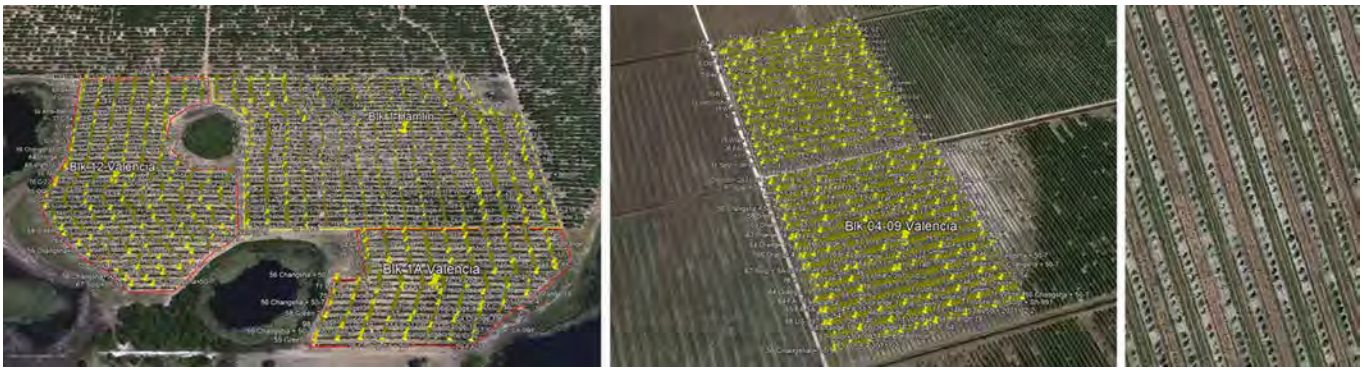

Figure 1. Rootstock trials near Lake Wales (left) and near Fort Basinger (center). Eight-tree plots (right).

Figure 2. Trees on large-size-inducing rootstocks (left) and small-size-inducing rootstocks (right) at the Lake Wales location. Note the leaning of some of the small trees because of hurricane Irma in 2017.

Rootstock effects on Valencia and Hamlin in large-scale commercial plantings

By Ute Albrecht, Sudip Kunwar and Jude Grosser

Prior to 1865, the only rootstocks used in Florida were sour orange and sweet orange. Use of grafted trees instead of seedling trees became necessary because of the devastating effects of phytophthora on sweet orange. Sour orange was widely used as a rootstock because of its resistance to phytophthora and other positive attributes, until trees started to decline because of the citrus tristeza virus which is still widespread in Florida.

Other diseases and events have shaped the citrus industry and rootstock preference in Florida. Florida Department of Agriculture and Consumer Services Division of Plant Industry budwood records document that from 1953 to 1974, sour orange and rough lemon were the most propagated rootstocks in Florida, followed by Carrizo/Kuharske (1974–1988), Swingle (1988-2018) and most recently US-942.

The rootstock can manipulate a grafted tree in many ways. It can induce tolerance or resistance to soil-borne stresses and diseases and manipulate horticultural attributes such as tree size, yield and fruit quality. Using superior rootstocks to manipulate disease tolerance has gained renewed importance with the arrival of HLB in Florida. This has led to the popularity of US-942, a hybrid of Sunki mandarin and trifoliate orange, which shows strong performance across most Florida production areas. Although traditional rootstocks such as Swingle, Kuharske, X-639, sour orange, Volkamer and rough lemon remain among the top 10 rootstocks, newer varieties are gaining in popularity.

In contrast to most other management strategies, use of superior rootstocks can increase profitability at no additional cost. This article summarizes the performance of more than 30 different rootstocks from breeding programs at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS), University of

California, Riverside (UCR) and Institutio Valenciano de Investigaciones Agrarias (IVIA) in Spain in commercial sweet orange field trials.

FLORIDA FIELD TRIALS SPECIFICS

Four field trials were established in 2015 in a collaborative effort between UF/IFAS Citrus Research and Education Center breeders and Lykes Brothers Inc. The trials are located near Fort Basinger (Highlands County) and Lake Wales (Polk County) and encompass a total area of about 80 acres (Figure 1, page 20). Each location contains both Valencia and Hamlin trials.

Each trial is arranged in replicated plots of eight trees for each rootstock with a one-tree gap between each plot. Tree spacing is 8 by 25 feet at Fort Basinger and 8 by 22 feet at Lake Wales. The Fort Basinger trial site consists of two-row beds and furrows, typical for the heavier flatwood-type soil at this location. The Lake Wales trial site is a typical Central Ridge site with a well-drained sandy soil.

The rootstocks were all propagated from seeds. Some of the UF/IFAS rootstocks (UFR-1, UFR-2, UFR-3, UFR-4, UFR-5, UFR-6 and UFR-17) and the Californian rootstocks (C-22, C-54, C-57, C-146 and X-639) are available for commercial use in Florida. Others are still experimental or only available for commercial use in Spain. All Californian and Spanish rootstocks are hybrids of mandarin (Sunki, Cleopatra or King mandarin) and trifoliate orange. The UF/IFAS varieties contain sexual and somatic hybrids and include a large array of different genotypes such as Nova mandarin, Changsha mandarin, Cleopatra mandarin, Succari orange, Hirado Buntan pummelo, sour orange, Benton citrange, Carrizo citrange and trifoliate orange. The rootstocks US-897, Swingle and sour orange are included in some of the trials for comparison.

ROOTSTOCK TRIAL RESULTS

During both the 2018/19 and the 2019/20 season, substantial differences in size and health of trees on different rootstocks across all trials were observed. Trees on some rootstocks were large, had a dense canopy and were undisturbed by HLB (Figure 2, page 20). Trees on other rootstocks were compact in size but looked healthy, although the impact of Hurricane Irma was noticeable for some of the trees. Other trees were of medium size and with varying degrees of health.

Hamlin

The average yield in the Hamlin trials was low (18.9 pounds/per tree) during the 2018/19 season because of the spread of canker through the grove after Hurricane Irma. Less canker was observed during 2019/20, and the average yield was 29.3 pounds/tree.

However, preharvest fruit drop was unusually high in this season.

The cumulative yields across both production seasons and tree sizes for the Hamlin trials are shown in Table 1 (page 22). Although there were differences among locations, when averaged, cumulative yields were largest in Hamlin trees on FA-5, UFR-5, C-54 and X-639. These trees were also among the largest trees in the trials. Yield efficiency (pounds of fruit per canopy volume) was highest in trees on Green 3, Amb+Benton and Changsha+Benton,

HAMLIN (2018/19-2019/20)								
Rootstock	Origin	Yield 2018/19 (lbs./tree)	Yield 2019/20 (lbs./tree)	Cumulative yield (lbs./ tree)	Height (ft.)	Canopy spread (ft.)	Yield efficiency (lbs./ft.^{3})	TSS (%)
FA-5	IVIA	24.7	40.3	64.9	7.3	7.0	0.46	8.5
UFR-5	UF	29.7	32.1	61.8	6.6	6.7	0.56	9.4
C-54	UCR	23.9	37.8	61.7	7.5	7.5	0.36	8.6
X-639	UCR	19.9	41.3	61.2	7.6	7.5	0.34	8.4
C-57	UCR	22.9	35.7	58.6	7.6	7.2	0.34	8.4
FA-517	IVIA	27.3	31.1	58.4	6.2	6.1	0.63	9.1
US-897	USDA	24.4	29.8	54.1	6.5	6.7	0.45	8.9
Swingle	USDA	23.3	30.5	53.8	6.3	6.5	0.52	9.1
V-17	IVIA	16.3	37.3	53.5	6.8	6.4	0.46	8.5
FA-5128	IVIA	18.1	33.9	52.1	6.8	6.9	0.41	8.4
FA-5115	IVIA	19.0	32.6	51.5	6.9	6.2	0.46	9.0
Green 7	UF	19.6	31.5	51.1	6.5	6.1	0.51	8.9
C-22	UCR	21.1	29.8	50.9	6.8	6.9	0.39	8.5
Orange 14	UF	21.5	29.0	50.5	6.9	6.7	0.41	8.6
FA-31	IVIA	17.4	32.1	49.5	7.0	7.0	0.33	8.3
Amb+Czo	UF	20.5	28.4	48.9	5.9	5.9	0.60	9.4
6058+2071-02-2	UF	17.2	31.5	48.7	5.7	5.9	0.56	8.7
UFR-4	UF	18.3	29.8	48.1	6.6	6.8	0.40	8.7
C-146	UCR	20.3	27.8	48.0	7.4	7.1	0.33	8.4
White 1	UF	17.4	29.1	46.5	5.8	6.0	0.51	9.5
UFR-1	UF	15.5	28.6	44.1	6.0	6.2	0.46	9.3
Wgft+50-7	UF	13.3	30.5	43.8	6.3	5.8	0.50	9.4
UFR-17	UF	17.0	26.4	43.4	6.3	6.2	0.46	8.9
UFR-6	UF	18.6	23.1	41.7	5.9	6.0	0.51	9.3
UFR-2	UF	15.4	26.1	41.4	6.1	6.3	0.39	8.7
FA-13	IVIA	16.6	24.3	40.8	6.8	7.0	0.30	8.2
Green 3	UF	13.7	23.8	37.5	5.0	4.9	0.74	9.6
Amb+Benton	UF	13.4	21.0	34.4	5.2	5.3	0.65	9.3
Changsha+Benton	UF	17.1	16.6	33.7	4.8	5.1	0.64	9.5
Sorp+Sh-991	UF	9.9	21.3	31.2	5.3	5.3	0.49	9.3
UFR-3	UF	12.2	16.8	29.0	5.3	5.0	0.51	9.1

Table 1. Average yearly and cumulative yield, tree height, canopy spread, yield efficiency and fruit total soluble solids (TSS) of Hamlin orange trees on 31 different rootstocks. Numbers presented are averages across both locations.

which were among the smallest-tree-size-inducing rootstocks.

Valencia

Yield and tree size were assessed in the 2018/19 season for the Valencia trials and are shown in Table 2 (page 23). Valencia data for the 2019/20 season were not available at the time of this writing. The average yield across both locations was 28.3 pounds/tree. Although there were differences among rootstocks depending on the location, C-22 and C-146 produced the largest average amount of fruit per tree despite producing some of the smallest trees. The lowest yields were measured for X-639 and UFR-2. The yield efficiency was greatest for Changsha+Benton and C-22. Interestingly, trees on US-897, which is considered a small-tree-size-inducing rootstock, were among the larger trees in both Hamlin and Valencia trials and among the largest-yield-inducing rootstocks.

Fruit quality was influenced by the rootstock in all trials. In general, fruit from trees on small-size-inducing rootstocks tend to produce a larger amount of soluble solids than fruit from trees on large-size-inducing rootstocks.

RESEARCH CONCLUSIONS

Tree size and yield efficiency are important factors for determining planting density and considering long-term profitability. Trees on small-size-inducing rootstocks with a high yield efficiency can be planted at high density and will result in greater early returns. Trees on large-size-inducing rootstocks should be planted at lower density and may not produce the desired yields during the

VALENCIA (2018/19)						
Rootstock	Origin	Yield (lbs./tree)	Height (ft.)	Canopy spread (ft.)	Yield efficiency (lbs./ft.^{3})	TSS (%)
C-22	UCR	45.6	5.1	5.6	1.19	9.5
C-146	UCR	39.7	5.8	5.8	0.85	10.0
FA-517	IVIA	37.6	5.1	5.2	1.11	9.9
US-897	USDA	34.2	6.0	6.3	0.61	9.1
C-57	UCR	33.9	5.2	5.5	0.83	9.6
C-54	UCR	33.5	6.0	6.3	0.56	9.7
White 1	UF	32.4	5.5	5.5	0.75	9.4
V-17	IVIA	32.2	5.3	5.4	0.86	9.8
Changsha+Benton	UF	31.9	4.3	4.3	1.49	10.5
Amb+Czo	UF	30.2	4.9	4.9	1.09	10.8
Wgft+50-7	UF	29.9	5.3	5.5	0.73	8.4
FA-5128	IVIA	29.7	5.8	5.7	0.63	8.4
FA-5	IVIA	29.0	5.6	5.7	0.73	9.2
UFR-6	UF	28.9	4.7	4.9	0.98	8.5
UFR-5	UF	28.4	5.2	5.4	0.73	8.7
UFR-17	UF	28.1	4.8	4.9	0.94	10.8
UFR-1	UF	27.0	4.9	5.1	0.87	9.5
FA-13	IVIA	26.5	6.1	6.0	0.48	10.1
6058+2071-02-2	UF	26.4	4.9	5.0	0.86	9.5
UFR-4	UF	26.4	5.2	5.7	0.68	9.5
Sour orange	N/A	25.3	6.3	6.0	0.43	9.6
Green 7	UF	25.2	5.1	4.9	0.85	9.8
FA-31	IVIA	23.1	5.9	5.9	0.43	9.2
FA-5115	IVIA	22.4	6.5	6.4	0.34	10.3
Orange 14	UF	21.4	4.6	4.6	0.86	9.4
Sorp+Sh-991	UF	21.3	4.5	4.3	0.90	9.8
Amb+Benton	UF	20.8	4.4	4.3	0.96	10.0
Green 3	UF	20.5	4.5	4.5	0.96	10.5
X-639	UCR	20.2	6.7	6.6	0.29	10.6
UFR-2	UF	17.5	4.6	4.5	0.77	8.4

Table 2. Yield, tree height, canopy spread, yield efficiency and fruit total soluble solids (TSS) of Valencia orange trees on 30 different rootstocks. Numbers presented are averages across both locations.

early production years.

However, because of the high vigor of these rootstocks, it is probable that these trees will cope better with HLB and therefore be more profitable in the longer term than trees on some of the small-size-inducing rootstocks. Another drawback of very small-size-inducing rootstocks may be their greater vulnerability to wind-induced uprooting.

More years of evaluation are needed to determine which rootstocks perform best and to determine the economics of tree vigor, planting density and longer-term profitability.

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