

Lemon Rootstock Trials in Arizona – 2007-08¹

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Abstract

*In a rootstock evaluation trial planted in 1993, five rootstocks, ‘Carrizo’ citrange, *Citrus macrophylla*, ‘Rough Lemon’, Swingle citrumelo and *Citrus volkameriana* were selected for evaluation using ‘Limoneira 8A Lisbon’ as the scion. 1994-2006 yield and packout results indicate that trees on *C. macrophylla*, *C. volkameriana* and ‘Rough Lemon’ are superior to those on other rootstocks in both growth and yield. *C. macrophylla* does not consistently outperform *C. volkameriana*. ‘Swingle’ and Carrizo’ are performing poorly.*

Introduction

There is no disputing the importance of citrus rootstocks to desert citrus production. The ideal citrus rootstock must be compatible with the scion, be adaptable to the appropriate soil and climactic factors and should also improve one or more of the following characteristics: pest and disease resistance, cold tolerance, precocity, internal and external fruit quality, yield and/or post-harvest quality. Ultimately, the value of a rootstock lies in its ability to improve production and/or quality of the fruit.

Climactic and soil characteristics of the desert citrus growing regions impose stress upon a citrus tree. Many times, rootstocks that are suitable for other areas are not suitable in the desert. Conversely, rootstocks that may be of limited value in other citrus growing areas might be more useful under desert conditions. It cannot be assumed that rootstocks will perform similarly across all climactic and soil conditions.

The first rootstock trial that we planted in 1993 was established to fill a large knowledge gap as to which were the appropriate lemon rootstocks for the Arizona industry. This trial includes rough lemon (*C. jambhiri*), a vigorous and formerly popular rootstock that is susceptible to *Phytophthora* root rot, and *C. macrophylla*, also popular, but susceptible to brown wood rot (*Coniophora eremophila*. and *Antrodia spp.*) and Macrophylla decline. Also included are *C. volkameriana*, a popular but untested rootstock, as well as ‘Carrizo’ citrange and ‘Swingle’ citrumelo as experimental rootstocks for the desert (‘Carrizo’ is commonly used as a rootstock for lemon in coastal California, while ‘Swingle’ is found in the same areas of California as well as in Florida). ‘Limoneira 8A Lisbon’ lemon is the scion. Data collected from these trials has included tree growth, mineral nutrition, fruit quality, fruit size and total yield. Previous results from this trial have been reported in Wright and Peña (2007), Wright and Peña (2006), Wright and Peña (2005), Wright and Peña (2004), Wright and Peña (2002), Wright and Peña (2001), Wright and Peña (2000), Wright *et al.* (1999), Wright (1998), Wright (1997), Wright (1996) and Wright (1995).

Materials and Methods

This trial was established in March 1993 in Block 26 of the Yuma Mesa Agricultural Center, near Yuma, Arizona. The land was laser leveled and fumigated prior to planting. Trees were planted on a 10-m x 10-m spacing. Ten

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replicates of each of the 5 rootstocks were planted for a total of 50 trees. Experimental design is randomized complete block.

Irrigation is border flood, and normal cultural practices are used. Yield data is typically collected during the fall and winter. Trees were picked twice during the season, on 9-27-07 and 11-28-07. Total yield is measured by counting the number of whole and fractional 65-lb. picking sacks harvested from each tree. About 30 lbs of fruit is collected from each tree, and passed through an automated electronic eye sorter (Autoline, Inc., Reedley, CA), which provides individual fruit weight, color, exterior quality and size data for each fruit. Fruit packout data is reported on a percentage basis.

All data is analyzed using SPSS 8.0 for Windows (SPSS Inc., Chicago, Illinois).

Results

A freeze in January 2007 damaged many of the trees in the region, sometimes dramatically reducing their yields for the 2007-08 harvest season. While 2006-07 yields for these trees were extremely low (Fig. 1), the freeze event occurred after the 2006-07 season harvest which occurred in November, 2006. Yields for the 2007-08 harvest season rebounded dramatically from the previous year, suggesting that the freeze of January, 2007 did not greatly affect the test trees.

For 2007-08, trees on *Citrus macrophylla*, *Citrus volkameriana* and Rough Lemon rootstocks had greater yields (ranging from 140 to 215% more) than those on 'Carrizo' citrange and 'Swingle' citrumelo (Figure 1). This continues a trend that has been apparent since the 1996-97 season. Compared to the previous year, yields for trees on all the rootstocks tested increased from 200% to 500%. We attribute this increase as a response to the low yields of the 2006-07 year; and those yields were most likely in response to high yields in 2005-06. It is likely that tree carbohydrate levels that were depleted during the 2005-06 year, were replenished during the low-yielding 2006-07 year, and were able to support a large fruit load for the 2007-08 season. It will be interesting to see if the trees continue the alternate bearing pattern.

Considering only the yield from the 2007-08 year, trees on *C. macrophylla*, *C. volkameriana* and Rough Lemon rootstocks had significantly greater yield, while trees on 'Carrizo' and 'Swingle' lagged (Figure 2). This is a typical result, and mirrors our findings for every year since 1998, with the exception of the 2006-07 season. Yields of trees on Rough Lemon rootstock and *C. volkameriana* rootstock are within 1% of each other. However, this is the second year in the last three that the yields of trees on *C. macrophylla* are less (about 10% less) than the yields of trees on *C. volkameriana*. For the 09-27 harvest, yields of trees on the three top performing rootstocks were about 75% greater than the yield of 'Carrizo', and about 125% greater than the yield of 'Swingle'. For the 11-28 harvest, yields of trees on the three top-performing rootstocks were 40% and 105% greater than the yields of trees on 'Carrizo' and 'Swingle' respectively.

Packout for the 9-27-07 harvest is shown in Figure 3. Trees on *C. macrophylla*, *C. volkameriana* and rough lemon had significantly more fruit of sizes 75 than trees on the other two rootstocks tested. For size 95, trees on *C. macrophylla* and *C. volkameriana* had significantly more fruit than did 'Swingle'; while 'Carrizo' and 'Rough lemon' were intermediate. This result is similar to first-harvest results from previous years. There were no significant effects of rootstock on fruit of size 115 or smaller. For the 11-28-07 harvest trees on 'Carrizo' rootstock had the most fruit of size 95, as compared to trees on Rough Lemon rootstock. All others were intermediate. Rough Lemon had the most fruit of size 115, and significantly more than *C. volkameriana*, 'Carrizo' or 'Swingle'. Trees on *C. macrophylla* had the most fruit of size 140, and significantly more than trees on 'Carrizo'. Trees budded to all the other rootstocks had intermediate amounts of size 140 fruit. There were no significant differences between rootstocks for fruit size 75 or 165 and smaller.

For 2007-08, rootstock also affected fruit grade, shape and color. For the 9-27 harvest, there was significantly more fancy grade fruit on trees on 'Carrizo' than on *C. volkameriana* and *C. macrophylla*. The other rootstocks produced intermediate levels of fancy grade fruit. Conversely, trees on 'Carrizo' produced less choice grade fruit than trees on

C. volkameriana or *C. macrophylla*. Also, fruit of trees on *C. volkameriana* were more rounded than fruit from trees on the other rootstocks. There was no effect of the rootstocks upon fruit color. For the 11/28/07 harvest, there was no effect of rootstock on fancy grade fruit, but ‘Carrizo’ produced more choice grade fruit than did *C. volkameriana*. Also, trees on *C. volkameriana* and Rough Lemon produced more rounded fruit than trees on *C. macrophylla*. Finally, fruit from trees on ‘Carrizo’ and ‘Swingle’ was more colored than fruit on *C. volkameriana*.

Discussion and Conclusions

It is still apparent that all rootstocks other than *C. macrophylla*, *C. volkameriana* and ‘Rough Lemon’ are unsuitable as rootstocks for lemon in Arizona in high pH soils. Reduced vigor, late fruit sizing and ultimate small fruit size are characteristics that have not yet been overcome.

Differences between *C. volkameriana* and *C. macrophylla* had been becoming increasingly clear. From 1997-98 until 2003-04, yield of trees on *C. macrophylla* has equaled or surpassed the yield of trees on *C. volkameriana*. However, for the past four seasons, yields of trees on these two rootstocks were virtually the same, and in 2007/08, yields for *C. macrophylla* were slightly less than yields for *C. volkameriana*. There is no clear trend as to which of these rootstocks produces earlier fruit, and overall fruit size appears to be similar. Arizona packinghouse managers report that fruit of trees on *C. macrophylla* have a smoother peel, which leads to better overall fruit quality. Growers also report that *C. volkameriana* produces more water sprouts on the trunk than does *C. macrophylla*, and that trees on *C. volkameriana* show more transient nutrient deficiencies in the winter (winter yellows), than do trees on *C. macrophylla*. Perhaps an altered fertilizer regime with more fall micronutrient application would improve the yield of *C. volkameriana* trees. In light of the January 2007 freeze, it is also notable that some producers report that trees on *C. volkameriana* appear to be more cold-hardy. It remains to be seen if yield for *C. macrophylla* will continue decline, in comparison with yield of *C. volkameriana*.

After a slow start, ‘Rough Lemon’ has not had significantly different yield than *C. volkameriana* for the past eight years. ‘Rough Lemon’ has not typically produced as well as *C. macrophylla*, but for the first time in 2004-05, it had the greatest yield. This was not repeated in 2005-06, 2006-07 or 2007-08. When there is more than one harvest per season, ‘Rough lemon’ sometimes produces less early-season fruit compared to the other two vigorous rootstocks tested, although this was not the case in 2007-08. ‘Rough Lemon’ is more difficult to grow in the nursery due to its greater susceptibility to *Phytophthora* root rot, so its availability is somewhat limited unless trees are special ordered on this rootstock.

Based on the results thus far, *C. macrophylla* appears to be a superior rootstock for lemons in Arizona; although the possibility exists that it may decline sooner than ‘Rough Lemon’ or *C. volkameriana*. The recent freeze event underscores the fact that it is probably not a good idea to plant all ones acreage on only one rootstock, thus either *C. volkameriana* or ‘Rough Lemon’ would be a good complementary rootstock as well.

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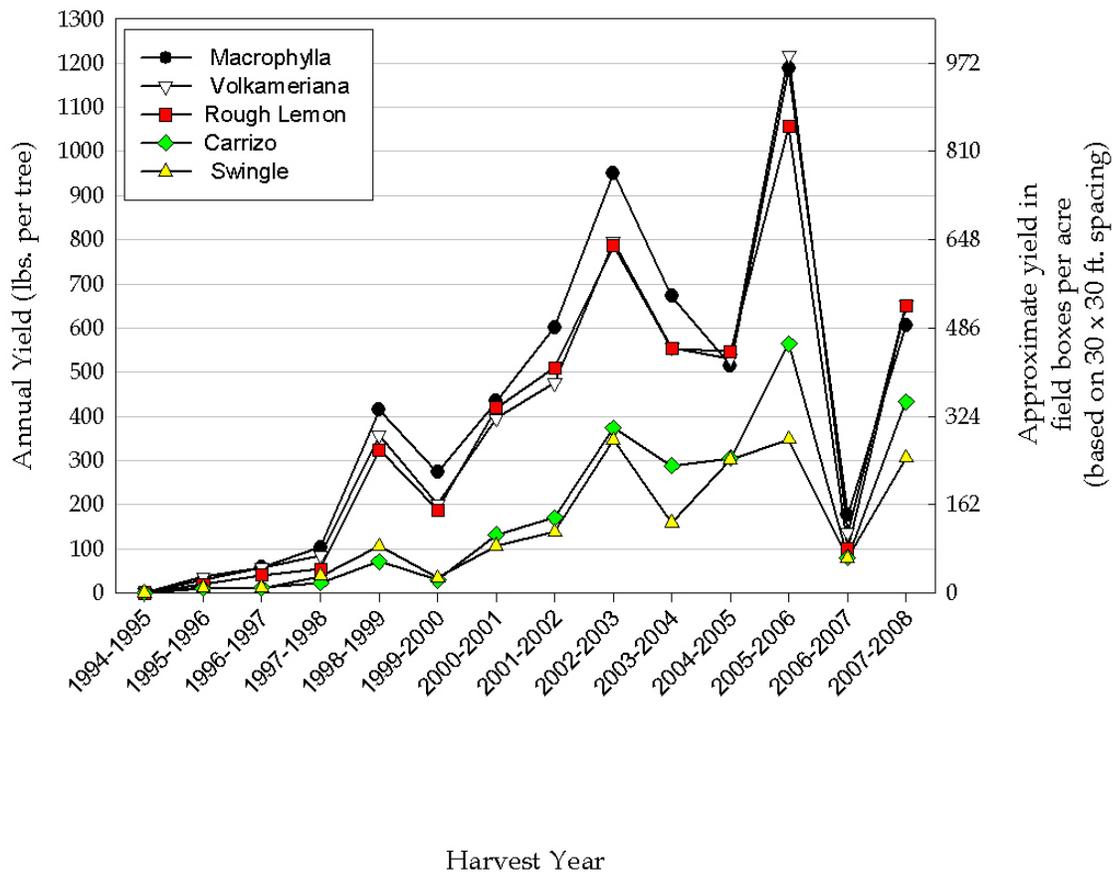


Figure 1. 1994 – 2007 'Limoneira 8A Lisbon' lemon yields on five rootstocks.

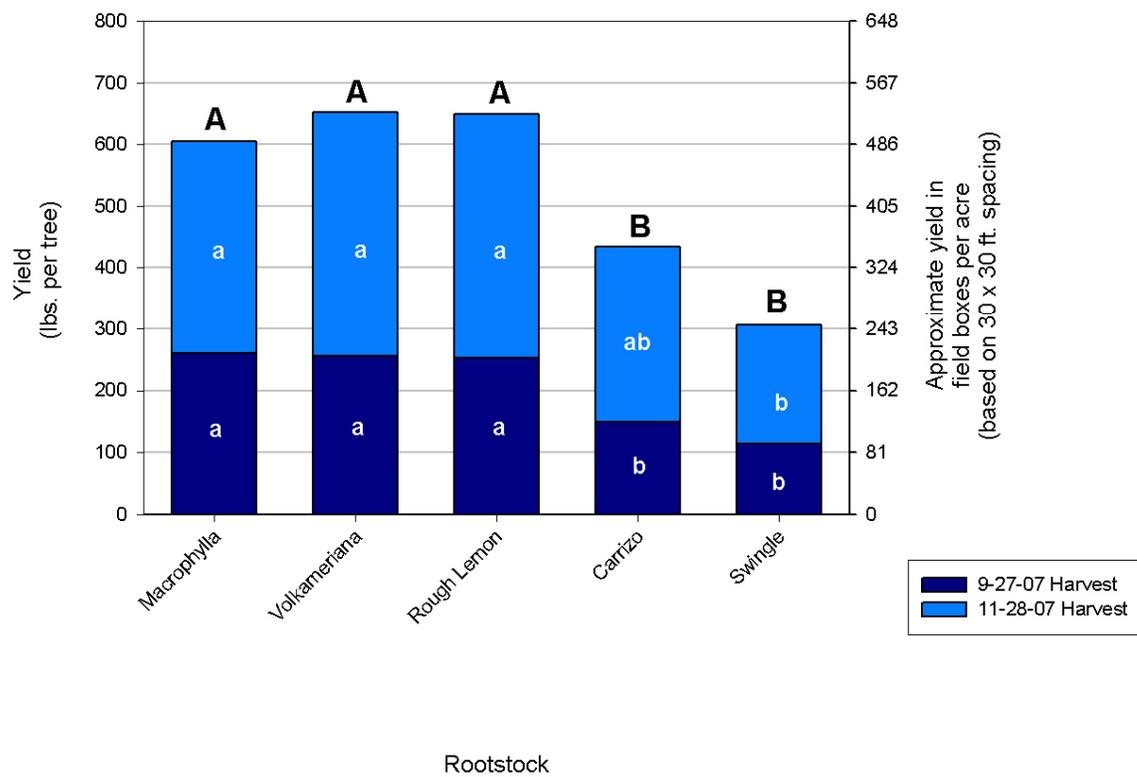


Figure 2. 2007-08 yield of 'Limoneira 8A Lisbon' lemon yields on five rootstocks. Mean separations by Duncan's multiple range test, 5% level.

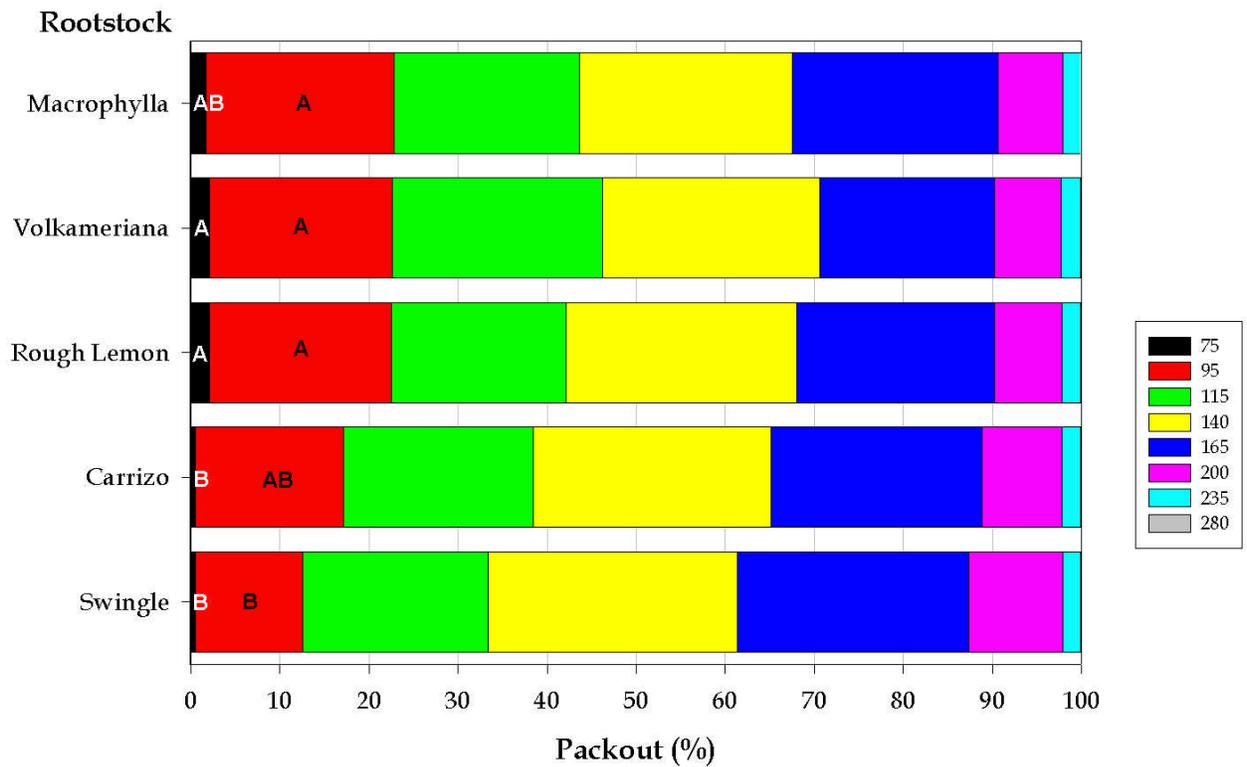


Figure 3. Packout of 'Limoneira 8A Lisbon' lemons on five rootstocks from the September 27, 2007 harvest. Means separation within fruit sizes by Duncan's multiple range test, 5% level. Bars of the same color are significantly different if the letters within them are different. Bars of different colors cannot be compared statistically.

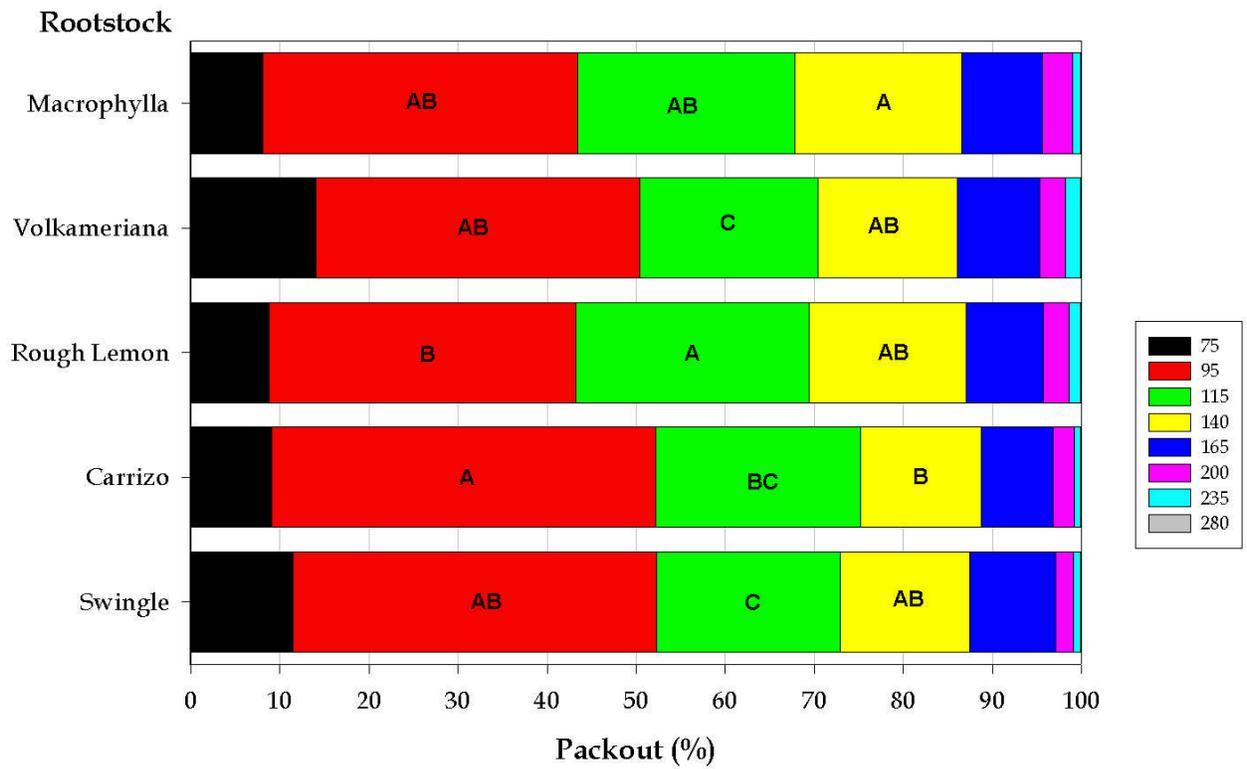


Figure 4. Packout of 'Limoneira 8A Lisbon' lemons on five rootstocks from the November 28, 2007 harvest. Means separation within fruit sizes by Duncan's multiple range test, 5% level. Bars of the same color are significantly different if the letters within them are different. Bars of different colors cannot be compared statistically.

Table 1. 2007-08 harvest exterior fruit quality, shape and color of lemons on four different rootstocks

Rootstock	9-27-07 Harvest					11-28-07 Harvest				
	Fancy (%)	Choice (%)	Juice (%)	Shape ^y	Color ^x	Fancy (%)	Choice (%)	Juice (%)	Shape	Color
<i>C. macrophylla</i>	43.96 b ^z	45.86 a	10.18 a	0.744 b	0.794 a	81.83 a	10.88 ab	7.29 a	0.761 b	1.017 ab
<i>C. volkameriana</i>	49.57 b	42.73 a	7.70 ab	0.771 a	0.793 a	86.19 a	8.65 b	5.16 ab	0.781 a	1.006 b
Rough Lemon	52.38 ab	39.80 ab	7.82 ab	0.762 ab	0.800 a	84.07 a	9.74 ab	6.18 ab	0.778 a	1.016 ab
Carrizo Citrange	62.23 a	33.70 b	4.07 b	0.759 ab	0.789 a	84.46 a	12.30 a	3.24 b	0.771 ab	1.037 a
Swingle Citrumelo	54.56 ab	38.26 ab	7.17 ab	0.756 ab	0.784 a	86.52 a	8.44 b	5.05 ab	0.771 ab	1.029 a

^z Means separation in columns by Duncan's Multiple Range Test, 5% level.

^y A value of 1.00 signifies a completely round fruit.

^x Signifies the red to green intensity ratio of the fruit. A greater value signifies more orange or red color.