Citrus Rootstock Acquisition and Evaluation — 2020-21[1]

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Introduction

Citrus macrophylla and *C. volkameriana* are the standard, vigorous rootstocks used widely across the Arizona and California desert lemon industry. They are both vigorous and produce high-yielding trees with fruit of excellent size. Lemon trees on both rootstocks are relatively cold-sensitive and are susceptible to the brown wood rot fungi (*Fomitopsis meliae)* that plague desert lemons. Also, *C. volkameriana* is susceptible to "winter yellows," and tends to produce excessive numbers of trunk suckers.

Many years ago, sour orange (*Citrus aurantium* L.) was the common rootstock for lemon in Arizona as it was the only rootstock available and is quite adaptable to the highly alkaline desert soil. Sour orange is of medium vigor and may be used to reduce the vigor of lemon scions (Ferguson *et al*., 1990, Roose 2014). However, its yields are similar to less than more recently introduced rootstocks, such as Carrizo. Carrizo is not commonly used for lemons in Arizona because yield and fruit size are less than for trees budded to *C. macrophylla* and *C. volkameriana*, and because it is not particularly tolerant of alkaline soils. In a trial at Thermal, CA yields of both sour orange and Carrizo are about 65% less than that of *C. macrophylla* and 45% less than that of *C. volkameriana*. Rangpur lime (*Citrus limonia)* is a hybrid of citron and mandarin and has never been widely used in the United States. However, in Brazil, Rangpur is known to confer drought tolerance on the scion, is vigorous and produces well on deep sandy soils. Bitters (C-22), Carpenter (C-54) and Furr (C-57) citrandarin (*Citrus sunki* x Swingle citrumelo [*Citrus paradisi* x *Poncirus trifoliata*]) are hybrids of 'Sunki' mandarin and Swingle citrumelo. All three were developed at the USDA citrus breeding program in Indio, CA and were released by the University of California in 2009. Information on these rootstocks can be found in Siebert *et al*., (2010).

In January 2016, we initiated a new lemon rootstock trial, the first to be planted at the University of Arizona's Yuma Mesa farm since 1993. The purpose of the trial was to evaluate the effect of the above-mentioned rootstocks on yield, fruit size, precocity, tree size, interior and exterior fruit quality, and disease tolerance (especially tolerance to brown wood rot – *Fomitopsis meliae*). A secondary purpose was to compare the effects of traditional flood irrigation with pressurized drip irrigation on the above attributes, and to measure water savings using the pressurized system.

High yielding, precocious trees with large fruit size are favored by the desert lemon industry. Desert lemons are marketed from mid-August to February. During the early and middle part of that window, lemons from other suppliers can be limited and sizes can be small, so high quantities of large fruit translate to good returns to the grower. Rootstocks are also known to affect drought tolerance, peel thickness, peel smoothness, fruit total soluble solids and acid levels, and percentage of juice in the fruit (Ferguson *et al*., 1990). Also, rootstocks can affect the growth of the brown wood rot fungi, *Fomitopsis meliae*, in the scion (Matheron and Porchas, unpublished data).

The experiment is located in block 6E (flood irrigated trees) and 6W (microsprinkler irrigated trees) at the Yuma Mesa Agriculture Center, near Somerton, AZ. The 2016 through 2019 reports for this experiment can be found as PDF files at: https://agriculture.az.gov/arizona-citrus-research-council-previously-funded-research-projects. The scion in this study is 'Corona Foothills,' and the rootstocks are those mentioned above.

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Materials and Methods

In its original form, the Rainbird drip irrigation system components in field 6W required many changes and adaptations to increase function and reliability. Clogging, ground squirrel damage (in 6W and 6E) and drip line deterioration were regular problems. Clogging was primarily due to fish entering the system from the canal that supplies the water to the system (the screen on the canal wall was missing – probably removed during regular canal cleaning and maintenance in November). We added another cleanable filter downstream from the canal wall, and this problem is more easily resolved, and no fish bones enter the pump (See below). A more aggressive ground squirrel control program continues to control populations. We are seeing a significant reduction in burrows and damage. Drip line deterioration due to UV rays was highly disappointing and was a problem that ultimately led to our decision to convert the double-line Rainbird pressurized system to Netafim microsprinklers and irrigation line. The new lines and sprinklers were installed in April 2021. This installation did not require additional funding from the ACRC. The new sprinklers deliver 10 gph to the trees and there are two per tree. Sprinklers are located at the trunk of each tree, facing toward the drip line. Water pattern is 270°.

The new system generally runs well, although the screen on the canal wall is again missing and will need to be replaced when canal maintenance occurs in November 2022. Meanwhile, we still have fish entering the system (Figure 1), but they are kept from entering the pump by the downstream screen. The system is checked daily for fish. Ground squirrel control in fields 6W and 6E is continuing. We have seen no evidence of UV damage to the irrigation lines in 6W.

Figure 1. Fish caught in irrigation pipe. This fish could not enter the irrigation pump because of a screen in the line but needed to be removed by hand.

Trees in field 6W were irrigated with the double line drip system, but that system was not dependable, therefore, we continued with flood irrigation through April 2021. When the microsprinkler system was installed, we supplemented the flood irrigation with microsprinkler irrigation from May 2021 through December 2021. Beginning in January 2022, we began the process of transitioning the trees from flood to microsprinkler. At the moment (May 2022), the trees are irrigated with microsprinklers every other day, and with flood irrigation when fertilizer is applied through the flood waters.

For 2021 as in 2019 and 2020, tree growth data was collected in June, including tree height, canopy volume (spherical), Also, a subjective tree health rating was taken, where 0 = dead, 1 = almost dead, 2 = poor vigor, 3 = adequate vigor, 4 = good vigor and 5 = excellent vigor.

For the 2020-2021 season, yields were collected on November 19, 2020 for Block 6W and December 8, 2020 for Block 6E. We had expected to pass the November and December 2020 fruit through our automated fruit sizer to collect packout data. However, there was a failure of the weight cell in the middle of the run. Therefore, only about 15% of the fruit packout data was collected for Block 6W and none for Block 6E. Since there was no difference in irrigation treatments between Block 6E and 6W, all the data is pooled for the 2020-21 season.

For the 2021-22 season, yields were collected on November 15 and 16, 2021. Because of the amount of fruit, it was not feasible to pass all through the automated fruit sizer, so fruit yield data was collected taken on a portable digital scale. Again, the 24-year-old fruit sizer malfunctioned, and we were unable to collect any packout data for the season. (The fruit sizer will be replaced with a newer model for the 2022-23 season.)

Since 2018, three trees have been lost to brown wood rot (*Fomitopsis meliae*), and one to *Fusarium solani*.

Results and Discussion

Results from the 2019 to 2021 tree size and health measurements are shown in Table 1.

Table 1. 2019 to 2021 Lemon tree height, canopy volume and health rating.

Rootstock Variety	Tree Height			Canopy Volume			Tree Health Rating		
	(m)			(m^3)			(0 to 5)		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**
Macrophylla	1.91 a	2.51 a	2.93 a	1.77 a	5.03 a	12.15 a	4.80 a	4.63 a	4.65 a
Volkameriana	1.87 a	2.38 b	2.72 b	1.41 b	4.16 b	8.54 b	4.74 a	4.43 abc	4.37 b
Rangpur Lime	1.74 b	2.24 c	2.60 bc	1.16 c	3.53 c	6.99 c	4.82 a	4.26 bc	4.33 bc
C-57 'Furr'	1.61 c	2.19 cd	2.52 cd	0.78 d	2.48 d	6.15 cd	4.62 ab	4.50 ab	4.13 bcd
C-54 'Carpenter'	1.57 c	2.15 cde	2.49 cd	0.78 d	2.40 d	5.78 cde	4.61 ab	4.21 c	4.17 bcd
Carrizo Citrange	1.50 c	2.18 cd	2.53 bcd	0.57 e	2.34 d	5.34 de	4.36 b	4.19 c	4.02 d
Sour Orange	1.49 c	2.04 e	2.31 e	0.57 e	1.99 d	4.69 e	4.37 b	4.17 c	4.02 d
C-22 'Bitters'	1.50 c	2.09 de	2.41 de	0.58 e	2.18 d	4.83 de	4.65 ab	4.22 c	4.07 cd

For data within columns with different letter designations there is at least a 95% chance that the values are significantly different. Data in different columns cannot be statistically compared.

Not surprisingly, trees on *C. macrophylla* and *C. volkameriana* rootstock were the largest, as shown by height and canopy volume. Rangpur lime produced intermediate sized trees, while the other rootstocks produced smaller sized trees. The citrandarins (C-22, C-54, and C-57) have produced smaller trees in studies conducted in California, and so their relatively small stature in relation to the others is not surprising. All the tree health ratings are good, there is no detrimental effect of rootstock upon overall tree health at this time.

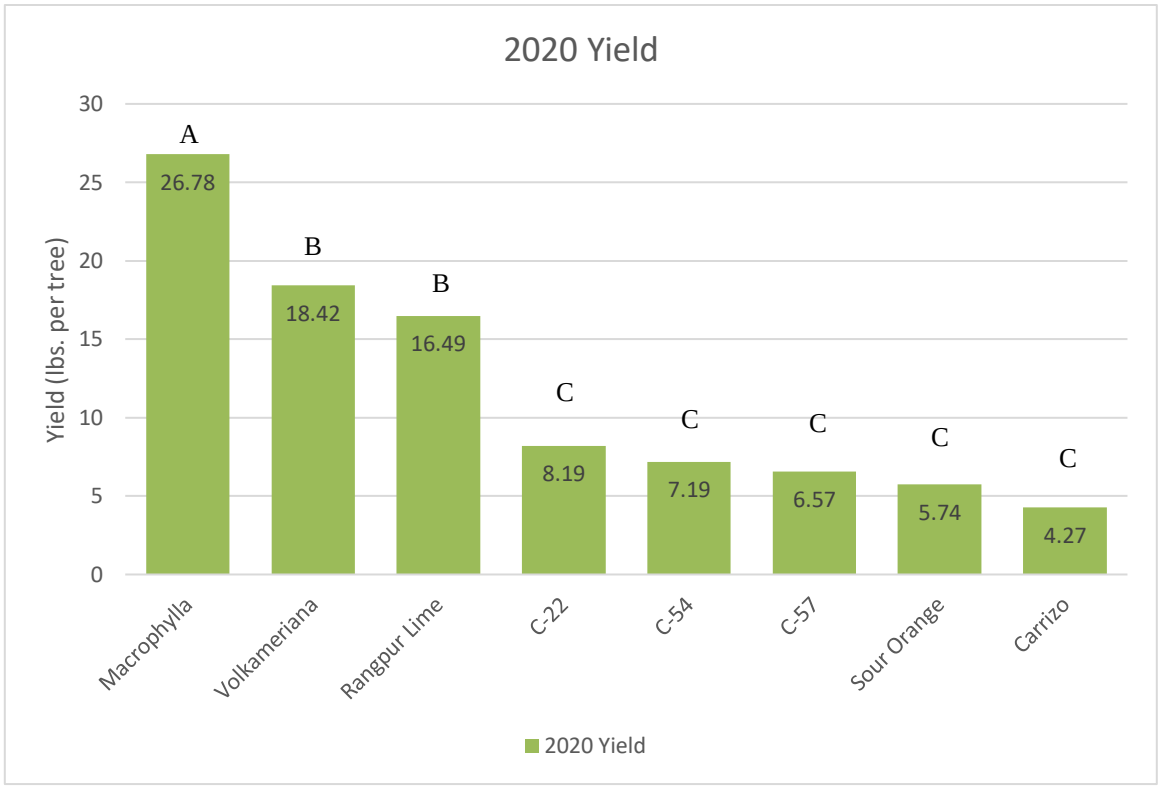

Figure 2. 2020 yields of Corona Foothills lemon on eight different rootstocks at the Yuma Mesa Agriculture Center, Yuma, AZ. For bars with different letter designations there is at least a 95% chance that the values are significantly different.

Yields for 2020 did not increase as much as we had expected, perhaps due to excessive fruit drop as a result of the extremely hot summer the region experienced in 2020 (Fig. 2). Trees on C. macrophylla had the greatest yield, followed by C. volkameriana and Rangpur Lime. Trees on the three citrandarins, Sour orange and Carrizo had the least yield, about 1/3 to 1/5 of the yield of the best performers.

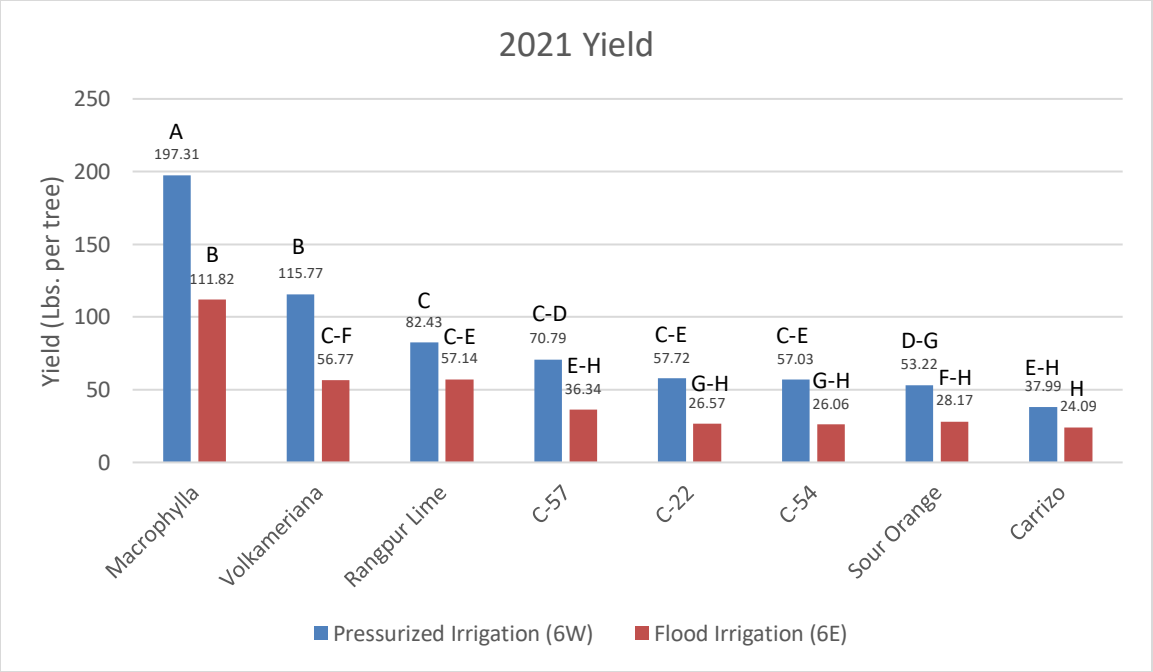

Figure 3. 2021 yields of Corona Foothills lemon on eight different rootstocks at the Yuma Mesa Agriculture Center, Yuma, AZ. For bars with different letter designations there is at least a 95% chance that the values are significantly different.

Yields for 2021 were much larger than for 2020, but with the same general trends (Fig. 3). Trees on C. macrophylla had the greatest yield , followed by trees on C. volkameriana, trees on Rangpur Lime, and then the citrandarins, Carrizo citrange and sour orange.

There was also a significant increase in yield for the pressurized irrigation field (6W) compared with the flood irrigated field (6E). Trees in field 6W averaged 84 lbs. of fruit, while those in field 6E averaged 46 lbs. of fruit. This is likely due to the extra water applied to the trees by the microsprinklers during the spring and summer when the fruit was growing quickly.

There was significant fruit drop in the fields prior to the harvest, so we counted the fallen fruit under each tree prior to harvest. For field 6W, there were more fruit drop, averaging 38 fruit per tree, while for field 6E, an average of 16 fruit dropped per tree. The rootstocks that led to the greatest fruit drop were C-57 (36 fruit per tree), C. macrophylla (35), Rangpur Lime (31), C. volkameriana (29), C-22 (27), sour orange (21), C-54 (21), and Carrizo (18). If trees had been harvested earlier, fruit drop would likely have been less.

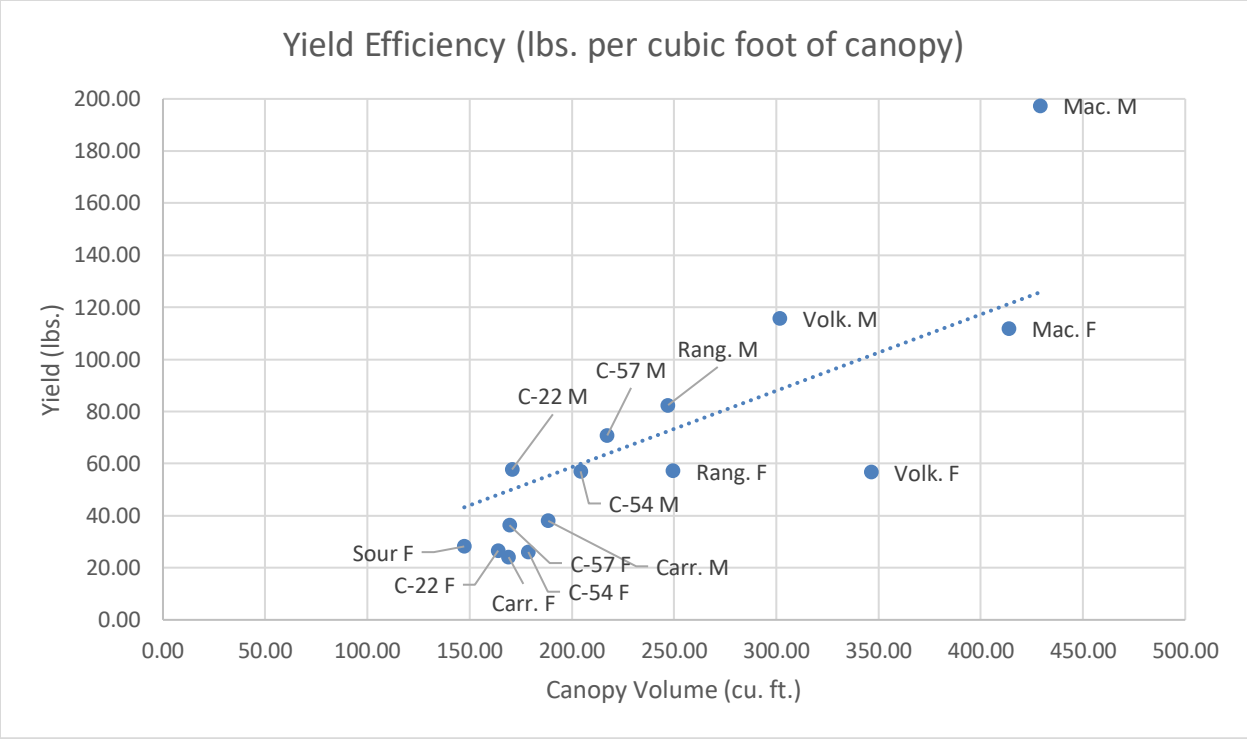

Figure 4. Yield efficiency of Corona Foothills lemons on eight rootstocks in Yuma, AZ. Value labels indicate the rootstock followed by "F" (Flood irrigation in field 6E), or "M" (Microsprinkler irrigation in field 6W).

Finally, we calculated yield efficiency for each of the rootstocks and irrigation systems (Figure 4). Yield efficiency is the yield divided by the canopy volume. We would like to see a rootstock that produces a large amount of fruit on a fairly small volume of canopy. At this time, none of the rootstocks stands out as far as having a large enough yield on a relatively small canopy, however C-22, C-57 and Rangpur lime are the most promising so far.

Plans for 2022-2023

In 2022, we expect to begin irrigating the trees in Block 6W exclusively with microsprinkler irrigation, likely in the fall. We will begin to collect data on water use at that time. Meanwhile, we will carry out normal fertilization, pest control and weed control in both blocks, apply flood irrigation in Block 6E in accordance with normal horticultural practices. We expect to collect tree size and health data in June 2022 and yield in fall and/or winter 2022.

References

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