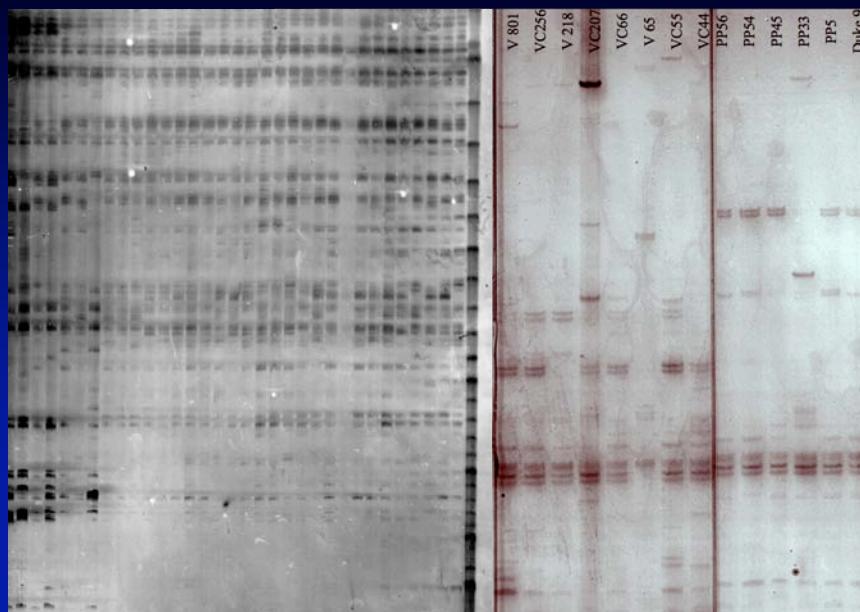
## Changes in the program

- Molecular methods
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  - Decide which varieties to field test

## Changes in the program

- **Molecular methods**
  - Parentage analysis
  - Decide which varieties to field test
  - Marker based breeding ?

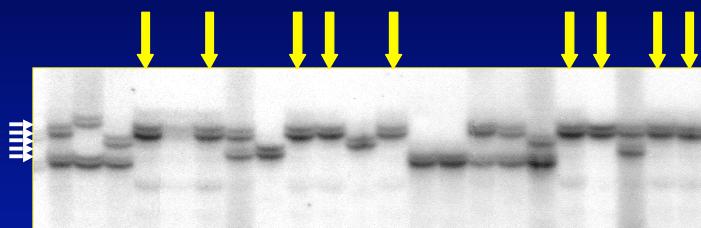
Molecular Markers: AFLP



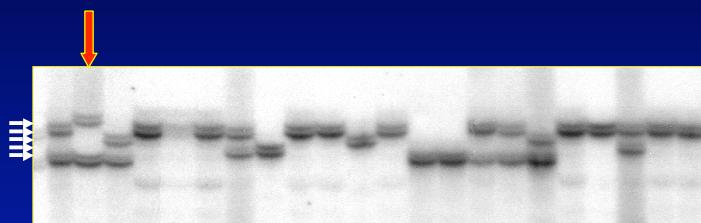
## Molecular Markers: microsatellites



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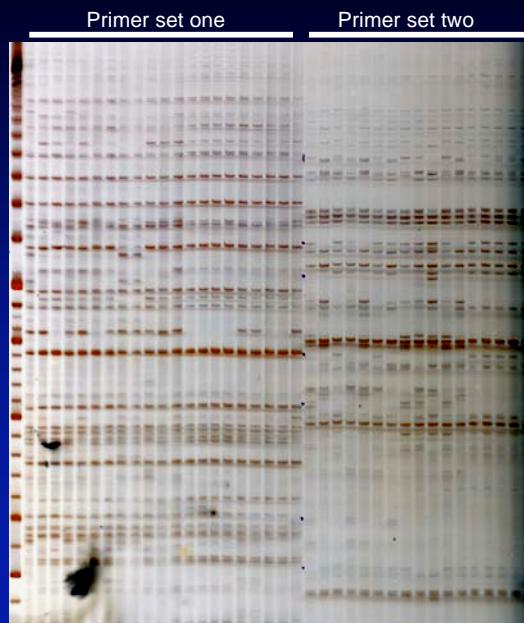
## Molecular Markers: microsatellites



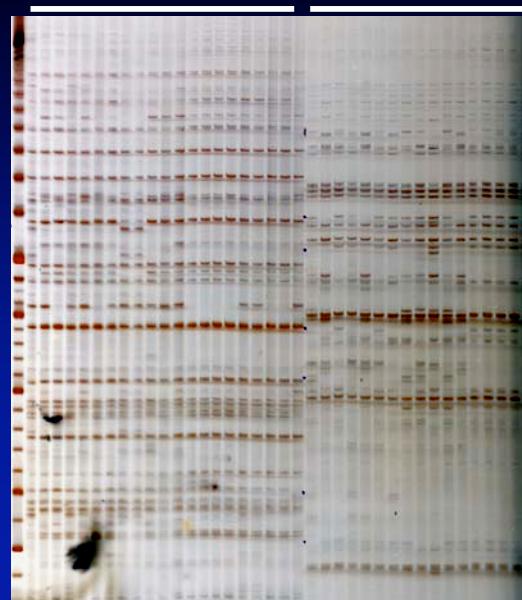
## Changes in the program

- **Pathogen: Molecular methods**
  - Population biology; pathogen diversity
  - PCR based assay
  
- **Avocado: Molecular methods**
  - Parentage analysis
  - For making field testing decisions
  - Marker based breeding ?

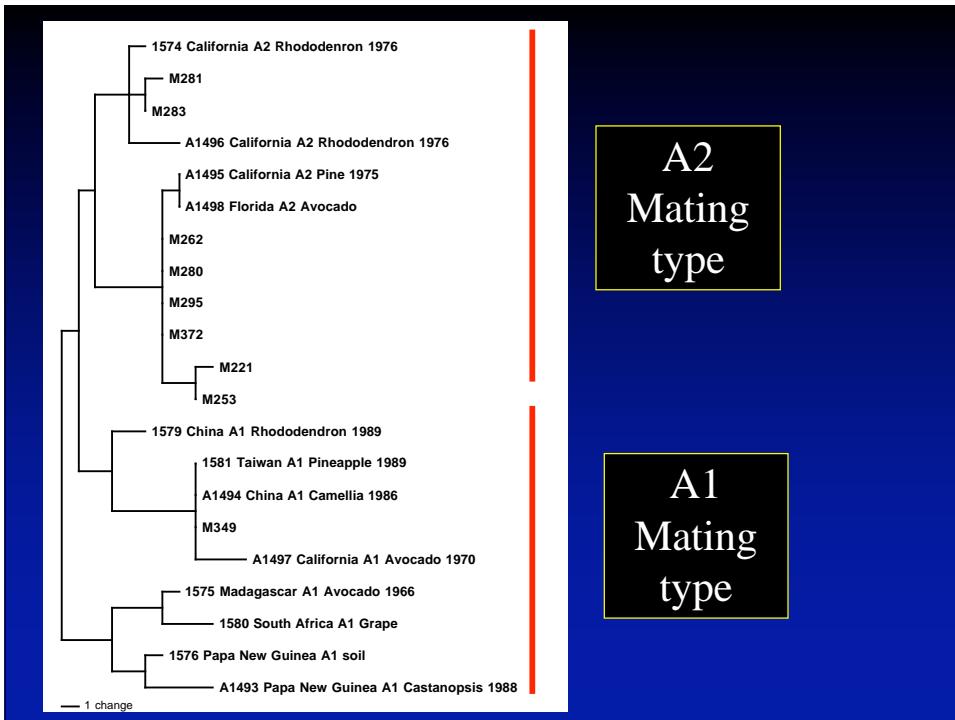
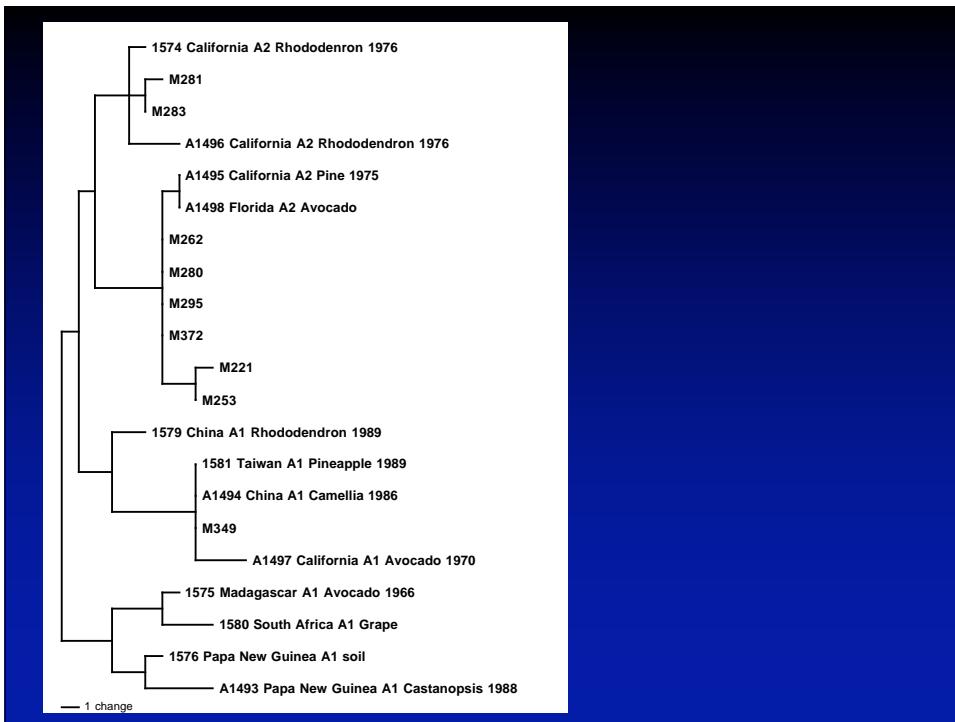
### *P. cinn*: Amplified Fragment Length Polymorphism

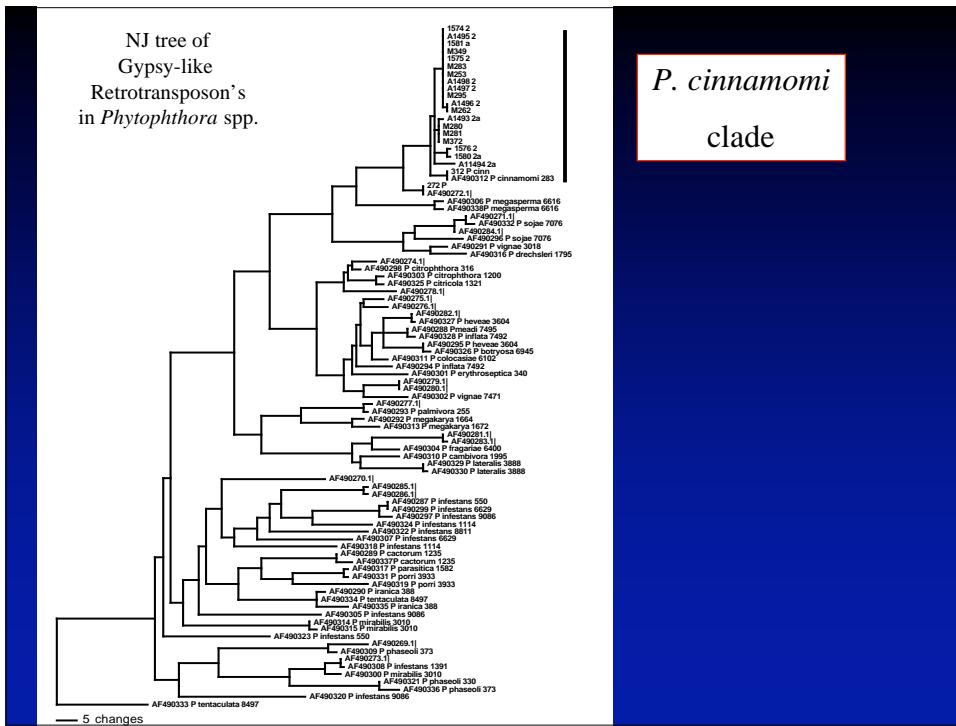


### Amplified Fragment Length Polymorphism



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1000110110110000  
0111111011110110  
0000011010001100
```





## Rootstock breeding program

Breeding blocks; recently replanted with the newest UC varieties and also include Dusa, are now sizing up and producing.

The rootstock collection at south coast is creating one big breeding block. Every year our number of seeds screened will increase.

## Rootstock breeding program

We are now implementing "molecular methods" for the rootstock research.

We now remove the seed from the screening plants and subject them to root rot conditions longer before making selections.

## Rootstock breeding program

The rootstock test plots have Thomas and Dusa. One new plot has a treatment of Thomas with fungicide and without out for further evaluation.

Focusing on more challenging plots with strong p.c. pressure. Dropping plots with low to no p.c. pressure quicker.

## Rootstock breeding program

Getting closer to releasing the PP #4 Zentmyer,PP # 14 Uzi, and PP # 24 Steddom. This will give growers more rootstock options.

Setting up plots with 200/to 220 trees resulting in 10 or 11 varieties in test. Focusing on getting more material out to the field faster to screen out the weak and problem selections faster. Dropped the component analysis because it wasn't effective.

## Rootstock breeding program

Brandon is now keeping better records including using spreadsheets to track all varieties progress, and using e-mail to connect with growers better.

## Acknowledgements

- California Avocado Commission & Avocado growers
- Brokaw & C&M Nurseries
- Root rot crew: Brandon McKee, Elinor Pond, & Erin Fuller
- Mary Lu Arpaia
- Gary Bender
- Ben Faber

