Citrus Rootstock Acquisition and Evaluation — 2022-23[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, with trees on *C. macrophylla* being more sensitive than *C. volkameriana*. Both 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 late-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 early large desert-grown 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 2020 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.

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

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regular problems. Ultimately, drip line deterioration due to UV rays was highly disappointing and was the 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. The 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. The water pattern is 270°. The new system generally runs well. While we still have fish entering the system, they are kept from entering the pump by a downstream screen. Ground squirrel control is continuing. We have seen no evidence of UV damage to the irrigation lines in 6W.

Trees in field 6W were irrigated with the Rainbird double line drip system, through April 2021. When the new Netafim 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. Generally, the 6W trees were irrigated with microsprinklers every day in the summer, and every third day in the fall, and with occasional "supplemental" flood irrigation during the hottest part of the summer. Microsprinkler irrigated trees are irrigated according to a schedule developed from Wright (2000). Flood irrigated trees are watered according to normal citrus cultural practices employed by the Yuma Agriculture Center.

For 2022, 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. We also counted the trees lost to and/or damaged by *Fomitopsis meliae* on September 30, 2022.

For the 2022-23 season, yields were collected on October 25 and 26, 2022 and December 13 and 14, 2022 for both blocks. The first harvest was a size pick using a #8 ring and the trees were stripped of fruit for the second pick. We passed the fruit from both harvests through our automated fruit sizer to collect packout data.

Results and Discussion

Results from 2021 (for comparison) and 2022 tree size and health measurements are shown in Table 1. There was no significant difference between flood- and microsprinkler-irrigated trees, so these data were pooled.

Table 1. 2021 and 2022 Lemon tree height, canopy volume and health rating.

Rootstock Variety	Tree Height		Canopy Volume		Tree Health Rating	
	(m)		(m^3)		(0 to 5)	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**
Macrophylla	2.93 a	3.27 a	12.15 a	22.41 a	4.65 a	4.68 a
Volkameriana	2.72 b	2.89 b	8.54 b	15.62 b	4.37 b	4.53 ab
Rangpur Lime	2.60 bc	2.66 c	6.99 c	11.93 c	4.33 bc	4.43 b
C-57 'Furr'	2.52 cd	2.50 d	6.15 cd	8.90 d	4.13 bcd	4.32 bc
C-54 'Carpenter'	2.49 cd	2.46 d	5.78 cde	8.95 d	4.17 bcd	4.18cd
Carrizo Citrange	2.53 bcd	2.50 d	5.34 de	8.69 d	4.02 d	4.34 bc
Sour Orange	2.31 e	2.38 e	4.69 e	7.80 de	4.02 d	4.02 d
C-22 'Bitters'	2.41 de	2.32 e	4.83 de	7.38 e	4.07 cd	4.12 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 again 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 three

locations 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 currently.

Yields for 2020 did not increase as much as we had expected, perhaps due to excessive fruit drop because 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.

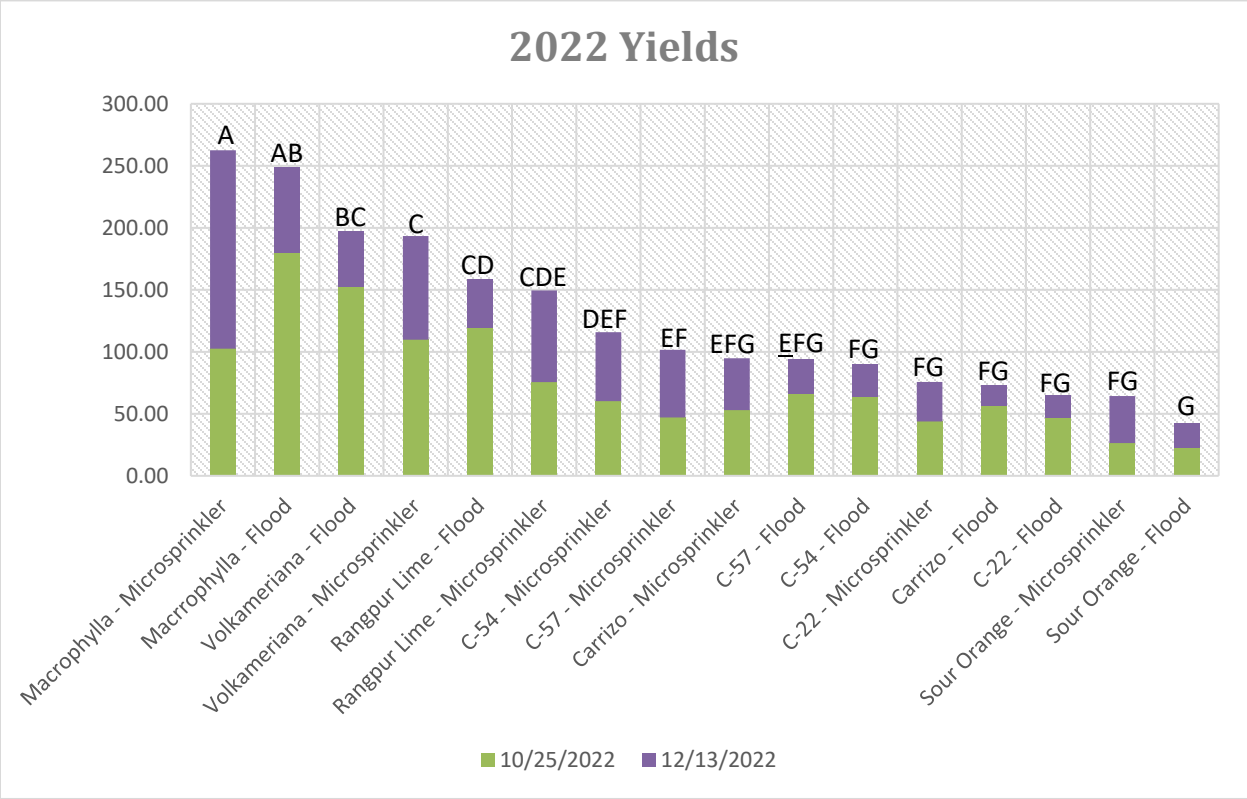


Figure 1. 2022 yields of Corona Foothills lemon on eight different rootstocks at the Yuma Mesa Agriculture Center, Yuma, AZ. For bars with different letter designations there is at least a 95% chance that the values are significantly different.

Yields for 2022 ranged from over 250 lbs. per tree for trees on *C. macrophylla* under pressurized irrigation to less than 50 lbs. per tree for trees on sour orange subject to flood irrigation (Fig. 2). Trees on *C. macrophylla* had the greatest yield , followed by trees on C. volkameriana, trees on Rangpur Lime, and then C-54 and C-57, Carrizo citrange C-22 and sour orange.

There was only a slight increase in yield for the pressurized irrigation field (6W) compared with the flood irrigated field (6E). Trees in field 6W averaged 132 lbs. of fruit, while those in field 6E averaged 121 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.

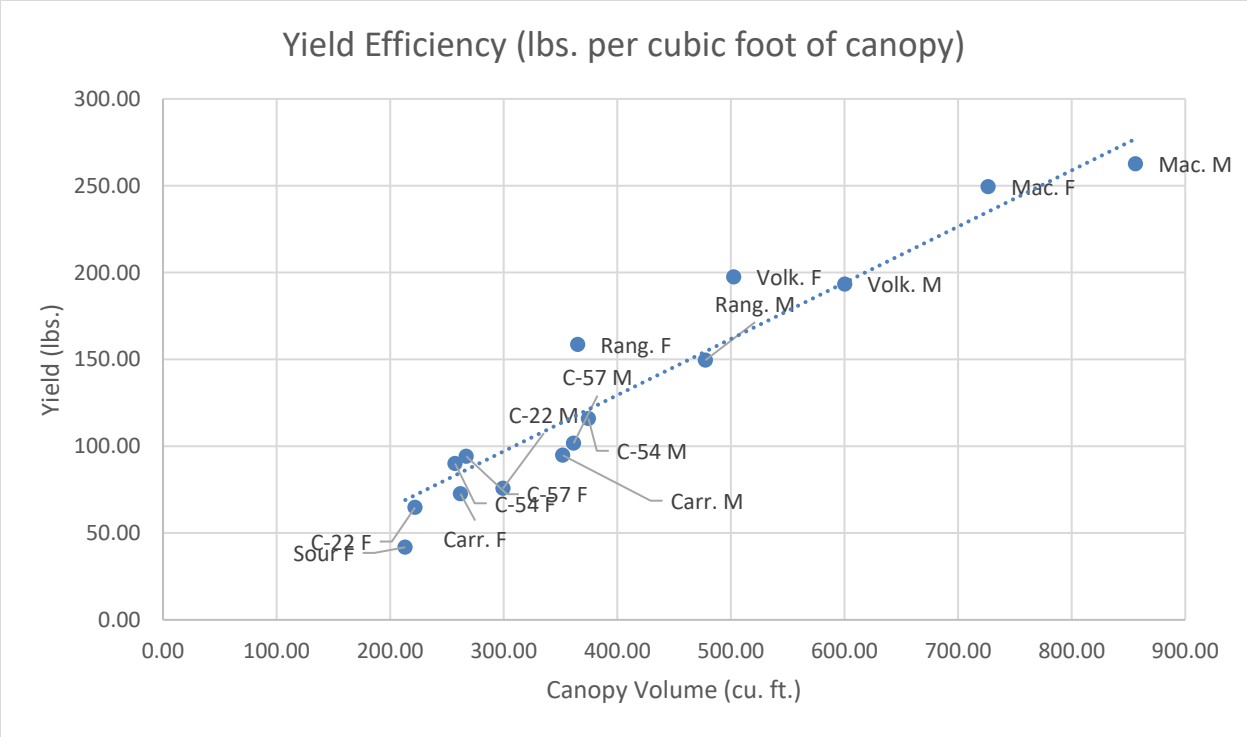
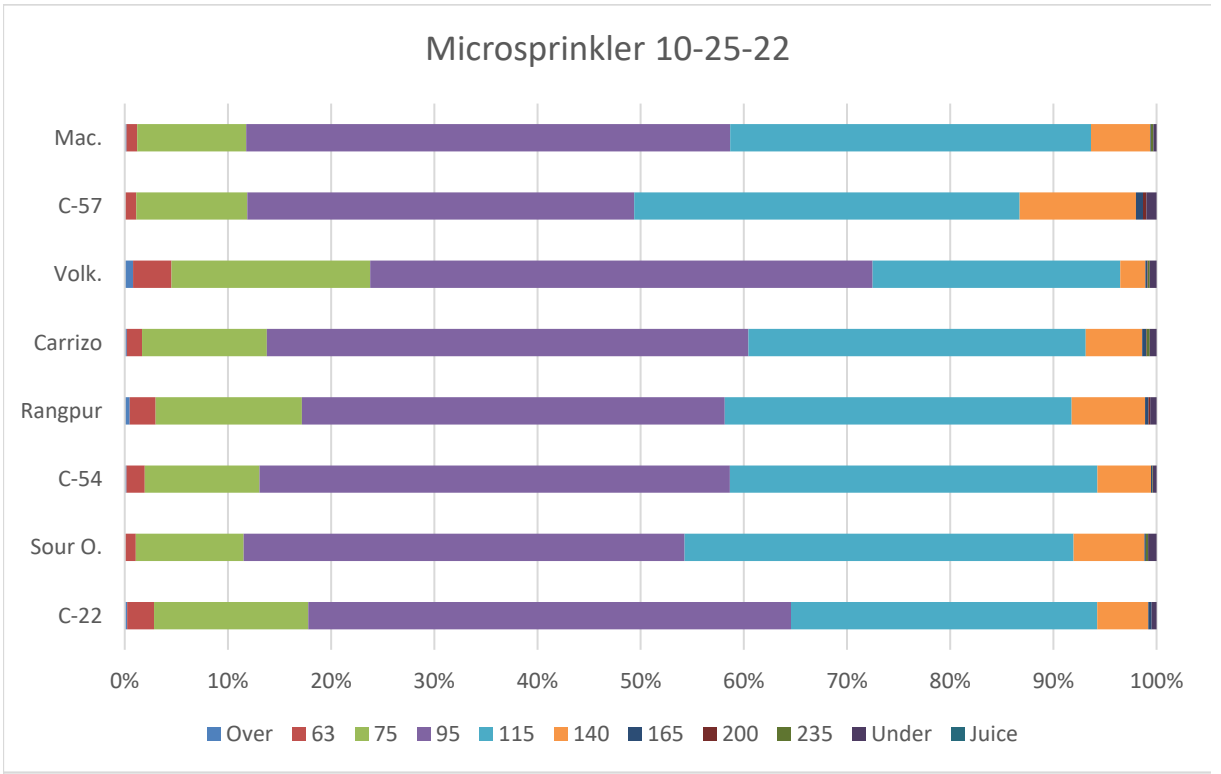


Figure 3. Yield efficiency of Corona Foothills lemons on eight rootstocks in Yuma, AZ. Value labels indicate the rootstock followed by "F" (Flood irrigation in field 6E), or "M" (Microsprinkler irrigation in field 6W).

Additionally, we calculated yield efficiency for each of the rootstocks and irrigation systems (Figure 3). 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. In the graph above, a rootstock that leads to good yield efficiency would be shown by a dot in the upper left quadrant of the graph. Unfortunately, currently, none of the rootstocks stands out as far as having a large enough yield on a relatively small canopy.

Packout for the two harvests and two irrigation methods is shown in Figures 4 and 5. For the microsprinkler-irrigated trees at the first harvest, there was very little difference in fruit size; the trees on *C. volkameriana* rootstock had slightly larger fruit, followed by those on C-22 and *C. macrophylla.* Results were similar for the second harvest, but there were smaller fruits for all the rootstocks, because of the strip pick. For the flood-irrigated trees at the first harvest, trees on *C. macrophylla* had the largest fruit size, followed closely by those on *C. volkameriana*, Carrizo and C-22.



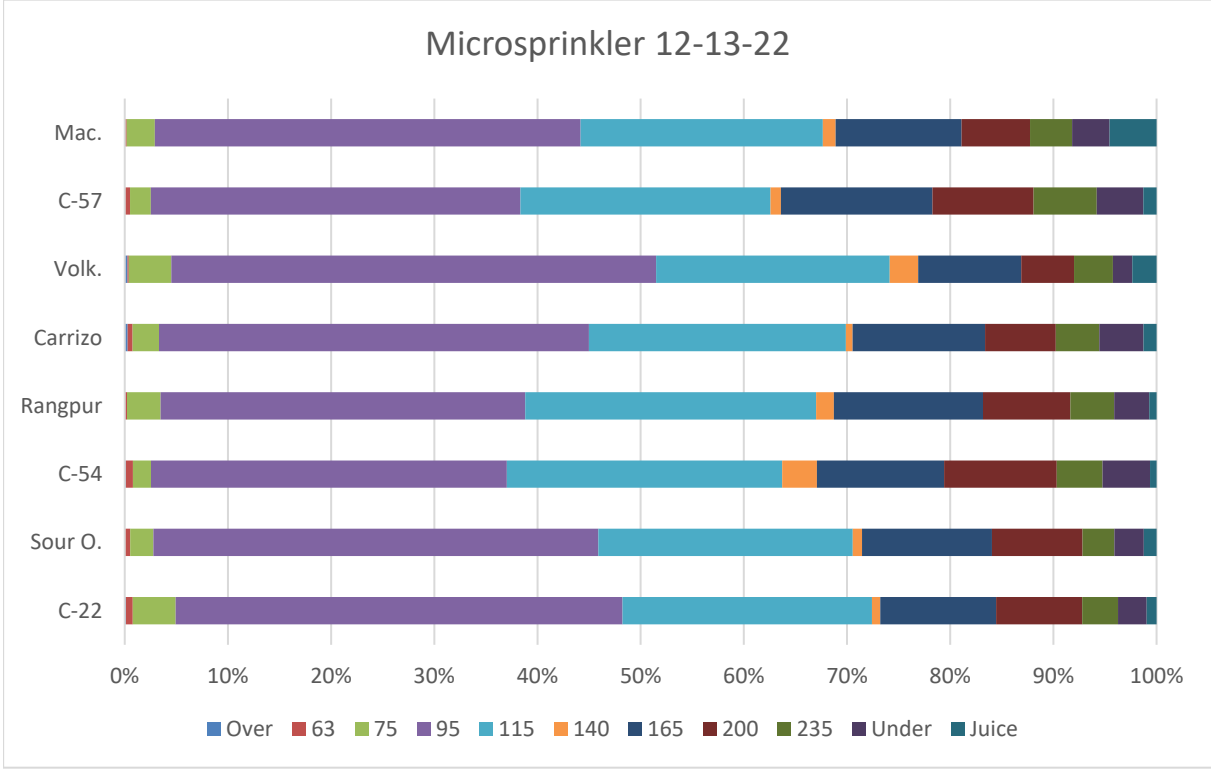


Figure 4. 10-25-22 and 12-13-22 packout of microsprinkler irrigated lemon trees on eight different rootstocks.

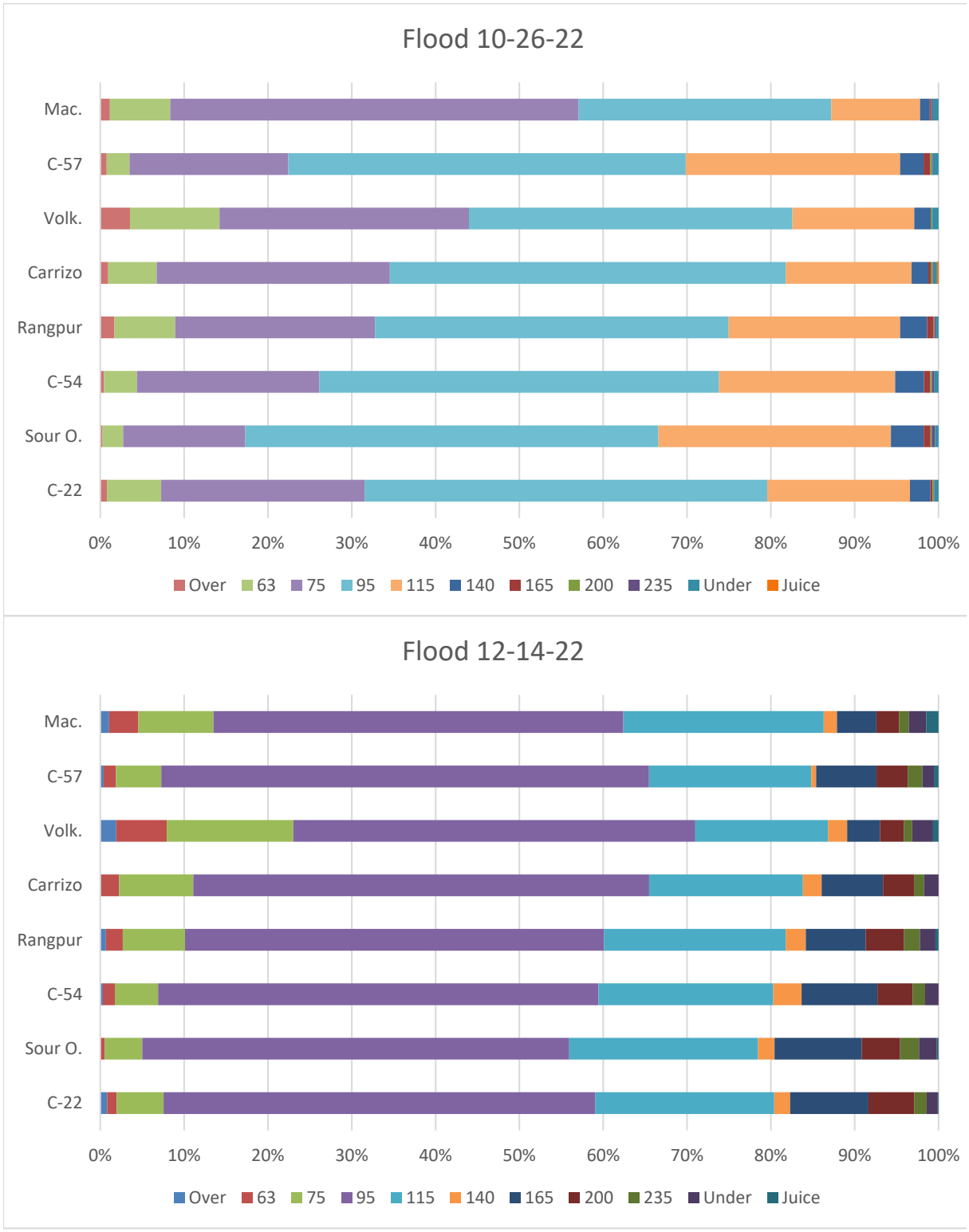


Figure 5. 10-26-22 and 12-14-22 packout of microsprinkler irrigated lemon trees on eight different rootstocks.

As of 12/31/18, three trees had been lost to brown wood rot (*Fomitopsis meliae*), and one to *Fusarium solani.* Further progression of Brown Wood Rot and other diseases is shown in Table 2.

Table 2. Dead and disease infested trees as of 12/31/22.

Rootstock	Number of Dead trees as of 12/31/21 (%)	Number of living trees with evidence of Brown Wood Rot as of 9/30/22 (%)
Brazil Sour Orange	6 (1.06%)	1 (0.18%
C. macrophylla	3 (0.53%)	5 (0.89%)
C. volkameriana	2 (0.36%)	3 (0.53)%
C-22 Bitters	1 (0.18%)	5 (0.89%)
C-54 Carpenter	1 (0.18%)	4 (0.72%)
C-57 Furr	1 (0.18%)	3 (0.53%)
Carrizo	0	2 (0.18%)
Rangpur Lime	0	2 (0.18%)
TOTAL	14 (2.5%)	20 (3.6%)

All told, just over 6% of the trees have been lost or damaged by brown wood rot since 1/1/19. Trees on C. macrophylla have been the most affected, followed closely by sour orange, C-22 and then *C. volkameriana.* Trees on Carrizo and Rangpur Lime have been least affected.

Plans for 2023-24

In 2023, we expect to continue irrigating the trees in Block 6W with microsprinkler irrigation, with occasional use of flood irrigation in July, August, and September to size the fruit and in the winter for frost control as needed. We will continue 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 2023 and yield and packout in fall and/or winter 2023. We will inspect the trees for disease and remove diseased limbs and entire trees that have died.

References

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