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HS1260

Florida Citrus Rootstock Selection Guide, 3rd Edition[1]

William S. Castle, Kim D. Bowman, Jude W. Grosser, Stephen H. Futch, and James H. Graham[2]

This 3rd edition of the Florida Citrus Rootstock Selection Guide is a revision of the 2006 publication. The guide is a convenient, easy-to-use reference to 20 characteristics of 45 rootstocks. Of those, 12 are time-honored commercial rootstocks (highlighted in blue), which are the most reliably characterized. The next 12 rootstocks are minor commercial ones (highlighted in green) that are less frequently used today in Florida but may have been prominent at one time. The third group consists of the most recently released 21 rootstocks (highlighted in yellow) for which there is limited commercial experience.

Much within the Florida citrus industry has changed since the discovery and spread of the presumed bacterial-caused disease, Huanglongbing (HLB). Rootstocks were not initially part of the discussion related to managing HLB, but that, too, has changed, particularly given the accumulating evidence that trees on various rootstocks may differ in the incidence or tolerance of the disease. Therefore, the authors have prepared this timely and necessary update of the former editions and considerably expanded the list of rootstocks to include many that have not yet undergone the usual extensive field evaluation in Florida. These new rootstocks offer improvements of many meaningful traits that appear essential to the future of our citrus industry, among them tree size control, high yield and juice quality, and possible HLB tolerance.

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***Note**: Print the Rootstock table on 11" x 17" (tabloid size) paper.*

Interactive Web Version

The revised Florida Citrus Rootstock Selection Guide is also available on the UF/IFAS Citrus Research and Education Center website (flrootstockselectionguide.org). Interested parties are strongly encouraged to visit the website because the version posted there offers a considerably expanded opportunity to interact with the rootstock information. The Selection Guide is supported by 105 downloadable citations related to each rootstock and trait. Furthermore, users of the website version can query the tabulated and background information via customized searches. Users can search for answers to specific questions.

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How to Use the Rootstock Selection Guide

[1] General

The rootstock information provided is a broad-based compilation of Florida information collected from field trials and commercial situations. The information is general in nature as it represents essentially "average" rootstock behavior across a range of conditions related mostly to scion variety and site conditions.

The quality of information varies due primarily to the time period of evaluation. Thus, the rootstocks have been grouped accordingly into three groups. **COMMERCIAL** rootstocks are time-honored rootstocks in terms of their use and are the ones for which the descriptions are the most reliable. **MINOR COMMERCIAL** rootstocks are ones such as Smooth Flat Seville that have been in minor commercial use for a while and others like rough lemon that were prominent at one time, but their importance has faded as newer rootstocks were introduced and adopted commercially. The information presented for most of the rootstocks in this category is reliable, but is sometimes not as fully developed as with the commercial rootstocks. **RECENTLY RELEASED** rootstocks are ones created in breeding programs and have been under evaluation in Florida for only a few years. They were eventually selected from field trials and small commercial cooperative trials. There is limited commercial experience.

It is also important to note that in rating rootstocks, the differences for a particular factor are sometimes based on a quasi-qualitative comparison and in other cases a more quantitative basis. **Tree height**, for example, is essentially a relative rating based on the standard of comparison: a tree on a particular rootstock rated as "Large" would be equivalent in height to a mature tree on rough lemon rootstock. On the other hand, a rootstock's rating regarding citrus nematode or Phytophthora tolerance is fundamentally based on quantitative screening trials plus commercial experience.

[2] Year of First Commercial Availability

is when the rootstock first appeared in the nursery use records of the FL. Dept. Agric. & Consumer Serv., Div. Plant Industry, Bureau of Citrus Budwood Registration. ***Rootstock use***: Information on rootstock use can be found in the annual reports of the Bureau available at this site: http://www.freshfromflorida.com/Divisions-Offices/Plant-Industry/Bureaus-and-Services/Bureau-of-Budwood-Registration.

[3] Horticultural Traits

Ease of seed propagation. If a rootstock produces seed fruit with many polyembryonic seeds that germinate well, it is rated Good [G]. Some rootstock seed trees produce lots of fruit, but usually only a few to no seeds [G;FS]. Rootstocks like Smooth Flat Seville produce lots of seed fruit and seeds that germinate well, but the seedlings are highly variable and 50% or more are discarded as off-types [G; sdlg var.].

Tree size is the size of the canopy of a mature tree. The ratings indicate relative tree vigor. A tree on a particular rootstock would be rated large [Lg] if it was comparable in vigor and size to one on Cleopatra mandarin or rough lemon, i.e., perhaps 14–20 ft tall. A small tree [Sm] would be less than 8 ft tall at maturity, and an intermediate tree [I] would be like one on C-35 citrange.

Suggested in-row spacing. The appropriate spacing without excessive crowding given the expected vigor and growth to maturity of common commercial scion varieties. Spacing would actually change according to the particular scion. Between-row spacing would be dictated mostly by cultural and harvesting machinery used.

Yield/tree is the amount of fruit on an individual mature tree at a recommended spacing, but recognizing that the bearing habits of different scion-rootstock combinations vary. For example, some are more precocious [early–bearing] than others. Comparisons of rootstocks for effects on tree yield should consider canopy size. Small trees usually produce less fruit/tree than larger trees, but the smaller trees can be planted at higher densities.

Yield/acre. Yield/tree x number of trees/acre. Generally, the relationship between these two variables [yield/tree and yield/acre] is directly proportional. However, there are situations where a tree has only intermediate yield/tree because of a smaller canopy, but yield/acre is high because more trees of smaller stature can be planted/acre.

Juice quality. Brix/acid ratio rating.

Fruit size is a relative rating based on legal standards.

[4] Tolerances

Salinity. Salty waters in Florida containing high levels of NaCl are problematic because rootstocks vary in their absorbance and translocation of the Na and Cl ions.

High pH. Rootstocks vary in their tolerance of calcareous soils mostly because of the $CaCO_3$ in the soil and/or the irrigation water. Such conditions commonly lead to calcium-induced Fe chlorosis. New evidence suggested that HLB-infected trees may also suffer stresses related to bicarbonate in the irrigation water.

Clay soil refers to soils with horizons containing >20% clay or loamy materials, and especially soils where such horizons are close to the soil surface. These soils are generally unsuitable for Swingle citrumelo, Carrizo citrange, and other citrumelo, citrange, and trifoliate orange rootstocks.

Wet soil [flooding]. Wet soils are poorly drained, chronically wet, or subject to extended periods of flooding. For additional soils information, see Field Guide to Soil Identification for Florida's Citrus-Growing regions, SP 362 [http://ifasbooks.ifas.ufl.edu/p-266-field-guide-to-soil-identification-for-floridas-citrus-growing-regions.aspx]

Drought. With the advent of generally practiced irrigation, drought is no longer considered an important rootstock factor.

Freezes. The threat of a seriously damaging cold event remains. Few stressful freeze events have occurred since the 1980s. Thus, the tolerance of many of the minor and recently released rootstocks has not been determined.

[5] Diseases and Pests

HLB [Huanglongbing]–bearing tree. Observations are accumulating that the incidence of HLB is less among trees on some rootstocks especially new rootstocks included in various field trials. This rating reflects those observations; however, the ratings are quite tentative and subject to change. The interpretation of the observations is speculative and highly subject to revision over time. Survey results from a grower-scale observation of HLB incidence among commercial scions and rootstocks are available by visiting http://www.crec.ifas.ufl.edu/extension/pdf/hlb_scion_survey.pdf.

Blight. As with HLB, rootstock tolerance to blight, a disorder of unknown cause, is based on field observation in research trials and commercial groves. It is a combined rating for overall incidence and rate and time to first losses. Thus, Cleopatra mandarin is rated "S-T" because while the incidence of blight is low among young trees, substantial losses can occur when the trees reach 12 to 15 years of age.

Phytophthora nicotianae ratings are a combination of foot and root rot tolerances which are similar within a rootstock, but some differ, e.g., sour orange has good foot rot tolerance but mediocre root rot tolerance.

P. palmivora/*Diaprepes weevil complex*. Rootstocks vary in their tolerance to *P. nicotianae* and *P. palmivora*, but when *P. palmivora* is present, it is not ordinarily problematic unless Diaprepes weevils are also present (*Phytophthora/Diaprepes* Complex). Most rootstocks are susceptible to this complex, but the ratings may vary depending on soil type.

Burrowing nematodes. All rootstocks are susceptible except for selections of Carrizo citrange, 'Ridge Pineapple' sweet orange, Milam lemon, and Kuharske citrange.

Citrus nematodes. Trifoliate orange has tolerance to citrus nematodes. That trait is inherited by many of its hybrids including Swingle citrumelo. **STING NEMATODE** is a pest in some instances especially in soils with high sand content. There are no known tolerant rootstocks.

Xyloporosis and Exocortis. These virus and viroid diseases, respectively, can be problematic for trees on certain rootstocks. However, they have been virtually eliminated from Florida because of clean budwood programs. Therefore, they are not included in this guide.

Tristeza. This disease is caused by an aphid-transmitted virus. Rating rootstocks is a bit complicated because there are strains and mixtures of strains of this virus that cause a range of symptoms leading to tree decline or in some cases, very mild effects.

Additional Comments

Incompatibility. There are just a few situations where a particular scion-rootstock combination, like Murcott budded to Carrizo citrange or Swingle citrumelo, declines from an apparent incompatibility that manifests itself at the budunion. Other problematic combinations were described by Garnsey et al. and are listed in the citations on the interactive website.

WARNING! Mandarins are perhaps the most sensitive scions to incompatibility especially with trifoliate orange-hybrid rootstocks. Nurserypersons and growers should be alert to the fact that new releases of mandarin scion types have generally not been tested for compatibility with a broad range of rootstocks.

Key to Symbols

G – Good; **H** – High; **I** – Intermediate; **L** – Low; **Lg** – Large; **P** – Poor; **R** – Resistant; **S** – Susceptible; **Sm** – Small; **T** – Tolerant; **UFR** – University of Florida Rootstock; * Blank space – Rating unknown; [ ] – Any symbol in brackets indicates a probable or expected rating; +/- Relative ranking; and, ? – Undetermined.

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	ROOTSTOCK *Blue=Commercial* *Green= Minor Commercial* *Yellow=Recently Released*	Year of first commercial availability [2]	Horticultural traits [3]							Tolerances [4]						Pests and Diseases [5]						
			Ease of seed propagation	Tree size	Suggested in-row spacing (ft)	Yield/ tree	Yield/ acre	Juice quality	Fruit size	Salinity	High pH	Clay soil	Wet soil (flooding)	Drought	Freezes	HLB incidence - bearing tree	Blight	*Phytoph. nicotianae*	*P. palmivora* root weevil complex	Burrowing nematodes	Citrus nematodes	Tristeza	
1	**x-639 (Cleo x Rubidoux TF)**	1994	G	Lg	8-12	I	I-H	H/H	I	G	[I]	[G]	[G]	?	[I-G]	L	?	T	[S]	[S]	?	T	1
2	**C-35 citrange**	1994	G	I	8-10	I	I-H	H/I	I	[P-I]	P	[P]	[I]	?	?	?	?	T+	[S]	[S]	R	T	2
3	**Carrizo citrange**	1962	G	Lg	8-12	H	I-H	I-H/I	I-Lg	P	P	P	I	G	G	I-H	I	I	[S]	[S]	S	T	3
4	**Cleopatra mandarin**	Long-established	G	Lg	8-15	L-I	I	H/H	Sm	G	I	G	P	I-G	G	L	S-T	S	[S]	S	S	T	4
5	**Kuharske citrange**	1994	G	Lg	8-12	H	I-H	I/I	I/Lg	[P-I]	[P]	?	?	[G]	[G]	?	?	I	[S]	[R]	S	[T]	5
6	**Sour orange**	Long-established	G	I-Lg	8-12	I-H	I-H	H+/H	I	G	G	G	G+	I	G	L	T+	T	T	S	S	S	6
7	**Swingle citrumelo**	1974	G	I	8-12	I	I	I/I	I	P	P	P	[G]	P-I	G	I	T	T+	[S]	S	R	T	7
8	**US-802 (Pummelo x TF)**	2007	G	Lg	14	H	I	L-I/I	Lg	?	[I]	[G]	[I]	?	G	I	G	T	T	?	?	T	8
9	**US-812 (Sunki x Benecke TF)**	2001	G	I	12	H	H	H/H	I	?	G	[I]	[I]	?	[G]	I	T+	T	[S]	?	?	T+	9
10	**US-897 (Cleo x TF)**	2007	G	Sm	8	L	H	H/H	Sm-I	?	[I]	[G]	[I]	?	I	I	I	T	T	?	?	T	10
11	**US-942**	2010	G	Sm-I	10	H	H	H/H	I	?	[G]	[G]	[G]	[G]	[G]	L	T+	T	T	?	?	T+	11
12	**Volkamer lemon**	1970	G	Lg	12-15	H	I-H	L/L	Lg	I	T	I	I-G	G	P	?	S	T	[S]	S	S	T	12
13	**Benton citrange**	1986	G	Lg	8-12	H	?	H/I	I-Lg	P-I	P	[P]	[I]	G	G	?	?	T	[S]	?	?	T	13
14	**Flying Dragon TF**	1978	G	Sm	5-7	L-I	H	H/H	Sm-I	P	P	G	I	P	G	?	P	T	[I]	S	R	T	14
15	**Goutou**	1994	G	I	8-10	[L-I]	[I]	L-I/L	Lg	?	[I]	G	[G]	?	?	?	?	S	[S]	[S]	?	T+	15
16	**Kinkoji**	1986	G	I	8-10	[I]	I	L-I/L	I	?	[I]	[G]	[G]	?	?	?	?	T	[S]	[S]	?	T	16
17	**Rough lemon**	Long-established	G	Lg	10-15	H	I-H	L/L	Lg	I	G	I	I	G	P	?	S	S	S	S	S	T	17
18	**Rusk citrange**	1960	G; FS	Sm-I	6-8	I	I-H	H+/I	I	P	P	?	P	[P]	P-I	?	[I]	T	[S]	S	?	T	18
19	**Shekwasha mandarin**	1986	G	I-Lg	8-15	L-I	I	I/H	Sm	[I]	G+	[G]	P	I-G	G	?	?	S	[S]	S	S	T	19
20	**Smooth Flat Seville**	1988	G; sdlgs var.	I	8-12	L-I	I	L-I/I	I-Lg	[I]	G	[G]	I	[G]	[I]	?	[T]	S	[S]	[S]	?	[T]	20
21	**Sun Chu Sha mandarin**	1988	G	Lg	8-12	L-I	I	H/H	Sm	[I]	I+	G	P	[I-G]	[G]	?	?	S	[S]	S	S	T	21
22	**Sweet orange**	Long-established	G	Lg	10-12	I	I	I/I	I-Lg	I	I	I	P	P	I	?	T+	S+	[S]	S	S	T	22
23	**Trifoliate orange**	Long-established	G	Sm	6-8	L-I	H	H/H	Sm-I	P-	P-	G	G	P	I-G	?	[S]	T+	[S]	S	R	T+	23
24	**US-852 (Changsha x TF)**	1999	P	I	12	H	H	H/H	I	?	[I]	[I]	?	?	G	I	G	T	[S]	?	?	T	24
25	**1584 (TF x Milam)**	2004	G; FS	I	8-12	H	?	I-H/I	I	[I]	?	G	T	?	?	?	?	I	[S]	?	T	T	25
27	**C-22 Bitters (Sunki x Swingle TF)**	2009	G	Sm-I	6-8	[I]	[I]	H/I	I	?	G+	?	?	?	?	[I]	?	I	?	?	S	I	27
28	**C-54 Carpenter (Sunki x Swingle TF)**	2009	G	I	8	[H]	[H]	H/I	I	?	I	?	?	?	?	[T]	?	I	?	?	G	I	28
29	**C-57 Furr (Sunki x Swingle TF)**	2009	G	I	8	[H]	[H]	H/I	I	?	I	?	?	?	?	[T]	?	G	?	?	G	I	29
30	**C-146 (Sunki x Swingle TF)**	2009	G	I	8	[H]	[H]	H/I	I	?	?	?	?	?	?	[T]	?	[G]	?	?	[G]	[I]	30
26	**US-896 (Cleo x Rubidoux TF)**	2015	G	Sm-I	10	H	H	H/H	I-Lg	?	?	?	?	?	I	T	T	T	[S]	?	?	T	26
31	**US-1279 (Changsha x Gotha Rd TF)**	2014	?	Sm-I	10	H	H	I/H	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	31
32	**US-1281 (Cleo x Gotha Rd TF)**	2014	?	Sm-I	10	H	H	H/H	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	32
33	**US-1282 (Cleo x Gotha Rd TF)**	2014	?	Sm-I	10	H	H	H/H	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	33
34	**US-1283 (Ninkat x Gotha Rd TF)**	2014	?	Sm-I	10	H	H	I/I	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	34
35	**US-1284 (Ninkat x Gotha Rd TF)**	2014	?	I	12	H	H	I-H/I	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	35
36	**US-1516 (Pummelo x TF)**	2015	G	I-Lg	12	H	H	L-I/I	I-Lg	?	?	?	?	?	?	T	?	T	[I]	?	?	T	36
37	**UFR-1 (4x Nova+HBP x Cleo+TF)**	2015	G	I	8-10	H	H	H	?	[G]	?	?	?	?	I	T	[I]	T	T	?	?	[T]	37
38	**UFR-2 (4x Nova+HBP x Cleo+TF)**	2015	G	I	8-10	I/H	I/H	I	?	[G]	?	?	?	?	I	I	[I]	T	[I]	?	?	[T]	38
39	**UFR-3 (4x Nova+HBP x Cleo+TF)**	2015	G; sdlgs var.	I	8-10	H	H	I	?	[I]	?	?	?	?	I	T	[I]	T	[I]	?	?	[T]	39
40	**UFR-4 (4x Nova+HBP x Cleo+TF)**	2015	G	I	10	I/H	I/H	I/H	?	[I]	G	G	?	?	I	T	[I]	T	[T]	?	?	[T]	40
41	**UFR-5 (4x Nova+HBP x Succari+TF)**	2015	G	I	8-10	H	H	H	?	[I]	G	?	?	?	I	[T]	?	T	[T]	?	?	[T]	41
42	**UFR-6 (4x Changsha+TF)**	2015	G	Sm	6-8	H	H	H	?	[I]	?	?	?	?	G	I	[I]	T	?	?	?	T	42
43	**UFR-15 (HBP x Cleo)**	2015	G; sdlgs var.	Lg	12	[I]	[I]	[I]	?	[G]	[G]	[G]	?	?	?	[T]	[G]	T	?	?	?	?	43
44	**UFR-16 (HBP x Shekwasha)**	2015	G; sdlgs var.	I/Lg	10-12	[I]	[I]	[I]	?	[G]	[G]	[G]	?	?	?	[T]	[G]	T	[T]	?	?	?	44
45	**UFR-17 (Nova+HBP x SO+Carrizo)**	2015	G; sdlgs var.	I	8-10	[H]	[H]	?	?	[I]	[G]	?	?	?	?	T	?	T	[I]	?	?	?	45

May 2015, Revision of SP 248, Florida Citrus Rootstock Selection Guide.

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