

# Rootstocks for Lemons – Data from Older Trials

Mikeal Roose, Claire Federici, Ricki Kupper and Zach Thomas  
Botany and Plant Sciences, University of California, Riverside

# Choosing a Rootstock

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- Consider scion
  - Compatibility (important for lemons)
  - intrinsic fruit quality (internal quality differs for lemons)
  - fruit size (reduction desirable for late navels)
- Stresses likely present
  - Soil (calcareous, salinity, drainage)
  - Climate (freeze probability)
  - Diseases (Phytophthora, citrus nematode, CTV, HLB)
- Probable harvest date (late harvest-granulation issue)
- Eliminate unacceptable choices
- Local experience is the best guide!

# Citrus Rootstocks in California

Major rootstocks	Minor rootstocks	New Rootstocks
Carrizo/Troyer	C32 citrange	Bitters (C22)
C35 citrange	Benton citrange	Carpenter (C54)
Rich 16-6 trifoliolate	African shaddock x Rub. trifoliolate (ASRT)	Furr (C57)
Rubidoux trifoliolate	Sun Chu Sha	X639
Pomeroy trifoliolate	Sweet orange	Trifeola
Swingle	Grapefruit (343 etc.)	US 812
Sour orange	Taiwanica	US 852
Rough lemon (Schaub etc.)	Rangpur	Forner-Alcaide 5?
Volkameriana		<b>US 942</b>
Cleopatra		<b>others</b>
Macrophylla		

# Effects of Citrus Rootstocks on Tree Performance, Disease Resistance and Fruit Quality

Rootstock	Yield/ Tree	Tree size	Tristeza declines	Phytoph- thora	Citrus nematode	Calcareous soils
Carrizo/Troyer	I-H	I-Lg	T	I	S/T	P-I
C35	I-H	I	T	T	T	P
Swingle	I	I	T	T	T	P
Trifoliata	I-H	I-Lg	T	T	S/T	P
Cleopatra	L-I	Lg	T	S	S	I
Sour orange	I-H	I-Lg	S	T	S	G
Rough lemon	I-H	I-Lg	T	S	S	G
Volkameriana	H	Lg	T	S	S	G
Macrophylla	H	I	S/T	T	S	I

Key: G=good, H=high, I=intermediate, L=low, Lg=large, P=poor, S=susceptible  
Sm=small, T=tolerant.

# Effects of Citrus Rootstocks on Tree Performance, Disease Resistance and Fruit Quality

Rootstock	Salinity	Poor soil drainage	Freeze Tolerance	Incompatible scions	Fruit Quality
Carrizo/Troyer	P	I	G	EL, FN?	G
C35	P	I	I	EL?, FN?	G
Swingle	P	P	G	EL, O?	G
Trifoliolate	P	G	G	EL, FNN	G
Cleopatra	G	P	O		I
Sour orange	G	G	G		G
Rough lemon	I	I	P		P
Volkameriana	I	I-G	P		P
Macrophylla	I	?	P	EL, LL	P

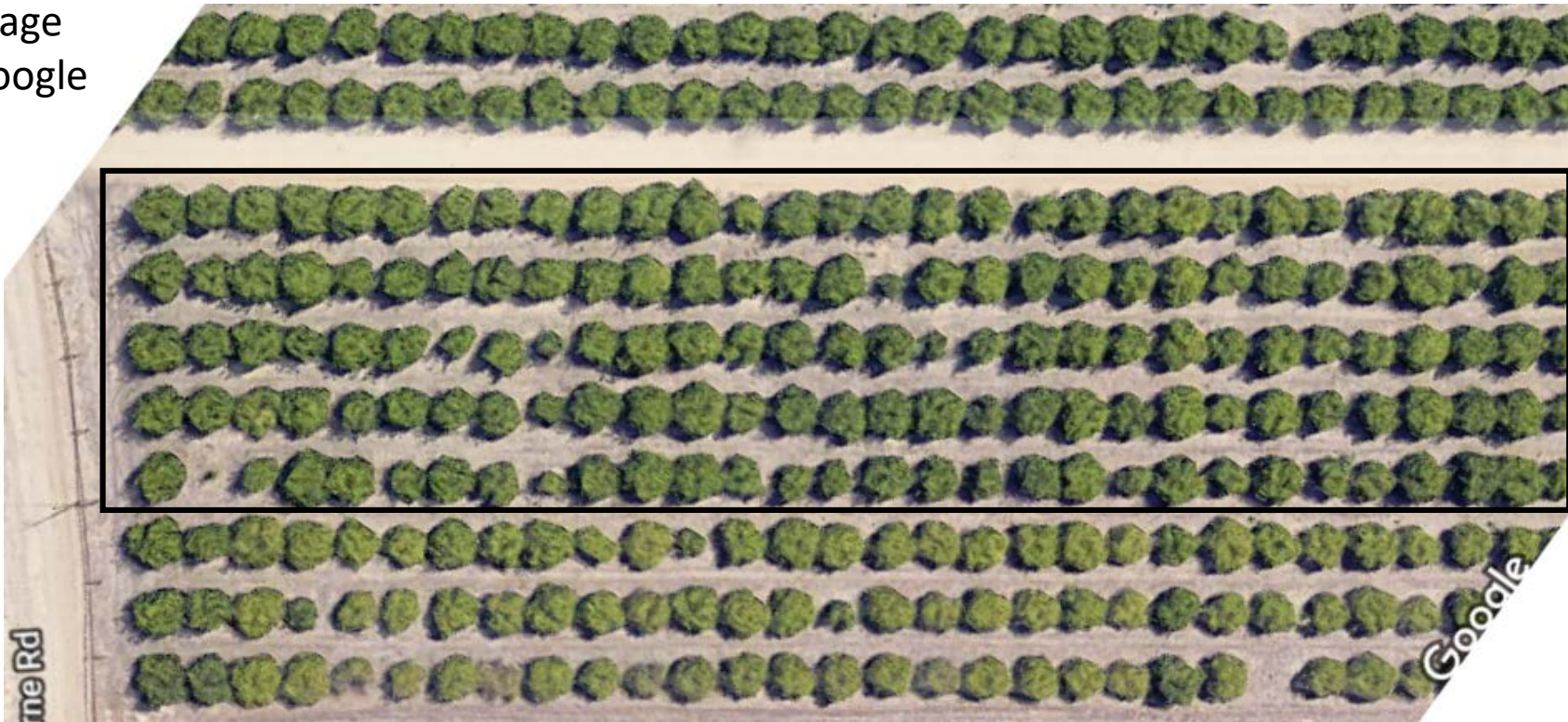
Key: G=good, H=high, I=intermediate, L=low, Lg=large, P=poor, S=susceptible  
 Sm=small, T=tolerant. EL=Eureka lemon, LL=Lisbon lemon, FNN=Frost nucellar  
 navel, FN=Fukumoto navel, O=Oranges (all)

# Limoneira Lower 28 Trial (1989 planting)

2019 image  
from Google

Lisbon

Eureka

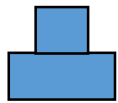


- Cooperator: Limoneira
- Limoneira 8A Lisbon on 14 rootstocks
- Allen Eureka on 13 rootstocks
- Yield data only for 2000-2005
- Rootstocks had only minor effects on distribution of ripe fruit during the year

# Bud Union Ratings

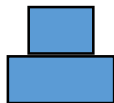
- We rate the bud union of each tree visually, with occasional validation by measuring circumferences.
- The rating scale is given below

Rating: 1



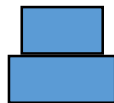
Ratio: 0.50

2



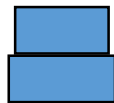
0.62

3



0.75

4



0.87

5



1.00

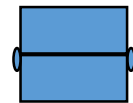
6



Scion

overgrowth

7



Bulge



SKFD



C35



VOLK



SBRD



MAC



MAC



RGST



CARP



CLEO

SKFD=Sunki x Flying Dragon  
 SBRD=Santa Barbara red lime  
 RGST=Rangpur x Sw. trifoliolate  
 CARP=Carpenter (C54)  
 CLEO = Cleopatra

Lisbon lemon rootstock trial (Limoneira Lower 28), planted 1989.

15 trees per rootstock in 3 reps of 5 trees/plot. Green – top 4, yellow=bottom 4

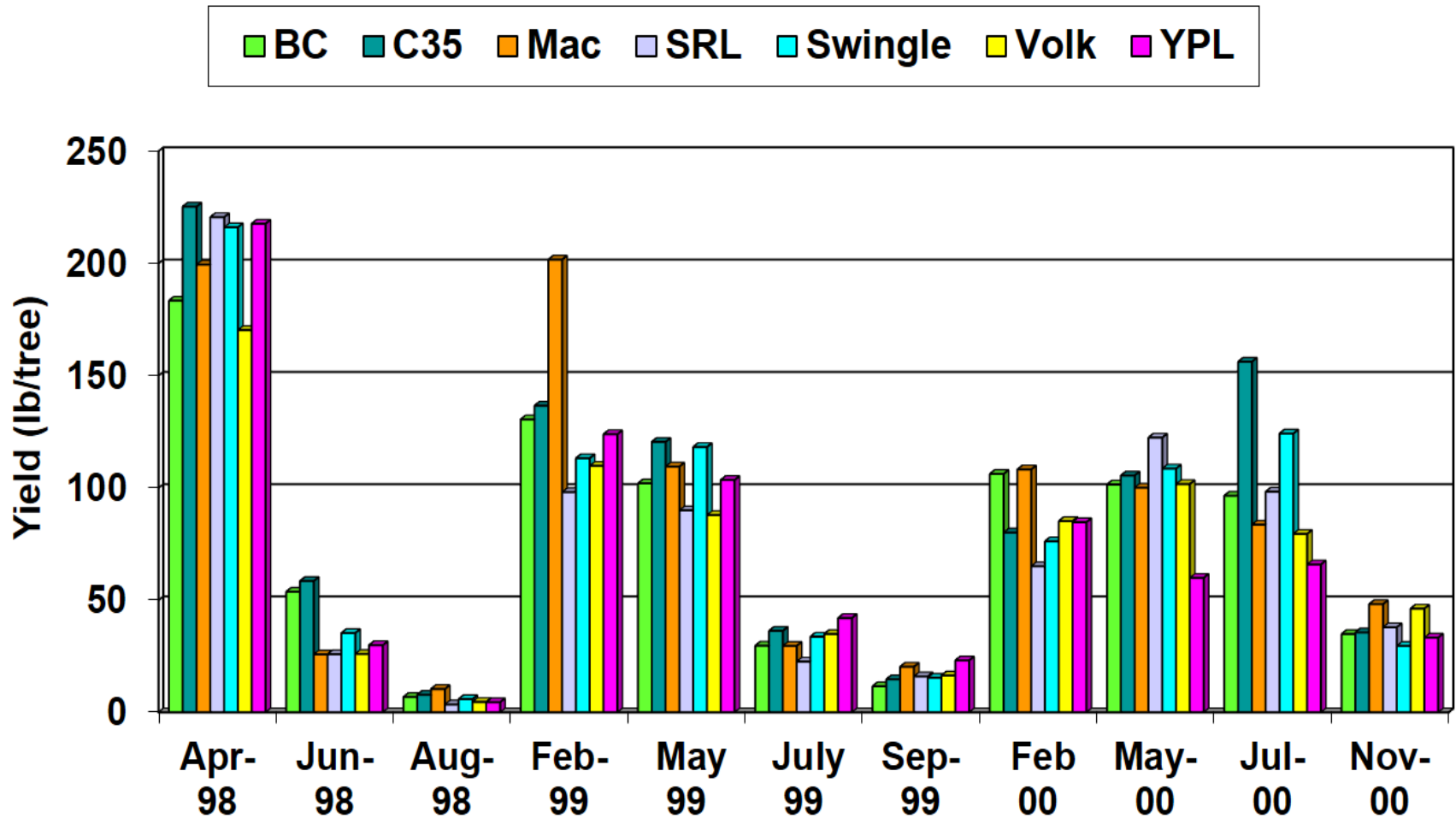
stock	2015 Tree Survival of 15	95-00 Total Yield lb/tree	2015 Canopy Volume m3	2015 Chlorosis Rating (0-5)	2012 Health Rating (0-5)	2015 Health RatingA (0-5)	2015 Health RatingB (0-5)	2015 Union Rating (0-7)	2015 Sucker Rating (0-3)
Benton citrange	14	1690.4	18.42	0.32	3.50	2.89	2.70	3.68	0.21
C32 citrange	8	1631.0	27.26	0.50	3.60	3.50	1.86	3.25	0.38
C35 citrange	14	1839.0	19.06	0.39	3.61	3.39	3.17	3.36	0.14
India lemon	15	1474.4	32.50	2.03	2.89	2.97	2.97	5.18	1.33
Koethen orange	10	1651.5	29.03	0.65	3.43	3.55	2.37	6.70	0.30
Macrophylla	10	2077.4	25.62	0.05	4.25	3.80	2.53	5.55	0.00
Rangpur x Troyer	14	1575.6	20.94	0.54	3.44	2.96	2.77	6.07	0.00
Schaub rough lemon	15	1642.7	29.81	1.57	3.33	3.00	3.00	4.54	1.67
Sun Chu Sha	9	1449.3	23.72	2.28	3.29	2.83	2.33	5.75	1.08
Swingle citrumelo	13	1834.7	24.85	0.42	3.78	3.88	3.37	2.58	0.84
Tosu	11	1309.8	28.71	0.82	3.58	3.64	2.67	3.46	0.81
Vangasay	15	1614.1	29.19	1.50	3.11	3.10	3.10	6.57	0.73
Volkameriana	13	1675.2	35.07	1.96	3.33	3.08	2.67	5.18	0.36
Yuma Ponderosa	9	1835.5	29.47	0.28	3.71	3.56	2.13	5.06	0.78
LSD(0.05)		187.9	2.97	0.68	0.48	0.33	0.97	0.54	0.59
F-test significance		***	****	****	**	****	*	****	****

Notes –Bark cracking was not significant and very few Lisbon trees expressed this. Canopy volume in cubic feet using Florida equation is value shown in table x 16.848.

2015 Health Rating A treats dead trees as missing and Health Rating B treats dead trees as having 0 health. Sucker rating is 0=none, 1=1-3 suckers, and 3 as >3 suckers.



# Seasonal Yield of Limoneira 8A in Lower28 Rootstock Trial



BC = Benton citrange, SRL=Schaub rough lemon, YPL=Yuma Ponderosa lemon

Figure 1. 2015 photos of bud-unions of 26-year-old Limoneira 8A  
Lisbon lemon on various rootstocks.  
Copper/paint on trunks to repel snails.



C35

India  
lemon

Schaub  
rough lemon

Rangpur  
x Troyer

Yuma  
Ponderosa  
lemon

Volkameriana

Sun Chu Sha



Macrophylla

Koethen  
orange

Tosu

C32

Benton  
citrange

Vangasay  
Rough lemon

Swingle  
citrumelo

Allen Eureka lemon rootstock trial (Limoneira Lower 28), planted 1989.

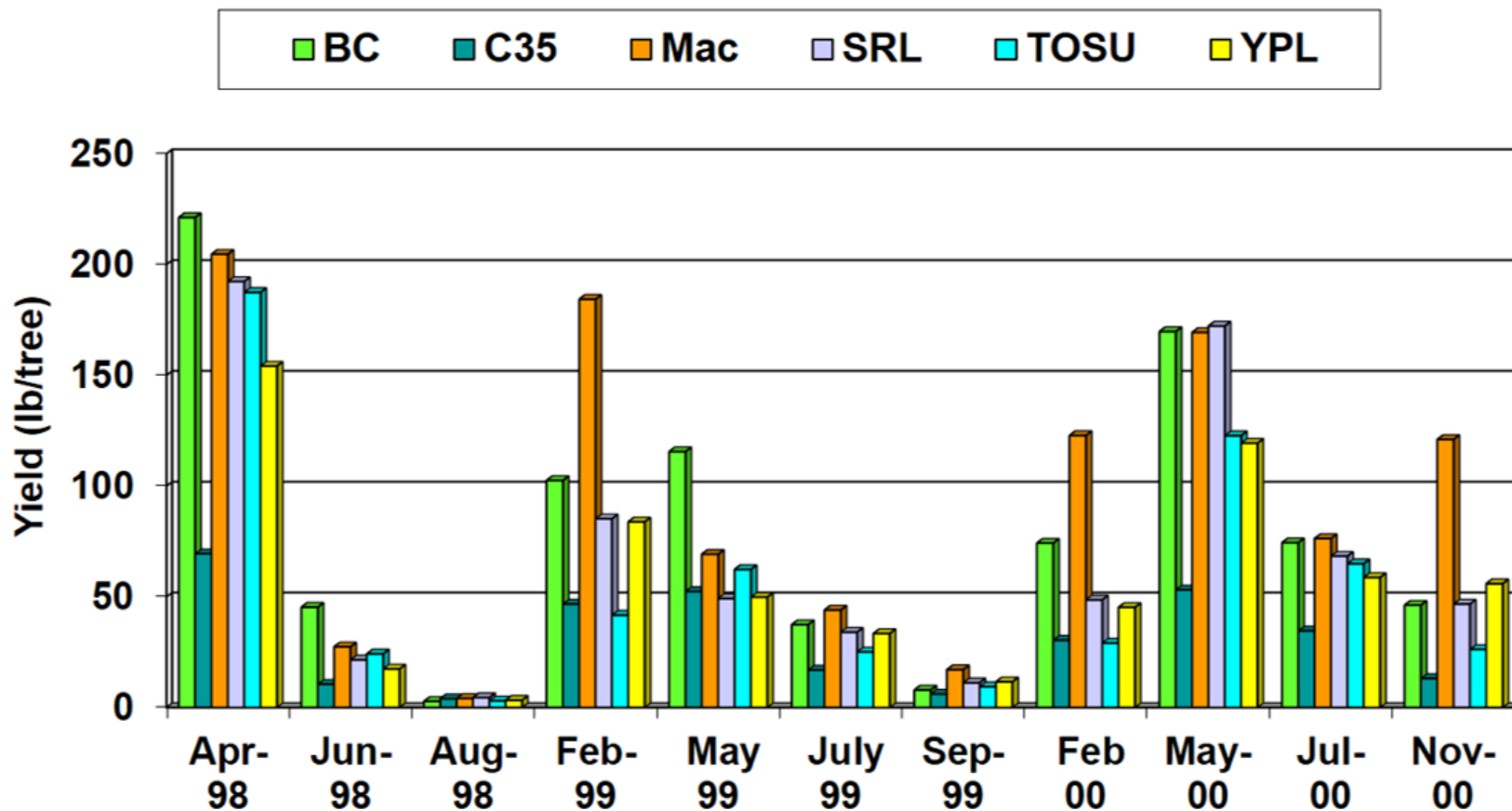
9 trees per rootstock in 3 reps of 3 trees/plot. Green – top 4, yellow=bottom 4

stock	2015 Tree Survival of 9	95-00 Total Yield lb/tree	2015 Canopy Volume m3	2015 Chlorosis Rating (0-5)	2012 Health Rating (0-5)	2015 Health RatingA (0-5)	2015 Health RatingB (0-5)	2015 Union Rating (0-7)	2015 Bark Cracking Rating (0-5)
Benton citrange	8	1793.1	20.19	0.38	3.22	2.94	2.61	4.00	2.06
C32 citrange	7	1733.4	25.84	0.29	3.00	3.29	2.56	3.07	3.36
C35 citrange	3	1838.1	31.42	0.17	3.83	3.33	1.11	3.17	2.17
India lemon	8	1349.6	28.58	3.44	2.88	2.13	1.89	5.64	4.44
Koethen orange	6	1544.3	29.50	1.00	3.58	3.17	2.11	6.33	2.75
Macrophylla	9	2034.3	21.73	0.39	2.61	2.50	2.50	6.11	3.83
Rangpur x Troyer	9	1572.2	18.90	0.44	2.89	2.56	2.56	6.00	1.44
Schaub rough lemon	8	1440.6	29.88	1.56	2.88	2.50	2.22	6.75	3.13
Sun Chu Sha	7	1229.4	21.33	1.29	2.86	2.71	2.38	6.00	2.86
Tosu	8	1345.0	27.38	0.50	3.13	3.25	2.89	3.19	2.81
Vangasay	9	1569.7	26.07	1.67	3.06	2.78	2.78	6.44	3.11
Volkameriana	9	1417.9	28.83	2.00	2.94	2.72	2.72	5.89	2.61
Yuma Ponderosa	7	1708.4	28.48	0.14	3.57	3.14	2.44	6.25	3.14
LSD (0.05)		242.8	5.82	0.93	0.40	0.43	1.08	0.76	1.04
F-test significance		***	***	****	***	****	0.16	****	***

Note – Sucker ratings are also significant. Canopy volume in cubic feet using Florida equation is value shown in table x 16.848.

2015 Health Rating A treats dead trees as missing and Health Rating B treats dead trees as having 0 health. Bark cracking – probably shell bark. 5 = nearly girdled

# Seasonal Yield of Allen Eureka lemon in Lower 28 Rootstock Trial



\* (6 of 9 trees on C35 died early in the trial, possibly due to incompatibility with Eureka. These trees are recorded as having 0 yield.)

BC = Benton citrange, SRL=Schaub rough lemon, YPL=Yuma Ponderosa lemon

# 2015 photos of bud-unions of 26-year-old Allen Eureka lemon on various rootstocks.

Copper/paint on trunks to repel snails.



C35

India  
lemon

Schaub  
rough lemon

Rangpur  
x Troyer

Yuma  
Ponderosa  
lemon

Volkameriana

Sun Chu Sha



Macrophylla

Koethen  
orange

Tosu

C32

Benton  
citrange

Vangasay  
Rough lemon

Bark shelling limited to scion in most cases, occurs on India lemon rootstock tissue

# Replant trial at Rancho Maria for Limoneira 8A Lisbon



Benton citrange

Cooperator: Jerry Friedrich

Sept. 2018 photos

ASRT



Bitters



Schaub RL



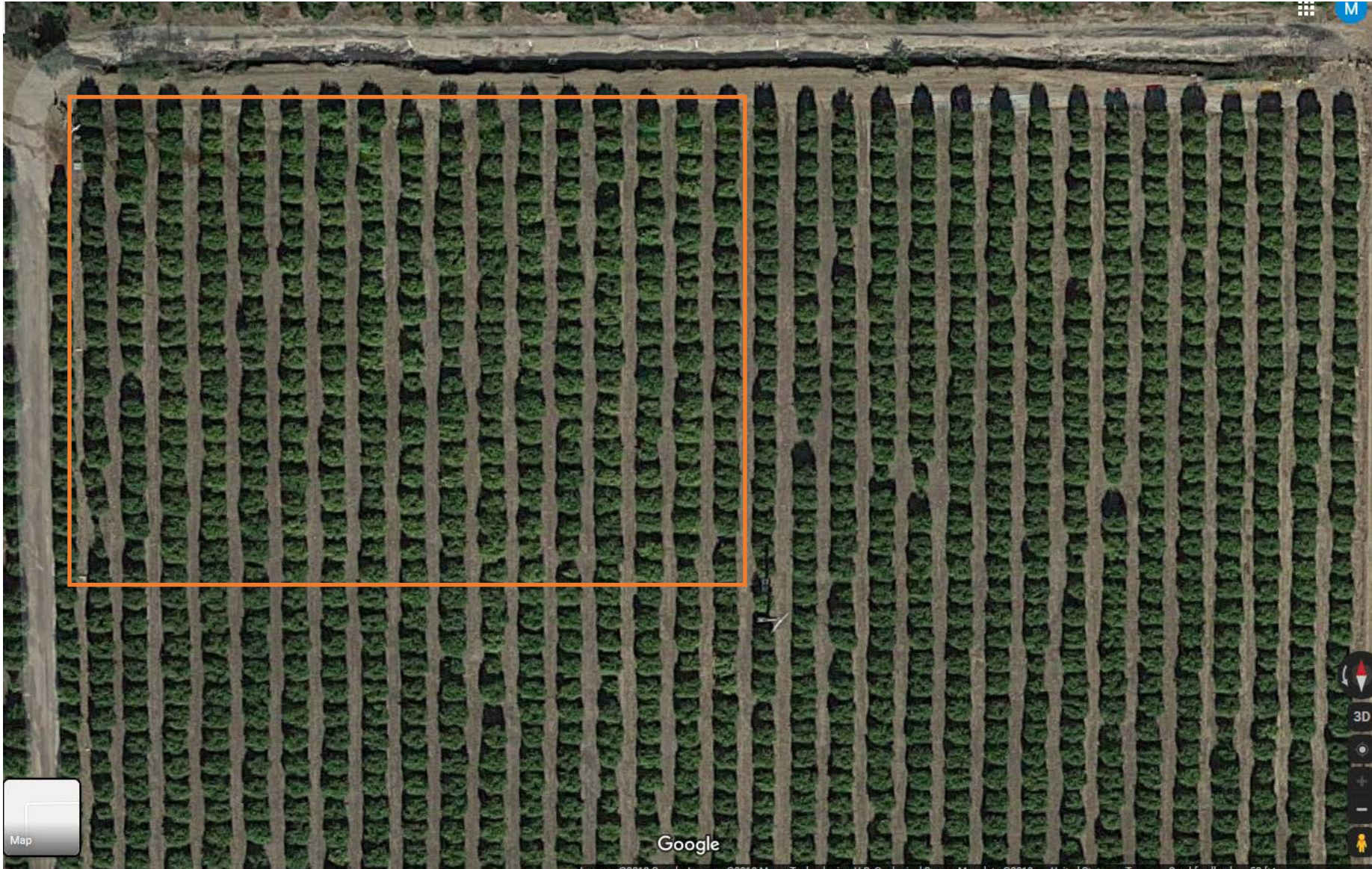
Swingle



Carrizo



# Rancho Maria Rootstock Trial – Planted 1993, 2019 image

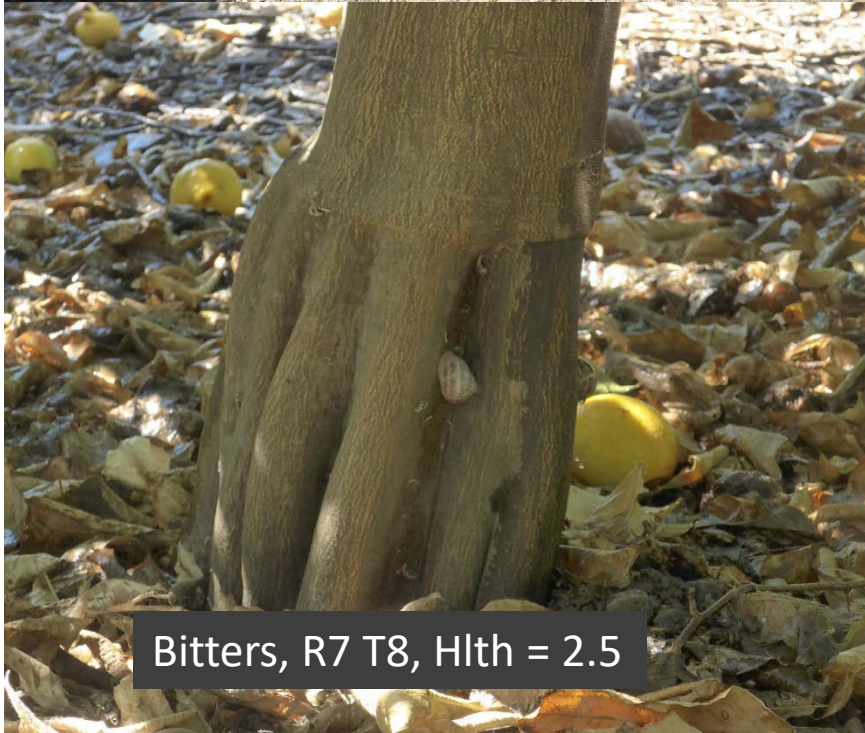




343 Grapefruit (R1, T7, Hlth = 3.50)

Swingle citrumelo (R7, T4, Hlth = 4.0)





Bitters, R7 T8, Hlth = 2.5



C35, R8 T6, Hlth = 2.5



ASRT, R7 T5, Hlth = 4.0



Carrizo, R8 T8, Hlth = 3.5



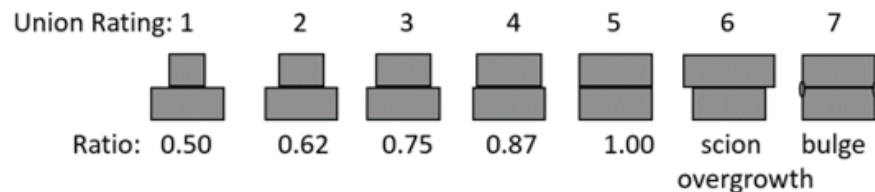
Swingle citrumelo (R11, T7, Hlth = 4.5)



Benton citrange (R8, T5, Hlth = 2.0)

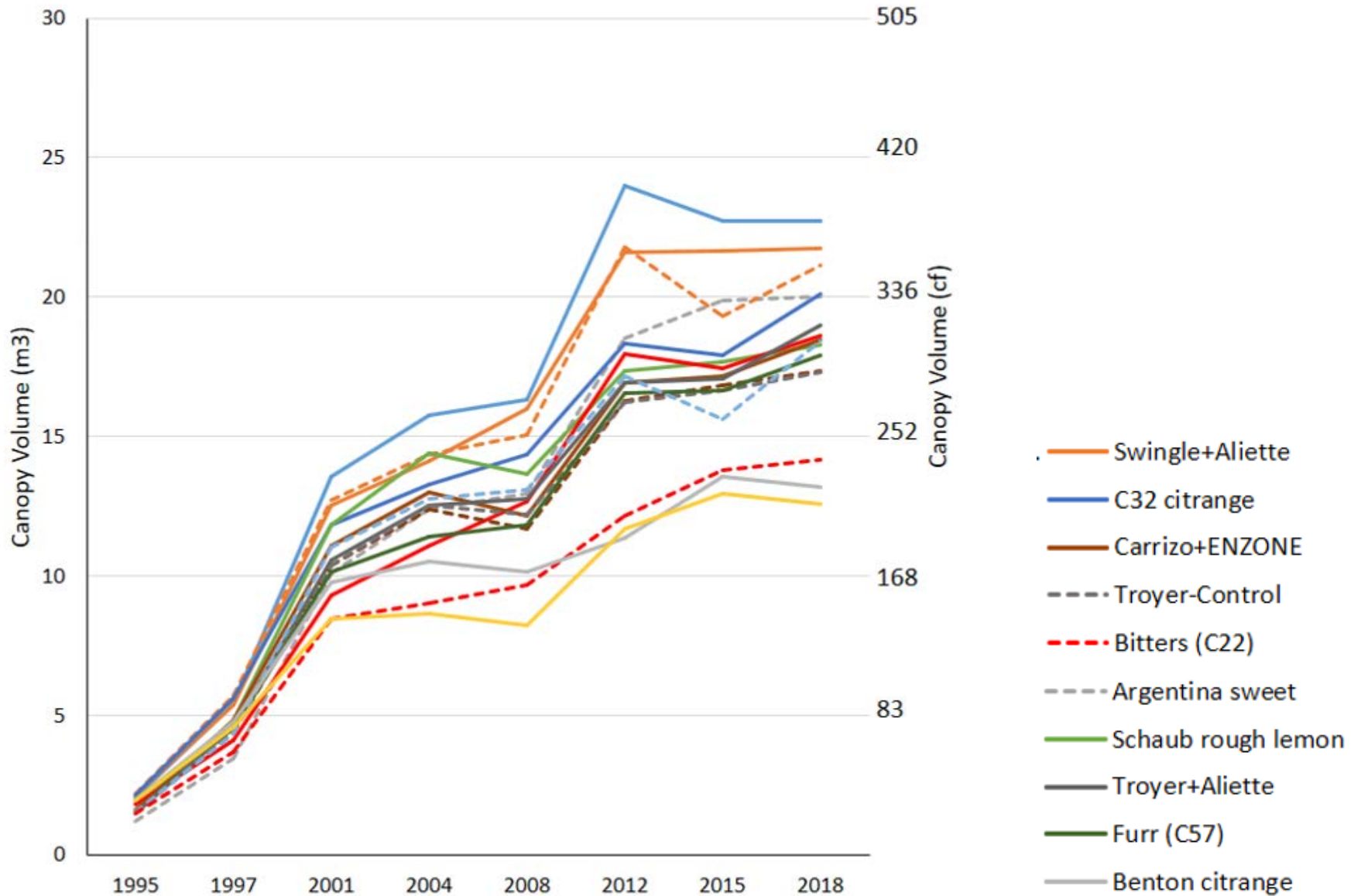
- Santa Paula Limoneira 8A Lisbon Replant trial
- Planted 1992
- 20 replications
- Not fumigated
- Aliette and ENZONE tested
- No yield data
- Ranked by canopy volume
- Top 4 in green
- Bottom 4 in yellow
- Health Rating treats dead trees as missing
- Health Rating B treats dead trees as 0 health

Stock	2018 Survival %	2018 Height (m)	2018 Canopy Volume (cf)	2018 Health Rating (0-5)	2018 Health RatingB (0-5)	2018 Chlorosis Rating (% leaves)	2018 Union Rating
Afr. Shad. x Rub. trif.	70	9.81	383	4.07	2.85	33.9	3.29
Swingle+Aliette	90	9.78	366	4.25	3.83	26.4	2.08
Swingle-Control	80	9.71	355	4.31	3.45	25.0	2.06
C32 citrange	85	9.55	338	3.85	3.45	45.6	3.22
Argentina sweet	85	9.68	336	3.82	3.42	54.4	5.00
Obovoidea	75	9.42	313	3.70	2.92	43.3	4.50
Carrizo+ENZONE	80	9.45	310	3.50	2.80	70.3	3.47
343 grapefruit	53	9.51	309	3.40	1.79	75.0	4.30
Schaub rough lemon	85	9.32	307	3.06	2.74	70.6	4.66
Troyer+Aliette	75	9.42	319	3.60	2.70	60.0	3.33
Furr (C57)	95	9.51	301	3.74	3.55	43.4	3.63
Carrizo-Control	75	9.42	292	3.43	2.58	68.3	3.60
Troyer-Control	75	9.35	291	3.53	2.65	65.0	3.53
Bitters (C22)	100	8.83	238	3.13	3.13	66.5	4.29
Benton citrange	100	8.46	224	2.58	2.58	86.2	3.95
C35 citrange	85	8.69	211	2.68	2.28	91.2	3.03
F-test (p)		****	****	****	****	****	****
LSD(0.05)		0.26	27.5	0.33	0.87	17.0	0.32



# Santa Paula Lisbon Lemon Replant Trial

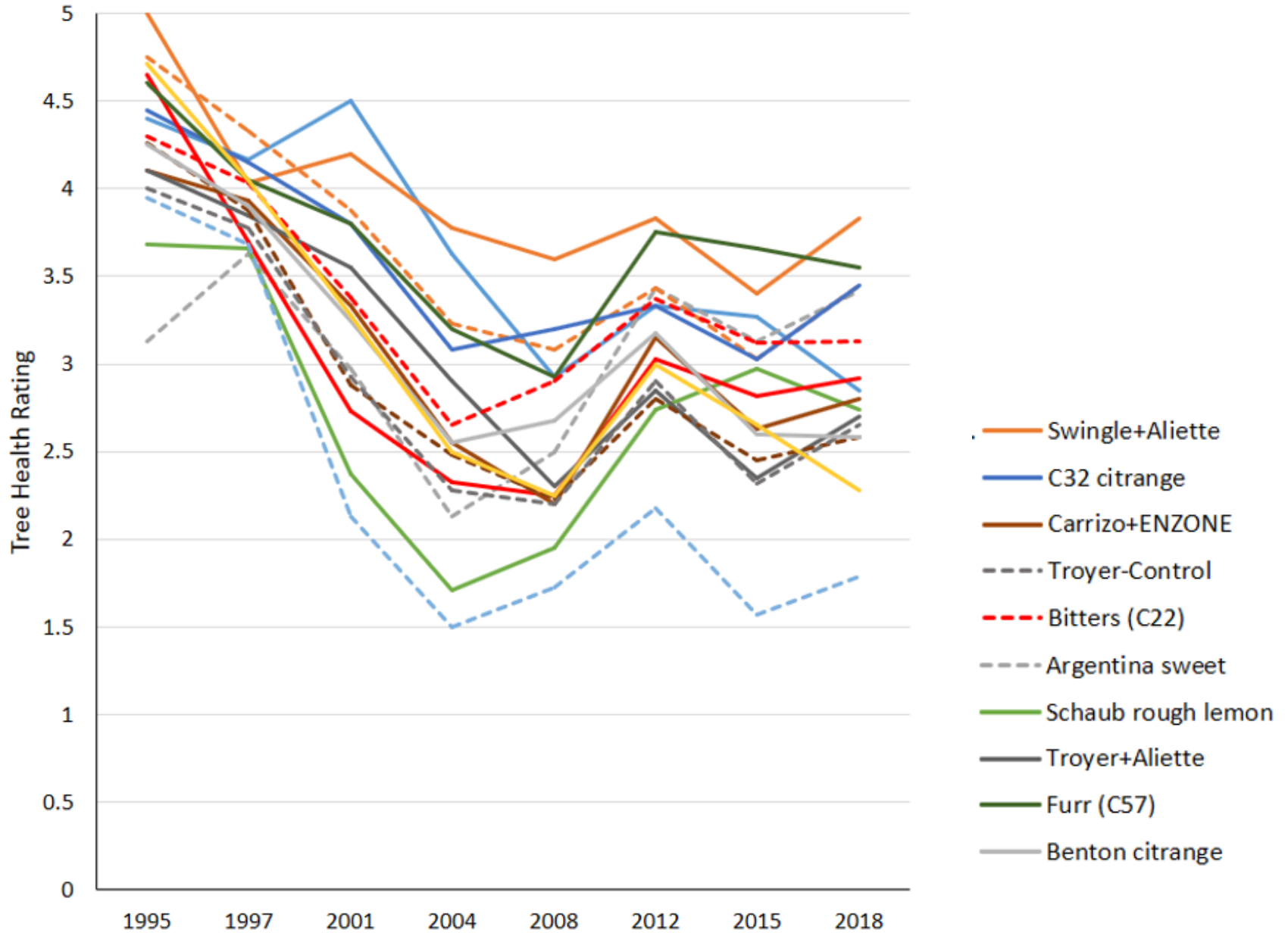
## Canopy Volume of Surviving Trees



# Santa Paula Lisbon Lemon Replant Trial

## Tree Health Rating on (0-5) Scale

Dead trees as 0 health



# Recommendations

- Macrophylla remains a top choice for Eureka but trees may not be long-lived
- Swingle seems appropriate for Lisbon but long-term (30 year?) compatibility is an issue
- Bitters, C35 and Benton are somewhat dwarfing and could be useful in high densities
- C32 could be useful with Eureka – need more long-term observations
- HLB tolerance – root health is very important, ability to regenerate phloem
- Some rootstocks available in CA with evidence of tolerance: Furr (C57), X639, C146 (soon)