Summary of Rootstock Trials (Roose program. Updated 5/12/09)

1977 Parent Washington navel rootstock trial at Lindcove (pulled in 2004). This trial was designed and planted by Dr. Bitters in order to evaluate performance of new and existing rootstocks in the San Joaquin Valley. The trial included 19 rootstocks in a randomized complete block design with 5 replicates of 2-tree plots. Rootstocks included many standards plus hybrids and other selections considered promising in tristeza tolerance trials. Soil type is a San Joaquin sandy loam. Some areas of the site had poor drainage, probably due to hardpan development. Trees were irrigated with mini-sprinklers, and supplied with nutrients and insect controls according to normal commercial practice. Trees were propagated at Lindcove Field Station and planted in 1977. The scion is Washington navel orange, VI 12, which contains citrus viroid IIa. The overall effect of this viroid on tree performance is expected to be small (it is not used for dwarfing), but responses on many of the rootstocks tested have not been measured. Yield records were taken each year, tree size and health was last evaluated in 2002. Leaf nutrient concentrations were measured for 3 years. Internal fruit quality was studied several times, and packout was collected from 1996-2003. The highest yielding rootstock was C32, followed by Pomeroy trifoliate, Troyer and Tosu. C35 produced smaller trees with high yield for their size. Trees on Rubidoux trifoliate were trees smaller than trees on Pomeroy trifoliate, but with similar yield relative to tree size. A significant observation was that trees on Swingle began to decline from apparent incompatibility after about 23 years. Click link for detailed data as .pdf file (detailed summary of 1977 navel trial at Lindcove)

1986 Atwood navel rootstock trial at Lindcove. This trial evaluates 21 rootstocks including 7 Rangpur selections, 3 rough lemon types and 8 other selections from the USDA Indio breeding program. There are 6 replications with 2 trees of each rootstock per replication. Brazil sour orange is the highest yielding rootstock, followed by several Indio selections that appear quite promising for high yield, large fruit size, and good fruit quality. None of the Rangpur types are promising. Packout data since 1997 and 3 years of fruit quality data. Last measured in January 2006. Click link for detailed data as .pdf file (detailed summary of Atwood navel trial at Lindcove)

1989 Lisbon lemon trial at Santa Paula. Cooperator: Limoneira. Trial of 14 rootstocks, mostly standards and some considered promising in Florida when the trial was designed. There are 3 replications with 5 trees of each rootstock per replication. Yield data collected from 1995 to 2000, but there were no statistically significant differences among rootstocks. Tree size measured in 2004. The largest trees were on lemon type rootstocks (Volk, India lemon, Yuma Ponderosa, and Schaub rough lemon), while trees on Benton citrange, Rangpur x Troyer, and C35 were much smaller. Hedging and pruning probably reduced differences between rootstocks.

1989 Eureka lemon trial at Santa Paula. Cooperator: Limoneira. Trial of 13 rootstocks, mostly standards and some considered promising in Florida when the trial was designed. There are 3 replications with 3 trees of each rootstock per replication. Adjacent to the Lisbon rootstock trial above. Yield data were collected from 1995 to 2000 and statistically significant differences were detected. The highest yields were from trees on Macrophylla followed by Benton and C32. Trees on Sun Chu Sha had low yields. Trees were measured in 2004, but hedging and pruning

tend to equalize tree sizes except for the smaller trees on Rangpur x Troyer, Sun Chu Sha, and Benton citrange.

1989 Valencia rootstock trial at Pauma Valley. Cooperators: Yoneo Kariya and Gary Bender. This trial is a replant situation and includes 12 rootstocks with 10 trees of each rootstock (completely randomized design). Yield data were collected from 1993-1998, and tree size was last measured in 2001. We were told that the grower would remove the trial, but this did not happen. The largest trees and highest yields were from trees on Yuma Ponderosa and Vangasay (a lemon type), followed by African shaddock x Rub. trifoliate and C32. C35 performed well up to 1998, but trees grew little after that time and tree health declined. The cause of this decline does not seem to be Phytophthora root rot or citrus nematode.

1990 Lane Late navel rootstock trial at Lindcove. Trial of 29 rootstocks, including 8 Florida selections, standards, and some Indio selections. 8 single-tree replications of each rootstock. F80-18 citrumelo, C32, C54, F80-08 citrumelo and Pomeroy trifoliate are the highest yielding rootstocks. Last tree measurement and evaluation in 2006. Packout data since 1995, 5-7 years of granulation and other fruit quality data. Click link for detailed data as .pdf file (detailed summary of 1990 Lane Late trial at Lindcove)

1990 Lane Late navel rootstock trial at Redbanks (near Woodlake). Cooperator: Griffith Farms. Trial of 30 rootstocks, nearly all the same as those in the 1990 Lindcove trial above. Trial design is 4 replications with 2 adjacent trees of each rootstock per replication. Tree size is considerably larger than that of the trees at Lindcove, and the highest yielding rootstocks are mostly different: Yuma Ponderosa, Carrizo, C32, Volk, and Sun Chu Sha. Fruit quality study of 5 standard rootstocks in 1997, granulation study in 2001. Freeze damage ratings from 1991 and 1999. Trees last measured and evaluated in 2006. Click link for detailed data as .pdf file (detailed summary of Lane Late trial at Redbanks)

1992 Lane Late navel replant trial at Lindcove (pulled in 2008). Trial of 11 rootstocks, mostly standards, but some advanced selections in a replant situation where old trees were cut off and new trees interplanted. Additional trees of 3 rootstocks were treated with Enzone or Aliette and Nemacure to control pathogen pressure. Randomized complete block design with 13 replications. Trees measured and rated in 2006 when the highest yielding rootstock was C35, followed by Carrizo+Enzone, African shaddock x Rubidoux trifoliate and C57. Tree health ratings were generally good except for sweet orange which was considerably lower than others. Yield and packline data from 1999-2006. Fruit quality studies in 2000 (6 rootstocks), 2002, 2003, and 2004. Trial was pulled in 2008. Click link for detailed data as .pdf file (detailed summary of Lane Late replant trial at Lindcove)

1992 Parent navel replant trial at UCR. This is a replant trial similar to the 1992 Lindcove trial above. Randomized complete block design with 17 replications. Trees were measured and evaluated in 2007 and we have analyzed yield data from 1999-2006. Highest yielding rootstocks are Swingle+Aliette, Swingle (control), C32, and C57. Trees on sweet orange perform poorly. A fruit quality study on 5 rootstocks was done in 2002. Click link for detailed data as .pdf file (detailed summary of Parent navel replant trial at UCR)

1992 Compatibility trial at South Coast (Irvine). This trial was planted to test compatibility of promising rootstocks with representatives of the major scion groups. Rootstocks were budded with navel orange, Satsuma, Pixie and Melogold, but only those combinations not already included in other trials were included. There are only 3 trees of each scion-rootstock combination. Yield records are not collected, but we have collected visual crop ratings in most years (relative to tree size). Tree size was last measured in 2007. Melogold was tested with 14 rootstocks. The largest trees were on Yuma Ponderosa, African shaddock x Rub. trifoliate, 1452 citrumelo, and Bakrai lime, whereas C22, C35, Benton, and Terra Bella citrumelo produced small trees. The highest crop ratings were for trees on lemon types: Bakrai lime, Yuma Ponderosa, Volk and Nicaragua lemon. Trees health ratings were mostly fair. For Satsuma, the largest trees were on 1452 citrumelo, Yuma Ponderosa, Volk, and C54, and these rootstocks also had the highest crop ratings. Most health ratings were fair, with that for Schaub rough lemon poor. For Pixie mandarin, the largest trees were on C57, Volk, and C54, and average crop ratings did not vary much. Tree health ratings were only fair, with that for Nicaragua lemon poor. Only 4 rootstocks were tested with Washington navel. 1452 produced large trees, C35 and Nicaragua lemon produced small trees, and Terra Bella citrange was intermediate. Crop ratings did not differ among rootstocks. The health rating for Nicaragua lemon was low.

1993 Lisbon lemon replant trial at Santa Paula. Cooperator: Somis Pacific (Don Reeder). This trial is similar to the 1992 replant trials, but includes 4 additional rootstocks, and 20 replications. Citrus nematode counts before planting were moderate, but in the two years after planting these, and Phytophthora counts, were low. Yield data are not collected. In 2008, the largest trees were on African shaddock x Rubidoux trifoliate, Swingle (with and without Aliette treatments), and C32. Benton, C35, and C22 produced smaller trees. Trees on 343 grapefruit and Schaub rough lemon had the lowest health ratings. Click link for detailed data as .pdf file (detailed summary of Lisbon lemon replant trial at Santa Paula)

1994 Mandarin trial at Lindcove. Eight experimental mandarins (TDE 3 and 4, Gold Nugget, USDA 88-2, USDA 88-3, Novelty x Ellendale, NISSV-E, and Koster) were budded on 4 rootstocks (C35, Carrizo, Rich 16-6 trifoliate and Cleo). There are only 2 trees of each combination. The last 3 scions listed were not promising and yield records were not collected from these trees. Yield records and tree sizes on other scions are collected in most years, but in some case fruit is held for displays or other purposes.

1997 Washington navel rootstock trial at Arvin. Cooperators: John Turco and Craig Kallsen. 30 rootstocks are included, but only 22 have enough replications to be analyzed as part of the trial. The rootstocks were "leftovers" from budding done to produce trees for other trials at Thermal and Woodlake. There are 9 replications of most rootstocks. The rootstocks include many standards plus promising selections from the UCR and Florida breeding programs. The 1999 freeze severely affected some trees, killing most trees on Macrophylla but few others. Yield records are not collected. The last tree size measurement was taken in February 2006 when the largest trees were on C32, 1452 citrumelo, and C54. Benton, C22, and several unreleased hybrids produced smaller trees (about 75% of Carrizo). Tree health ratings were good. The trees in this trial generally produced many suckers - it is not clear why. Click link for detailed data as .pdf file (detailed summary of Washington navel trial at Arvin)

1997 Moro blood orange trial at Woodlake. Cooperator: Terry Baker. This trial was designed to assess performance of 32 rootstocks in a calcareous site. There are 12 replications. A similar trial planted in Thermal was removed by the cooperator in 2001 before the trees fruited. The site is only moderately calcareous and few trees have shown symptoms as yet. The rootstocks include many standards plus promising selections from the UCR and Florida breeding programs. Yield records are not collected, but considerable alternate bearing has been noted. Tree size and health ratings were collected in 2006, and show that nearly all trees have survived, the largest trees are on Vangasay lemon, Volk, C57 and C32, and the smallest on some experimental hybrids, Schaub rough lemon, Swingle, and trifoliates. Tree health ratings are mostly fair to good, but trees on Carrizo are among the worst in the trial. This is a concern given the importance of this rootstock in California. Trees on Rich 16-6 and Rubidoux trifoliate were more chlorotic than others, but even for these the level was only moderate (1.7 on a 0-5 scale). Click link for detailed data as .pdf file (detailed summary of Moro trial at Woodlake)

2001 Lisbon lemon trial at Oxnard. Cooperator: John Broome, Jr. This one of four trials planted in 2001 to evaluate performance of various rootstocks in calcareous sites. The experimental trees were interplanted among existing lemons on Troyer and Macrophylla. The site has a high stress level with many of the existing trees showing severe chlorosis. The trial includes 29 rootstocks including many standards and selections from the UCR and Florida breeding programs, with 15-16 replications of each. The last tree size and health measurements were collected in April 2008. No yield records are taken. The largest trees were on Rangpur x Marks trifoliate, Sunki x Flying Dragon, Schaub rough lemon, Yuzu x trifoliate, C57, and African shaddock x Rub. trifoliate. Most of these rootstocks had moderate or good iron chlorosis tree health and ratings except Schaub rough lemon which had somewhat poorer health and more chlorosis. A sour + Carrizo somatic hybrid from the University of Florida breeding program produced semidwarf trees with little chlorosis. Trifoliates, Sun Chu Sha, and some experimental hybrids had considerable iron chlorosis. Click link for detailed data as .pdf file (detailed summary of Lisbon lemon trial at Oxnard)

2001 Washington navel trial at Woodlake. Cooperator: David Roberts. Similar to the 2001 lemon trial in design and rootstocks, with 13 replications. Site is very calcareous. Trees were measured and rated in 2007 when it was discovered that a significant number of trees had been budded with Valencia rather than navel. Not all trees had fruit so the scion for some remains to be determined. The preliminary data analysis summarized here ignores scion. The largest trees were on C54, Schaub rough lemon, African shaddock x Rubidoux trifoliate and Trifeola, and small trees were on trifoliates, C22, and some experimental rootstocks. Trees on trifoliates, Sun Chu Sha mandarin, Carrizo, 1452 citrumelo, and some experimental rootstocks had severe chlorosis. Those on C22, C57, Cleo, X639, and several experimental hybrids had very little iron chlorosis. Trees with the best health ratings were those on Trifeola, C146, X639, Volk, C54, Cleo, C57, C22, and some other experimental hybrids. Trees with relatively poor health ratings included trifoliates, Carrizo, Sun Chu Sha, Benton, and some experimental hybrids. Overall, this trial will be quite informative about rootstock tolerance to calcareous soils. Click link for detailed data as .pdf file (detailed summary of 2001 navel trial at Woodlake)

2001 Lane Late navel trial at Porterville. Cooperator: John Richardson. Similar to the 2001 lemon trial in design and rootstocks, with 10 replications. The soil is reported by USDA-NRSC

as a Porterville clay, typically having pH 6.6-8.4 with 0% calcium carbonate in the upper 32 inches, and a similar pH range but 0-1% calcium carbonate from 32-72". Existing trees on this site generally had moderate levels of chlorosis with some spatial variation across the trial site. These characteristics suggest considerable spatial variation in depth to the calcareous layer and consequently variation in tree performance is likely. Trees were measured in 2006. The largest trees were on X639, C57, and Volk, and the smallest were those on Carrizo and several experimental hybrids. Chlorosis ratings were mostly intermediate (0.8 to 3.0 on a 0-5 scale) and seemed unrelated to tree size or health. Tree health ratings were mostly fair to good with only a few experimental rootstocks having mean ratings below 3 on a 0-5 scale. Thus far, this trial does not seem particularly informative about iron chlorosis tolerance, but this may change as tree roots reach the calcareous soil layer. Click link for detailed data as .pdf file (detailed summary of Lane Late trial at Porterville)

2001 W. Murcott trial at Orange Cove. Cooperator: Tom Mulholland. Similar to the 2001 lemon trial in design and rootstocks, but only 4 trees per rootstock. There are also two trees of Lane Late navel per rootstock in the same field. These trees were "extras" left over after propagation of trees for the other 2001 trials. Yield record was taken in 2004 and a crop rating in 2005. Tree size was measured in 2004.

2005 Fukumoto navel trial at Lindcove. The purpose of this trial is to evaluate compatibility of Fukumoto navel budwood from 4 healthy and 4 declining source groves with C35, Carrizo, and Volk rootstocks. The trial has 9 Fukumoto bud source locations, 3 source trees per location, each budded on 3 rootstocks, with 4 replications using a split-plot design. This trial was planted at Lindcove in June 2005, adjacent to a companion trial of Craig Kallsen and Neil O'Connell that investigates stress effects on decline of Fukumoto. During greenhouse propagation, the buds collected from average trees in declining groves grew as well as those from healthy groves and the control (Foundation Block). Tree health, suckers, and gumming were rated in October 2006, but there were no significant differences among bud sources or rootstocks. Tree health, canopy volume, and bud unions were rated in December 2008. There were small but statistically significant differences among rootstocks in tree size, tree health, and bud union appearance, with the largest trees on Volk and the smallest on C35. Tree health ratings were highest for trees on Carrizo, but all rootstocks had mean health ratings in the very good to excellent range (4.33 to 4.7 on a 0-5 scale). The 9 bud source locations did not differ significantly for any of the traits tested, and there were no significant rootstock x bud source interactions. Overall, we have not seen evidence of the decline that affects Fukumoto trees, but the trees may still be too young. Click link for detailed data as .pdf file (detailed summary of Fukumoto trial at Lindcove)

2006 CTV tolerance trial at Irvine. The objective of this trial is to evaluate 50 rootstocks, mostly new selections, for tolerance to four CTV isolates. Seedlings of standard and experimental rootstocks were grown in a greenhouse at UCR, grafted with Valencia orange scion and, just before planting, inoculated with one of four CTV isolates selected with assistance from Dr. Marylou Polek, Central California Tristeza Eradiation Agency. The trees were planted in the field at SCREC in June and July 2006 and will be evaluated for tree health, tree size, CTV symptoms, and possibly yield. Seedlings of standard and experimental rootstocks were grown in a greenhouse at UCR, grafted with Valencia orange scion and, just before planting, inoculated with one of four CTV isolates selected with assistance from Dr. MaryLou Polek, Central

California Tristeza Eradiation Agency. The trees were planted in the field at SCREC in June and July 2006. In 2007 trees were tested for CTV to evaluate effectiveness of inoculation and those testing negative were reinoculated. By 2008 near all trees tested CTV positive. By 2008, there was clear evidence of decline and stunting in trees on sour orange and some other rootstocks, including African shaddock x Rubidoux trifoliate. There were only slight differences in average effects of the different CTV isolates. Probably several additional years will be needed to reach conclusions about all rootstocks in this trial. Click link for detailed data as .pdf file (detailed summary of 2006 tristeza tolerance trial at Irvine)

2008 Tango trial at Porterville. Cooperator: Harrison Smith. The objective of this trial is to evaluate performance of Tango mandarin on 23 rootstocks. Trees were grown at TreeSource nursery and planted in June 2008 using a randomized complete block design with 11 replications and single-tree plots. The soil type is a heavy Porterville Adobe.