

FINAL REPORT Covering FY2010Agency: California Citrus Nursery Board Agreement No.: R00-10AFiscal Year: 2010 Project Completion Percentage: _____Project Leader: Mikeal L. RooseLocation/Department: Botany and Plant Sciences, University of California, Riverside, CA 92521Phone: 951-827-4137 Fax: 951-827-4437 E-Mail: mikeal.roose@ucr.eduProject Title: Citrus Rootstock Breeding and Evaluation**Project Objectives and Timetable:**

The original proposal outlined 8 major objectives for 2010. These are listed below with summaries of results. We expect to complete all except one (additional iron chlorosis screening) which was deleted due to a budget reduction of about 25% after allowing for CCNB funding.

FY2010 Progress and Findings:

The report below includes some results from experiments started in previous years but not completed until after the 2009 report was submitted.

1) Evaluation of existing rootstock trials. Nine trials were scheduled for evaluation (tree size measurements, health, budunions etc.) during the current year and eight have been completed. Only the Moro trial at Woodlake has not been completed. On this the tree health, chlorosis, crop and budunion ratings were recorded but canopy volume has not yet been measured. We purchased a handheld computer with GPS for field data entry and have used this successfully to collect data on five trials. This avoids the labor needed for a separate data entry step. Data from four trials has been analyzed and these results are summarized in the attached tables. We had hoped to convert the Lindcove Atwood and Lane Late trials to regulated deficit irrigation trials, but after discussion with irrigation specialists we concluded that these trials do not have sufficient replication to provide an informative experiment. The Atwood trial has been terminated and half of the Lane Late trial is also terminated.

Evaluation of the Fukumoto trial indicates no clear differences in tree health between trees propagated with budwood from healthy and declining groves. Most trees are in good health after 5 years. Perhaps additional time is needed to detect decline symptoms. A more detailed summary and table is on the attached sheet.

2) Propagate trees for new trial to test early bearing and adaptation to high intensity management. Seedlings of 28 rootstocks were budded with Washington navel and budding was completed in October. They should be ready for field planting in spring or early summer of 2011. Rootstocks to be included in this trial are listed below:

African Shaddock x Rub. trifoliolate	Furr (C57)	Shekwasha x Eng.trifoliolate
Argentine Sweet	Macrophylla	Sta Barbara Red Lime
Bitters (C22)	Obovoidea	Sun Chu Sha
Brazil sour	Pomeroy trifoliolate	Sunki X Flying Dragon
C146	Rangpur x Marks trifoliolate	Swingle
C35	Rangpur x Shekwasha	Tosu
Carpenter (C54)	Rangpur x Swingle trifoliolate	Volkameriana
Carrizo	Rich 16-6 trifoliolate	Yuma Ponderosa Lemon
Cleo	Rubidoux trifoliolate	
Flying Dragon	Schaub rough lemon	

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3) Screen selected new hybrids for nucellar embryony. Seeds of 24 standard and new or introduced rootstocks were planted to screen for nucellar embryony and for testing for Phytophthora tolerance (see 5) below). These selections have sufficient uniformity to proceed to the Phytophthora screening.

4) Iron chlorosis tolerance screening. The overall project budget was not sufficient to pursue additional iron chlorosis screening this year. However, results of the trial completed in late 2009 were not reported previously and are summarized below and in the last table attached. This trial compared a number of standard and experimental rootstocks with selected new hybrids (identified by their parentage) at 0, 5, and 15% calcium carbonate. As expected, Pomeroy and Rubidoux trifoliolate, and Swingle were among the most susceptible rootstocks with high levels of chlorosis symptoms. Sour orange, Volkameriana, Schaub rough lemon, Macrophylla and Obovoidea showed no symptoms, and Cleo and Sun Chu Sha had symptoms only at 15% calcium carbonate. Carrizo was intermediate. Bitters, C146, and several of the new hybrid selections have overall chlorosis ratings of less than 1.0, values indicative of useful levels of tolerance. Results of this seedling trial should be interpreted cautiously because not all "calcareous" soils have similar composition. For example, although we did not observe any iron chlorosis on rough lemon seedlings in this experiment, in field trials with budded trees, we have seen symptoms on this rootstock.

5) Test hybrids for Phytophthora root rot resistance. Among 38 rootstocks tested for tolerance to *P. citrophthora* in winter and spring of 2009, but not previously reported, the most tolerant included Pomeroy trifoliolate, African shaddock x Rubidoux trifoliolate and two unreleased trifoliolate hybrids. The most susceptible rootstocks were sweet orange, Carrizo, C35, Carpenter (C54), sour orange, and several other hybrids. Twenty four rootstocks were tested for tolerance to *P. parasitica* during summer and fall of 2009. Tolerant rootstocks, as judged by change in root mass after inoculation, included Tosu, Swingle, Obovoidea, Shekwasha x English trifoliolate, Macrophylla, and a new hybrid of African shaddock x Flying Dragon. Susceptible rootstocks included sweet orange, Carrizo, Santa Barbara red lime (a Rangpur type), Schaub rough lemon, Cleo and some hybrids. In this test, Volk, C35, Pomeroy trifoliolate, and sour were intermediate in tolerance. Tolerance to *P. citrophthora* and *P. parasitica* is not strongly correlated, making selection for both more difficult. Seed was collected from 24 rootstocks and hybrids to initiate a test of *P. citrophthora* during the winter of 2011. This trial is on schedule for inoculation in late January 2011.

6) Test rootstocks for salinity tolerance. Seeds of 11 standard and advanced selection rootstocks were collected and planted to produce seedlings for this test. The rootstocks to be tested are Pomeroy trifoliolate, Carrizo, C35, Brazil sour, Bitters, Carpenter, Furr, Cleo, Macrophylla, Rangpur x Shekwasha, and Shekwasha x English trifoliolate. We expect to start salinity exposure in spring 2011. The main purpose of this test is to validate the method and characterize existing rootstocks before beginning tests of newer hybrids.

7) Initiate new rootstock trials for Clementine Nules and DaisySL. Seed of 25 rootstocks was collected and planted at Lindcove to produce trees for these trials. Scions are expected to be a Clementine (probably Nules) and DaisySL (for a desert location). Seedlings of most genotypes grew well in flats through the summer, but have not grown well following transplanting to pots. Additional fertilizer treatments have been applied but most seedlings have not improved. We do not understand the cause of the recent problems in propagating trees at Lindcove. Two trifoliolate selections from Australia had poor seed germination and may not be included. These two selections were added to the trial design later and seed collected much later than the optimal period.

8) Investigate compatibility problems. We consulted with other researchers and nurseries regarding compatibility problems in satsuma, Beck navel, and Fukumoto. No new experiments were initiated this year.

Technology Transfer. Three new rootstocks were released in fall 2009: Bitters (tested as C22), Carpenter (C54) and Furr (C57). A brief description of these is on the project web site. We plan to have more detailed summaries of rootstock characteristics and additional test data on the web site during the coming year.

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Signature  Date 1/12/11

1986 Atwood Navel Orange Rootstock Trial at Lindcove.

This trial includes 21 rootstocks. Trees were planted at Lindcove in 1986 to evaluate various Rangpur types (many listed as "red lime" in the tables below) and many selections from the USDA Indio breeding program. Sour orange, Troyer, and Borneo Rangpur are standard cultivars. This is the first trial that includes many of the rootstocks from the Indio breeding program. The trial includes 6 replications with two trees of each rootstock in each replication. The soil type is a San Joaquin loam. There are areas of poor drainage where standing water is common and trees are likely stressed. Phytophthora gummosis has been a problem with some trees on Rangpur types and rough lemon. Yield data has been collected annually since 1989. Other data collected: fruit quality data on all rootstocks in 1992 and 1995, freeze damage in 1999, fruit quality on three size classes from 5 promising or standard rootstocks in 2000, and packout data from 1996 to 2009. Trees on some non-promising rootstocks, mainly Bishop red lime and Santa Barbara red lime 131, were top-worked with various low-seeded mandarin selections in 2002 to evaluate productivity of these selections when surrounded by navels that do not produce viable pollen. Therefore, the 2001-2005 fruit size data on Bishop red lime is based on fewer trees and that for Santa Barbara red lime 131 is not included in the analysis.

Conclusions - Rangpur types are not promising for this site. Sour orange and African Shaddock x Rubidoux trifoliolate are two available rootstocks that produce large trees with high yields, good fruit quality, and good packouts. Among the unreleased rootstocks, Shekwasha x English trifoliolate and Rangpur x Shekwasha are promising, with good yields, moderate tree size, and large fruit size. Rangpur x Swingle trifoliolate and Sunki x Flying Dragon are also promising, producing trees similar to or slightly smaller than those on Troyer, but having higher yields and no disadvantages in fruit quality or packout. The Sour x Cleo hybrids, selected as salt tolerant, have been disappointing. They produce dwarf trees with poor health ratings and small fruit size.

Cumulative yield per tree over entire experiment; canopy volume measured in Dec. 2009; cumulative yield to canopy volume ratio; budunion rating on scale of 1-7 (1=severe benching, 5=smooth, 6 = scion overgrowth, and 7 = bulge); and Dec. 2009 tree health rating on 0 (dead) to 5 (excellent) scale. Rootstocks ranked by cumulative yield.

Rootstock	Survival %	Yield in lb/tree					Canopy Volume m ³	Yield/ Volume lb/m ³	Union Rating (0-7)	Health Rating (0-5)
		2006	2007	2008	2009	TOTAL				
Shekwasha x Eng. trif.	100	256	391	338	331	4694	31.72	153.03	3.46	4.04
Brazil sour orange	100	276	352	308	232	4674	45.04	112.78	4.88	3.98
Afr. Shadd. x Rub. trif.	100	270	336	289	281	4452	43.10	123.20	3.25	3.92
Rangpur x Shekwasha	100	207	348	306	200	4240	30.91	144.68	3.83	3.85
Rangpur x Sw. trifoliolate	100	242	329	296	260	4021	27.08	152.98	3.50	3.96
Gomeri rough lemon	100	241	310	280	215	3884	28.65	146.06	4.09	3.71
Sunki x Flying Dragon	100	184	278	247	186	3737	19.38	197.50	3.67	3.48
Troyer	100	228	278	242	208	3688	25.68	150.73	3.75	3.71
Indio rough lemon	100	206	294	260	178	3619	24.72	150.11	4.20	3.48
4481 citrumelo	91	225	256	236	167	3296	28.27	149.63	2.75	2.82
Citrus species x OP	100	163	218	211	99	3056	24.98	126.85	3.67	3.02
Santa Barbara red lime 131	100	123	182	191	111	3054	15.49	201.53	4.83	2.54
Santa Barbara red lime 7	100	157	203	199	113	2929	17.69	172.96	4.71	2.46
Soh Jhalia rough lemon	100	143	184	197	103	2889	19.92	147.59	3.79	3.02
Philippine red lime	100	146	210	204	125	2809	15.83	182.98	4.54	2.69
Bishop red lime	83	128	218	206	115	2362	16.98	175.06	5.07	2.56
Kusaie lime	83	169	268	206	107	2587	22.71	133.16	4.50	2.27
Borneo Rangpur lime	100	103	159	144	102	2573	14.64	181.21	4.64	2.41
Australian red lime	100	145	198	165	102	2297	14.55	177.59	4.80	2.53
Sour x Cleo #79	100	104	114	118	60	1802	10.45	176.04	5.54	3.10
Sour x Cleo #22	92	33	35	36	17	717	5.76	142.64	3.75	2.25
LSD (0.05)		55	79	66	65	803	7.91	34.53	0.63	0.69

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Fukumoto Budsource Trial

2005 Fukumoto navel orange bud source x rootstock trial at Lindcove. The objective of this trial is to determine whether decline of Fukumoto on C35 and Carrizo rootstocks, as observed in some commercial groves, is bud transmissible, that is, due to genetic or pathogen factors present in some bud sources. Buds were collected from 3 source trees in each of 8 Fukumoto groves in Tulare and Kern Co. In each county, two healthy groves and two groves affected by decline were sampled. In decline-affected sites, buds were collected from declining trees. Budwood tested negative for CTV and citrus leaf blotch and, with control buds from the CCPP Foundation Block tree (LCFB), was used to propagate trees at Lindcove. Trees were propagated on C35, Carrizo, and Volk rootstocks. The experiment has 4 replicate blocks. The tables below summarize results through April 2010. Gumming was noted on some 1-2 year-old trees, but affected a relatively small percentage overall and was not associated with bud source. In 2010, nearly all trees had good or excellent tree health ratings and these did not differ significantly among rootstocks or bud sources. Trees on Carrizo were larger than those on C35 or Volk. Trees on C35 had significantly more rootstock overgrowth (benching) than trees on Carrizo or Volk. In fall 2009, the highest yield, as measured by a fruit count, was for trees on Volk. In addition, trees on Volk and C35 had significantly more rootstock suckers than those on Carrizo. Trees on C35 and Carrizo had significantly more scion sprouts growing from the bud union area than those on Volk. Trees propagated from some bud sources had more scion sprouts than others, but this was not related to whether the bud source grove was healthy or declining. Overall, there is little evidence so far that declines are bud transmitted, but decline is not always observed until trees are somewhat older than those in this trial.

Effects of rootstock on tree performance, averaged over all bud sources. Differences among rootstocks were consistent across all bud sources.

Stock	No. Trees	2007 Health Rating	2008 Health Rating	2010 Health Rating	Canopy Volume m ³	Tree Height m	Union Rating (0-7)	2009 Fruit Count
Carrizo	108	3.82	4.71	4.19	5.51	2.59	4.13	87.3
C35	107	3.80	4.56	4.03	4.86	2.44	3.32	85.0
Volk	101	3.95	4.33	3.97	4.83	2.44	4.82	129.1
LSD(0.05)	-	0.22ns	0.31	0.29ns	0.48	0.11	0.25	12.2

Tree health rating on 0-5 scale where 0 is dead and 5 is excellent. Bud union rating on scale of 1-7 (1=severe benching, 5=smooth, 6 = scion overgrowth, and 7 = bulge).

Effects of bud source on tree performance, averaged over rootstocks. Sources coded G were healthy groves, and those coded P were declining.

Bud Source	No. Trees	2007 Health Rating	2008 Health Rating	2010 Health Rating	Canopy Volume m ³	Tree Height m	Union Rating (0-7)	2009 Fruit Count
KernG1	36	3.97	4.76	4.15	5.47	2.58	4.24	118.9
KernP1	33	3.98	4.33	3.93	5.45	2.54	4.12	94.7
TulrP1	35	3.97	4.61	4.03	5.41	2.58	4.28	114.1
TulrG1	36	3.76	4.69	4.29	5.32	2.48	4.00	103.8
TulrG2	35	3.91	4.60	4.28	5.09	2.44	4.20	95.1
KernG2	35	3.84	4.38	3.99	5.04	2.58	3.86	101.3
KernP2	36	3.90	4.69	4.14	4.85	2.45	4.03	97.3
LCFB	34	3.86	4.38	3.97	4.72	2.45	4.08	89.9
TulrP2	36	3.51	4.36	3.81	4.32	2.34	3.86	90.1
LSD(0.05)	-	0.37ns	0.54ns	0.50ns	0.83ns	0.20ns	0.44ns	21.2ns

The number of dead trees ranged from 1-3 among the 9 bud sources, and was 1, 6, and 11 for Carrizo, C35 and Volk respectively. Nearly all tree death occurred within the first 2-3 years after planting.

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Elderwood Heights Orange Rootstock Trial (Calcareous Soil)

Elderwood Heights navel/Valencia orange rootstock trial, planted in 2001. Cooperator - David Roberts. Soil is generally, but not uniformly calcareous. Experimental trees were interplanted in existing grove. Due to a mix-up during propagation in a commercial nursery, experimental trees are a mixture of navels (~64%) and Valencias (~21%), with 15% not classified. The number of trees planted per rootstock varied so the column labeled "N" does not indicate tree survival. Only 13 trees had died by 2010.

As expected, Valencia trees were larger than navel trees, but effects of rootstock did not vary with scion so overall rootstock means are shown. In 2010, the largest trees (by height, since crowding by neighbors reduced the value of canopy width measurements) were on African Shaddock x Rubidoux trifoliolate, 1452, Carpenter (C54), Volk, Trifeola, and Schaub rough lemon. Small trees included trifoliolate oranges, C22, Benton, two somatic hybrids from the University of Florida, and some other hybrids. Carrizo, Furr (C57), X639 and some of the other hybrids were intermediate in size. Tree health ratings were mostly intermediate (2 – 3.4 on a 0-5 scale) with the highest ratings for Schaub rough lemon, Carpenter (C54), X639, Volk, and some hybrids. Only two experimental trifoliolate hybrids had less than 89% tree survival, but 3 of 15 trees on Sun Chu Sha were in very poor health. Rich 16-6 and 4008 trifoliolate and two hybrids had poor (less than 2) health ratings and were very chlorotic. Trees on Bitters, Furr, Cleo, two somatic hybrids and several other hybrids had little iron chlorosis. Promising rootstocks that combine good growth, health, and low chlorosis include Carpenter, Sunki x Flying Dragon, Rangpur x Shekwasha, and Cleo. The two somatic hybrids from the University of Florida program^{UF} were dwarfing, had low chlorosis and moderate health ratings. Some rootstocks, such as African shaddock x Rubidoux trifoliolate and 1452 citrumelo, grew well in spite of moderate or severe chlorosis.

Elderwood Heights calcareous soil rootstock trial with Washington navel orange scion (~21% Valencia). N indicates the number of trees measured. Bud union rating on scale of 1-7 (1=severe benching, 5=smooth, 6 = scion overgrowth, and 7 = bulge). Only two trees in the trial had ratings of 6 or 7. Health rating is 0-5 scale where 0 is dead and 5 is excellent, and mostly reflects canopy density and color. Chlorosis rating is 0-5 scale, where 0 is no chlorosis and 5 indicates 100% of leaves affected. Rootstocks ranked by tree height in 2010.

Stock	N	2010 survival (%)	2007 Height (m)	2010 Height (m)	2007 Canopy (m ³)	2010 Union Rating	2010 Health Rating	2010 Chlorosis Rating
Afr. Shad. x Rub. trif.	8	88.9	2.86	3.49	6.09	2.88	2.56	3.69
1452 citrumelo	3	100.0	3.10	3.37	5.58	4.00	2.67	4.17
Carpenter (C54)	14	100.0	2.96	3.30	6.60	3.50	3.21	2.75
Volkameriana	12	100.0	2.77	3.19	5.44	4.88	3.13	2.96
Trifeola	9	100.0	2.88	3.10	5.92	2.50	2.89	3.56
Schaub rough lemon	15	100.0	2.81	3.06	6.12	4.77	3.40	2.47
Sunki x Jac. trifoliolate	12	100.0	2.57	2.99	4.55	2.79	2.75	2.83
Rangpur x Shekwasha	16	100.0	2.43	2.96	4.16	4.44	3.13	1.38
Cleo	14	100.0	2.41	2.90	4.07	5.00	3.00	2.11
Taiwanica x trif. 2	10	100.0	2.60	2.86	4.00	2.25	3.20	2.10
C146	14	100.0	2.52	2.86	4.51	2.42	3.14	2.21
X639	15	100.0	2.38	2.83	4.31	2.65	3.17	2.40
Taiwanica x trif. 5	10	100.0	2.67	2.83	4.22	2.55	2.95	2.80
Shekwasha x Eng. trif	15	100.0	2.34	2.72	3.77	3.29	2.87	2.77
Yuzu x trif	12	92.3	2.54	2.70	4.54	3.00	2.73	2.38
Carrizo	10	90.9	2.43	2.64	3.51	3.00	2.45	3.55
Furr (C57)	13	92.9	2.36	2.64	4.37	2.64	2.82	2.15
Wilking x trif.	8	75.0	2.51	2.62	3.09	2.75	1.67	3.17
Sunki x FD trif	13	92.9	2.34	2.58	5.27	2.38	3.07	1.73
Sun Chu Sha	15	100.0	2.49	2.51	3.86	4.70	2.30	3.47
Siam pumm x trif	7	100.0	2.26	2.50	3.41	3.38	2.36	3.57
Rang x Marks trif 1	7	75.0	2.26	2.47	2.89	3.30	1.69	4.00
C35	15	100.0	2.22	2.45	3.12	2.33	2.60	2.53
Nova+HB pumm. ^{UF}	6	100.0	2.00	2.38	3.14	3.92	3.00	1.75
Brazil sour x Cleo	14	100.0	2.14	2.29	3.47	3.04	3.00	2.21
Rich 16-6 trif.	12	92.3	1.92	2.15	1.92	2.83	1.81	4.29
Benton citrange	14	100.0	1.96	2.07	2.71	3.23	2.46	3.36
C22 (Bitters)	16	100.0	1.69	2.06	2.35	3.81	2.88	1.47
Sour+Carrizo ^{UF}	15	100.0	1.69	2.05	2.11	3.23	2.90	1.83
Rang x Marks trif 2	11	91.7	1.68	1.85	2.16	3.40	2.33	2.68
Sauvage sour x Cleo	8	100.0	1.56	1.61	1.09	3.71	1.88	3.00
4008 trifoliolate	10	90.0	1.51	1.47	0.98	2.33	1.20	4.83
LSD (0.05)			0.38	0.44	1.33	0.51	0.59	0.65
F-test (GLM)			***	***	***	***	***	***

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Lane Late Navel Trial at Woodlake

Lane Late navel orange rootstock trial at Woodlake (Redbanks). Cooperator: Griffith Farms. Trial planted in 1990. Eight trees per rootstock, 2-tree plots. Rootstocks with "HRS" and "F80" names are selections from the USDA breeding program in Florida. Total yield is cumulative yield per tree for all harvests 1995-2006 except 1996 and 2003 harvests were not recorded. Conclusions: Health ratings of most trees were good (3.5-4.0) and tree losses were low. When the trees were 20 years old, in 2010, the largest trees were on Sun Chu Sha mandarin, C32, Carrizo and Furr (C57). Small trees were those on Flying Dragon trifoliolate, HRS811, HRS812, and HRS807 rough lemon. Lemon type rootstocks generally had high yields relative to tree size, but also had many suckers. Larger numbers of suckers were also seen on trees on HRS811, HRS 827, and a Rangpur x Swingle trifoliolate hybrid. Bud unions of HRS811 and Flying Dragon had extreme rootstock overgrowth that likely predicts an eventual compatibility problem. Limited data from this trial and from a similar trial at Lindcove show that fruit from trees on lemon type rootstocks (Yuma Ponderosa, rough lemon, and Volk) often have high levels of granulation when fruit are held into May. Overall, if large trees are acceptable, Sun Chu Sha is a good choice. Carrizo and Troyer were only slightly less productive. For high density plantings, HRS827, Rich 16-6, and Benton produced smaller trees with good yield related to tree size.

Lane Late navel rootstock trial at Woodlake. Trial planted in 1990. Canopy volume was measured and trees were rated for various traits in May 2010. Yield/canopy volume ratio is calculated using 2006 canopy volume since yield data collection stopped in 2006. Bud union rating on scale of 1-7 (1=severe benching, 5=smooth, 6 = scion overgrowth, and 7 = bulge). Sucker count is count of number of living rootstock suckers per tree in May 2010 except that trees with > 10 suckers were given a value of 11. Tree health rating is on a 0 (dead) to 5 (excellent) scale and mostly reflects canopy density and color. Rootstocks ranked by total yield.

Rootstock	Yield (lbs/tree)				2006 Canopy Volume (m ³)	2010 Canopy Volume (m ³)	Yield/ 2006 C. Vol. (lb/m ³)	2010 Union Rating	2010 Sucker Count	2010 Health Rating
	2004	2005	2006	Total						
Yuma Ponderosa	309	651	404	3038	34.44	46.89	91.70	4.42	3.00	4.17
Sun Chu Sha mandarin	282	691	410	2903	45.81	65.07	63.97	5.00	1.29	4.21
Volkameriana	263	671	375	2869	30.81	45.67	94.84	4.60	5.00	3.92
Carrizo	316	590	370	2865	44.18	56.45	65.95	3.56	0.00	4.19
C32 citrange	278	578	415	2850	43.40	59.94	66.53	3.21	0.43	4.07
Troyer	243	582	342	2610	41.62	49.57	64.18	3.57	0.14	4.43
F80-18 citrumelo	223	599	348	2547	38.50	45.62	67.24	2.63	2.25	3.75
C146 Sunki x trifoliolate	158	566	370	2424	31.07	45.19	81.90	2.50	2.38	3.81
HRS827 Rangpur x trif.	138	579	322	2406	27.66	39.26	88.41	3.21	6.14	4.07
Schaub rough lemon	234	533	326	2379	21.60	36.73	112.08	nd	9.14	3.93
Sour orange	117	607	420	2318	32.14	47.62	72.70	4.67	3.25	3.88
F80-08 citrumelo	161	547	345	2281	28.55	39.10	80.55	3.81	3.13	3.69
Rich 16-6 trifoliolate	239	539	207	2266	23.41	36.35	97.30	3.43	0.29	3.57
Benton citrange	240	486	226	2228	23.20	35.59	99.16	3.30	4.00	3.50
Furr (C57)	156	524	279	2169	34.29	50.59	65.62	2.81	1.38	3.69
Rangpur x Sw. trifoliolate	133	528	284	2154	29.21	42.07	74.93	3.40	10.13	3.75
C35 citrange	99	507	307	2111	29.19	39.48	74.80	3.07	0.57	3.57
Carpenter (C54)	119	439	307	2111	36.77	47.75	58.93	3.17	5.17	3.75
Bitters (C22)	149	533	273	2108	25.28	41.17	83.59	3.69	2.25	3.75
Pomeroy trifoliolate	214	421	231	2069	26.79	33.12	82.79	2.44	4.25	3.56
HRS801 Changsha x trif.	136	546	255	1993	34.53	48.76	58.43	3.40	2.60	3.90
HRS807 rough lemon.	116	460	265	1971	15.95	23.41	124.98	4.50	10.67	3.33
Rangpur x Troyer	123	452	256	1961	24.67	30.17	81.56	5.44	3.00	3.69
Rubidoux trifoliolate	126	504	231	1953	22.89	32.51	83.02	3.31	1.00	3.75
HRS804 citrange	136	452	262	1947	21.22	33.81	96.36	2.88	0.38	3.63
Swingle citrumelo	86	518	208	1834	19.32	30.77	100.43	1.94	2.50	3.56
HRS812 Sunki x trifoliolate	60	409	249	1629	24.31	36.09	66.19	3.13	1.38	3.63
HRS811 Sour x trifoliolate	102	361	146	1260	11.66	17.21	166.39	1.18	7.33	3.25
Flying Dragon trifoliolate	18	236	71	561	7.72	12.54	74.66	1.00	0.00	3.98
LSD(0.05)	113	105	95	474	7.84	10.77	22.18	0.77	3.06	0.48

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Ratings of chlorosis in 2009 iron chlorosis experiment for seedlings grown 11 weeks in soil amended with 0, 5, and 15% calcium carbonate. Rating scale: 0= no chlorosis, 1=pale green leaves, 2=green interveinal chlorosis, 3=yellow interveinal chlorosis, 4=shoot tips dead or dying and 5=plant dead or dying.

Variety	Percent Calcium Carbonate			
	0	5	15	All
African shaddock	0.00	0.80	1.60	0.80
Brazil sour	0.00	0.00	0.00	0.00
C146 (Sunki x Sw. trif.)	0.00	0.00	1.60	0.53
Bitters (C22)	0.00	0.00	1.40	0.47
CPB 4475 citrumelo	0.00	2.00	2.20	1.40
Carrizo	0.00	1.40	2.80	1.40
Cleo	0.00	0.00	1.00	0.33
Macrophylla	0.00	0.00	0.00	0.00
Obovoidea	0.00	0.00	0.00	0.00
Pomeroy trifoliolate	0.60	3.40	4.00	2.67
RR94-1-1(Afr shad x 4475)	0.00	1.20	1.00	0.71
RR94-1-2(Afr shad x 4475)	0.00	0.40	1.20	0.53
RR94-1-37(Afr shad x 4475)	0.00	2.60	2.40	1.67
RR94-1-38(Afr shad x 4475)	0.00	0.00	2.00	0.67
RR94-1-8(Afr shad x 4475)	0.00	0.80	2.80	1.20
RR95-2B-3(Afr shad x FD)	0.00	0.00	1.20	0.40
Rangpur x Marks trif 82	0.00	0.40	1.40	0.60
Rangpur x Swng trif 81	0.00	0.00	2.80	1.00
Rangpur x Shekwasha 72	0.00	0.40	2.50	0.86
Rubidoux trifoliolate	0.00	3.20	3.60	2.27
Schaub Rough Lemon	0.00	0.00	0.00	0.00
Shekwasha x Eng trif 73	0.00	0.60	2.40	1.00
Santa Barbara Red Lime 79	0.00	1.00	1.80	0.93
Sun Chu Sha	0.00	0.00	1.40	0.47
Sunki x FD 80	0.00	0.00	2.60	0.87
Swingle citrumelo	0.00	3.60	3.60	2.40
Tosu	0.00	0.00	1.20	0.40
Volkameriana	0.00	0.00	0.00	0.00
Overall Mean	0.02	0.78	1.73	0.84
LSD (0.05)	-	0.96	1.14	0.50

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